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# EIGHTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR ASIA AND THE FAR EAST

Bangkok, 17–28 January 1977

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Vol. II Technical Papers



UNITED NATIONS

E/CONF.68/3/Add.1

Department of Economic and Social Affairs

# EIGHTH UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR ASIA AND THE FAR EAST

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## Vol. II Technical Papers

UNITED NATIONS
New York, 1980

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# FOREWORD

The official records of the Eighth United Nations Regional Cartographic Conference for Asia and the Far East, held at Bangkok, Thailand, from 17 to 28 January 1977, are issued, as were those of the previous conferences, in two volumes: volume I, *Report of the Conference*,[1] and the present publication, volume II, *Technical papers*, which contains the texts of the technical background papers submitted to the Conference by the participating Governments.

These technical papers are grouped according to the agenda item to which they relate. They have been edited in accordance with United Nations style and practice. The views expressed in these papers are those of the authors and do not imply the expression of any opinion on the part of the United Nations Secretariat.

The official records of the previous United Nations Regional Cartographic Conferences for Asia and the Far East have been published as E/CONF.18/6 (Sales No. 55.I.29) and E/CONF.18/7 (Sales No. 56.I.23) for the First Conference; E/CONF.25/3 (Sales No. 59.I.9) and E/CONF.25/4 (Sales No. 61.I.8) for the Second Conference; E/CONF.36/2 (Sales No. 62.I.14) and E/CONF.36/3 (Sales No. 64.I.17) for the Third Conference; E/CONF.50/4 (Sales No. 65.I.16) and E/CONF.50/5 (Sales No. 66.I.3) for the Fourth Conference; E/CONF.52/4 (Sales No. E.68.I.2) and E/CONF.52/5 (Sales No. E.68.I.14) for the Fifth Conference; E/CONF.57/2 (Sales No. E.71.I.15) and E/CONF.57/3 (Sales No. E.72.I.20) for the Sixth Conference; E/CONF.62/3 (Sales E.74.I.7) and E/CONF.62/4 (Sales No. E.74.I.25) for the Seventh Conference.

[1] *Eighth United Nations Regional Cartographic Conference for Asia and the Far East*, Vol. I, *Report of the Conference* (United Nations publication, Sales No. E.77.I.12).

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[1] Except for slight revisions made for conformity with United Nations usage, the figures appearing in this volume have been reproduced without alteration from the papers submitted by Governments.

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## *Explanatory notes*

The following symbols have been used in the tables throughout the report:

Three dots (. . .) indicate that data are not available or are not separately reported

A dash (—) indicates that the amount is nil or negligible; in the mapping inventory, nil or negligible on the map scale used

A blank in a table indicates that the item is not applicable

A minus sign (−) indicates a deficit or decrease, except as indicated

A full stop (.) is used to indicate decimals

Use of a hyphen (-) between dates representing years, e.g., 1971-1973, signifies the full period involved, including the beginning and end years.

Reference to "dollars" indicates United States dollars, unless otherwise stated.

# TECHNICAL PAPERS
# PRESENTED TO THE CONFERENCE

# AGENDA ITEM 6

## Country reports and progress made by countries since the Seventh Conference

### CARTOGRAPHIC ACTIVITIES IN AFGHANISTAN*

*Paper presented by Afghanistan*

The Afghan Cartographic and Cadastral Surveys Institute is involved with the completion and revision of map coverage on the scale 1 : 50,000; completion of maps on the scale 1 : 25,000 for the areas under development or likely to be developed, mapping on larger scales for various development projects and preparation of cadastral maps on the scale 1 : 2,000. In addition to these major activities, the Institute prepares various geographical and other special-purpose maps; the Institute also is responsible for the geodetic network of triangulation, precision levelling and gravimetric observations.

#### CURRENT ACTIVITIES

*Topographic mapping on the scales 1 : 50,000 and 1 : 25,000*

Almost the entire area of Afghanistan is covered by maps at 1 : 50,000 scale. These maps, however, need revision and updating, especially in the developing areas. It is planned to complete and update the maps through the ongoing mapping programme at 1 : 25,000 scale. It is estimated that approximately 200,000 km$^2$ will be covered during the next 14 years.

The survey is being carried out by photogrammetric methods followed by ground verification. The required aerial photography is being taken by the Institute with Zeiss RMK and RMK-A cameras, with the help of military and civil aviation organizations. Because of the height ceiling of 6,000 m for the aircraft available, the scale of photography required for mapping at 1 : 25,000 scale—that is, 1 : 40,000—could not be obtained and the Institute must use photography on scales in a range from 1 : 20,000 to 1 : 30,000.

Efforts are being made to procure an aircraft with a higher ceiling capability to meet the photographic needs of the country. Aerial triangulation is being carried out on the Wild A8 and A10 using the independent-models methods, and the strip adjustment is done with a Hewlett-Packard 10 electronic computer. Efforts are being made to introduce better adjustment programmes.

#### LARGE-SCALE MAPS FOR DEVELOPMENT PROJECTS

In addition to the ground survey, some project maps are being prepared by photogrammetric methods. As the number of projects is increasing, the Institute will need to procure additional photogrammetric instruments and also to train more photogrammetric operators.

#### GEODETIC FRAMEWORK

In Afghanistan, the primary geodetic control is being carried out by means of a triangulation network with an average side length of 50 km; during the past three years, 40,000 km$^2$ in Nangarhar, Kabul, Ghazni and Kandahar provinces have been covered. The net is further broken down into second-, third- and fourth-order triangulation points to provide the necessary control for photogrammetric and ground surveys.

First- and second-order geodetic levelling lines approximately 2,000 km in length have been observed, and permanent monuments have been established at 5-km intervals.

For gravimetric observations, a pair of Worden precision gravity meters have been purchased and observations between New Delhi and Kabul airports have been completed. Four geodetic base lines have been measured with the AGA-8 Geodimeter, and astronomical observations for azimuth determination are carried out with a T4 theodolite and other related instruments.

#### GEOGRAPHICAL AND OTHER SPECIAL MAPS

The physical and administrative maps of Afghanistan have been completed on the scale 1 : 2,000,000, and work is in progress to compile the physical map at 1 : 1,000,000 scale in four component sheets.

The Institute has also compiled a 16-sheet series of hypsometric maps on the scale 1 : 500,000. These maps, however, are provisional and require further improvement.

* The original text of this paper appeared as document E/CONF.68/L.103.

### Cadastral maps

The cadastral survey in Afghanistan is being carried out in two phases: a land inventory survey covering the entire country for the administration of an improved tax system; and an accurate survey of the areas where a permanent land registration system will be adopted on a priority basis.

The immediate concern is to prepare the first-phase maps for the entire country to permit implementation of the land tax system and to furnish information needed for determination of the titles and ownership of the land. With this purpose in mind, the first-phase surveys are carried out by tacheometric and plane-table methods. Under this programme, provisional maps covering each village are prepared on the scale 1 : 2,000. Boundaries are determined in the field in accordance with information given by the owners and their neighbours. Cadastral survey lists showing the names of claimants, the area and the classification of each parcel of land are prepared by the surveyors in the field.

A composite map of each village is prepared at reduced scale, and copies of these maps along with other information are supplied to the Land Reform Department for determination of ownership and assessment of land tax.

During the past eight years of operation, approximately 4 million ha have been covered by land inventory surveys. A pilot project has been undertaken in Nangarhar Province to apply rectified photography based on ground and aerial triangulation control. After due evaluation, it is anticipated that a major portion of the work will be dealt with by this method.

### Expansion programme

To meet the growing need for accurate and up-to-date maps for development and other activities, the Afghan Cartographic and Cadastral Surveys Institute is in the process of expanding. A shortage of personnel is being alleviated through the organization of training programmes; and modern instruments and new survey techniques are being introduced with the assistance of the United Nations Development Programme (UNDP) and of other countries, such as India, which has provided four experts in various fields.

The Government of Afghanistan has given priority to the development of the Institute; and in 1976, it allotted to the annual budget an additional amount of $1.5 million for the procurement of instruments. The Government has also sought and received assistance from UNDP, which is now taking a keen interest in the activities of the Institute.

It is hoped that with this co-operation and assistance, the Afghan Cartographic and Cadastral Surveys Institute will reach the stage at which it will be able to cope with the ever-increasing demands of cartographic activities in the country.

## CARTOGRAPHIC ACTIVITIES IN AUSTRALIA, 1973–1976*

*Paper presented by Australia*

This report presents a brief review of the progress of cartography in Australia during the period 1973–1976. The progress shown is a consolidation of the work carried out by federal and state mapping agencies, the chief contributors of which are listed below:

(a) *Federal agencies*: Division of National Mapping, Department of National Resources; Royal Australian Survey Corps, Department of Defence; Hydrographic Office, Royal Australian Navy (RAN), Department of Defence; and Australian Survey Office, Department of Administrative Services.

(b) *State agencies*: Central Mapping Authority of New South Wales; Department of Mapping and Surveying, Queensland; Department of Lands, South Australia; Department of Lands, Tasmania; Department of Crown Lands and Survey, Victoria; and Department of Lands and Survey, Western Australia.

Agencies from whom additional information may be obtained are listed in the annex to this report.

Co-ordination of geodetic survey and topographic mapping is effected through the National Mapping Council, on which all of the above-mentioned federal and state agencies are represented.

### Geodetic survey

The extent of the geodetic survey of Australia as at the end of 1975 is shown in figures 1 and 2. During the period from 1 January 1973 to 15 October 1976, the major achievements were:

(*a*) Crustal movement surveys across the Markham Valley in Papua New Guinea were carried out in 1973 and again in 1976 and reported by the Division of National Mapping in technical reports 18 and 23;

(*b*) Heighting by vertical angles of all the major islands in the Torres Strait was undertaken and reported in technical report 19, Division of National Mapping;

(*c*) Newly developed rapid first-order levelling procedures were used in the levelling of a 2,500-km traverse along the north-eastern coast; and levelling connexions to horizontal control stations, tide-gauges and other installations have been continued;

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.27.

(*d*) Doppler satellite observations were taken at 96 major junction points of the Australian geodetic network between February 1975 and October 1976; a number of Doppler fixes for mapping control also were observed;

(*e*) The photographic zenith tube at Mount Stromlo near Canberra operated continuously until November 1975, when mechanical problems led to a shut-down of the instrument. Refurbishment is almost completed. During the period, more than 750 plates were obtained;

(*f*) In 1974, work was begun on construction of a building in the Orroral Valley, near Canberra, to house a lunar laser-ranging system on loan from the National Aeronautics and Space Administration (NASA) of the United States of America, to be operated by the Division of National Mapping. By early 1976, the building had been completed, and the laser and matching telescope had been installed and aligned.

### Aerial photography

Generally speaking, aerial photography is undertaken by federal and state authorities for their own mapping purposes. Most state photography is on medium scales with large-scale photography flown for special projects.

Some states fly large-scale colour photography and the federal authorities are producing colour photography at 1 : 25,000 scale for the Bureau of Mineral Resources, Geology and Geophysics.

A federal programme of black-and-white photography at 1 : 150,000 scale has just begun, the programme on the scale 1 : 84,000 having been completed.

### Topographic map coverage

#### *Federal programme of 1 : 250,000 mapping*

The existing series on the scale 1 : 250,000, which was completed in 1968, is being maintained on a partial revision basis with revision being effected as necessary to preserve adequate stocks. The specification for the new metric series at this scale has been finalized and to date 12 maps have been published.

#### *Federal programme of 1 : 100,000 mapping*

It is intended to publish line maps on the scale 1 : 100,000 to cover only the more populous area of the country with the sparsely settled central area (about 4 million km$^2$, amounting to about half the area of the continent), covered by contoured orthophoto maps at 1 : 100,000 scale.

To date, about 800 line maps on this scale have been published and work is well in hand on the remaining 700 sheets in the series (see figures 3 and 4). It is envisaged that the programme of first-edition 1 : 100,000 maps will be completed in the late 1980s.

#### *Mapping activities of the Australian states*

Each Australian state has its own mapping authority to produce general topographic map coverage of its territory, as well as mapping for specific administrative and development projects.

The main thrust of the state mapping programmes is towards large-scale mapping, and an indication of the area covered by mapping at 1 : 50,000 scale and larger is given in figure 5.

### Bathymetric mapping surveys

The Division of National Mapping continued its programme to produce bathymetric maps of the Australian continental shelf at 1 : 250,000 scale.

In addition to awarding and monitoring contracts, the Division made a modest beginning on "in-house" participation during 1973; operations have escalated to two vessels chartered each year for periods of from four to seven months and manned by divisional survey staff. Positioning during off-shore operations is by satellite navigation supplemented by sonar Doppler equipment and/or a short-range radio positioning system.

Bathymetric map presentation and format as reported during the seventh Conference have varied little except for the printing of sounding detail on the reverse of the map. It was considered that this information would be of benefit to some map-users.

Depth information collected in conjunction with off-shore exploration surveys by private firms and hydrographic data produced by the Hydrographic Service of RAN are included on the maps as appropriate.

Developmental work is continuing and it is expected that instrumentation and production techniques will be improved in the future.

Figure 6 shows the extent of this series and gives an indication of the progress made as of 30 June 1976.

### Hydrographic surveys and nautical charting

In Australia, the responsibility for hydrographic surveys of coastal waters rests with the Hydrographic Service of the Royal Australian Navy. Harbours and port sites are surveyed by the appropriate state, harbour or commercial organization. All navigational charts for Australian waters are published by RAN.

The Hydrographic School located on HMAS *Penguin*, also at Sydney, conducts regular courses in hydrographic surveying for officers of Sub-Lieutenant/Lieutenant rank and sailors of Able Seamen and Petty Officer rank.

#### *Hydrographic surveys*

Throughout the period, the hydrographic surveys needed to provide safe shipping routes for deep-draught vessels to newly developed ports have continued. The surveys conducted by RAN since 1974 are shown in figure 7. The future programme envisages a continuation of the survey of the main coastal routes.

#### *Hydrographic ships*

Two ships, HMAS *Moresby* (2,300 tons) and HMAS *Flinders* (800 tons), are employed full time in hydrographic surveying. HMAS *Moresby* is based at Fremantle and conducts its operations in the western half of the continent; HMAS *Flinders*, based at Cairns, works in the Great Barrier Reef and assists with surveys of Papua New Guinea waters.

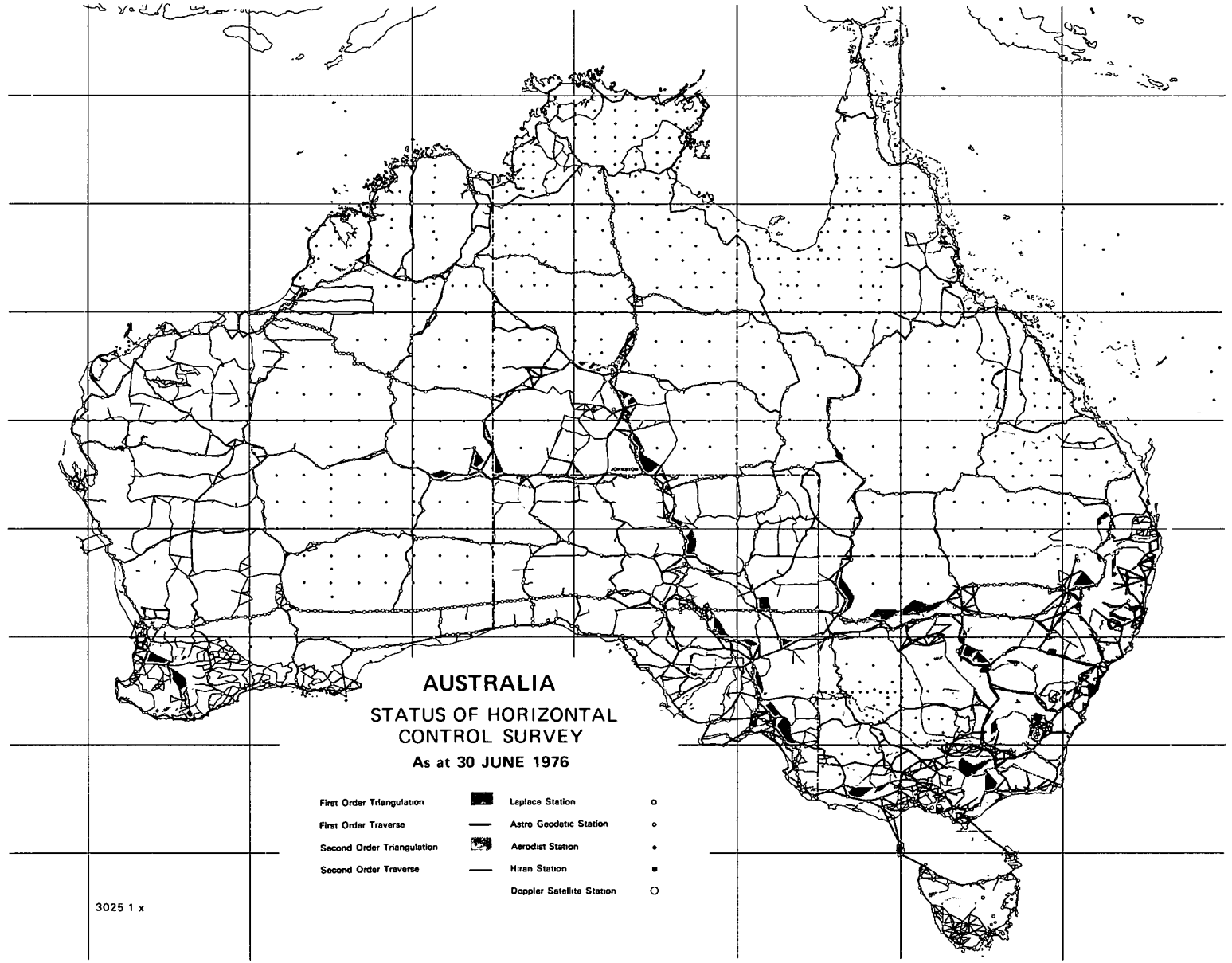



*Figure 1. Australia: status of horizontal control survey as at 30 June 1976*

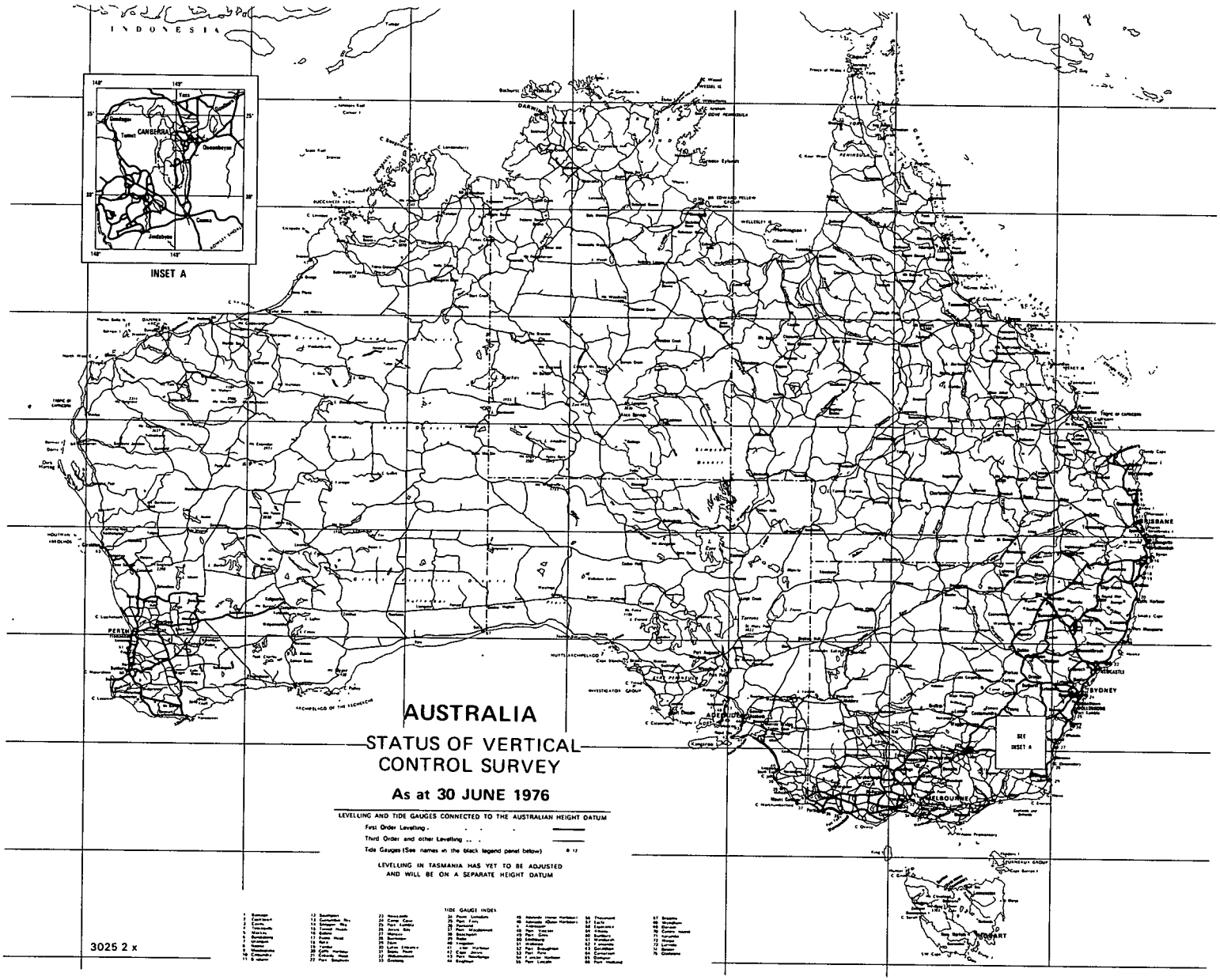



*Figure 2. Australia: status of vertical control survey as at 30 June 1976*

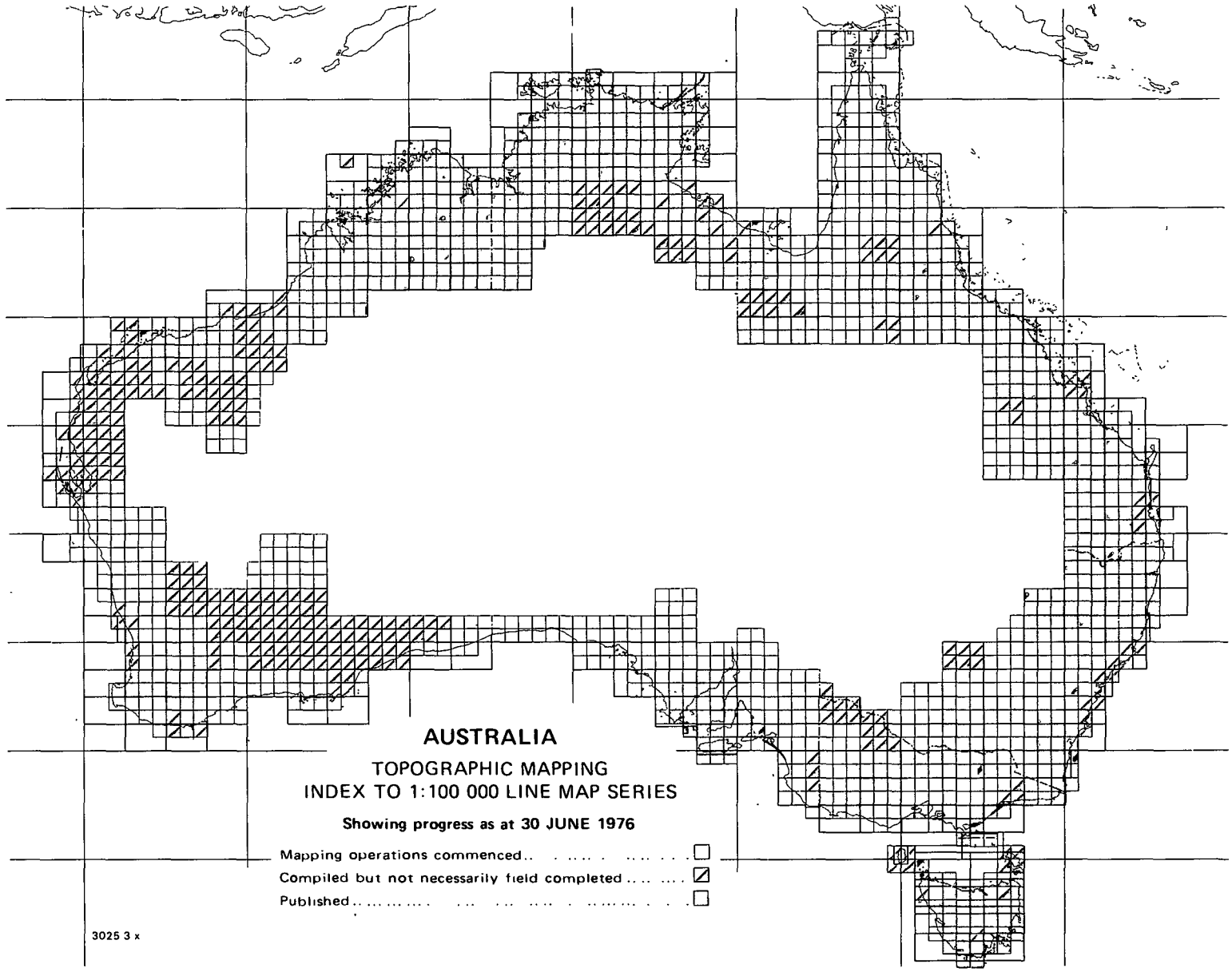



*Figure 3. Australia: topographic mapping index to 1 : 100,000 line map series*

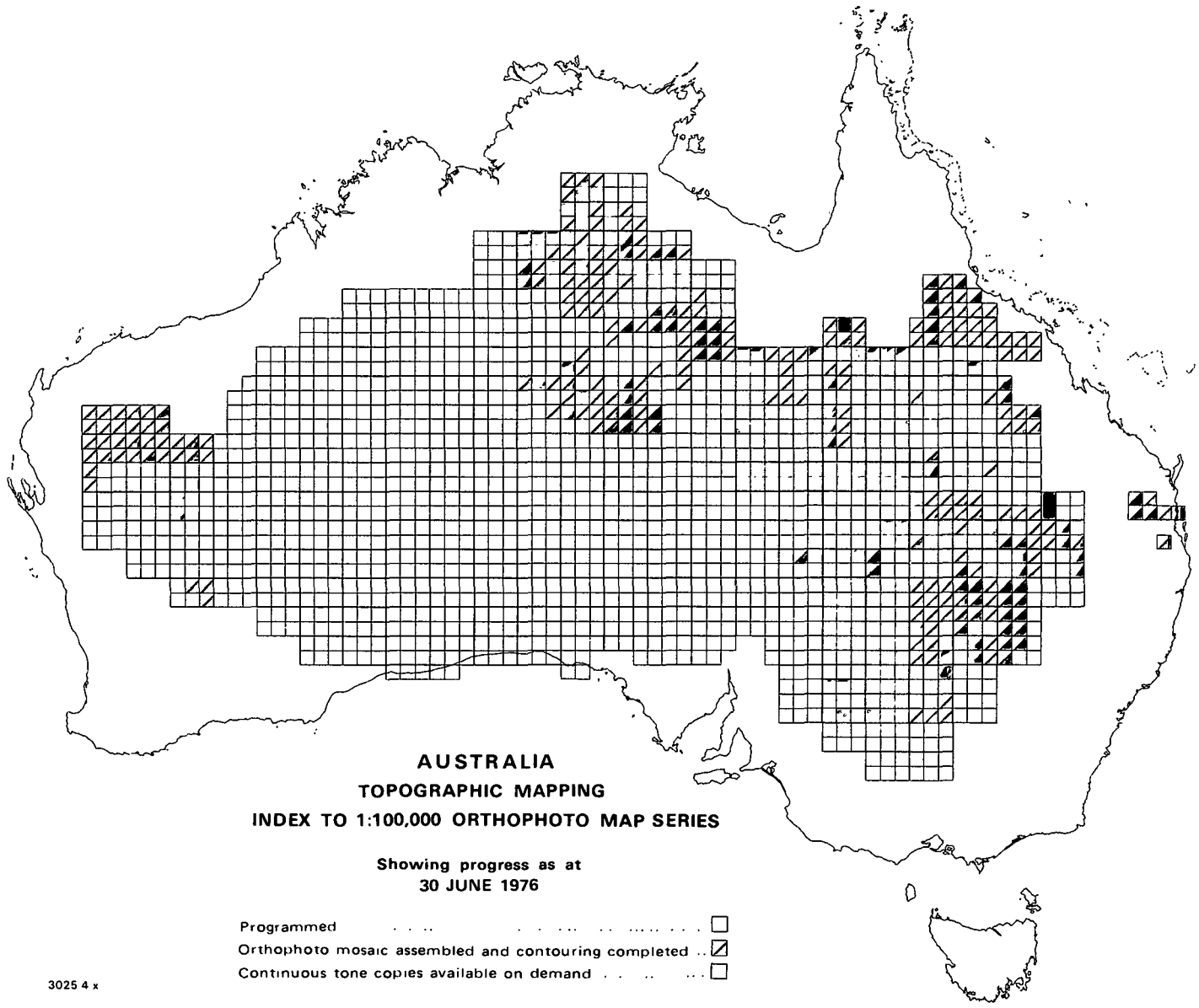



*Figure 4. Australia: topographic mapping index to 1 : 100,000 orthophoto map series*

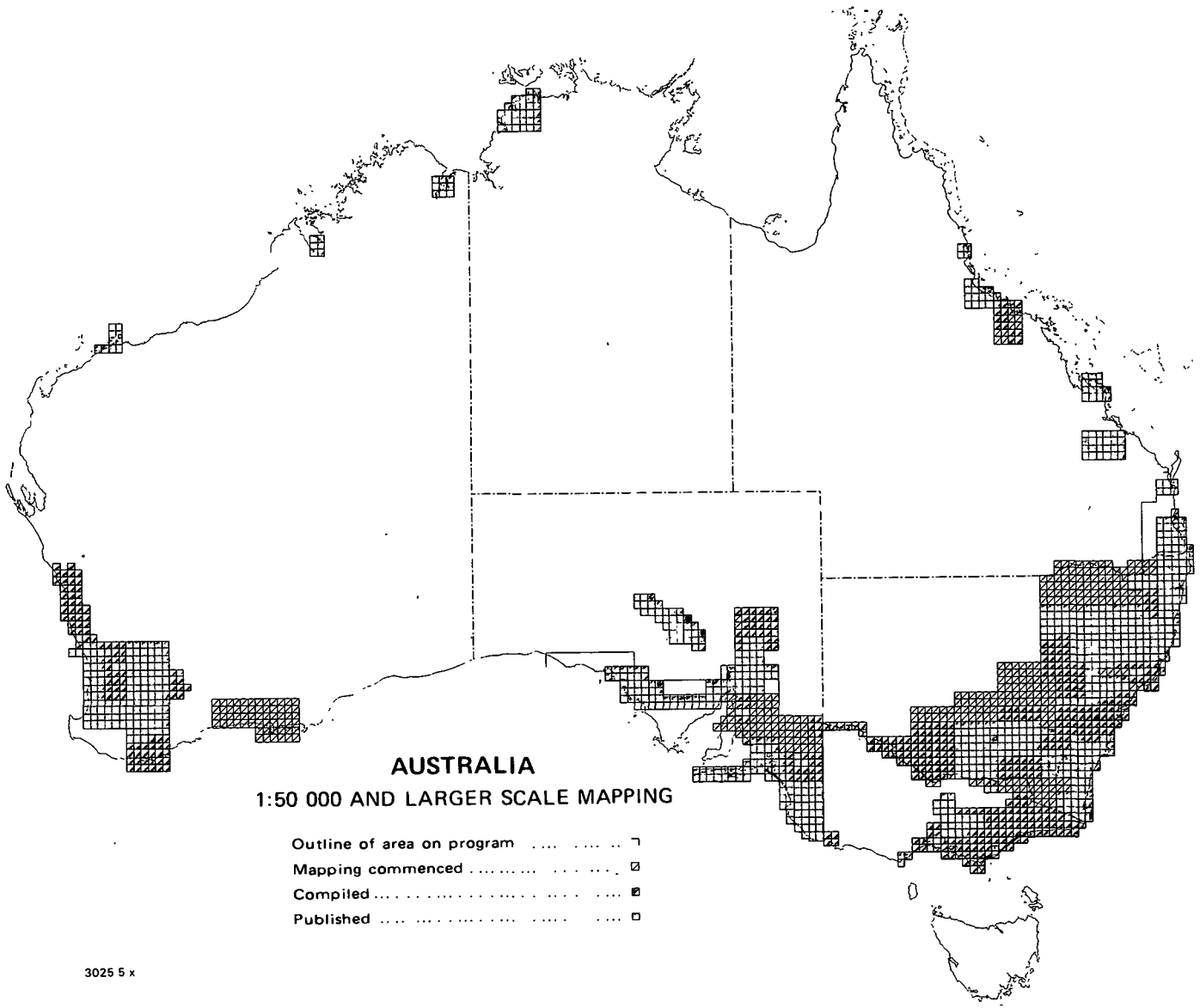



*Figure 5. Australia: mapping at 1:50,000 and larger scales*

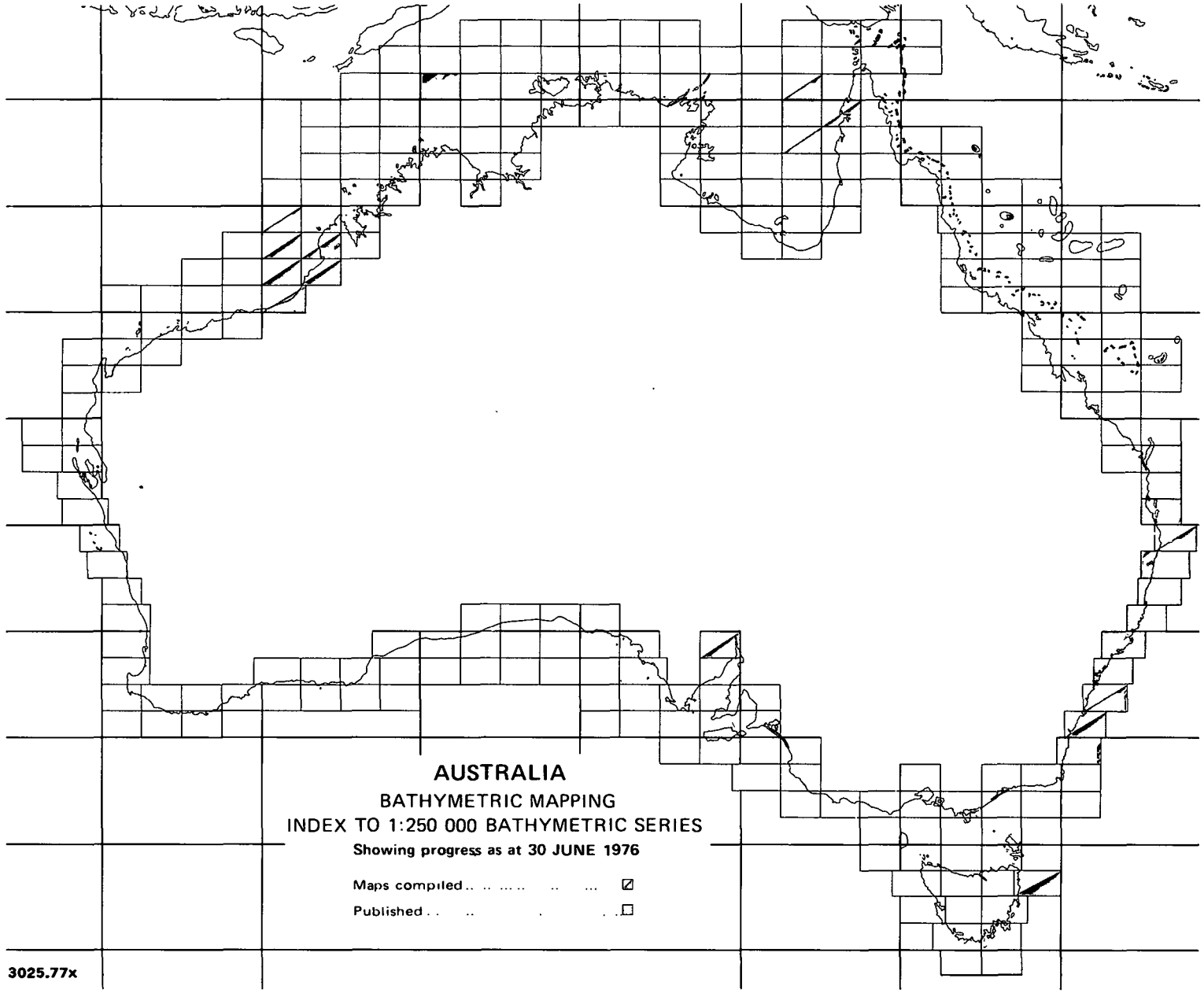



*Figure 6. Australia: index to bathymetric mapping series at 1:250,000 scale*

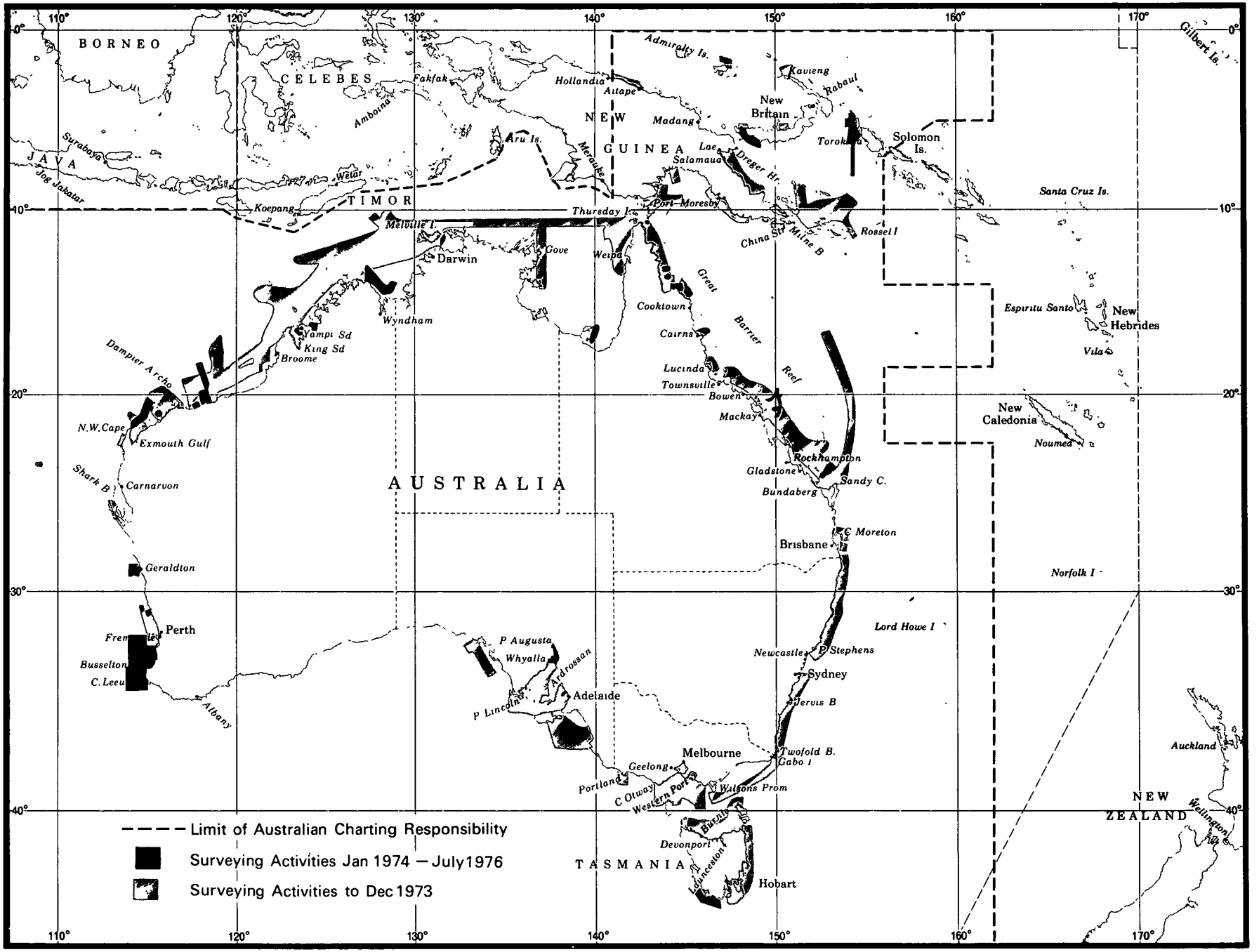



*Figure 7. Australia: limit of Australian charting responsibility*



3025.7 x

A new 10-m survey motor boat of aluminium construction with water-jet propulsion and an operating speed of 13 knots was designed and the first prototype has completed one year of operational service. An additional six boats are to be built over the next two years.

A new oceanographic vessel, HMAS *Cook* (2,650 tons), is under construction and is expected to replace the aged HMAS *Diamantina* in 1979.

### *Nautical charting*

*Automated charting*

The acquisition of a semi-automatic chart production system known as AUTOCHART is expected to be completed in mid-1977. This system will eliminate much of the manual compilation and scribing procedures in the production of nautical charts.

*Chart production*

During the years 1973–1976, the following new charts and new editions were published:

| *Year* | *New charts* | *New editions and large corrections* |
|---|---|---|
| 1973/74 | 22 | 19 |
| 1974/75 | 13 | 9 |
| 1975/76 | 11 | 8 |

*International co-operation*

Chart coverage of Australian waters is maintained by co-operative arrangements with the British Admiralty. In general, new charts are produced by Australia and arrangements exist for the reproduction of each other's charts. Australia has now published five charts of the 1 : 3,500,000 international series under the auspices of the International Hydrographic Organization.

A co-operative arrangement regarding hydrographic surveying and charting between Australia and Papua New Guinea is at the final stages of negotiation.

## GEOLOGICAL AND GEOPHYSICAL SURVEYS

### *Geological surveys*

Geological mapping of Australia and its territories, including the Australian Antarctica Territory, has continued at 1 : 25,000 scale. The mapping has been carried out by the Commonwealth Bureau of Mineral Resources and the state geological surveys operating independently or jointly. The areas mapped to date on mainland Australia and Tasmania are shown in figures 8 and 9. Mapping of Australia at this scale is expected to be substantially complete by 1980. Of the 540 sheets on the scale 1 : 250,000 covering the land mass of Australia (including Tasmania), 89 per cent had been published by 1 January 1976; many others have been issued as preliminary maps. Mapping of selected areas at 1 : 100,000 scale is being undertaken by the Bureau of Mineral Resources and by some state surveys. In addition, selected areas have been and are being mapped at 1 : 50,000 scale. Some of the maps are special-purpose maps. Several states have embarked on the production of systematic geological state maps at 1 : 1,000,000 scale.

Arising from the systematic mapping of particular mineral provinces and sedimentary basins, a large number of regional geological maps on the scale 1 : 1,000,000 or 1 : 500,000 have been published. These maps cover in one or two sheets the whole of the geological entity designated.

A four-sheet geological map of Australia on the scale 1 : 2,500,000 was published by the Bureau of Mineral Resources in August 1976, and maps of all states and the Northern Territory have been published in recent years or are about to be published. In addition to a general geological map of the Northern Territory at 1 : 2,500,000 scale, a map of the Cainozoic geology of the territory has been published at the same scale.

All metric scale maps make use of the topographic bases compiled by the Division of National Mapping. Colour photography is used extensively for the mapping of geological features; all 1 : 100,000 mapping by the Bureau of Mineral Resources is done with the aid of colour photographs at 1 : 25,000 scale.

Co-ordination of mapping programmes and standardization of geological symbols between the states and the Commonwealth are achieved through programme discussions and an annual conference of government geologists.

### *Magnetic surveys*

In 1973–1974, first-order magnetic reoccupation measurements were made at approximately 70 stations throughout Australia and Papua New Guinea, and on Nauru. Third-order measurements were made at approximately 4,000 stations (at an average spacing of about 30 km) in the western, central and northern parts of the continent; this survey is now over 95 per cent complete. An isogonic map reduced to epoch 1975.0, based on these surveys, was produced in 1975; for the first time, the map was drawn from a polynominal expression fitted to the field data.

A project to measure the secular change of the earth's magnetic field at roughly annual intervals was begun in 1975, in order to determine regions of unusual change in rate, such as is currently occurring near the western coast. The survey parties were transported by aircraft of the Bureau of Mineral Resources, and reoccupied nearly all continental stations in about 10 weeks. In addition, long aeromagnetic profiles at 3-km altitude were obtained, including two which traversed Australia from east to west.

During the period 1973–1976, approximately 600,000 $km^2$ of regional airborne magnetic coverage was made, using aircraft belonging to the Bureau and employing contractors.

The coverage of magnetic data from airborne and marine surveys by the Bureau of Mineral Resources and other organizations is shown in figure 10.

Over the land masses and coastal areas, the aircraft are flown between 150 and 600 m above ground level and at a line spacing from 1.5 to 3 km. Navigation for much of the flying is currently aided by a Doppler navigation system. The magnetic, navigational and other data are recorded by a digital data-acquisition system.

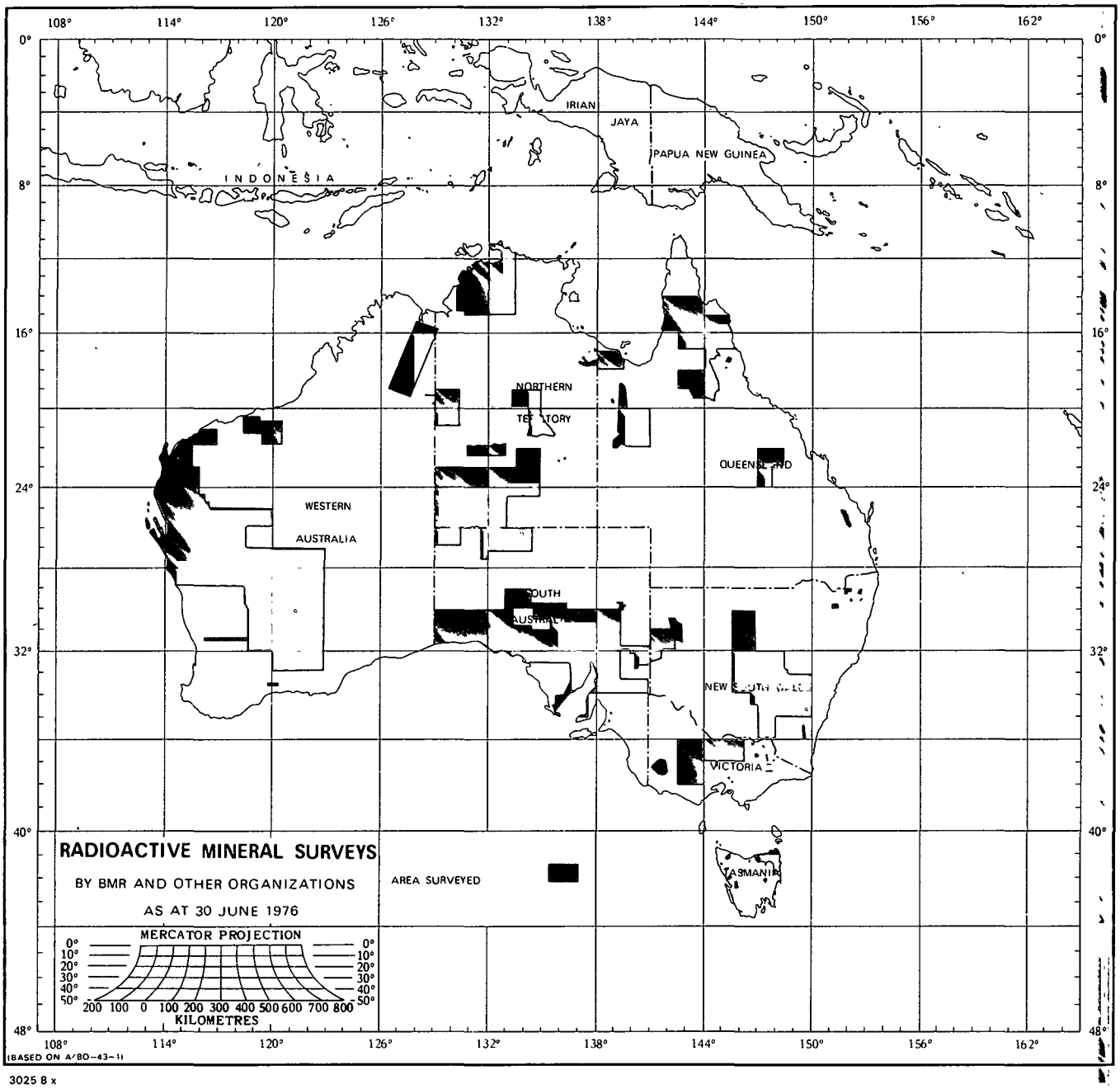



*Figure 8. Australia: radio-active mineral surveys as at 30 June 1976*

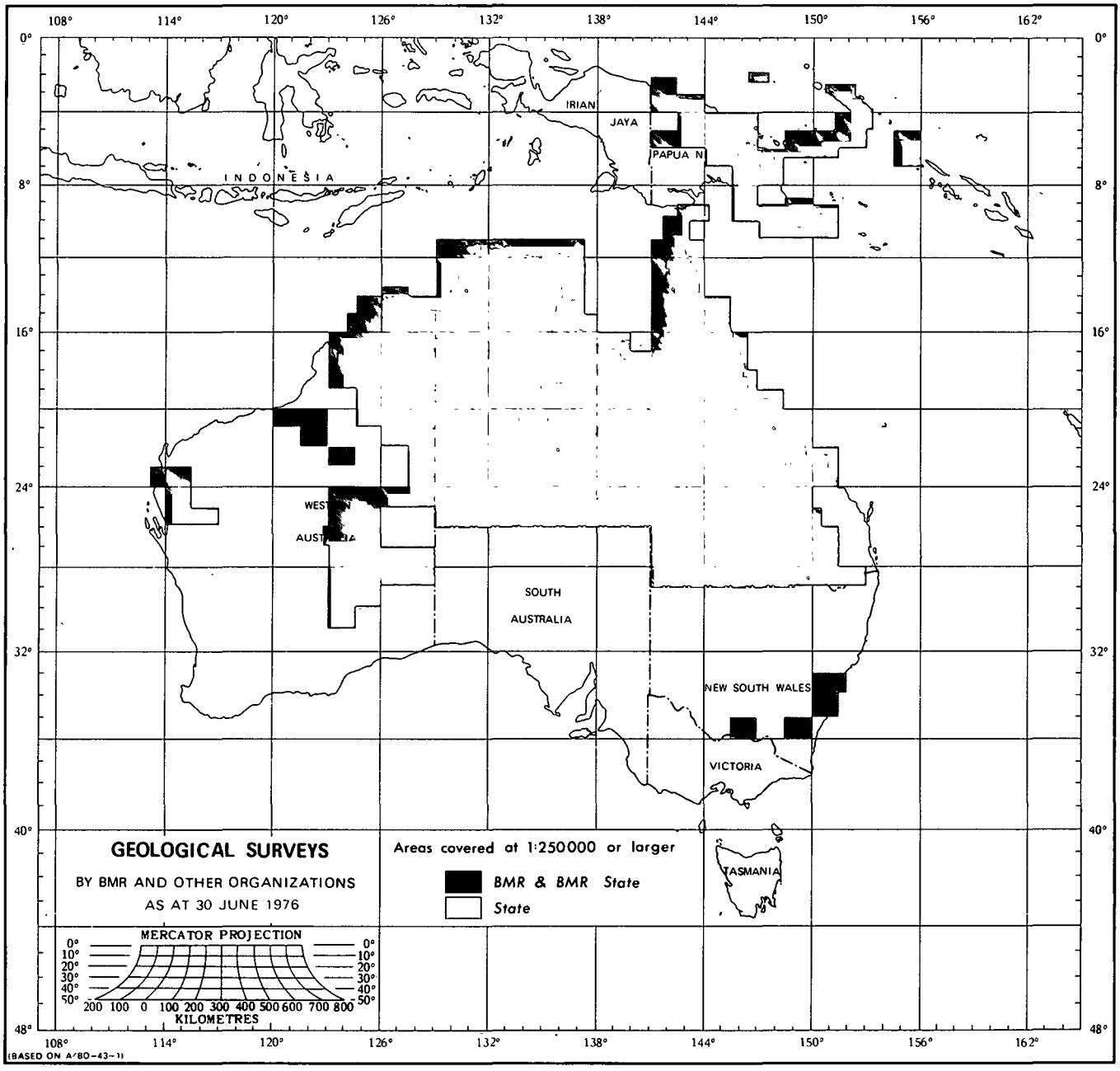
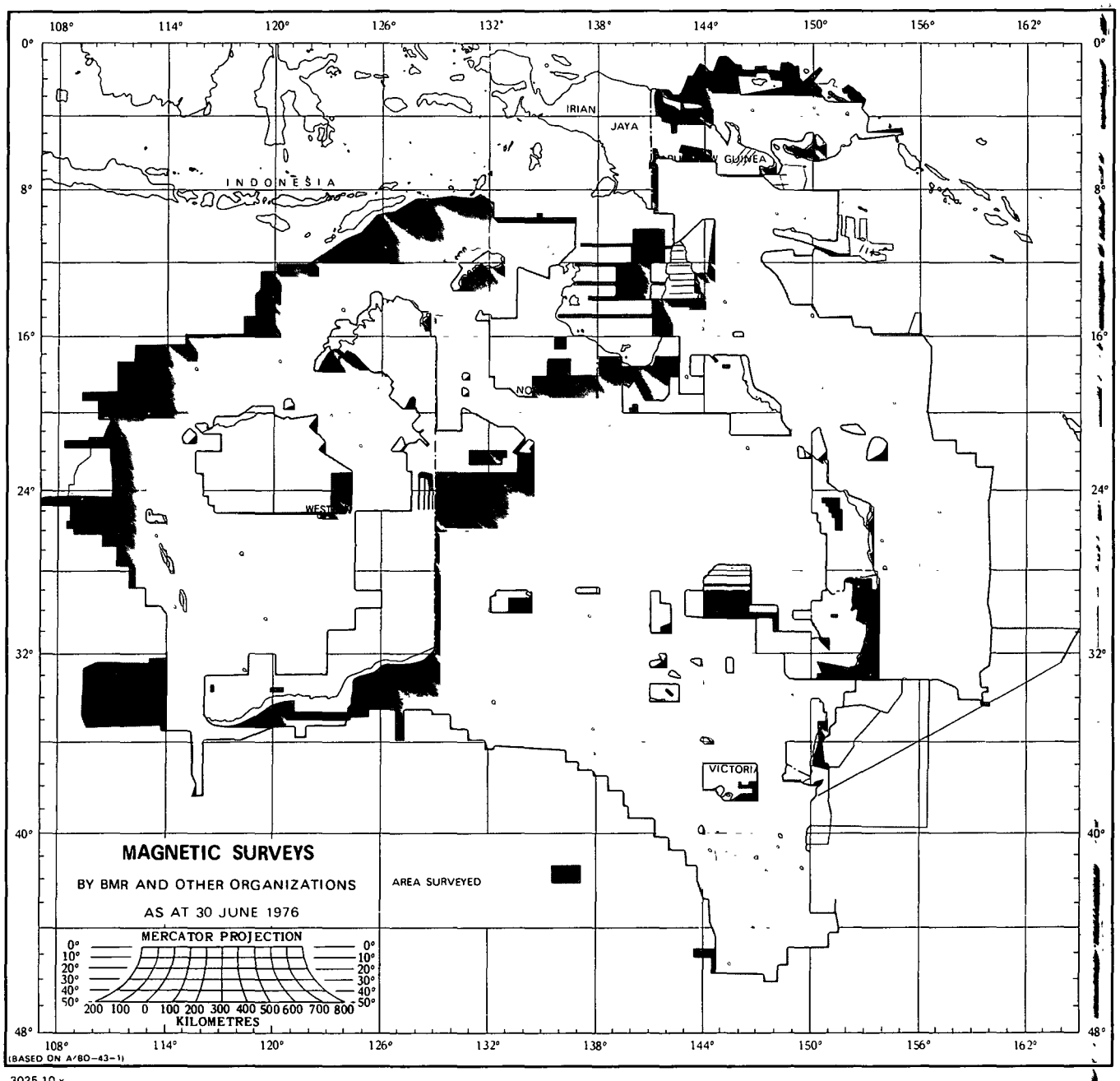



*Figure 9. Australia: geological surveys as at 30 June 1976*




3025 10 x

*Figure 10. Australia: magnetic surveys as at 30 June 1976*

The results of the magnetic surveys are reduced, plotted and contoured by computers and are presented as magnetic profiles and contours on controlled planimetric base maps.

All regional airborne magnetic data acquired by the Bureau from 1951 to 1974, magnetic survey data flown under the Petroleum Search Subsidy Act and marine magnetic data obtained from 1967 to 1973 have been compiled to produce a Magnetic Map of Australia on the scale 1 : 2,500,000. This project involved the digitizing of a considerable amount of data not already on a magnetic tape and the reduction of a large number of different surveys to a common magnetic datum. The map was published in August 1976.

### *Gravity surveys*

Regional gravity surveys have been carried out in Australia and Papua New Guinea over the areas shown in figure 11. Most of this work has been done by the Bureau of Mineral Resources, much of it under contract.

Over land areas, helicopters are used for transport between ground stations where gravity and barometric elevation are read mainly on an approximate 11-km grid. Aerial photographs are used for positioning. Elevation control is surveyed on ground traverses about 80 km apart. Gravity control is obtained from a national network of stations on a 250-km grid.

The results of the gravity surveys are reduced by the use of computers. Those over the land and the off-shore results over the Bonaparte Gulf and the Timor Sea have been published as gravity contour maps on the scale 1 : 500,000; the land areas are shown on controlled planimetric base maps. The remaining off-shore work will be published as contoured maps on the scale 1 : 1,000,000. Computer plotting and contouring of gravity data are currently being used.

A gravity map of Australia on the scale 1 : 5,000,000 was published in July 1976. This map shows Bouguer anomalies over the continental area and free-air anomalies over the seas.

### *Oceanographic surveys*

Reconnaissance geological mapping of the Australian continental margin to 500 m was begun by the Bureau of Mineral Resources in 1967. Ships' tracks form a grid of about 20-km spacing. To date, four cruises have been completed: (*a*) on the north-western Australian shelf; (*b*) in the Arafura Sea; (*c*) in eastern Australian waters south of the Barrier Reef; and (*d*) in Tasmanian waters and the Bass Strait. Maps are being published on the scale 1 : 1,000,000, showing distribution of the sediments and rock types; seven sheet areas have been mapped and four sheets published.

Multisensor marine geophysical surveys have been carried out by the Bureau of Mineral Resources since 1965. Bathymetric, seismic, gravity and magnetic measurements have been made along parallel traverses more or less normal to the coast. In the Bonaparte Gulf and the Timor Sea and on the north-western continental shelf, the traverses were 16 km apart. In the Bismarck Sea, the Gulf of Papua and the eastern and southern continental margins, they were 32 km apart; and in the western continental margin, about 50 km apart. They extend from the 20-m to the 4,000-m isobath. The areas surveyed are included in figure 11, which illustrates areas covered by gravity surveys. Navigation was aided by the use of satellite Doppler and sonar Doppler equipment. Data were recorded in digital form on magnetic tape.

Gravity contour maps, and gravity, magnetic and seismic profiles on the scale 1 : 500,000, covering parts of the Bonaparte Gulf, the Timor Sea and the north-western shelf, have been published. For the remaining area, maps at 1 : 2,500,000 scale showing ships' tracks, water depths, Bouguer anomalies, free air anomalies and magnetic anomalies; and maps at 1 : 1,000,000 scale allowing ships' tracks and seismic profiles along ships' tracks have been published.

### *Radiometric surveys*

Radiometric surveys have been carried out by the Bureau of Mineral Resources over the areas shown in figure 11.

The level of radio-activity is recorded by four-channel gamma-ray spectrometers in aircraft flown between 100 and 150 m above ground level and at a line spacing from 500 to 1,500 m. These surveys are usually made in conjunction with a magnetic survey.

The results of these surveys are presented as radiometric profiles, contours and point source anomalies, on controlled planimetric base maps.

## National and Regional Atlases

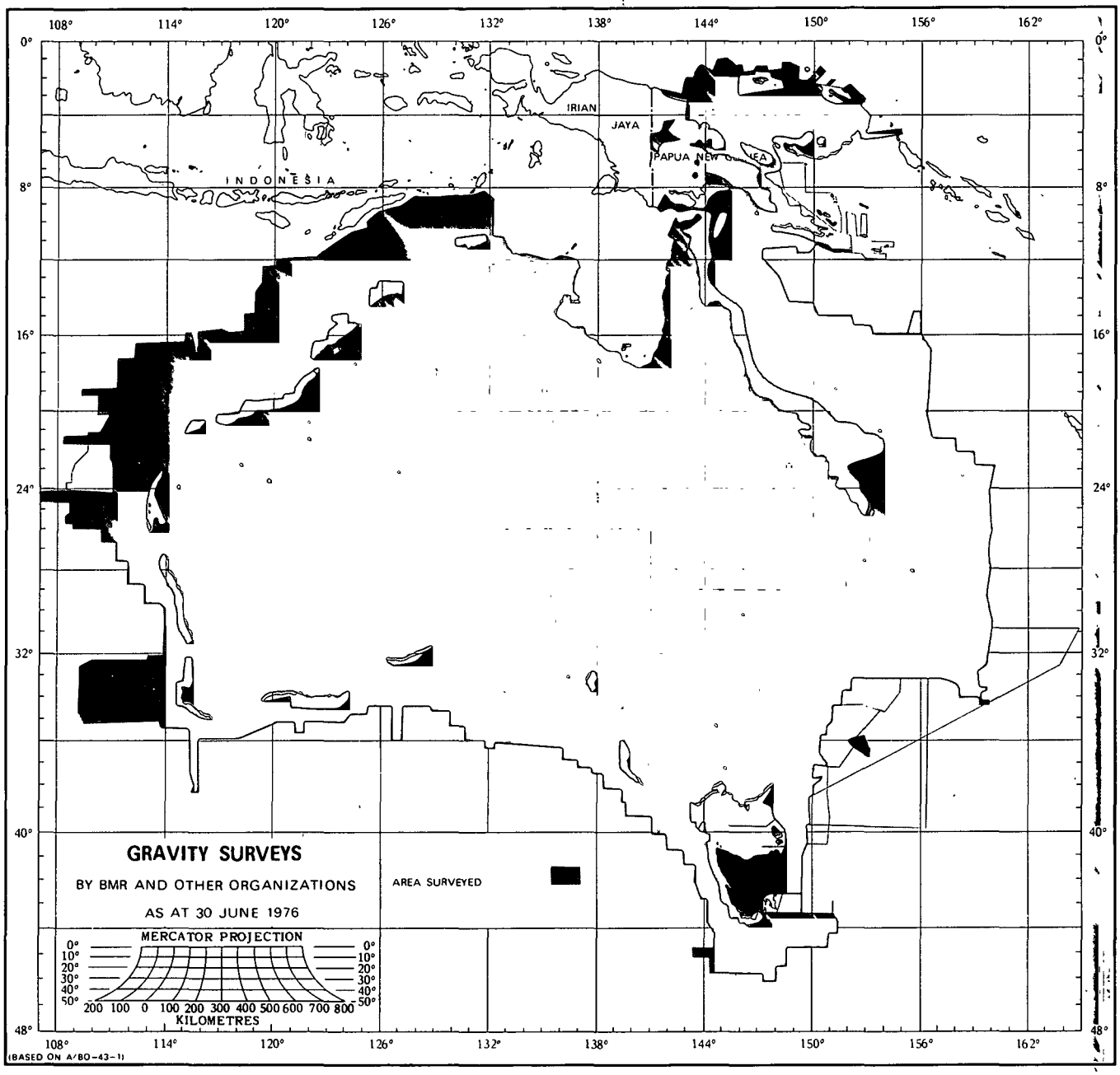
### *Atlas of Australian Resources*

Eight new sheets have been published in the second series of the Atlas of Australian Resources. Seven sheets deal with climate, ground water, water use, manufacturing industries, railways, major urban areas and government; the eighth is a locational index for the entire series. In addition, a completely revised sheet on population distribution and growth has been published; and the last sheet of the second series, on natural vegetation (map scale 1 : 6,000,000), is in press. The completed second series, like the first series (1952–1960) it gradually replaced, will consist of 30 large map-sheets, each with a supplementary booklet.

Meanwhile, general plans have been made for production of a third series of the Atlas and preparatory work is in progress. The third series is planned to be significantly expanded in range of subject-matter and markedly reduced in sheet size without loss in map detail; it will present shorter supplementary texts on the same sheets as the map. Maps of Australia will range in scale from 1 : 5,000,000 to 1 : 30,000,000; and a major innovation will be a variety of maps of Australian cities with over 100,000 population, on the scales 1 : 250,000 and 1 : 500,000.

### *Atlas of Resources of New South Wales*

Additions during 1973–1976 to the Atlas of Resources of New South Wales, a serially published loose-leaf atlas of map-sheets with supplementary booklets, comprise a




3025 11 x

*Figure 11. Australia: gravity surveys as at 30 June 1976*

sheet and text on landforms. In addition, a sheet on natural vegetation is in preparation and the double-scale wall-map version of it at 1 : 1,500,000 scale is expected to be published in 1976 by the New South Wales Department of Decentralisation and Development at Sydney.

*Resources Atlas of Queensland*

The Queensland Department of Mapping and Surveying is producing the Resources Atlas of Queensland for publication as a single volume in 1976. It will cover 20 topics, with maps generally at 1 : 8,000,000 scale, and will be distributed by the Queensland State Public Relations Bureau, Brisbane.

*Burdekin-Townsville region resources series*

The Burdekin-Townsville region resources series covering seven topics was completed with publication during 1973–1976 of the topics on land use and water resources. Each topic consists of a cover holding one or two folded map-sheets, with maps mainly on the scales 1 : 1,000,000 and 1 : 2,000,000, and an explanatory booklet. The part of Queensland covered by the series has an area of about 160,000 km$^2$; the series was produced by what is now the Australian Department of National Resources.

## Other thematic maps

The Division of National Mapping began production several years ago of a series entitled *Thematic Mapping Bulletin*, at first with a restricted circulation. Beginning with No. 5 (1975), the *Bulletin* has become an annually published document. *Thematic Mapping Bulletin No. 6*, the most recent issue, gives details of 1,200 Australian thematic maps published or in preparation during 1975.

Brief notes about selected thematic maps and mapping activities are given below. Geological and geophysical maps are mentioned elsewhere and a separate report covers the national atlas and various regional and other thematic atlases.

*Forestry*

State forest services have continued to produce numerous large-scale serial maps of areas under their control and of forest types. For the FORWOOD national forestry conference in 1974, continental maps were produced on the scales 1 : 2,500,000 and 1 : 5,000,000, showing forest ownership, forest types and forest plantations.

*Vegetation*

Of the seven vegetation series sheets of Western Australia at 1 : 1,000,000 scale being produced as a project of the Department of Geography, University of Western Australia, the first three sheets have been published. In addition, dye-line maps at 1 : 250,000 scale are being published for the south-western area of the state. Publication has also commenced of maps at 1 : 250,000 in a series by the Western Australian Department of Agriculture.

Much of the tropical rain-forest of northern Queensland has been covered in a series of maps on the scale 1 : 100,000, prepared by the Division of Plant Industry of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), at Brisbane.

*Soils*

The Division of Soils of CSIRO, at Adelaide, recently published a new continental map of soils at 1 : 5,000,000 scale with an accompanying book. Soils maps at or about 1 : 250,000 scale have been produced by the soil conservation authorities of several states.

*Water resources*

In 1975, the Australian Water Resources Council published a study entitled *Groundwater Resources of Australia*, which includes four continental maps on the scale 1 : 5,000,000. Several maps on the rainfall and water resources of Australia also were produced for inclusion in the Council publication, *Review of Australia's Water Resources 1975*. A considerable number of maps showing hydrometric stations have been or are being produced by state and federal water authorities.

*Land classification*

As part of various land evaluation surveys, many maps classifying land on environmental characteristics continue to be produced, notably by the Division of Land Use Research of CSIRO, at Canberra; the Victorian Soil Conservation Authority; and, more recently, The Queensland Department of Primary Industries.

*Land use*

The Division of National Mapping has begun a series of reconnaissance land-use maps at 1 : 1,000,000 scale, based in part on satellite imagery, which is described in a separate paper submitted to this Conference.[1]

Regional land-use maps at 1 : 250,000 and larger scales have also been prepared by a number of state government agencies, notably in Queensland, New South Wales and Victoria.

*Regional studies*

A number of regional studies have been prepared by various state government agencies since 1973. These studies include a wide range of thematic maps on human activities as well as environmental characteristics, together with assessments in map form of land capability and proposed land use. Examples are the Moreton region study by the Queensland Co-ordinator-General's Department, the regional recommendations for the use of publicly owned land by the Victorian Land Conservation Council and the regional planning reports of the South Australian State Planning Authority.

[1] "The use of LANDSAT imagery in land-use mapping in Australia", under agenda item 10.

### Technical assistance to other countries

*Training*

During the period 1973–1976, more than 70 trainees from Malaysia, Hong Kong, Nigeria, Papua New Guinea, the Philippines, Tonga, and the United Republic of Tanzania were provided with both formal and on-the-job training in all aspects of surveying (both topographic and hydrographic) and cartography.

*Aid projects*

As part of defence aid projects, the Royal Australian Survey Corps has continued the co-operative mapping programmes in Indonesia and Papua New Guinea.

**Annex**

**Agencies from which additional cartographic information may be obtained**

Inquiries concerning the geodetic survey, aerial photography, topographic and bathymetric mapping, national and regional atlases and thematic mapping should be directed to:
The Director, Division of National Mapping, Department of National Resources, P.O. Box 548, *Queanbeyan*, N.S.W. 2620.

Inquiries relating to geological and geophysical surveys and mapping should be sent to:
The Director, Bureau of Mineral Resources, Geology and Geophysics, P.O. Box 378, *Canberra City*, ACT 2601.

Inquiries about hydrographic surveys and nautical charting should be directed to:
The Hydrographer, Hydrographic Service, *Garden Island*, N.S.W. 2000.

## CARTOGRAPHIC ACTIVITIES IN BANGLADESH*

*Paper presented by Bangladesh*

### Cartography in Bangladesh

Bangladesh has emerged very recently as an independent and sovereign State in the region of South-East Asia. The geographical features of this country, which comprises approximately 55,598 square miles, are typical of the area. Rivers coming down from the Himalayas flow through Bangladesh and carry alluvial sediments which have formed the deltaic basin of the country. Its typical landscape is a wide alluvial plain extending from the north to the south, with several minor low hills along the eastern and south-eastern sections of the country. Mapping and cartographic activities have immensely increased because greater attention is currently being given to the economic development of the country. Mapping and cartographic requirements are the responsibility, in general, of the Survey of Bangladesh, the Directorate of Land Records and Surveys, Bangladesh; and the Department of Hydrography of the Bangladesh Inland Water Transport Authority (BIWTA).

The Survey of Bangladesh, under the able guidance of the Surveyor General of Bangladesh, is responsible for:

(*a*) Establishment and maintenance of geodetic controls throughout the country;

(*b*) Preparation of topographic maps at various scales and of special large-scale contour maps for the execution of national development projects.

The Director General of Land Records and Surveys is responsible for the preparation and maintenance of cadastral maps which are usually 16 inches to 1 mile (1 cm to 0.4 km) or 32 inches to 1 mile (1 cm to 0.2 km) and which are related to individual holdings of land concerning right of possession of landholders. From these maps, other administrative maps are compiled at different scales, for example, 4 inches to 1 mile (union map), 1 inch to 1 mile (police-station map), 1 inch to 4 miles (district map) and 1 inch to 8 miles (country map).

The Chief Hydrographer of the Department of Hydrography carries out all types of hydrographic surveys, both of inland waters and of coastal waters, and prints navigational charts, following Admiralty practice in this respect.

Other government departments assigned to undertake engineering construction prepare, within a limited scope, very large-scale maps and diagrams within their own resources.

The South Asian subcontinent in the first half of the twentieth century is said to be a well-mapped area. The Survey of Bangladesh has the same level of professional standards in the field of surveying and mapping. It has quite a number of well trained and experienced personnel and is centrally located at Dacca, the capital of Bangladesh.

The old office which previously functioned under one Deputy Surveyor General in what was then Pakistan, has been expanded to meet the requirements of topographic maps at different scales for government offices, autonomous organizations and semi-autonomous organizations in Bangladesh. Preparation of topographic maps on a large scale for execution of national development projects in power and water resources, communication, flood control, irrigation, and rural and urban development is currently receiving full attention due to the fact that the Government has placed heavy emphasis upon the economic development of the country.

*Revisional survey*

Because the country lies in a deltaic basin of a number of rivers, the topography continues to change. It is difficult to maintain up-to-date maps and revisional surveys are therefore necessary. A revisional survey of the entire country has been undertaken in a systematic manner.

* The original text of this paper, prepared by the Survey of Bangladesh, appeared as document E/CONF.68/L.126.

*Chittagong Hill Tracts*

The Chittagong Hill Tracts are in the south-eastern region of Bangladesh. Geodetic controls are too sparse in the area to permit small-scale surveying, such as ½ inch to 1 mile (about 1 : 125,000). On the other hand, large-scale maps are urgently required for the economic development of the area. Therefore, efforts are being made to establish more controls through the use of aerial methods, as the hilly area which is covered by forest is not easily accessible. In this effort, the entire area of Bangladesh has been photographed with Canadian assistance. Aerial triangulation is being carried out for mapping of the area on modern stereoplotting instruments. A full-fledged photogrammetric office is now functioning at the Survey of Bangladesh.

*Geodetic survey*

The Survey of Bangladesh has undertaken a programme of reobserving the old stations of the Calcutta longitudinal series, as many of these stations have deteriorated with the passage of time. To update the old maps, more new stations are now being established by a geodetic traverse network deriving from Tellurometer observations.

TOPOGRAPHIC MAPPING

The entire area of Bangladesh is covered by a series of topographic maps on the scales 1 : 2,000,000 and 1 : 1,000,000; maps on the latter scale are classified and cannot be discussed here.

The entire country is covered separately by 27 map-sheets on the scale 1 : 250,000 and 266 sheets on the scale 1 : 50,000.

Both series are being revised in order to update the old maps. Aerial photographs are being used for brief preparation of the 1 : 50,000 scale maps, with the help of ground controls and verifications. The maps of the 1 : 250,000 series, however, are being prepared by compilation of the maps at 1 : 50,000 scale.

A new series of maps at 1 : 25,000 scale has been proposed and a programme for undertaking this series is under consideration.

Topographic maps are produced in different colours, the number of which ranges from 8 to 12; large project maps, however, are limited to two or three colours.

All types of maps are currently drawn manually on the drawing-paper sheets; but with a view to minimizing the cost, method scribing is also followed.

PHOTOGRAMMETRIC COVERAGE

With the increase of development activities, demands for ground information in the form of maps and photography have considerably increased. The method of map-making is now changing from ground survey to photogrammetric methods. For quite some time, photographs have been used in the preparation of topographic and project maps, employing the aerial survey graphic method. But with the development of the photogrammetric method, map-making has become more rapid. Precision stereoplotting instruments are currently used for aerial triangulation and plotting.

The aerial photography of Bangladesh on the scale 1 : 30,000, undertaken with the assistance of Canada, has produced photographs and their enlargements which are being used to revise maps. Rectified mosaics are now supplied to various government agencies and private organizations engaged in development work.

A scheme is under way to establish a full-fledged photography unit in Bangladesh, with an aircraft fitted with a camera for the purpose of taking aerial photographs as and when required.

## CARTOGRAPHIC ACTIVITIES IN CANADA*

*Paper presented by Canada*

This report summarizes cartographic activities in Canada by the federal Government during the past three years. Responsibility for activities in geodesy, topographic mapping, aeronautical charting and map production is assigned to the Surveys and Mapping Branch of the Department of Energy, Mines and Resources; and activities in hydrography and oceanography are undertaken by the Marine Sciences Branch of the Department of Environment.

GEODETIC SURVEY OPERATIONS

The Geodetic Survey of Canada is responsible for the establishment and maintenance of the national framework of primary horizontal and vertical control, the establishment of mapping control as required for the national mapping programme and the maintenance of a national survey control data bank.

*Primary horizontal control*

The Canadian primary horizontal control network consists of approximately 5,700 stations, mostly in the southern and middle regions of the country. The network comprises mainly first-order triangulation, with some first-order traverse, second-order triangulation and extensive Aerodist surveys which are, in general, second order. Surveys added to the network from 1974 to 1976 included the completion of several loops of triangulation and the extension and densification of control in areas of economic importance.

The Doppler satellite positioning programme initiated

* The original text of this paper appeared as document E/CONF.68/L.112.

in 1973 was completed in 1976. It consists of a network of 163 first-order stations spaced from 300 to 500 km apart and covering all of Canada. These points will be used to strengthen the networks and to help establish the datum for the proposed new North American datum and adjustment.

Improvements in the form of length measurements and Laplace azimuth observations to bring the existing primary triangulation networks up to desired standards were completed in 1976. This improvement work was based on a systematic evaluation of all networks and will prepare them for the proposed new North American adjustment.

The Geodetic Survey of Canada has continued the programme of establishing a uniform network of second-order control, according to needs, in all parts of the country, and to improve and integrate the many existing lower order surveys scattered throughout the country. In addition, the programme will result in the preparation of secondary networks for the new general adjustment.

In 1975, the Geodetic Survey of Canada acquired inertial survey equipment. Extensive tests were carried out under varying weather and terrain conditions, both vehicle- and helicopter-mounted. The tests indicated that the system could produce second-order horizontal accuracy and vertical accuracy suited for large-scale mapping. In 1976, the system was used in production. Major operations included 2,700 km of vertical control for 1 : 50,000 mapping on Vancouver Island, 5,600 km (430 points) of horizontal and vertical control for second-order densification and mapping control in southern Alberta, 550 km (30 points) for second-order horizontal control in northern Saskatchewan and 50 control points at 10 Indian reserves in Alberta for large-scale mapping.

*Primary vertical control*

The Canadian geodetic level network is the responsibility of the Geodetic Survey of Canada. The network consists of 104,200 km of first-order levelling and 20,000 km of second-order levelling, mostly along highways and railways in the southern parts of the country. The total number of bench-marks is 44,800.

In the past three years, there has been a marked increase of levelling in the northern areas in support of resource development. In 1974, a line was completed to Dawson City in the Yukon; and in 1976, first-order levelling along the shoreline of the Mackenzie River was completed to the Arctic Red River. In the near future, the latter line will be extended to tidal bench-marks on the Arctic Ocean. In northern Quebec and Labrador, a line was completed between Fort George on James Bay and Goose Bay on the Atlantic Ocean. Annual relevelling of special lines to study subsidence at two large earth-filled dams is continuing.

During the three-year period, 8,700 km were added to the network and 3,600 km of existing lines were relevelled to increase bench-mark density or to imprive accuracy, or both. This high percentage of relevelling is in keeping with the general policy to relevel all lines over 40 years old.

*Astronomical observations*

During the three-year period from 1974 to 1976, astronomical observations were made at 275 field stations, to give a total of 351 Laplace stations and 949 deflection stations. At all Laplace stations, an effort is made to observe for latitude as well as longitude and azimuth; thus, nearly all Laplace stations are also deflection stations. Most of the astronomical observations in Canada are being updated for polar variations, changes in catalogue (reduction to the FK4 system) and changes in the longitude of the national observatories responsible for the time-signal corrections. This update will give uniform data for the new North American datum and adjustment.

*Computations, research and development*

Canada, together with other North American countries, is participating in a programme to carry out a new adjustment of horizontal control networks to be based on a redefined datum. The Geodetic Survey of Canada is responsible for the Canadian programme. The primary and secondary horizontal control networks are being evaluated, improved and extended; and an effort is being made to integrate networks of all agencies. The North American Datum of 1927 may be replaced by an earth-centred datum suited for world-wide use. Completion of the continental adjustment will take place some time after 1980. However, because of pressure from Canadian user agencies, a 1978 adjustment is planned for this country.

A computer-based national positional control survey data bank is currently becoming operational. The file will readily provide control survey data in the fields of geodesy, surveying and mapping to government agencies, industry and the general public.

After extensive testing of the Mekometer and developing procedures for operation, it was concluded that the instrument could measure short distances (from 100 to 1,600 m) with a standard deviation of 0.2 mm +1-2 ppm. A national base line was established at Ottawa; and in the past three years, 17 base lines for calibration of electromagnetic distance-measuring instruments had been established in populated areas throughout the country, in co-operation with provincial agencies. Additional base lines are yet to be established. The base lines will be remeasured annually for two or three years in order to maintain a standard with the national base line and to determine their stability.

As previously mentioned, the Geodetic Survey of Canada acquired an inertial survey system in 1975. Although the equipment was used on production in 1976, testing and experimenting are still being carried out to develop its maximum potential for establishing second-order and mapping control.

## Topographic and general-purpose mapping

*Map production*

The topographic map of Canada on the scale 1 : 50,000 is considered the base map for resource development, administration, national defence, scientific research,

education and recreation. Of the 13,150 sheets in this series, 7,200 have been published. It is proposed to complete the coverage of the Canadian mainland by 1985 and a major part of the Arctic islands by 1995. Approximately 600 sheets in this series are revised and published as new editions each year.

The series at 1 : 250,000 scale is complete in 918 sheets, of which about 40 are revised annually. The series at 1 : 25,000 scale covers only areas of high population density and is not being expanded beyond the current coverage of 690 sheets.

Many of the Canadian provinces are currently embarking on their own mapping programmes at larger scales than those provided by the federal Government. Close co-operation between the two levels of government is maintained to facilitate the map production. The vast areas of the Yukon and Northwest Territories are being mapped with a series of planimetric photo maps at 1 : 30,000 scale which are used for resource exploration and land administration.

Work on the International Map of the World on the Millionth Scale (IMW) is continuing, with completion of all Canadian sheets anticipated before 1978.

*Research and development*

Block adjustment of independent models has been in operational use for the past four years. Originally, the Stuttgart University Programme Package for Aerial Triangulation with Independent Models (PAT-M) was used exclusively, but that programme has recently been supported by an in-house programme (SPACE-M) which gives a stronger solution in certain circumstances, particularly in areas where a number of lakes exist. This lake-levelling aspect is particularly useful in northern Canada because of the large number of lakes in that region.

The development of the automated cartography system in Canada is being focused on three main areas:

1. Development of an interactive digital photogrammetric compilation system which would permit direct entry of "clean" data into the cartographic data base for subsequent colour-separation scribing of topographic maps and other applications;

2. Development of a contouring package from the digital terrain models produced by Gestalt Photomapper GPM-2, including mapping of planimetric detail produced by the photogrammetric system mentioned above. The Gestalt Photomapper is in the process of being installed in the Surveys and Mapping Branch;

3. Development of new improved software for the operation of the automated cartography system which plots the output from the two areas described above.

*Aeronautical charts*

A new series of charts has been initiated to separate visual from instrument flight rule traffic in the terminal radar areas on the scale 1 : 250,000. The coverage is planned for all major centres in Canada.

The Aeronautical Charts Division continues to maintain the visual flight rule charts on the scales 1 : 500,000 and 1 : 1,000,000; and the wide range of plotting, radio navigation, instrument approach, radar surveillance and controller charts, and associated publications needed to support area traffic activities in Canada.

*National Atlas*

The bound version of the fourth edition of the *National Atlas of Canada* was published in 1974; and in 1976, the Royal Canadian Geographical Society presented its Gold Medal to the National Atlas as an indication of the high regard it holds for the fourth edition as a presentation of geographical knowledge about Canada.

Publication of the fifth edition is planned in 1979. It will use data from the 1971 and 1975 censuses.

*Hydrography*

The Canadian Hydrographic Service maintains just over 1,100 navigational charts of Canadian waters and about 15 new charts are published each year. Three of these charts (INT 109, 110, 111) are in the international series at 1 : 3,500,000 scale. An active programme is under way to convert all charts and publications to a bilingual (French and English) and metric format. For this purpose, a new four-colour presentation has been developed in which the bathymetry is shown primarily by contours rather than soundings. The new presentation incorporates as many as possible of the recommendations of the North Sea International Chart Commission of the International Hydrographic Organization.

Canada is producing the first four sheets of the fifth edition of the General Bathymetric Chart of the Oceans (GEBCO). The first sheet 5.05, covering the northern portion of the Indian Ocean, was published in 1975. Three sheets of the Atlantic Ocean; and sheet 5.09, covering the southern Indian Ocean, are in hand.

The programme of publishing charts at 1 : 250,000 scale showing the bathymetry, Bouguer gravity anomalies, magnetic anomalies and surficial geology of the Canadian continental margin is continuing. One or more versions have been published of 100 sheets, including five of the Pacific coast.

The first Canadian chart to be produced using the automated cartography system was published in 1976. Work is continuing on the development of an interactive graphics system that will permit the system to be used in chart compilation and simplify the editing of field data collected by automated techniques.

*Oceanography*

The Ocean and Aquatic Sciences sector is the centre responsible for the provision of advisory services and expertise on those ocean matters of interest and benefit to the Canadian economy in resource development and environmental programmes. Advisory services are provided through research studies in physical, chemical and biological oceanography, including growth and decay of ice, dynamics of coastal and ocean circulation, real-time forests of sea and swell conditions, real-time and non-real-time tidal and water-level information, measurement; collection, storing and retrieval of environmental

data; ecological studies and publication of various oceanographic papers and products for the fishing and off-shore exploration industries.

Research studies and surveys in oceanography and other earth sciences are carried out from the Bedford Institute of Oceanography, Dartmouth, Nova Scotia; and in the Pacific region, from the Institute of Ocean Sciences, Patricia Bay, British Columbia. International aspects of ocean affairs are co-ordinated at Ottawa, with assistance from the regional offices. Canada participates in the Intergovernmental Oceanographic Commission (IOC), the International Council for the Exploration of the Sea (ICES) and many other international marine organizations and fisheries commissions.

These activities include co-operation and collaboration with other scientists and laboratories throughout the world, international exchange of data, development of the Integrated Global Station System (IGOSS) and of pollution and environmental monitoring.

## CARTOGRAPHY IN THE CENTRAL AFRICAN EMPIRE*

*Paper presented by the Central African Empire*

The territory of the Central African Empire is completely covered by cartographic maps on the scale 1 : 200,000. These maps were established from an aerial survey on the scale 1 : 50,000 taken during the period 1950–1960.

There have been changes, however, such as the construction and modification of the road network, the building of new villages and the delineation of new administrative responsibilities, which have rendered those maps obsolete. New up-to-date maps are needed, for which the Government of the Central African Empire is seeking financial assistance.

*Activities of the National Topographic Service*

The National Cadastral Service undertook all large-scale topographic mapping up to 1973. In 1974, however, the new Ministry of Public Works, Equipment and Management of the Territory was established, under which the National Topographic Service was set up in parallel with the Cadastral Service and the Urbanism Service. This newly established National Topographic Service has not reached its full objective; in time, it will become the National Geographic Service.

A committee, responsible to the Ministry of Public Works, Equipment and Management of the Territory, has also been appointed with a view to channelling all ministerial requests for cartographic needs through that office.

To date, all of the cartographic and topographic needs of the Central African Empire have been met by the Institut géographique national (IGN), France.

For the development of cartography in the Central African Empire, the Government is looking forward to co-operating with different countries within the framework of technical assistance.

* The original text of this paper, prepared by André-Blaise Kanguite, Director of the National Topographic Service at the Ministry of Public Works, Equipment and Management of the Territory, Bangui, Central African Empire, appeared as document E/CONF.68/L.121.

## BRIEF NOTES ON CARTOGRAPHIC ACTIVITIES IN THE CONGO*

*Paper presented by the Congo*

The Congo cannot submit a paper to this Conference on the activities and progress made since 1973, the date of the Seventh Conference, nor was it able to do so at the Third Regional Conference for Africa at Addis Ababa in 1972.

For the time being, a report is not being presented because topographic coverage of the country was made by the Institut géographique national (IGN), France; and had been undertaken within the framework of Congolese-French technical assistance. The mapping of the Congo was made from aerial surveys on the scale 1 : 50,000, from maps at 1 : 200,000 scale and, for certain areas, from maps at 1 : 50,000 scale.

The extent of the coverage can easily be found in publications emanating from the Institut géographique national.

As concerns cadastral accomplishments in the Congo, no progress has been made since 1960. This lack is mainly because outside help has not been available since the country attained independence and also because of the lack of funds and manpower which prevented the Congolese services from performing large-scale cartographic mapping.

The Government, nevertheless, being fully aware of the importance of mapping to the development of the

* The original text of this paper appeared as document E/CONF.68/L.116.

country, had foreseen in its triannual development programme (1975–1977) the needs for ways and means of strengthening the National Topographic and Cadastral Services. To this effect, the Government established, in January 1976, the Congolese Geographical Institute, which will be responsible for the production of maps on the scales 1 : 200,000 and 1 : 50,000 previously undertaken by IGN.

## BRIEF NOTES ON A DRAFT PROGRAMME FOR A TOPOGRAPHIC AND CADASTRAL SURVEY IN THE CONGO*

*Paper presented by the Congo*

Even before the Congo attained independence in 1960, the former Topographic and Cadastral Services had made topographic surveys and had conducted cadastral surveys of nearly all urban centres known at the time. It had also begun cadastral surveys in rural and agricultural areas. Since then, however, towns have greatly expanded and several new urban centres have been created.

Such undertakings, however, no longer reflect realities and they do not fulfil actual needs. Even though the newly created office has been involved in sporadic works in a few centres, their coverage is too limited to use as a basis for the establishment of up-to-date records.

The same statement applies to cadastral surveying in rural and agricultural areas, where no change has been reported mainly because of lack of means placed at the disposal of the Topographic and Cadastral Services.

### Brief summary of the programme

The programme for the topographic and cadastral survey will consist of:

(*a*) Updating the old maps and producing maps of the new urban centres and of the rural areas;

(*b*) Undertaking cadastral work, such as delineation of properties and land assessment.

### *Methods*

For the implementation and execution of this project, the Government is looking forward to utilizing new methods and, in particular, to all possibilities that aerial photogrammetry can place at its disposal.

### *Execution of the project*

The first triannual development plan of the Government (1975–1977) included the modernization of topographic and cadastral equipment in the urban centres and the strengthening of the Topographic and Cadastral Services. Unfortunately, such an objective could not be reached for lack of funding. The important fact, however, is that the Government is conscious of its needs in the topographic and cadastral fields.

It should equally be noted that the Topographic and Cadastral Services of the Congo do not possess the necessary equipment nor the specialized personnel needed for the undertaking of such a project. The task of the Government is limited at this stage to the seeking of ways and means for the execution of this project, the provision of equipment and the training of the requisite personnel.

In view of the urgency attached to such mapping, the Government is requesting technical assistance.

* The original text of this paper appeared as document E/CONF.68/L.125.

## A BRIEF REPORT ON THE SURVEY AND MAPPING OF CYPRUS IN THE PAST THREE YEARS*

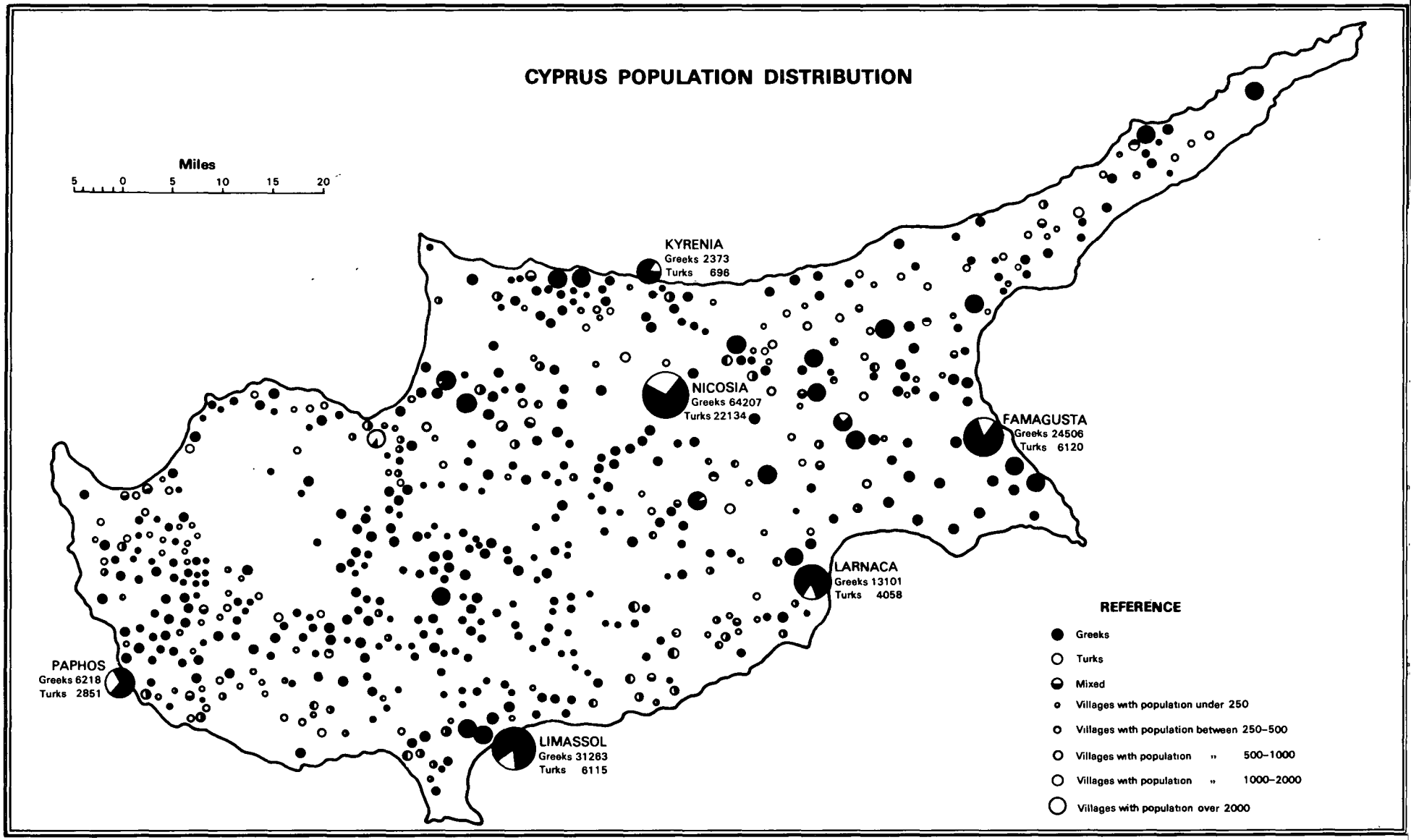
*Paper presented by Cyprus*

### Geographical and historical background

Although the geography and history of Cyprus have not changed since the Seventh Conference, its demographic composition has been forcibly changed by Turkey since the Turkish invasion of the island in July–August 1974. Therefore, a short explanation of the facts is necessary so that the reasons for the lack of progress in the field of cartography may be understood. Figure 12 shows the distribution of population of Cyprus prior to July 1974, details of which are given below. It will be observed that the distribution of population was such that one could not say that a particular area of the island was purely Turkish. Figure 13 shows the Attila line, with approximately 40 per cent of the area of the island to the north, from where 200,000 Greek Cypriots were uprooted and forced to leave their homes and land. This area is now inhabited by Turkish Cypriots and by Turks brought from the mainland of Turkey.

Cyprus is the third largest island in the Mediterranean, with an area of 3,572 square miles. It lies in the north-eastern corner of the eastern Mediterranean basin at the

* The original text of this paper, prepared by Andreas Christofi, Senior Land Survey Officer, Department of Lands and Surveys, Ministry of the Interior, Cyprus, appeared as document E/CONF.68/L.24.




SOURCE: Prepared by the Department of Lands and Surveys, Cyprus, on the basis of the 1960 census of population.

*Figure 12. Cyprus: population distribution*

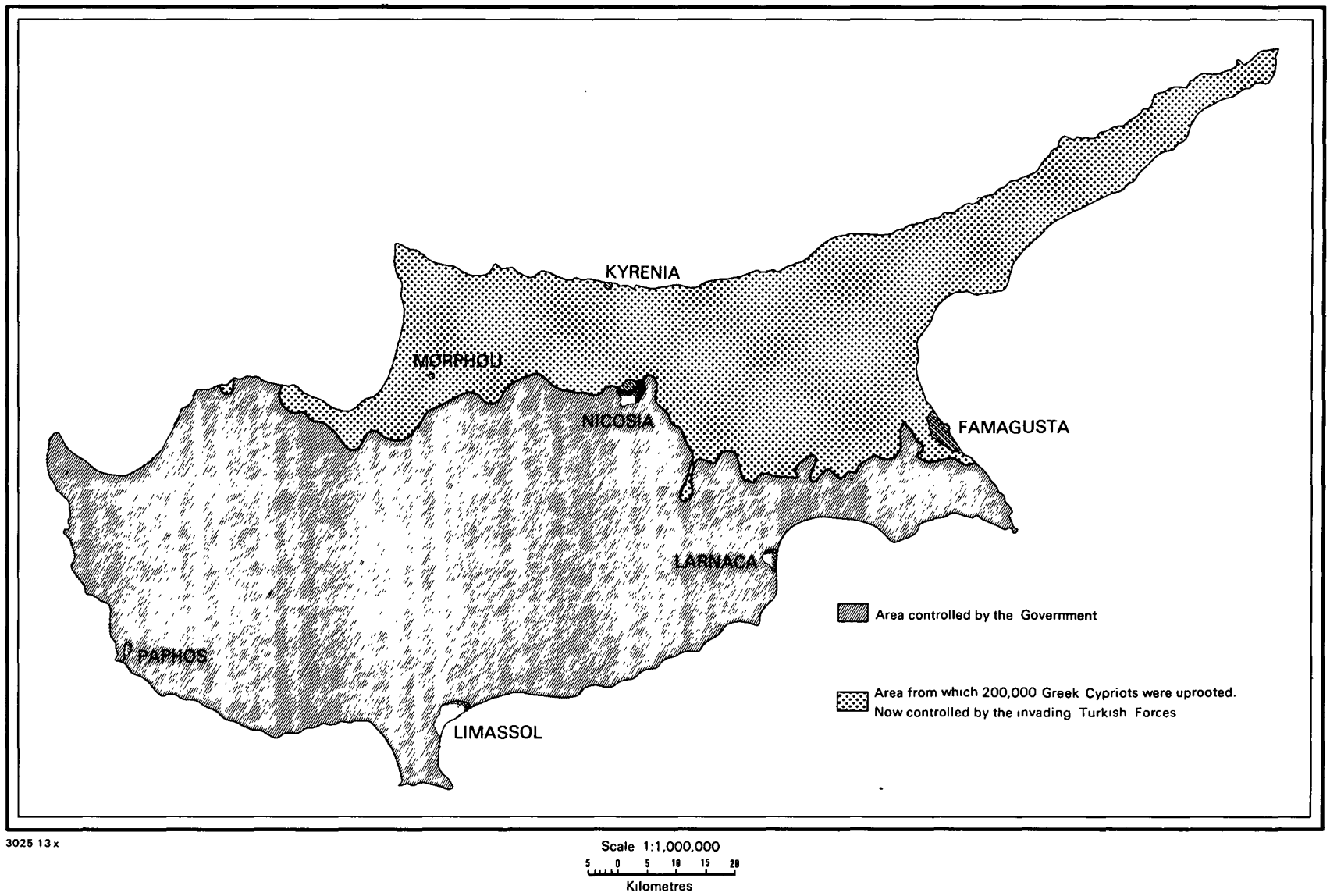



*Figure 13. Cyprus: area controlled by the Government*

meeting-point of three continents—Europe, Asia and Africa—and this fact has added considerably to the importance and development of the island through the ages. The island has a population of 650,000 (mid-1973) of which 530,000 (82 per cent) are Greeks and 120,000 (18 per cent) are Turks. The language of the overwhelming Greek Cypriot majority is Greek and their religion Greek Orthodox. They belong to the autocephalous Church of Cyprus, which has played a leading role in the island's liberation struggles. The language of the Turkish community is Turkish and its religion is Moslem.

### Responsibility for mapping in Cyprus

The Department of Lands and Surveys, under the Ministry of the Interior, is responsible for all cadastral and topographic surveys in the island, whether for government or public use. Although cadastral surveys (now mainly revisional surveys) are still carried out using the traditional chain and tape, new topographic surveys are done by photogrammetric methods. Up to the end of 1968, such mapping was given out to contract; in January 1969, however, the Department established a small photogrammetric unit and it has since been compiling its own maps by stereoplotting. Although Cyprus receives help in its efforts to complete its national mapping series on the scale 1 : 5,000 as explained below, all surveys for cadastral purposes are carried out by Cyprus with its own resources. Obviously, no form of survey or mapping is undertaken in the occupied areas. The District Land Offices of Kyrenia and Famagusta, with all the land records, are in the occupied areas.

In an effort to provide shelter for the 200,000 people who are displaced from their homes by the Turkish invading forces, the Government has launched a programme for the construction of a larger number of low-cost houses to be temporarily allocated to persons who are still living in tents. Parallel to this effort, a self-help housing scheme has been introduced for those refugees who are willing to undertake the building of their own houses. In these cases, the Government will provide for each family a building site in selected areas, which have been appropriately parcelled out, plus cash assistance. Figure 14 shows the areas where displaced persons still live in camps, the areas where the housing scheme programme is under way and the areas that have been parcelled out for the self-help housing scheme. Approximately 10,600 displaced persons are still living in camps. The number of housing units built or under construction is 4,850 and will provide shelter for some 22,000 people; 2,850 parcels have been divided for allocation and will, when built on, provide shelter for some 13,000 people. The remainder of the displaced population has moved into the main towns and into some villages in the area controlled by the Government.

It will be seen from the figures given above that an enormous amount of work has fallen on this Department: the acquisition of land and payment of compensation for all schemes; large-scale topographic mapping of the sites; setting-out of the layouts; and surveying the houses. All technical manpower has been diverted from other sections of the Department, to help speed up the work connected with this major project. For this reason, ordinary cadastral surveying for the private sector has been somewhat neglected in the past two years.

### Topographic map coverage

In addition to the topographic maps produced by the Department as described in the previous progress report,[1] the following new editions were produced during the period under review, some of them to replace out-of-date editions in the non-metric system. All new topographic maps produced in Cyprus are in the metric system. A small collection of these maps is on exhibit in the exhibition hall and may be inspected at leisure.

The topographic map of the island on the scale 1 : 50,000 has been reduced photographically to scale 1 : 100,000. After careful generalization and redesigning, the map was compiled in four large sheets, which when joined offer the best wall map ever produced for the island. It is a multicolour edition showing administrative boundaries, land use, a classified road network and contours at 100-m vertical intervals. The map is used in schools and for detailed administration and planning purposes. It has been produced in English and Greek editions. A Turkish edition is under preparation. This map has replaced the ½-inch-to-1-mile map of Cyprus described in the 1973 progress report.

By further photographic reduction and generalization, a new administration and road map of the island has been produced on the scale 1 : 250,000. The map is printed in nine colours, showing district boundaries, the sovereign base area boundaries and an up-to-date classification of the road network. Relief is depicted by layer tints. The most valuable component of this map is the population distribution by ethnic groups. At a glance, the map-user can tell the approximate size of a village, and whether it is inhabited by one community or the other or by both. The map is produced in English, Greek and Turkish editions, and is offered in either flat form of folded with covers.

To meet the great demand for a small, concise and handy map of the island to be used as reference to various reports and for general use, a special coloured map on the scale 1 : 500,000 has been compiled. It shows all the main towns by name and the position of all villages. Owing to lack of space, not all the names of villages are given. It shows the motor road network in two categories only and the main rivers with dams. Contours are shown at 200-m intervals. The district and sovereign base area boundaries are also shown on the map. Only an English edition has been produced.

### Thematic map coverage

Using the administration and road map referred to above as a base map, the Department, in co-operation

[1] "Survey and mapping of Cyprus in the past three years", paper prepared by A. Christofi, *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.74.I.25), pp. 23–30.

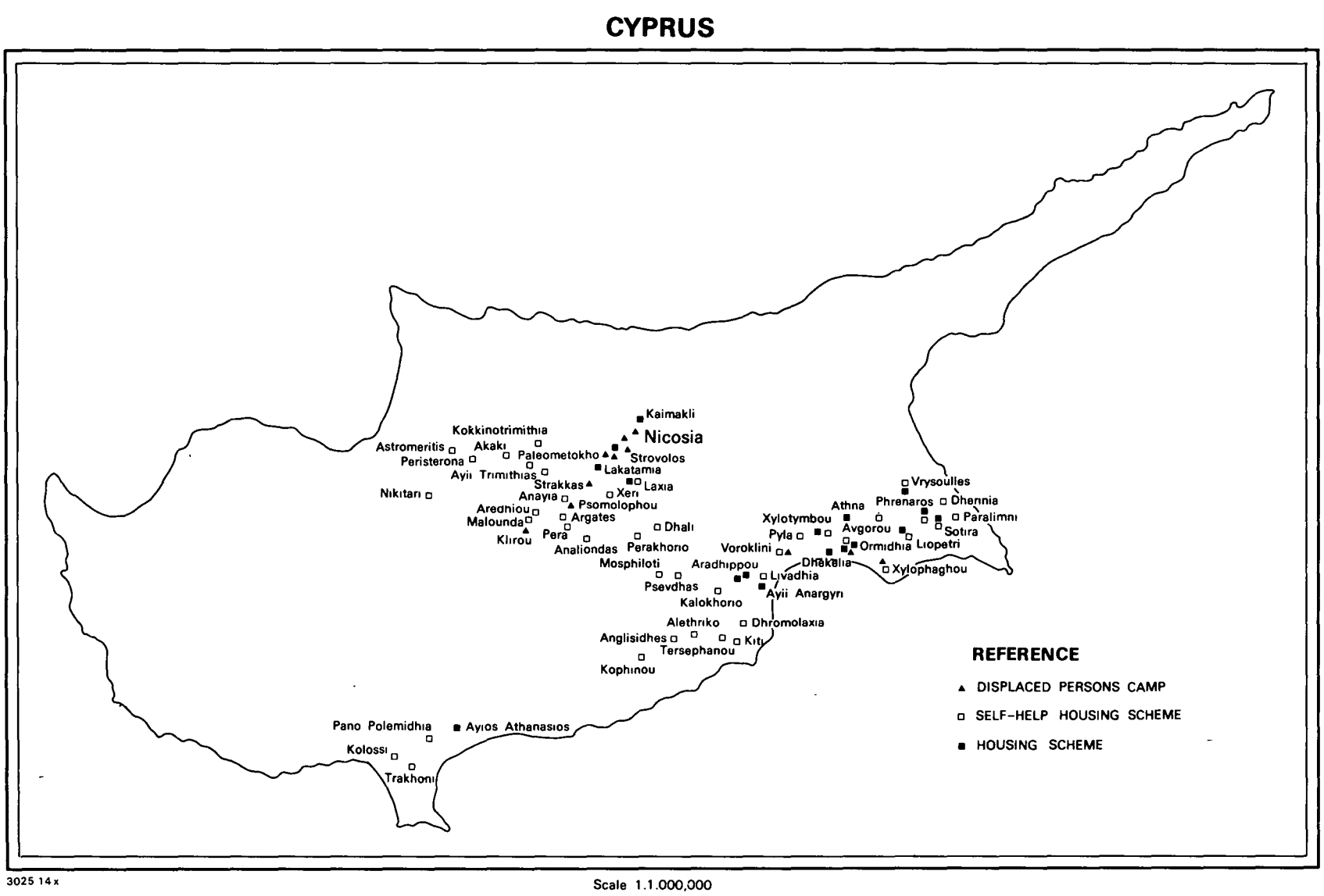



*Figure 14. Cyprus: camps for displaced persons and housing schemes*

with the Water Development Department of the Ministry of Agriculture and Natural Resources, has prepared the most detailed land-use map ever to have been produced. The scale of the map is 1 : 250,000 and it shows the land use in the following main categories:

(a) *Irrigated areas*: citrus orchards, deciduous trees, table grapes, bananas and vegetables;

(b) *Dry farming*: cereals, carobs, olives, both alone and intercropped with cereals, vines and tobacco;

(c) *Forests*: main forests, low forests, scrub, etc.

For many years, the need was felt for a school atlas for elementary-school children. There was a long-standing request by the Ministry of Education for such a publication, but the Department could not get round the problem of compiling it, for a number of technical and administrative reasons. This year, the work is in hand; the cartographic work has been completed and has been passed on to the printers. The atlas is composed of a number of maps and diagrams of the island at various scales, the most prominent of which are:

(*a*) A map on the scale 1 : 6,000,000, showing Cyprus and the countries of the eastern Mediterranean between latitudes 30° and 45° North and longitudes 18° and 42° East;

(*b*) A map showing the distribution of agricultural products. The zones of cultivation are also distinguished on this map, which is on the scale 1 : 1,250,000;

(*c*) A map showing classical and contemporary cultural sites, archaeology and the forests of Cyprus by name, on the scale 1 : 1,250,000;

(*d*) A map showing the distribution of the hotel capacity of the island in 1956 and 1976. The comparison is presented both graphically and arithmetically at 1 : 1,250,000 scale;

(*e*) A map of Nicosia town, showing the distribution of the basic services in the capital, such as ministries, other government offices and public buildings, schools, banks, hotels and embassies, on the scale 1 : 15,000;

(*f*) A map at 1 : 10,000 scale of the rural area of Phinikaria village, showing the land-ownership pattern before and after land consolidation of holdings;

(*g*) A map on the scale 1 : 25,000 of the rural area of Kiti village, showing the difference in the agricultural development of the area after the construction of a dam in the vicinity.

### National topographic map series on the scale 1 : 5,000

The national topographic mapping of the island on the scale 1 : 5,000, commenced in 1969, was accelerated in 1973 in order to produce maps for a water-engineering study, with technical assistance from the United Kingdom of Great Britain and Northern Ireland, to convey water from the south of the Troodos Mountains to Larnaca and Famagusta. The British Directorate of Overseas Surveys (DOS) offered to help by undertaking the flying of new aerial photography and the mapping of half the area of the first priority, totalling some 2,460 km$^2$. Figure 15 shows the area photographed in 1973, the mapping of which is nearing completion.

In spite of the Turkish invasion, which brought misery and destruction to 200,000 Greek Cypriots and shattered the economy of the island, agricultural and industrial development of the area controlled by the State has not ceased. Development projects in the districts of Limassol and Paphos necessitated the continuation of the mapping in those areas. To this end, further aerial photography was flown in October 1976 for mapping and for re-afforestation in the Paphos Main State Forest, which was severely burnt during the Turkish bombings in 1974. The photography was contracted by DOS, as part of their assistance in the joint project. The area photographed for mapping covers some 1,300 km$^2$, and the area covered by infra-red photography in the forests is about 400 km$^2$. Mapping will commence early in 1977, and it is anticipated that it will be completed towards the end of 1978.

Pre-selected control points in the areas photographed were pre-marked by suitable signals, which will be used as a basic control for aerotriangulation purposes and block adjustment. Figure 15 shows the areas photographed recently for the continuation of the mapping project. Samples of the maps produced by both the Directorate of Overseas Surveys and the Director of Lands and Surveys are on display in the exhibition hall.

### Future programme

The national topographic mapping will continue piecemeal until every square metre of the ground is covered. Steps are being taken for a continuous revisional programme, so that sheets covering the towns and suburbs will be brought up to date at least every five years, and those in the rural areas at less frequent intervals. But the programme of mapping, so necessary for the social and economic development of any country, cannot be carried out when 40,000 troops of a foreign Power occupy 40 per cent of the soil of the island. Neither mapping nor any other form of survey can be carried out inside or near the border of the occupied area. It is hoped that very soon foreign troops will be withdrawn from Cyprus in accordance with General Assembly resolution 3212 (XXIX) of 1 November 1974, so that its people can be left alone to solve their problems and live in peace, as they did for so many generations.

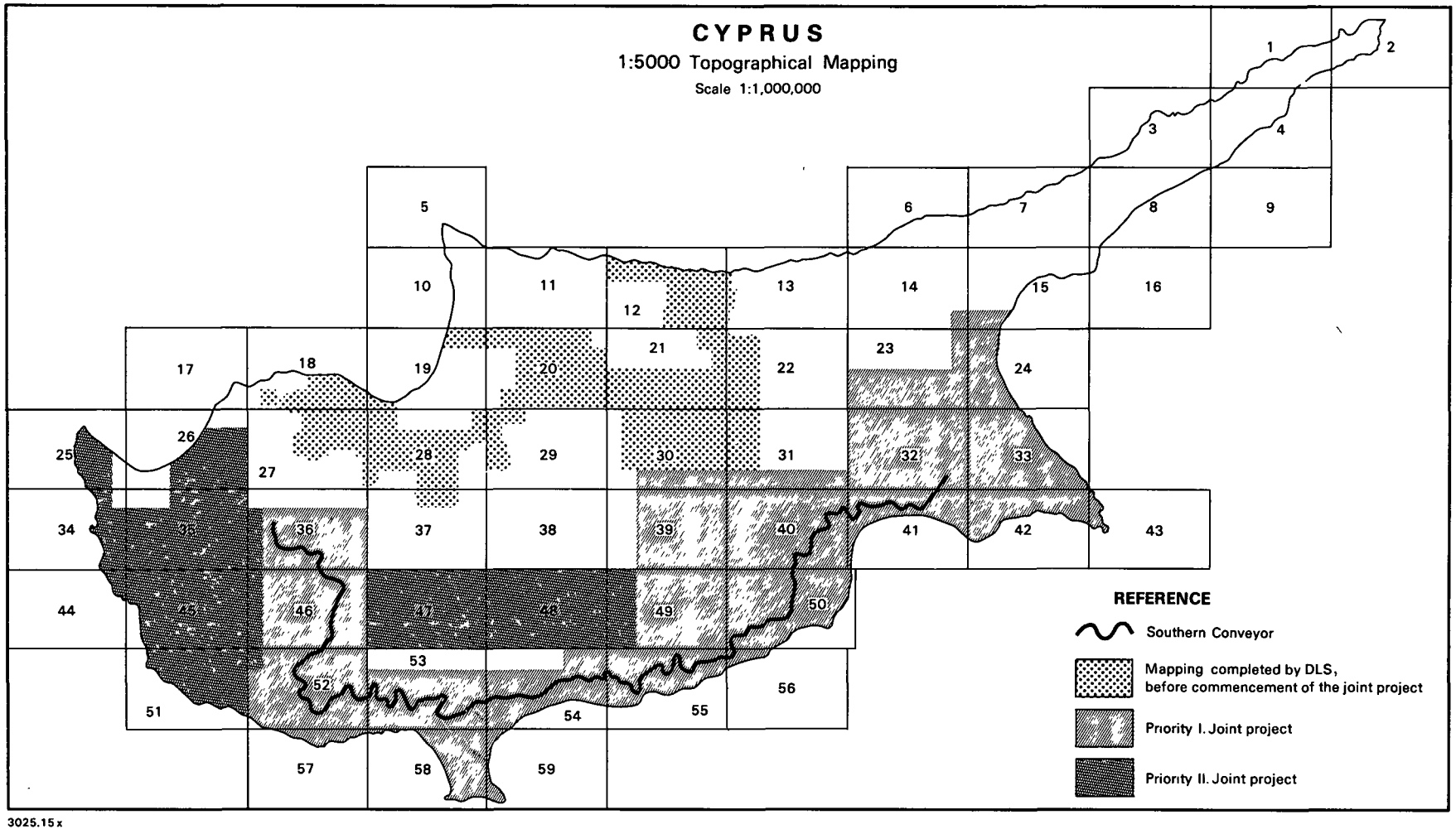



*Figure 15. Cyprus: topographic mapping at 1:5,000 scale*

# EGYPTIAN NATIONAL REPORT*

*Paper presented by Egypt*

As late as 1889, all the triangulation and cadastral surveys and the reproduction of other kinds of mapping were united under the direction of the Survey Department, currently the Egyptian Survey Authority (ESA).

Surveys and mapping had been carried out by traditional methods before photogrammetric techniques were introduced when the Military Survey Department was set up in 1954. Since that time, work has been developed by using new instruments, tools and materials. The military survey currently undertakes the production of military maps, which had previously been carried out in a limited way by the Survey of Egypt.

Although ESA is responsible for official production of surveys and mapping in Egypt, other unco-ordinated efforts exist so as to meet the needs of the project studies required by the various government departments. Aerial surveys in ESA are carried out in close liaison with the military surveys. The Egyptian Remote Sensing Centre (RSC) at Cairo was established in 1971 as a research division of the Academy of Scientific Researches and Technology. The Centre is a co-operative venture between Oklahoma State University (United States of America) and the United States National Foundation of Science, and the Egyptian Academy. RSC is involved in research work with the Government, national agencies and private firms on local and international levels.

To meet manpower requirements for mapping and surveys, an apprenticeship system was used as long ago as 1900. The first school of surveying in Egypt was founded in 1928 and was directed by the Survey Department to train the required technical operators. Then, in 1966, the Training Centre was established. Lastly, in 1968, the Institute of Survey Technicians was established under the direction of the Ministry of High Education. Requirements for the supervisory cadre of personnel are fulfilled by the graduates of civil engineering departments in the Egyptian universities and the survey section of the High Polytechnical Institute at Cairo. Some selected staff receive further advanced training at internationally recognized establishments.

## GEODETIC ACTIVITIES

### *Super-networks*

Facilities for utilizing modern techniques of Doppler satellite surveying do not exist in Egypt. However, the subject is being studied and perhaps implementation of these methods will be achieved in co-operation with European countries.

### *Triangulation*

First-order triangulation in Egypt comprises:

(*a*) North-coast chain, extending from Rafah in the eastern Sinai to Sallum in the west on the border of Egypt with the Libyan Arab Jamahiriya;

(*b*) Nile Valley chain, extending from Cairo in the north to Adindan in the south on the border of Egypt with Sudan;

(*c*) Red Sea chain along the coast, extending from Suez in the north to the Egypt-Sudan border in the south, with an interlink to the north-coast chain across the Sinai Peninsula;

(*d*) Other chains across the Western and Eastern deserts.

It is planned to have Laplace fixes on the spheroid of Helmert (1906) and then Hayford (1910), in addition to base lines, at 200 km intervals along the chains. The geodetic chains are considered to be belts to control the three other lower order triangulations for mapping of the country.

The tolerances assigned to triangulation chains ranging from the first order to the fourth order are 2″, 5″, 15″ and greater than 15″ for triangle closures; and 1 : 25,000, 1 : 10,000 and 1 : 5,000 for the computed base lines. T4 and T3 theodolites and 24 m invar tapes are used for astronomical, azimuth and base-line measurements, respectively.

### *Levelling*

The datum adopted for precise levelling in Egypt was the mean sea level at Alexandria. Precise levelling covered the Nile Valley. In the Eastern and Western deserts, main lines of bench-marks had been established parallel to the main roads and valleys. These levelling lines totalled 12,000 km in length. Over the past five years, most of the lost bench-marks have been renewed.

### *Gravity measurement*

Activities relating to gravity measurement in Egypt are undertaken by the Geodetic Department of ESA, in collaboration with the International Association of Geodesy (IAG) and the Engineering Department of Alexandria University. To date, 250 gravity base stations have been observed on the precise bench-marks in existence on the main routes in different parts of the country.

In 1961, Helwan Observatory Station was connected with the International Potsdam System. This endeavour was assisted and advised by Professor Tongstrom of Uppsala University (Sweden). For the secondary gravity network, there is a station in the Nile delta.

The Geodetic Department of ESA is currently involved in surveying the deflection of the vertical in the area of the

* The original text of this paper appeared as document E/CONF.68/L.69.

Muqattam plateau east of Cairo. In a circular area with a 100-m radius, the contour lines after Bouguer are to be plotted, making use of all the gravity observations that have been taken by petroleum and mining firms in the specified area.

## Photogrammetry

### *Aerial photography*

In Egypt, aerial photography is carried out by private firms and the Egyptian Air Force. The aerial photographic equipment owned by ESA consists of three Wild RC8 aerial cameras with 6-inch Aviogon lens, another three with 6-inch Infargon and gyroscopic stabilized platforms and one RC8 aerial camera with Aviotar lens. The country is almost covered by wide-angle aerial photography on scales in a range from 1 : 10,000 to 1 : 60,000.

A considerable part of the Western Desert is covered by 1 : 50,000 super-wide-angle aerial photography. The Aswan High Dam Reservoir has infra-red photographic coverage.

Systematic aerial coverage of the entire area of cultivated land at 1 : 10,000 scale was undertaken three times a year in 1966–1967, for survey of the main summer, winter and flood crops—cotton, wheat and rice. These photographs were later used in the production of engineering plans on the scale 1 : 1,000, for the electric transmission line routes in the Egyptian villages and also for housing projects.

Within the general scheme of co-operation between the Governments of Egypt and France, agreed upon in 1975, a special programme of collaboration in cartography will be carried out through an association between ESA and a French consortium set up by the Institut géographique national (IGN) and the Société française de stereotopographie. Aerial photography defined in this programme is to cover various areas of considerable size in Egypt—the Canal, Greater Cairo, the north-western coast and the Qattarah depression region. This effort will produce the following coverage:

| *Area (square kilometres)* | *Scale* | *Type of coverage* |
|---|---|---|
| 900 | 1 : 6 000 | Normal angle |
| 17 000 | 1 : 15 000 | Wide angle |
| 29 000 | 1 : 25 000 | Wide angle |
| 4 000 | 1 : 40 000 | Wide angle |
| 20 000 | 1 : 50 000 | Wide angle |

### *Restitution*

Since 1954, photogrammetry has been used exclusively for the production of small- and medium-scale mapping. For the new series on the scale 1 : 50,000, plotting is done on the scale 1 : 25,000, to be subsequently reduced for reproduction at 1 : 50,000.

The horizontal and vertical data necessary for field control are based on third-order triangulation chains and levelling bench-marks. Resection and electronic distance-measurement traverses by infra-red distancers (Wild D110) and other related aids are used. Pre-signallization is used in some cases where white chalk or black tar paints are utilized, depending upon the terrain background.

Field controls identified or signallized on the aerial photographs are extended by aerial triangulation, carried out by independent models (semi-analogue triangulation). The data observations are processed on the Industrial Computer Limited (ICL) 1906 computer in the Central Agency for Public Mobilization Statistics at Cairo.

Within the general scheme for co-operation between Egypt and France and the special programme of collaboration in cartography, technical aids are defined to practise fully analytical aerial triangulation and digital terrain mapping in the Egyptian Survey Authority.

Orthophotography is not used in Egypt, as conventional rectification satisfies photo-mapping requirements in the developed areas, which are exclusively flat.

The photogrammetric equipment currently in use in Egypt includes: Wild A8 and A10 Autographs; Wild B85 Aviograph; Zeiss-Jena Stereometrograph C; Zeiss SEG V rectifier; and a completely equipped photographic laboratory.

## Cartography

### *Format and scales*

*Large-scale mapping series*

In the large-scale mapping series, the map-sheets are based on grid lines covering rectangular areas as follows:

(*a*) Scale 1 : 10,000 covers 6 × 4 km;
(*b*) Scale 1 : 5,000 3 × 2 km;
(*c*) Scale 1 : 2,500 1.5 × 1 km (cadastral maps);
(*d*) Scale 1 : 500 0.5 × 0.5 km (town maps).

*Old medium- and small-scale mapping series*

The old medium- and small-scale mapping series did not cover the entire country; in particular, the Western Desert was insufficiently mapped. The series on the scale 1 : 500,000 did not follow the International Map of the World on the Millionth Scale (IMW). The hachured map series at 1 : 100,000 scale was based on grid lines extending 40 × 60 km. The series on the scale 1 : 25,000 ($7\frac{1}{2}' \times 10'$) covered the entire area of cultivated land.

*New medium- and small-scale mapping series*

The new medium- and small-scale mapping series was begun in 1959; it is based on the subdivision of IMW as follows:

| *Map scale* | *Area covered (degree or minute)* |
|---|---|
| 1:500 000 | 2° × 3° |
| 1:250 000 | 1° × 1.5° |
| 1:100 000 | 30′ × 30′ |
| 1:50 000 | 15′ × 15′ |
| 1:25 000 | $7\frac{1}{2}' \times 7\frac{1}{2}'$ |

### *Drafting and printing*

Direct scribing on the plotting instruments is not used. Maps are fair-drawn for reproduction using both me-

thods, scribing and inking the blueprints on ordinary drafting paper. The photo-lettering machine has been introduced to prepare the Arabic names, but some names and titles still must be hand-written.

### Map production

Since 1959, the traditional procedure used for mapping and surveying at small and medium scales has been replaced by photogrammetric methods. An extensive programme has been carried out to produce a new map series at 1 : 50,000 scale produced from originals at 1 : 25,000 scale.

Most of the important areas of Egypt have been covered by this new series; yet, all the cultivated land had been covered by the old series at 1 : 25,000, which are revised periodically.

The maps at 1 : 100,000 scale are produced for areas covered by the former series. Maps on the scale 1 : 250,000, however, are produced from the old hachured maps at 1 : 100,000 scale and from the new maps available. The old maps at 1 : 500,000 scale are republished in the new subdivisions of IMW. Large-scale maps—1 : 10,000 and 1 : 5,000—are prepared for cadastral and town mapping.

Other project surveying required for various governmental agencies is carried out under the direction of the Egyptian Survey Authority as needed.

### Cadastral mapping

The first cadastre was begun in 1898 and lasted 10 years. With no existing triangulation control, it was done by separate surveys, village by village. The control was in the form of a rapid traverse around each village. A series of large-scale map-sheets was provided on the scale 1 : 4,000, and later on the scale 1 : 2,500. The latter scale was chosen because of the extreme subdivision of land into small holdings; 40 per cent were under 0.5 *feddan* with another 50 per cent under 5 *feddans* (1 *feddan* = 4,200.83 $m^2$). In 1899, a systematic triangulation of the second order was begun, and a second cadastre was begun in 1924. Accordingly, radical changes have occurred in surveying methods. Permanent national traverse nets have been controlled by triangulation with a new co-ordinated reference, to permit the entire country to fall into the first quadrant. The traverse points were plotted on maps at 1 : 1,000 scale. Detailed surveys were later undertaken by field-parties. Map-sheets were then provided on the reduced scale 1 : 2,500 for public use at a moderate price per copy.

The second cadastre has not yet covered all the cultivated land. The traditional procedure currently used for the cadastral survey should be replaced by a new procedure which would increase efficiency and reduce the manpower requirements and costs. Such an improvement would foster the very important process of the cadastral survey. The recently established Survey Research Institute, a department of the Ministry of Agriculture and Irrigation, is conducting field experiments for a proposed procedure which would make use of electronic computers, plotters and distancers.

#### *Town mapping*

Traditional surveying and mapping procedures are still used for town maps on the scales 1 : 500 and 1 : 1,000. A special triangulation net is carried out with specially measured base lines.

### Remote sensing

The Egyptian Remote Sensing Centre offers a full range of earth resources data acquisition and processing services, including:

(*a*) Consultation and planning for application of both satellite and airborne multispectral data;

(*b*) Data analysis and processing using advanced digital processing, display and recording techniques;

(*c*) Presentation of results in imagery, maps and other data formats.

The following facilities and equipment are available to RSC:

(*a*) A multispectral data analysis system developed by Bendix Corporation for the space programme of the United States National Aeronautics and Space Administration (NASA);

(*b*) Complete photographic development equipment;

(*c*) Other remote-sensing equipment for data collection and analysis;

(*d*) Aircraft equipped with airborne remote-sensing equipment, including multispectral digital scanners, infrared thermo-vision cameras, gamma-spectral radiometric scanners, a four-lens multispectral aerial camera and aeromagnetic systems.

Projects conducted by RSC in Egypt and in other countries of the Middle East are described below.

#### *National projects*

The national projects undertaken by RSC are:

(*a*) Interpretation of geological, geophysical, soil characteristics and ground-water potential in the Suez Canal-Sinai region, the area of the Kharaga and Dakhla oases in the Western Desert and El Dikheila-Alexandria in western Egypt;

(*b*) Regional prospecting for iron ores in the Bahariya oasis-El Fayom area;

(*c*) Geological interpretation of LANDSAT satellite imagery for the western Nile delta area.

#### *Regional and international projects*

The regional and international projects currently under way include:

(*a*) Land systems maps from Earth Resources Technology Satellite (ERTS) imagery for the upper Nile basin in southern Sudan;

(*b*) Feasibility study of a proposed transnational project for the major regional aquifer in north-eastern Africa and the Arabian Peninsula aquifers, under contract with the United Nations Environmental Programme (UNEP);

(*c*) Feasibility study on the use of remote-sensing

satellite imagery interpretation for development of crop information systems for countries in the Middle East, by the United Nations and the Food and Agriculture Organization of the United Nations.

### Training and educational facilities

Prior to 1967, when the High Polytechnical Institute began to offer courses, no degree course in surveying, photogrammetry or geodesy had been available in Egypt. Surveying and mapping were carried out and supervised by civil engineers who had graduated from Egyptian universities and who had had a considerable amount of surveying studies during their undergraduate courses. Some staff members selected from the university graduates receive advanced training and post-graduate courses through government scholarships to study at universities abroad and at internationally recognized training centres or through the newly instituted post-graduate courses in surveying at the civil engineering departments of Egyptian universities.

For the cadre of technicians, special training courses are offered in surveying, photogrammetry and cartography. These courses are provided by the Institute of Survey Technicians, which was established in 1968 and which is a two-year institute following the secondary education stage (certificate of matriculation). Many subjects are taught—cadastral and topographical surveying, photogrammetry, mining surveying, geodesy and office computations, as well as such related subjects as mathematics, descriptive geometry and physics. Foreign students who speak Arabic can attend the Institute. A similar school exisits in the Military Survey, and a training centre was recently established in ESA for new personnel to attend specific courses before entering their positions at ESA. Existing personnel also can take refresher courses or learn new techniques at the ESA training centre.

## CARTOGRAPHIC ACTIVITIES IN FIJI*

*Paper presented by Fiji*

The Fiji archipelago lies approximately 18° south of the equator on the 180th meridian. It comprises more than 300 islands of varying size scattered over 164,000 square miles (425,000 km$^2$) of the Pacific Ocean. About 100 of these islands are inhabited, most of the remainder being used for temporary residence and planting. The two main islands are Viti Levu and Vanua Levu, which together comprise an area of 6,148 square miles (15,923 km$^2$) or 87 per cent of the total land area of 7,055 square miles (18,272 km$^2$).

The whole of Fiji is covered by a major triangulation network, which has been broken down by minor triangulations in certain important areas. Cadastral surveys are tied on to the triangulation system, although boundary marks are not yet generally co-ordinated. As the major triangulation was carried out in the early part of the twentieth century, there is a need to check and upgrade the triangulation work.

The responsibility for mapping work is assigned to the Department of Lands and Survey. However, the Department does not have a self-sufficient mapping division and is almost entirely dependent upon overseas assistance. In this regard, the United Kingdom Directorate of Overseas Surveys (DOS) has carried out the necessary mapping work to date. With this assistance, the major islands were mapped at 1 : 50,000 scale in the 1950s and these maps form the topographic series. In addition, DOS has prepared administrative and topographic maps on the scales 1 : 250,000 and 1 : 500,000, together with land-use maps at 1 : 250,000 scale. Some revisional work has been carried out on the 1 : 50,000 topographic maps which are most in demand for planning and development purposes. However, in view of their age and the need to adopt the metric system, plans are in hand to upgrade these maps and also to introduce larger scale maps.

The Department of Lands and Survey has a small aerial photogrammetry unit which prepares topographic maps for land development and planning purposes only. Most of Fiji is covered by existing aerial photography taken over 10 years ago. *Ad hoc* photography is undertaken by the aerial photography unit with the Wild RC8 camera owned by the Department and locally hired aircraft, in order to update photographic coverage in the developing areas.

* The original text of this paper appeared as document E/CONF.68/L.118.

## CARTOGRAPHIC ACTIVITIES IN FINLAND*

*Paper presented by Finland*

This paper presents a brief description of cartographic activities in Finland.

Of the topographic maps, the most important map is the basic map of Finland. The mapping is carried out at 1 : 10,000 scale and, in part, in Northern Finland, at 1 : 20,000 scale, and the maps are printed in six or three colours at 1 : 20,000 scale. The contours are drawn at 5-m

* The original text of this paper appeared as document E/CONF.68/L.110.

intervals; and, when necessary, 2.5-m auxiliary contours are used. A normal-sized sheet covers an area of 10 × 10 km.

The field-work for the basic map was begun in 1947 and was completed in 1975. The last sheets will be printed by the end of 1977. The next stage will be the continuous revision and updating of the entire series, a total of 3,712 sheets. This work has already begun. Thus far, approximately 500 maps have been revised or renewed.

A reduction of the basic map to the scale 1 : 50,000 is available for certain areas.

The topographic map at 1 : 100,000 scale is produced in from seven to nine colours and normally covers an area of 30 × 40 km.

The general map at 1 : 400,000 scale is a six-colour series.

Of the thematic maps, the most important map is the road map of Finland at 1 : 200,000 scale. It is a detailed and exact tourist map, but it is also suited for many other purposes. This series, comprising 19 sheets, is kept up to date continuously and new editions appear every two or three years. A special version of the road map shows fields, swamps and 20-m contours as additional information.

The motoring road map on the scale 1 : 750,000 and the general road map on the scale 1 : 1,500,000 are revised annually.

Other thematic maps are listed below:

(*a*) Tourist map at 1 : 100,000 scale, of certain areas;

(*b*) Outdoor map on the scale 1 : 25,000 or 1 : 50,000;

(*c*) Environs maps of several towns and their surroundings on various scales;

(*d*) Aeronautical chart at 1 : 500,000 scale;

(*e*) Postal map of Finland at 1 : 800,000 scale;

(*f*) Pre-Quaternary rocks map at 1 : 100,000 scale;

(*g*) Quarternary deposit map at 1 : 100,000 scale;

(*h*) Agrogeological soil map at 1 : 20,000 scale;

(*i*) Atlas of Finland.

The investigation of remote sensing in Finland was begun in 1970 and research activities dedicated to the machine-processing of remotely sensed data were initiated in 1973. On the basis of the results achieved in testing the remote-sensing methods for mapping of agriculture, forestry and water resources, the following conclusions may be drawn:

(*a*) Automated remote-sensing techniques which utilize satellite imagery are applicable to the classification of land in cropland, potential cropland, forests and waste lands;

(*b*) The methods are applicable for the inventory of forest resources, at least for determination of forest area and for determination of total timber volume;

(*c*) The methods are especially applicable for monitoring of land use, forest resources and their damages.

At this stage of technical development, co-operation with countries of Africa and Asia in resource mapping applications would be appropriate and desirable from the point of view of Finland.

It is very important that access to satellite data through ground receiving-stations located in various countries also will in future be allowed for all countries. Finland suggests that this type of resolution be approved by this Conference.

Alterations in the structure and partition of a real estate are made in Finland at the real estate survey operations. These alterations are public deeds and surveyors act with the authority of a judge. The most general operation is parcelling-out; other operations that should be mentioned are the division of real estate, boundary surveys, road surveys with expropriation of land and other compensation, and land consolidation. About 25,000 real estate survey operations are carried out annually.

The real estates are recorded using two different registers. In rural areas, there is a land register; and in the most densely populated urban areas, a register of building sites. There is a trend towards fusion of these two registers in the near future. At the same time, the manual operation system used for the existing registers will tend to be replaced by automatic data-processing.

There are currently approximately 1.7 million real estates in Finland. The annual increase is about 30,000.

The main responsibility for mapping, land surveys and registration of real estates in Finland is carried by the National Board of Survey, which has approximately 2,300 employees. Other organizations include the Geodetic Institute, the Army Map Service, the Geological Survey, the Agricultural Research Centre and the National Board of Navigation. The private firms produce large-scale maps for industrial employers and municipalities for various purposes. They have also carried out numerous assignments abroad. Each city takes care of the real estate operations and of the Register of Building Sites in its own area.

The Government of Finland has sponsored some topographic mapping and photogrammetric operations in the United Republic of Tanzania, as a part of the bilateral development co-operation between Finland and the countries of East Africa. Expert assistance has also been used in some countries of Africa, the Americas and Asia. It is hoped that this type of development co-operation will continue and increase in the future.

## BASIC MAPPING OF FINLAND, 1947–1975*

*Paper presented by Finland*

Topographic mapping of Finland was begun during Swedish rule in 1770 and was carried on by the Russians after the war of 1808–1809. Between those dates there was a long period in which no activity took place. Thus, by the time Finland became independent in 1917, only the southernmost part of the country was covered by topographic maps. The scale of these maps was either 1:21,000 or 1:42,000. They were compiled without proper geodetic control and were inaccurate both in planimetry and in elevation. The ground information was inadequate or out of date.

The National Board of Survey, which was responsible for the mapping of Finland, initiated in 1919 a new topographic map series at 1:20,000 scale. The production of those maps using the methods and resources available at that time was very slow, only a few sheets per year. The lack of topographic maps was partially compensated by the so-called "Parish Map" at 1:20,000 scale, which was based on legal survey maps. In addition to ground details, it contained property boundaries; but it had no contour lines. The area covered by these two maps was still very small when the Second World War broke out.

After the war, a new plan was made for the mapping of Finland. That plan implied a fusion of the two earlier map series into a new basic map on the scales 1:10,000/1:20,000.

The basic map contains the usual information of a topographic map supplemented by property boundaries and cadastral registration numbers. It is based on a controlled photo-mosaic, photo map, at 1:10,000 scale. Contour lines are surveyed at 5-m intervals. The map is printed at 1:20,000 scale in six colours (see figures 16 and 17 in pocket[1]).

The basic map was planned to cover the southern parts of Finland up to the latitude of Oulu. Northern Finland should be covered with a somewhat simpler type of map, the topographic map, made only at 1:20,000 scale without property boundaries and printed in three colours.

Taking into account the new photogrammetric methods currently available, it was estimated that the mapping of Finland would be completed in approximately 20 years. The Army Map Service offered its co-operation by taking the main responsibility for the topographic map of northern Finland.

### GROUND CONTROL

The map projection chosen for the basic map was that already used as a base for the earlier map series, a Gauss-Krüger conformable projection with 3°-wide projection zones. The sheet-line system is based on these projection zones. The standard size of a map-sheet is 10 × 10 km.

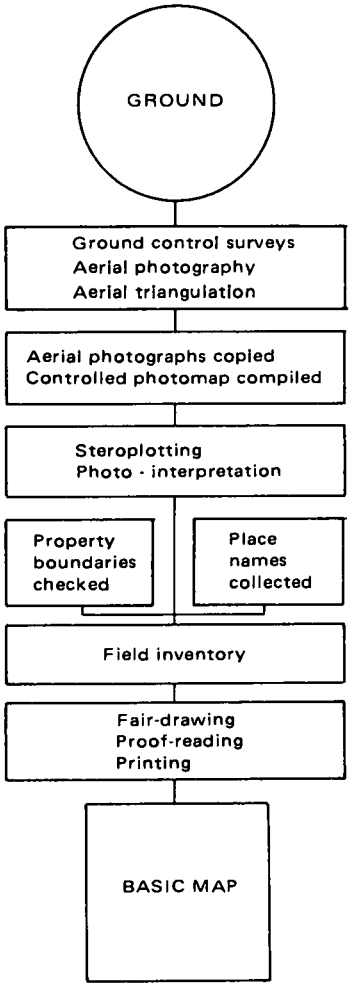



*Figure 18. Finland: production process of the basic map*

The geodetic control for the basic map is based on the first-order triangulation and levelling networks of the Geodetic Institute of Finland. Additional measurements of the first and lower orders are made by the Geodetic Division of the National Board of Survey and the Army Map Service. There are two or three triangle points per map-sheet. The triangulation method has been essentially improved by electronic distance-measurements.

Lines of the basic levelling network are 5-8 km apart. Additional elevation control points needed for stereophotogrammetric operations are obtained by trigonometrical survey.

* The original text of this paper, prepared by H. E. Lyytikäinen, Director, Cartographic Department, National Board of Survey, Finland, appeared as document E/CONF.68/L.113.

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figures 16 and 17 are in this pocket.

## Photogrammetry

Aerial photography is done using aeroplanes owned by the National Board of Survey and hired aeroplanes in the peak season.

A wide-angle camera with 6-inch focal length has been the standard equipment for photography at 1 : 31,000 scale. Additional photography with an 8-inch normal-angle camera at 1 : 22,000 scale for compiling photo maps and for photo-interpretation has been used in certain areas. The control points needed for photo maps in addition to signalized geodetic ground control points are obtained by aerial triangulation. Both analogue and analytical triangulation methods are used. Block adjustments are made by electronic computers.

The photo map is compiled at 1 : 10,000 scale using rectified photographs. In hilly areas, orthophotographs are made for compilation.

For the field inventory, photographs are dyed brown and mounted together to build stereograms, which can be viewed with stereo spectacles.

## Topographic surveys

The manuscript of the map is made by drawing the planimetric details, the contour lines and the property boundaries on the photo map (see figures 19 and 20). Geographical names and cadastral registration numbers also appear. The manuscript is made in part in the office, in part in the field. Planimetric details are identified by photo-interpretation as far as possible. The same procedure is applied to property boundaries, using an index map compiled with the aid of legal survey maps and documents.

The contour lines are plotted using stereo instruments. In heavily wooded areas, a portion of the contours may remain to be surveyed in the field. To check and complete the results of photo-interpretation of planimetry and boundaries, a field inventory is also necessary. At the same time, the place-names are collected by interviewing the local people. The final approval and checking of the spelling of names is made by special linguistic authorities.

## Cartography and printing

The fair-drawing of the basic map is made on plastic sheets by separating planimetric details, contour lines and property boundaries on to three different sheets. The purpose of this step is, in addition to colour separation for printing, to make it possible to produce various types of copies at 1 : 10,000 scale according to order. The copies can be made in different combinations of drawings which may also be copied together with the photo map.

For printing, the drawings are photographically reduced to 1 : 20,000 scale. Planimetry is printed in black, contour lines in brown and property boundaries in red. In addition, blue is used for waters, yellow for cultivated land and another red for roads.

## First coverage of the basic map

The basic mapping of Finland was begun in 1947 with very small resources. Considerable efforts were needed to enlarge the organization to meet the demands of the huge project, to acquire the necessary equipment and to recruit and train the personnel. In August 1975, the project reached a significant stage. The field-work of the first coverage of the map was completed. Fair-drawing and printing of the remaining map-sheets will take two more years. After that period, the 3,712 sheets covering the whole of Finland will be ready (see figures 21 and 22).

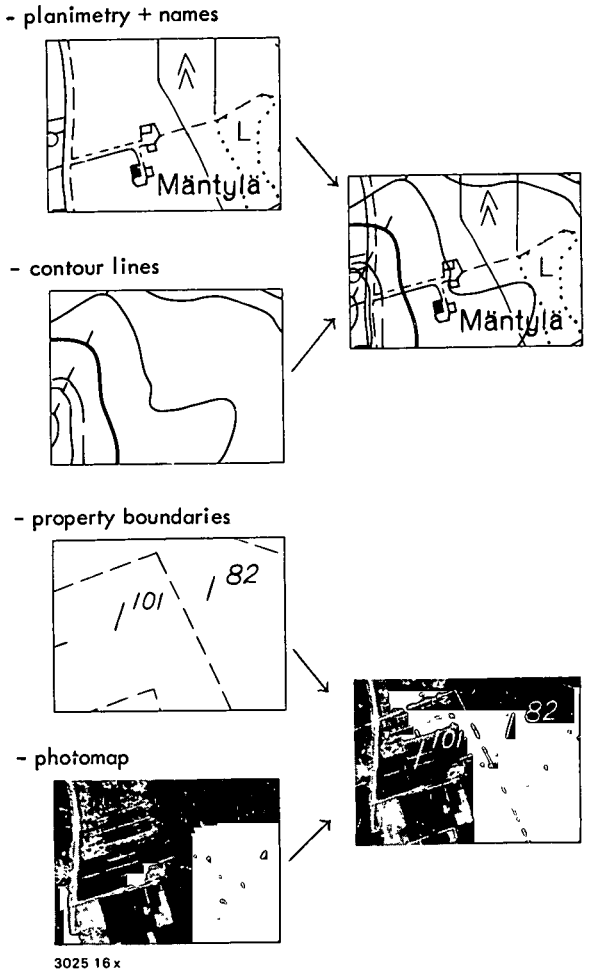



*Figure 19. Finland: drawings of basic map and photo map at 1:10,000 scale*

## Revision of the basic map

It is of the utmost importance that the basic map be continuously kept as up to date as possible. Almost all resources available for the mapping of Finland have been used to complete the primary coverage of the basic map. It has not yet been possible to keep the map up to date, except for a few of the most important areas. As the first sheets are now almost 30 years old, their revision is urgently needed and will be time-consuming. Thus, it has

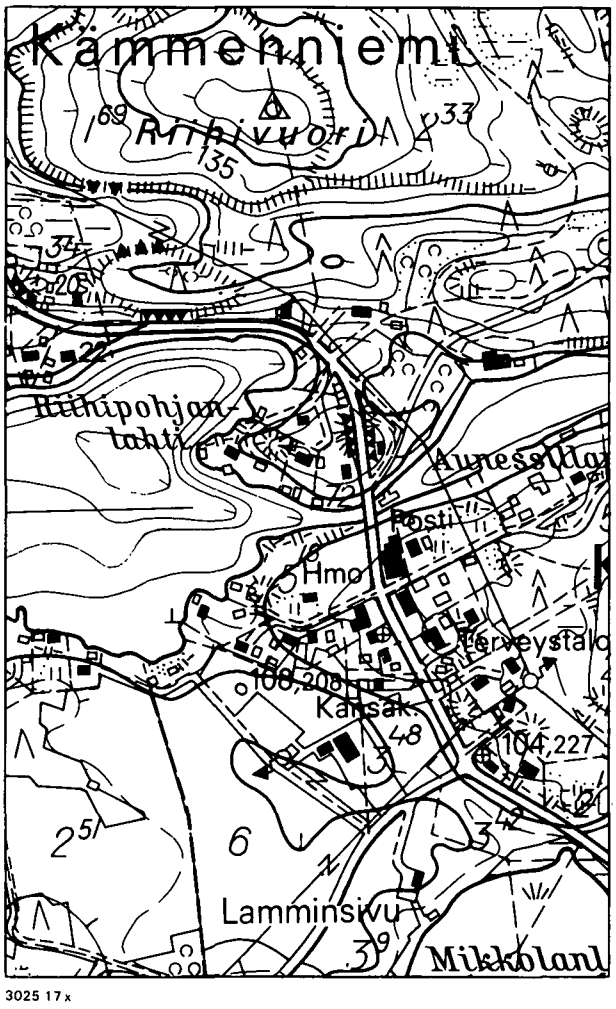



*Figure 20. Finland: combined copy planimetry plus contours plus boundaries*

been planned to concentrate most of the available resources on renewal work until a reasonable revision interval of from 5 to 15 years, according to the area concerned, has been reached. Parallel to updating operations, the basic map will be partially supplemented with extra information concerning, e.g., soils and depths of the lakes. It may prove necessary to connect mapping at larger scales to the revision of the basic map in the most urbanized regions. Automation of cartography should offer new ways to satisfy the increasing demands for maps.

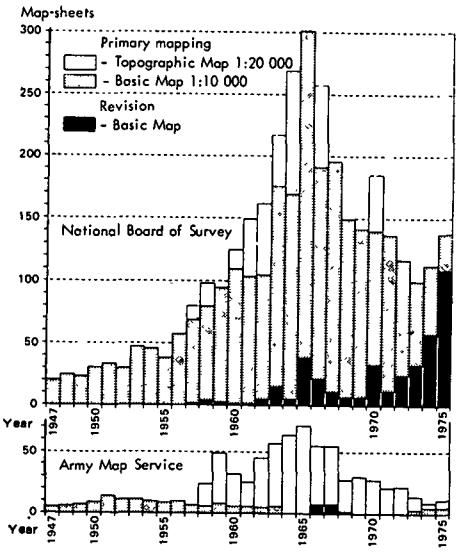



*Figure 21. Finland: annual output of mapping*

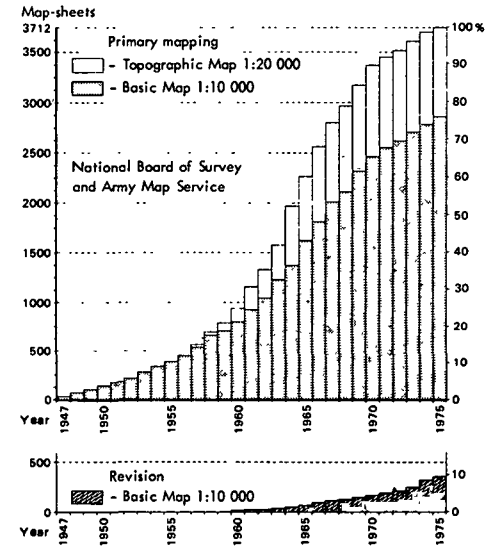



*Figure 22. Finland: cumulative annual progress of mapping and revisions*

# TOPOGRAPHIC MAPPING IN THE FRENCH TERRITORIES OF THE PACIFIC*

*Paper submitted by France*

Up to the Second World War, the mapping of the French territories throughout the world, including those in the Pacific, had reached different stages of advancement and in many cases had been neglected. Apart from marine charts, all of which were very old, only partial or incomplete local military or cadastral surveys existed. Since 1945, when the jurisdiction of the Institut géographique national (IGN) was extended to these territories and considerable advances were made in methods, modern surveys have been carried out on a systematic basis, so that most of the Territories have now been provided with basic mapping cover similar to that of metropolitan France (see figures 23–28).

## New Caledonia and its dependencies

New Caledonia, which was less neglected than most French possessions, was provided at a fairly early stage with a reliable topographic map, in addition to marine charts.

The first coastal hydrographic survey was carried out from 1855 to 1865 and was used as the basis for a number of detail maps on various scales and for a general map on the scale 1 : 300,000, which also covered the New Hebrides and the Loyalty Islands. Then, beginning in 1870, a local service carried out cadastral surveys. A little later, from 1879 to 1883, a triangulation was carried out and surveys were made by a military mission; and these undertakings served as the basis for compiling and publishing a multicoloured hachured map on the scale 1 : 107,000. These documents, revised and updated to varying degrees, were those which existed when IGN took charge.

In 1951, a first-order geodetic net was established in order to link up the lower order triangulations carried out locally. At the same time, precise levelling and aerial photographic coverage were carried out with a view to preparing a basic map on the scale 1 : 50,000 for the whole of New Caledonia and the Loyalty Islands, to be supplemented by a map at 1 : 20,000 scale for the more developed areas. Publication, which was completed in 1962, is of the French metropolitan type, i.e., in five colours: black (planimetry, lettering, margin and marginal information); blue (hydrography); sepia (contours); green (vegetation); grey (relief shading). The projection used is Universal Transverse Mercator (UTM). (international spheroid).

In 1965–1966, a derived map on the scale 1 : 200,000, in five sheets, was prepared from the basic map; it shows both the topography and the road system and is in eight colours.

These maps have not been revised since they were first published.

## New Hebrides archipelago

Before the establishment of the French-British Condominium in the New Hebrides in 1906, the archipelago had been covered only by British hydrographic surveys which had been used by the French Hydrographic Service in preparing the general map referred to above in connexion with New Caledonia. Between 1909 and 1911, cadastral surveys were carried out on the larger islands by a military mission on behalf of the Compagnie française des Nouvelle-Hébrides. As these surveys were completed, they were used for the preparation of a number of sheets at 1 : 100,000 scale.

From 1956 to 1965, IGN carried out geodetic and photogrammetric surveys for the preparation of a standard base map. The surveys were used for the production of a map on the scale 1 : 100,000 in 15 sheets; this series was of the French metropolitan type in five colours and was based on the UTM (international spheroid) projection. It was published between 1965 and 1971, and has not been revised since that time. The same surveys, updated locally, were also used for the preparation of maps at 1 : 50,000 scale drawn to the same specifications as the 1 : 100,000 map. These maps were published between 1961 and 1976.

## French Polynesia

The hundred or so islands, islets and atolls, geographically divided into five archipelagos which together make up French Polynesia, are shown on marine charts prepared in the second half of the nineteenth century. These charts consist of general small-scale charts, charts on the scale 1 : 100,000 for Tahiti and Moorea, and local large-scale maps.

Also, until about 1890, a topographic bureau set up at Papeete in 1862 carried out cadastral surveys; but the results of those surveys were for the most part lost in the 1906 cyclone. In 1913, a new service was assigned the task of conducting cadastral surveys of the main islands, according to development needs.

In 1951, IGN carried out the necessary survey operations for the preparation of a standard base map for which the astronomical points of the Service hydrographique de la Marine were used. These surveys resulted in the publication of provisional multicoloured maps on the scales 1 : 40,000 for the Society Islands (1958), and 1 : 20,000 and 1 : 50,000 for the Tuamotu Islands (1967). These maps were prepared using the UTM (international spheroid) projection. They have not been revised since they were first published.

A road and touring map of Tahiti and Moorea was published in 1964. A relief version of this map also exists.

* The original text of this paper, prepared by G. Alinhac, Institut géographique national, France, appeared as document E/CONF.68/L.6.

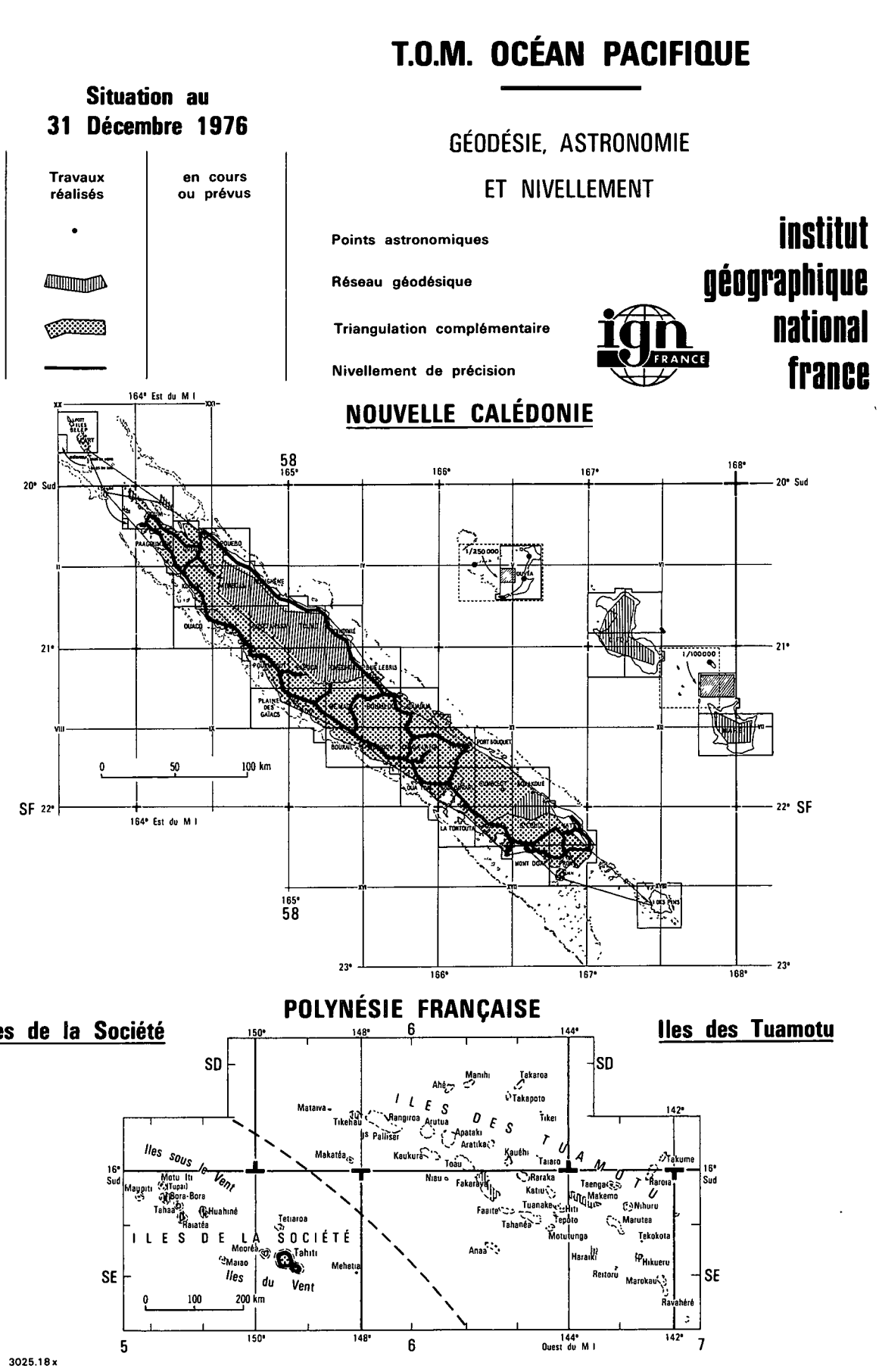



*Figure 23. France: Nouvelle-Calédonie et Polynésie française, géodésie, astronomie et nivellement*

# T.O.M. OCÉAN PACIFIQUE

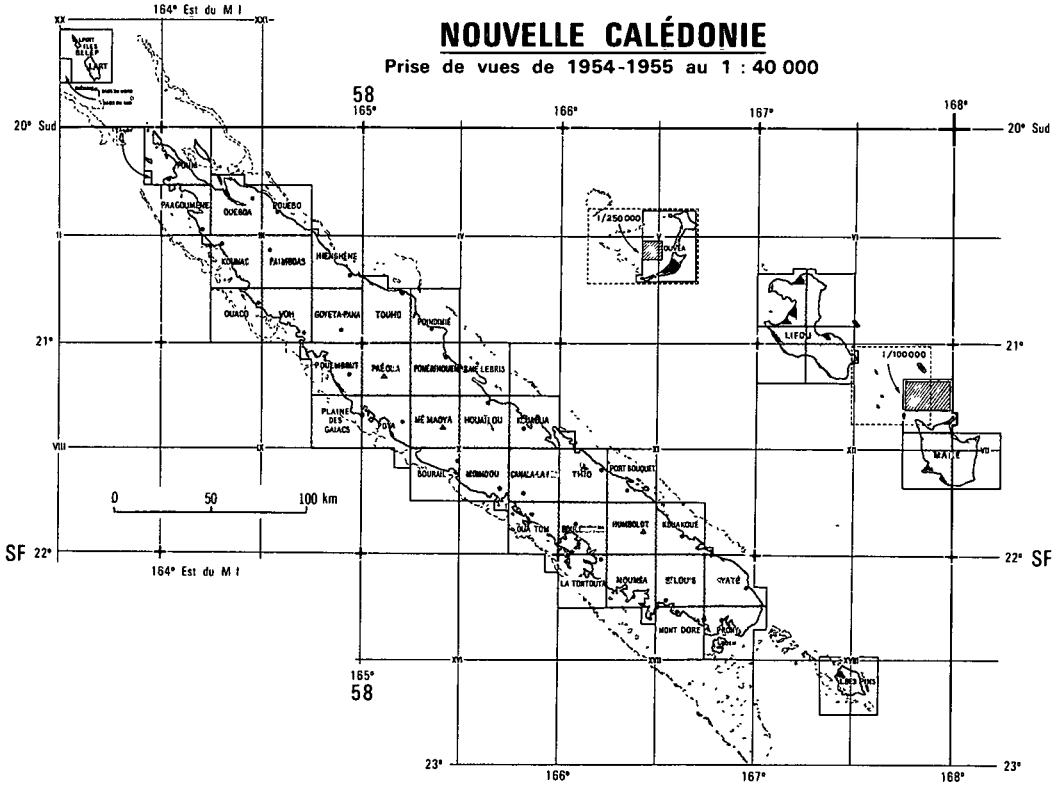
**Situation au**
**31 Décembre 1976**

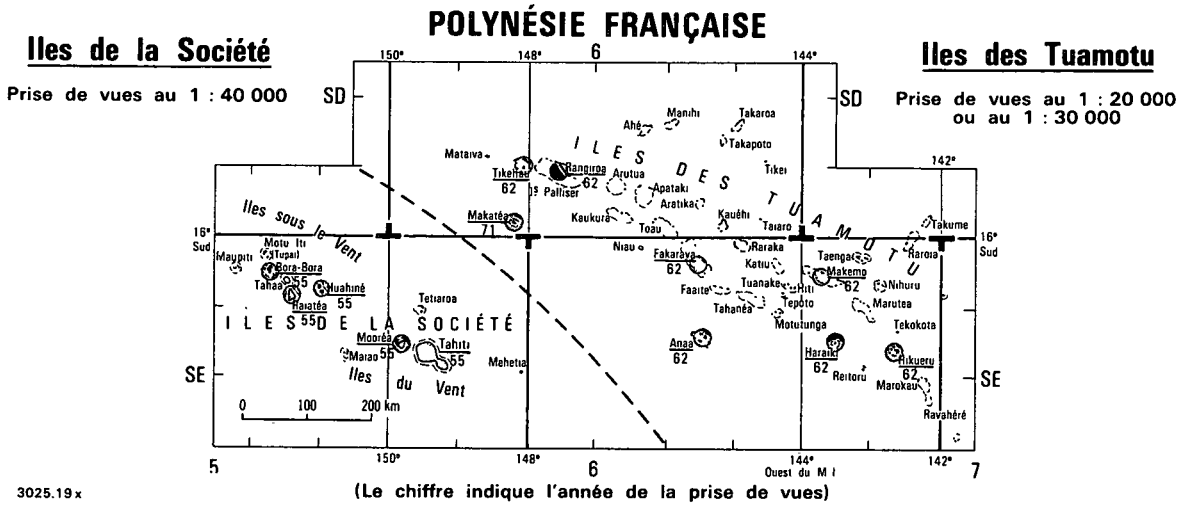
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## COUVERTURE PHOTOGRAPHIQUE

N O T I C E — *La couverture photographique satisfait aux conditions générales ci-après :*
— Chambres métriques de prise de vues.
— Axe de prise de vue sensiblement vertical.
— Couverture totale de chaque zone par des bandes de photographies rectilignes et parallèles.
— Recouvrement longitudinal de deux clichés successifs d'une bande : 60 %.
— Recouvrement latéral de deux bandes adjacentes : 15 %.
— Excellente netteté.

*Ces clichés permettent :*
— L'étude détaillée du terrain par examen stéréoscopique des épreuves.
— L'obtention d'agrandissements, jusqu'à 4 et même 5 fois, des photographies originales.
— La restitution précise.




3025.19 x

*Figure 24. France: Nouvelle-Calédonie et Polynésie française, couverture photographique*

# T.O.M. OCÉAN PACIFIQUE

**Situation au 31 Décembre 1976**

PUBLICATION

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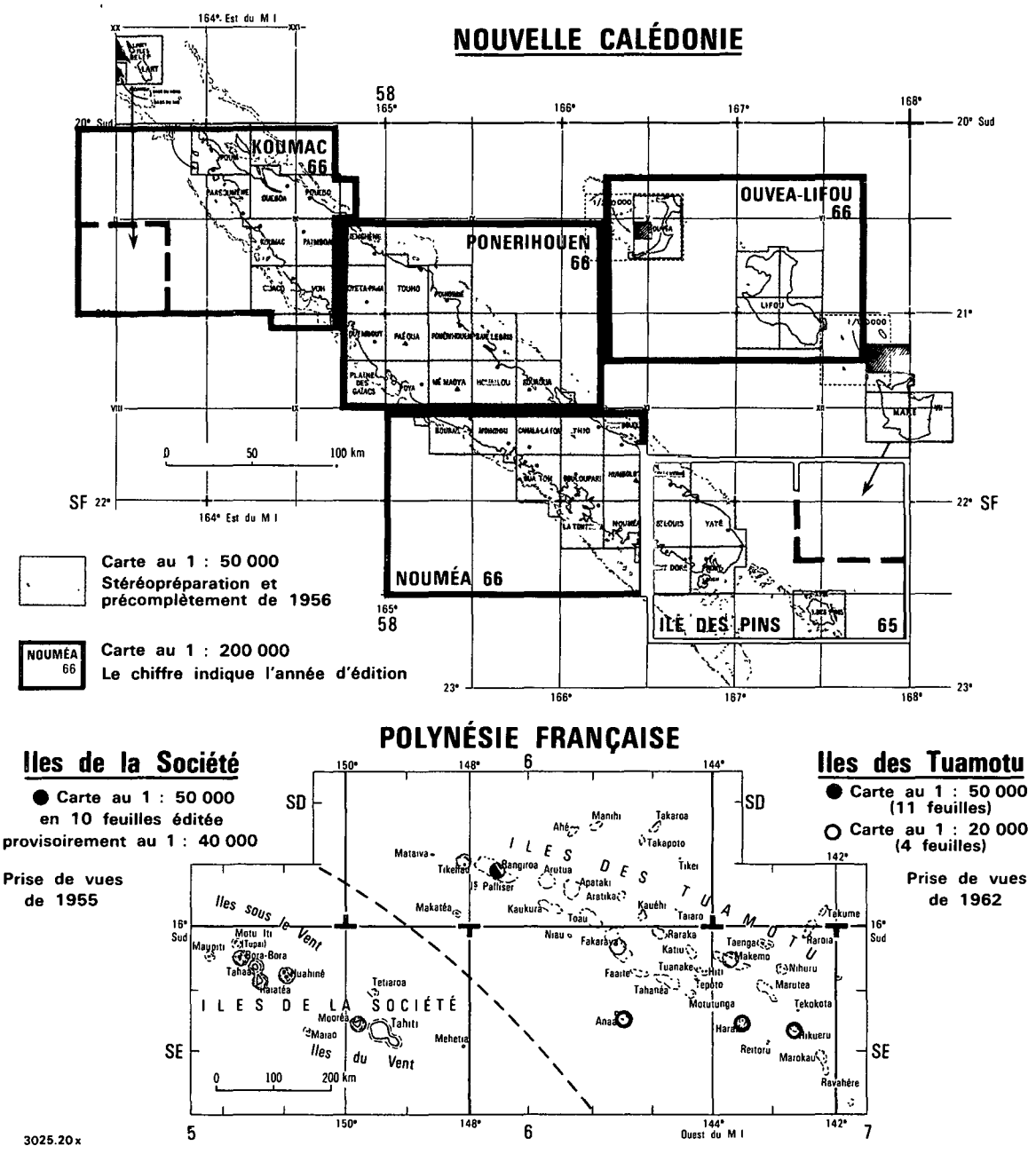



*Figure 25. France: Nouvelle-Calédonie et Polynésie française, publication*

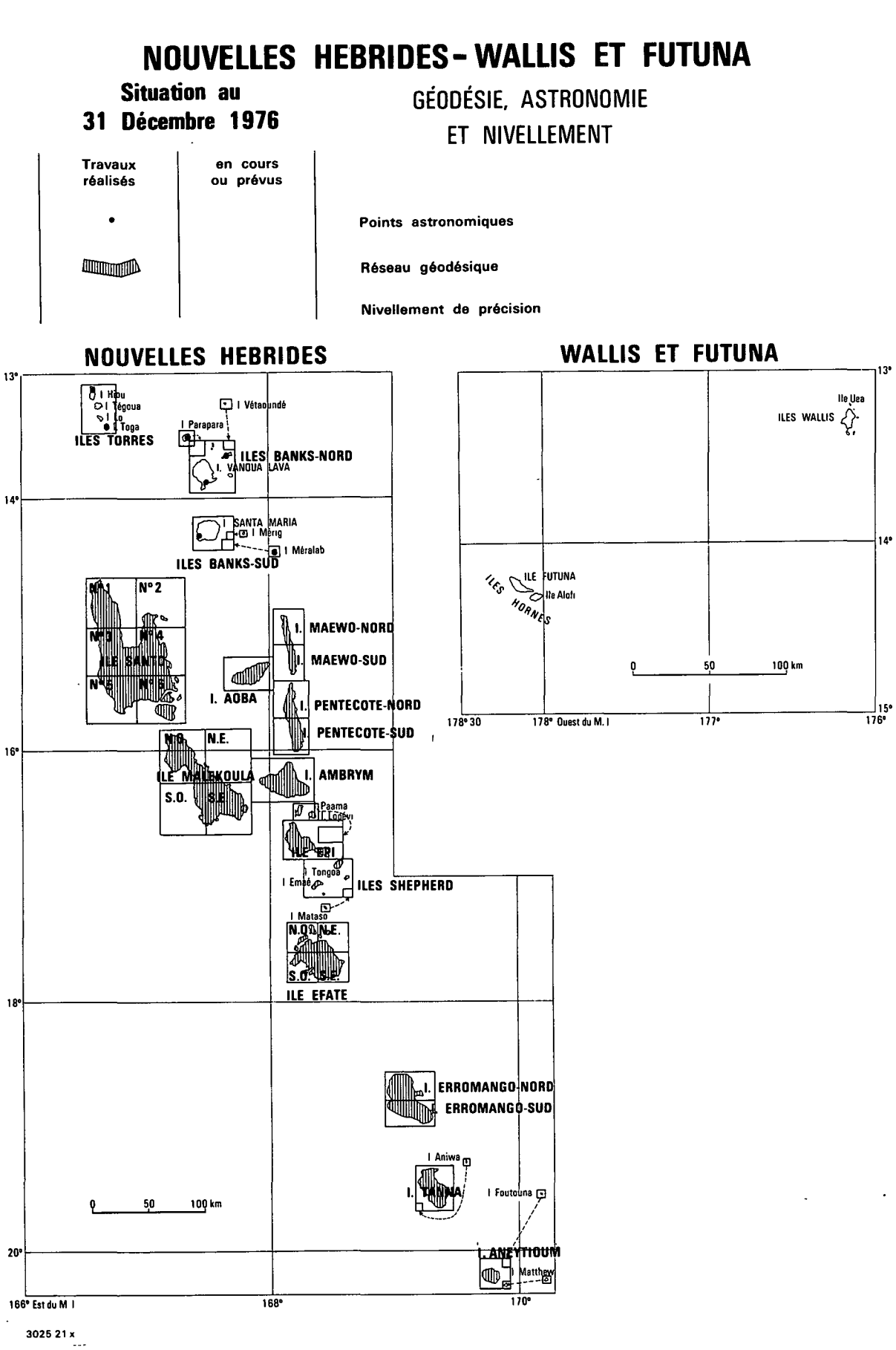



*Figure 26. France: Nouvelles-Hébrides—Wallis et Futuna, géodésie, astronomie et nivellement*

# NOUVELLES HEBRIDES - WALLIS ET FUTUNA

**Situation au 31 Décembre 1976**

| Travaux réalisés | en cours ou prévus |
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| ☐ | ☐ |

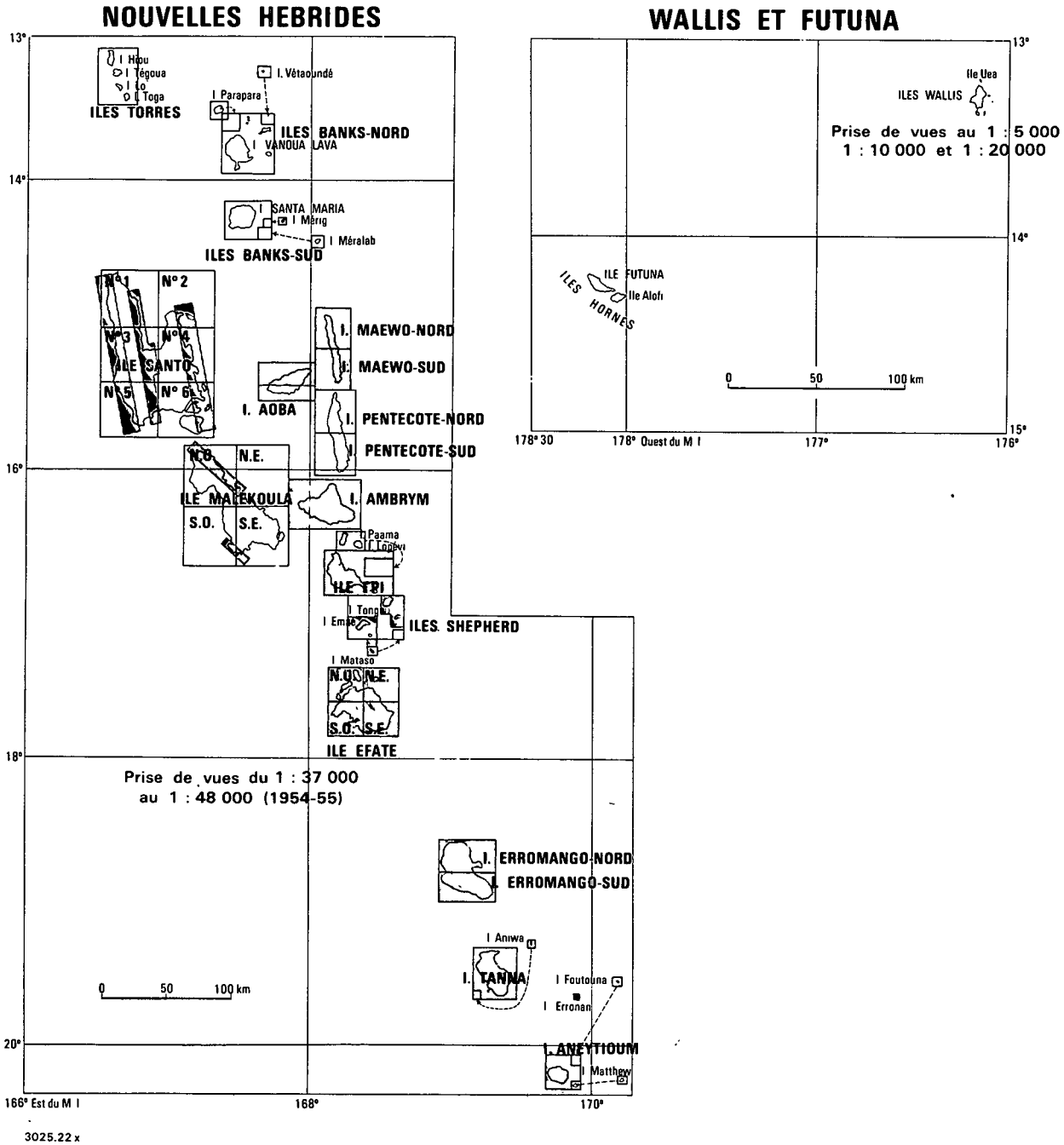
## COUVERTURE PHOTOGRAPHIQUE

N O T I C E — *La couverture photographique satisfait aux conditions générales ci-après :*

- Chambres métriques de prise de vues
- Axe de prise de vue sensiblement vertical.
- Couverture totale de chaque zone par des bandes de photographies rectilignes et parallèles.
- Recouvrement longitudinal de deux clichés successifs d'une bande : 60 %.
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- Excellente netteté.

*Ces clichés permettent :*

- L'étude détaillée du terrain par examen stéréoscopique des épreuves.
- L'obtention d'agrandissements, jusqu'à 4 et même 5 fois, des photographies originales.
- La restitution précise.




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*Figure 27. France: Nouvelles-Hébrides—Wallis et Futuna, couverture photographique*

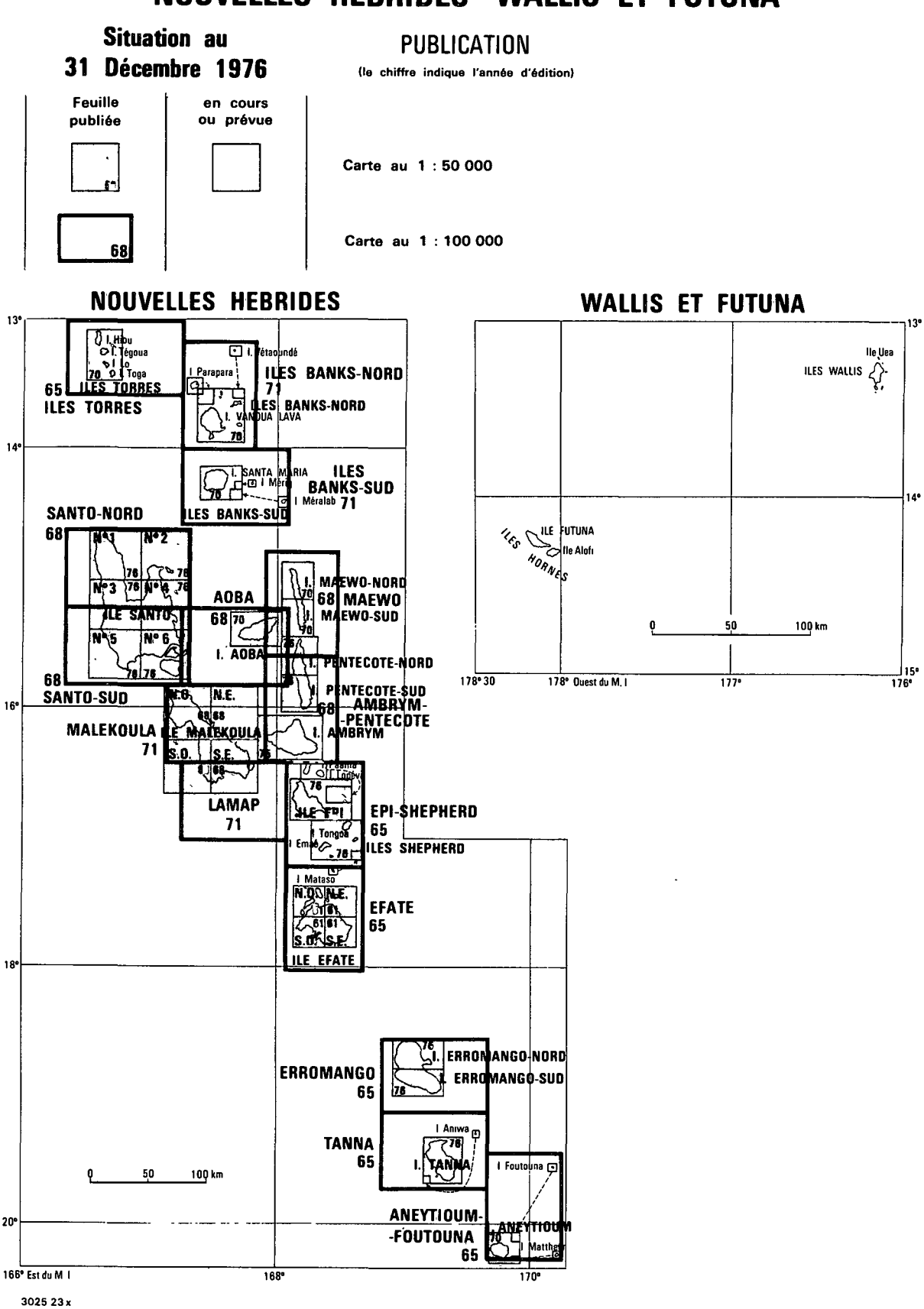



*Figure 28. France: Nouvelles-Hébrides—Wallis et Futuna, publication*

# GEODESY, PHOTOGRAMMETRY, SURVEYS AND CARTOGRAPHY IN THE FEDERAL REPUBLIC OF GERMANY*

*Paper presented by the Federal Republic of Germany*

The activities concerning production, development and research in cartography and related fields in the Federal Republic of Germany are distributed over federal and state survey organisations, municipal and private organisations, research institutions and universities. During the past few years, considerable development has taken place in all the fields concerned. In particular, the further development of automation and technical capabilities has been vigorously pursued.

## GEODESY

Detailed reports on geodetic activities are presented to each General Assembly of the International Union of Geodesy and Geophysics.

With regard to networks, electronic distance-measurements have been taken with different types of equipment in order to determine the special effects of refraction and to improve the scale of the first-order triangulation network. New adjustments and computations have been carried out in connexion with the national first-order triangulation network with the unified European Triangulation Network and with satellite traverses. All precise levellings have been readjusted. New levelling measurements have been performed for studying recent crustal movements in the Alps and in the Upper Rhine Trench.

New instrumentation devices, such as a transportable photographic zenith tube, photo-electric registration and automatic star-tracking, have been developed for geodetic astronomy. Longitudes and latitudes have been observed for the first-order triangulation network.

Activities related to satellite geodesy are mainly through a special research group (SFB 78) of the Technical University of Munich. A satellite observation station has been established which provides facilities for ranging of earth satellites with a laser of third generation and for photographic camera observations also with an illuminating laser, Doppler measurements and C-band radar measurements during the Geodetic Earth Orbiting Satellite (GEOS-C) campaign.

In addition, a number of theoretical studies have been carried out. The new standard earth model GRIM has been computed and the adjustment of the western European satellite triangulation has been finished.

With regard to physical geodesy, many theoretical studies have been performed. Geoids have been computed for central Europe and for the area of the Federal Republic of Germany. Furthermore, a map of the deflections of the vertical has been computed.

In the field of gravimetry, measurements have been performed at sea, in the world gravity net, in the national net, and for other special purposes. The measurements for a new national basic network, including absolute-gravity measurements at four stations, will be performed in 1977.

Earth-tide research has dealt with studies of the disturbing effects by observatory and field measurements, with instrumental developments and improvements, as well as with theoretical investigation, geophysical interpretation and studies on earth models.

## NATIONAL MAP SERIES: CARTOGRAPHY

In the greater part of the Federal Republic of Germany, the series of topographic maps (on the scales 1 : 5,000, 1 : 25,000, 1 : 50,000, 1 : 100,000, 1 : 200,000 and 1 : 1,000,000) have been concluded, satisfying current demands. It is only the German basic map on the scale 1 : 5,000 (Deutsche Grundkarte) which awaits completion, having been issued in part as a photo map.

The available manpower and funds are being concentrated on the regular updating of the map series, at adequate time intervals of about five years. Partially orthophoto techniques are applied for revision of maps.

From the available map series, numerous special editions for national, communal and private purposes are derived. Recreation maps on the basis of the topographic maps on the scales 1 : 25,000 and 1 : 50,000 are of special interest. Most survey departments also issue topographic atlases.

Within the series of official small-scale maps, the new general topographic Map on the scale 1 : 200,000 was completed at the end of 1973. Numerous thematic maps have been issued at that scale. Work is under way on the new sheets of the world series at 1 : 500,000 scale and on the International Map of the World on the Millionth Scale (IMW).

The German Hydrographic Institute issues many hydrographic and navigation charts. It is also concerned with accelerating production by automation. The Federal Research Centre for Area Studies and Regional Policy has published an Atlas for Spatial Development. Research has been taken up for computer-aided thematic maps.

A special study group has been established for automation in cartography. The group is equipped with plotters, interactive terminals and computers. Their main task is automatic generalization of maps. First results have been obtained. Several universities also contribute to the topic.

Other experiments concern digital terrain models and automatic digital interpolation of contour lines.

The automatic plotting of cadastral maps, without

* The original text of this paper, prepared by Professor F. Ackermann, Stuttgart University, Institute of Photogrammetry, Stuttgart, Federal Republic of Germany, appeared as document E/CONF.68/L.109.

generalization, has reached a high degree of performance.

### Survey departments and cadastral surveys

Most state survey departments are remeasuring or readjusting the geodetic networks of lower order. The possibilities for photogrammetric network densification are being studied.

The introduction of electronic tacheometry has greatly influenced the economy and performance of cadastral field surveys, reducing to some extent the application of photogrammetric methods for those surveys.

Preparations are being made to establish universal data banks which will be based on the cadastral survey system. They will contain technical, legal and administration information, and are to be extended to include other administrative and factual information.

### Photogrammetry

The development and production of photogrammetric cameras and instruments by industry has continued in the Federal Republic of Germany. In particular, the development of a monocomparator and of an analytical instrument system should be mentioned. Experimental investigations into the performance of electronic image-correlation have been carried out.

Conventional application of photogrammetric methods for mapping, engineering and planning purposes has regularly continued. Special applications of photogrammetry have increasingly received attention.

As concerns numerical photogrammetry, research and practical application have been extended. Accuracy investigations have proved the self-calibrating methods of block triangulation to be highly effective. Such methods have been developed and are being applied. They allow application of photogrammetry to densification of geodetic networks.

Special development can be reported in the field of remote sensing and image processing. Apart from some regular application of thermal mapping and infra-red photography for forestry inventories, many activities are concentrated on theoretical and experimental research.

A vast experimental programme is under way, in the course of which data of various sensors have been acquired for four different test areas. Processing of the data is in progress, and the results will be published in due time.

### Education and training

The system of survey education at universities and secondary universities (*Fachhochschulen*) has not been substantially changed recently. Due to considerably increased numbers of students, there currently exists an over-production of survey engineers and geodesists, not all of whom can find adequate jobs.

In-service training courses for foreigners are being established in different states of the Federal Republic of Germany, covering the topics cartography, photogrammetry, land information systems, and ground control survey.

## TECHNICAL NOVELTIES IN CARTOGRAPHY IN HUNGARY*

*Paper presented by Hungary*

Thematic maps, representing natural features, population conditions, and spatial characteristics of production in an expressive and therefore easy to read and memorizable form, have become the standbys of economic management in the flow of information in modern times. Economic management, reasonable regional division of labour and organization of the optimal exploitation of natural resources require maps containing the most recent data.

Traditional methods cannot be used to produce maps in large quantities and within a short time; one must resort to the use of computers. To advance economic management and regional planning, a six-volume atlas series was published in Hungary in 1974, representing the entire area of the country and its natural and economic conditions on more than 1,500 uniform-scale maps, containing data for the same period of time (1970). Computers were utilized to process on maps the large number (several hundred thousands) of data, in order to measure the proportional point symbols and to establish the category grades. The computer elaborated the sizes of the signs and the grades of categories also with several (a maximum of seven) mathematical methods. The values that most expressively represented the real situation were selected by the editor from among the several limits of value and put into tables.

The computing of data has since been supplemented by programmes permitting the line-printers of the computer to compile the drafts of sign and diagrammatic maps in a maximum of four variations, chosen from the several (seven) variations and on several (maximum of four) scales (for example, 1 : 200,000, 1 : 500,000, 1 : 1,000,000, 1 : 2,000,000) simultaneously with data processing.

Not only map drafts but parts of fair drafts, suited for direct plate-making, can be prepared by automatic scribing instruments attached to the computer. For the time being, the computer is only used in the production of the numerous maps of complex thematic atlases. Other

* The original text of this paper, prepared by Professor Sándor Radó and Arpád Papp-Váry, National Office of Lands and Mapping, Budapest, appeared as document E/CONF.68/L.66.

maps are produced in the traditional way but more and more economically, using new materials and drawing instruments.

Plastic drawing bases (plastic drawing materials) are widely employed. Fair-drafts are prepared by graving methods, the masks by the use of strip films. The names are set on self-adhesive (strip) films by film-setting devices; and in the case of certain map types prefabricated self-adhesive screen films are widely used for the preparation of tones.

Recently, the map production process has also been accelerated by the introduction of further important technical innovations:

(*a*) The time required for reproduction (exposition, development, fixing) has been considerably reduced through the use of copying layers, chemicals and presensitized printing-plates of a new type.

(*b*) A uniform pin system is used for the registration on one another of the parts of work (films) in the entire working process. The registration by pins, applied also on the printing press, has considerably reduced the time used for the setting to the plate;

(*c*) Chemical technologies have been incorporated in the production of rapid proofs and a high-speed four-colour printing-press is being used;

(*d*) Map-folding and binding work have been completely mechanized;

(*e*) To satisfy the increasing demand of tourism for maps, illustrated by drawings and colour photographs and supplemented by information text, there is wide application of the processing of a painted map base or of colour photographs by photographic colour separation and their reproduction in four colours. Automatic small-size film-setting machines permit the rapid production of (book-like) text pages, printed on both sides;

(*f*) The map series, printed on a transparent plate that can be projected on the wall or showing several matters at the same time by the fitting together of several sheets, is one of the modern study aids. In Hungary, the great demand for colour of projection and for reproduction on plastic plate could be best ensured by the application of silk-screen printing.

The modernity and advanced technical level of the above-described methods applied in Hungary are proved by the extensive exports of maps. In addition to the application of modern technology, the secondary and university education of cartographers is the guarantee for the high level of the contents of maps produced in Hungary.

Hungarian educational institutions and enterprises are ready to provide assistance in the solution of the cartographic problems of Asia and the Far East and in the attainment of the most advanced cartographic technologies.

## NATIONAL REPORT ON CARTOGRAPHY IN INDIA, 1972–1976*

*Paper presented by India*

The Survey of India is the oldest and the largest cartographic agency in India and is the national organisation. Founded in 1767, it has evolved over a period of 209 years into a modern institution which has kept abreast of the technological developments in geodesy, photogrammetry and modern cartographic techniques. The National Atlas Organisation, the Naval Hydrographic Office and the Military Surveys also carry out cartographic work in their own spheres. The National Remote Sensing Agency was set up recently for an in-depth study of satellite imagery and other remote-sensing techniques for preparation of resource inventories in India.

### Brief history

The first authoritative map of India was published by D'Anville in 1752, when the exploration of the then unknown India was still largely in French hands. It had been compiled from routes of solitary travellers and rough charts of the coast.

The Survey of India may be said to have been founded in 1767, when Lord Clive formally appointed Major James Rennell as the first Surveyor General of Bengal. Rennell's maps were originally military reconnaissances and, latterly, chained surveys based on astronomically fixed points; and they do not pretend to the accuracy of modern maps of India based on the rigid system of triangulation commenced at Madras in 1802 and since extended over the whole of India. Even now, however, the relative accuracy of these old maps makes them valuable in legal disputes.

Important changes of far-reaching consequence in surveying and mapping policy were introduced in 1905, when the Government of India appointed a committee to recommend measures for bringing out more modern and contoured maps of the country. Among the important recommendations of this committee were the measures for standardization of the size of the map, the basic surveying scale of 1 inch to 1 mile, the relegation of preparation of cadastral maps to the authority of the state governments, the production of maps in four colours (black, brown, blue and green) and a revision cycle of 25 years.

The planned execution of the task suffered a serious

* The original text of this paper, prepared by Major-General K. L. Khosla, Surveyor General of India, appeared as document E/CONF.68/L.68.

setback first due to outbreak of the First World War and later in 1931, when the establishment of the department was cut down drastically and its annual expenditure halved due to financial stringencies. By 1939, despite the reduction of scale for certain less important areas, only three fourths of the programme could be completed.

During the Second World War, topographic survey work in India practically ceased. Subsequently, the main effort of the department was directed to large-scale surveys for utilitarian purposes, so that up to 1952 no appreciable progress could be made to complete the topographic cover.

With the change from the foot-pound-second to the metric system in 1956, the task of the department became enormous. This challenge is being met successfully, and it is expected that by the target date of 1979 the entire country will be covered by modern topographic maps at 1 : 50,000 scale. It is then planned to use the basic scale of 1 : 25,000 to cater for the pressing needs of various user agencies.

### Geodetic survey

Geodetic triangulation, trilateration, base measurement and precision levelling were carried out for topographic and development surveys. A study was made of epeirogenic, tectonic and crustal movements across faults and thrusts in selected areas for the international geodynamics project; an assessment was made of secular changes in the heights of Himalayan peaks and deformation studies for major dams and archaeological monuments were undertaken. In addition, gravimetric, geomagnetic, astronomical and tidal observations were carried out.

### Topographic survey

The entire country is being systematically covered by surveys on the scale 1 : 50,000. To make the maps more useful for developmental purposes, the contour interval has been reduced from 20–40 m to 10–20 m to suit different terrains. When complete coverage at 1 : 50,000 scale has been achieved (probably by 1979), scale 1 : 25,000 will become the primary scale for the country, with contours at 5–10 m.

The department also carried out special-purpose surveys for development projects, cities, cantonments and industrial complexes. The scale for these projects varies from 1 : 1,000,to 1 : 15,000, with the contour interval varying from 0.5 to 5 m. These maps are generally published in two colours, black and brown, with additional colours when specially required.

Large-scale metric cadastral and town surveys are being carried out by the states. An attempt is being made to have uniform mapping procedures, as far as possible, between the central and state agencies.

### Photogrammetric survey

A variety of first-, second- and third-order instruments are being used for topographic and developmental mapping. With the expansion of this modern facility, an increasing amount of the cartographic load is being diverted to photogrammetric surveys.

During the period under report, eight officials of the department received advanced training in photogrammetry in Canada, the Federal Republic of Germany and the Netherlands.

### Education in cartography

The Survey of India trains its own staff and has the following training establishments: (*a*) Centre for Survey Training and Map Production; and (*b*) Indian Photo-interpretation Institute.

The Centre for Survey Training and Map Production was established by the Government of India in 1967, in collaboration with the United Nations Development Programme (UNDP). Its cartographic branches are responsible for training and pilot studies. A new branch, the Directorate of Research and Development, has been added to this centre.

The Survey Training Institute runs basic, refresher and advanced cartographic courses for Indian as well as foreign students. During the period from 1972/73 to 1975/76, 1,895 persons, including 128 from Afghanistan, Bangladesh, Bhutan, the Gambia, Malawi, Nepal, Sri Lanka and Thailand, were trained in the Institute.

The Indian Photo-interpretation Institute was founded in 1966 with the assistance of the International Institute for Aerial Surveys and Earth Sciences (ITC), Delft, the Netherlands. Its main objectives are as follows:

(*a*) To impart training in photo-interpretation techniques at post-graduate level in the fields of forestry, geology, soil survey and related disciplines;

(*b*) To carry out research in photo-interpretation techniques;

(*c*) To act as a consulting agency for special projects.

Over 200 persons, including six foreigners, were trained by the Institute during the period under review.

In addition to the training institutes mentioned above, on-the-job training is given in geodesy, map reproduction and cartography. *Pari passu* inspection of the individual survey technicians by the supervisory officers, does much to improve the quality of the work turned out. Tests for promotion of technicians of various grades are conducted regularly.

A number of officers are sent abroad to receive advanced training in various fields of cartography.

The foreign students sent to training institutes in India are sponsored by the following programmes:

(*a*) The Technical Co-operation Scheme of the Colombo Plan;

(*b*) United Nations Development Programme fellowships;

(*c*) Special Commonwealth African Assistance Plan;

(*d*) Technical Aid Plan for Bangladesh;

(*e*) Indo-ARE Cultural Exchange Programme.

### Automation in cartography

Because of the tremendous advantages of automation

in the field of cartography, especially to a vast country like India, the growth of this field is being watched with special interest. As a mark of its recognition of this important field, India submitted a paper entitled "Automated cartography system" to the Seventh Conference of the International Cartographic Association, held at Madrid, Spain during April–May 1974. Further, India has pledged its full support to the International Cartographic Association for Advancement of this important field in developing countries.

Efforts in India have been directed towards evolving a suitable system catering for Indian needs. The first problem concerned the general concept of the system; that is, should the system be "off line" or "on line" to a central processing unit. The following advantages and disadvantages of both the systems were duly considered:

| *Type of system* | *Advantages* | *Disadvantages* |
|---|---|---|
| 1. Off line | 1. Greatly reduces the cost of capital investment.<br>2. Allows the independent assessment of each stage.<br>3. Permits the use of a small controller to drive the automatic plotter. | 1. Time-consuming.<br>2. Requires magnetic-tape units at both digitizing and plotting stages.<br>3. Raises financial charges for processing on an external computer. |
| 2. On line | 1. Immediate processing and plotting of the digitized data.<br>2. Permits immediate revision and editing.<br>3. Speedy drafting from the minimum number of input co-ordinate points by data reduction and data interpolation.<br>4. Creation of one type of data tape only—cartographic data tape instead of three sets required for off-line process. | 1. Requires a larger computer within the production line.<br>2. For optimum utilization, requires multiple sets of digitizing and plotting equipment.<br>3. Larger capital investment. |

After analysing the problem in depth, the installation of an off-line system was favoured because of: (*a*) the smaller capital investment; and (*b*) the flexibility and suitability of the system for a gradual approach to the adoption of automated techniques.

The next phase was the question of selection of the system equipment. A study is currently being made of the merits and demerits of the various systems and equipment available in the market. The immediate goal in automation is to devise a system for the automated production of topographic maps on various scales in a range from 1 : 5,000 to 1 : 250,000.

Contact has been established with some of the leading manufacturers of the world. As a test of the efficiency of the respective systems, they have seen requested to test-plot a section from a typical Indian topographic map at 1 : 50,000 scale. These plots have been received from two firms so far and several others are yet to send their results. All the samples will be evaluated with regard to their fidelity in recovering the original map image, time and cost factors, ease in operation, maintenance and repair facilities of the offered equipment etc. A final decision will be taken after considering all factors.

In the meantime, to gain practical experience under Indian working conditions, the government is acquiring a Calcomp 502 flat-bed plotter, which will be interfaced with a Hewlett-Packard 9830 desk calculator. The capabilities of such a system are admittedly limited, but for the initial experimental work, it should prove sufficient.

## Thematic cartography

Preparation of thematic maps in India, depicting the natural and social conditions of the country on a scientific basis, has been taken up in comparatively recent years. The Indian National Atlas Organisation is the major central agency responsible for production of such maps. Thematic maps are now playing an important role in development planning.

The first edition of the National Atlas of India, comprising of 26 thematic maps, was produced in 1957. This atlas is being enlarged and will eventually contain as many as 300 plates covering such diverse aspects as physical, social and economic characteristics of the country. Several new single-theme atlases, such as the Irrigation Atlas of India and the Tourist Atlas of India, are being compiled. Two new resources atlases of India—the Atlas of Water Resources and the Atlas of Land Resources—have also been put in hand. The Atlas for Forest Resources, compiled in collaboration with the Indian Forest Research Institute and the various state Forest Departments, portrays the current status of forestry in India with a view to helping conservation and development planning of forests.

The Map Office of the Registrar-General of India has undertaken the preparation of census atlases for individual states as well as for the whole of India. These atlases will portray the usual demographic data and other related aspects of socio-economic characteristics of population as revealed by the census data. An atlas marking the centenary of the Indian Census (1872–1971) is also

being brought out. A new Administrative Atlas of Tamil Nadu was published by the Registrar-General of India in 1974.

The Planning Atlas of the Damodar Valley Region, showing various physical, economic and social characteristics of the valley, has also been published.

An abridged edition of the Climatological Atlas of India, prepared by the India Meteorological Department, has been published. In addition, this Department has produced the Rainfall Atlas of India.

The Geological Survey of India has published mineral maps of individual states on the scales 1 : 1,000,000 and 1 : 2,250,000. They are also preparing a Geological Atlas of India and geological quadrangle sheets.

The Town and Country Planning Organisation of the Government of India is engaged in preparing various types of planning maps. They have recently produced maps of urban areas of some 250 towns of India.

The Department of Agriculture of the Government of India has prepared the Indian Agricultural Atlas. Various state governments and private publishers also compile thematic atlases of their special needs.

Progress in the field of research has been achieved due to intensive in-depth study of the basic science of geography. The importance of structure of areal units in thematic mapping, and problems relating to classification of thematic scales, models, cartographic representation and generalisation are kept under constant study. Other aspects of thematic mapping, such as cartography, symbols and legends, design and layout of maps, space limitation on choropleth maps and the application of isopleth technique in population mapping, are receiving earnest attention. Of the many cartographic problems, those relating to geomorphology, settlement and economic information and transportation mapping are being studied.

The techniques of quantitative methods and computer graphics in the field of thematic cartography have been introduced recently in this country. A new technique for computer mapping for preparation of thematic maps by the choropleth method has been developed and a method for determining spatial linkages of functional regions has been evolved.

Aerial photography and satellite imagery are being effectively used in the production of different types of thematic maps in India. Aerial photographs have been successfully used for studying forms of aeolian sandy deposits in Rajasthan. A soil map of parts of Bihar has been compiled using Apollo space photography.

It may not be inappropriate to mention the importance of systematic ground surveys for the preparation of thematic maps. Field research and programmes for preparation of geomorphological, land-use and urban maps on the scale 1 : 50,000 has been intensified.

Training in thematic cartography, as an academic discipline, is being imparted in different universities, and in addition to the facilities available in the training wings of the Survey of India, a special cell for training in thematic mapping has been established in the National Atlas Organisation.

Modern techniques, remote-sensing methods and thematic surveys have introduced new dimensions in thematic cartography in India.

### Cartographic technology

An increasing number of maps are being produced by scribing. A large number of draftsmen have been trained. Most of the equipment required for this technique has been developed in India. The polyester sheets are being tested for their suitability for use as scribed coats and for peel-coat (masking).

Three dimensional plastic relief maps have been developed with entirely indigenous equipment and materials. The technique used is quite distinct from that developed in western countries.

The printing presses have been modernized with the help of the sophisticated equipment acquired. There has been considerable expansion in this field to meet the increasing demand for printing of topographic, geographical, project and thematic maps.

### Oceanic cartography

The National Hydrographic Programme is coordinated by the Chief Hydrographer to the Government of India on behalf of the Hydrographic Survey Committee of the National Harbour Board. The programme takes into account revisional surveys required by modern standards for safety of shipping, navigational dangers reported, deficiencies in existing navigational charts and recommendations of shipmasters, and requests for surveys from maritime states, ports and other agencies.

During the period covered by the report, 15 major surveys were completed. These surveys were directly connected with major port development activities to ensure optimum usage of the port under development while ensuring the safety of navigation. Extensive surveys of a very high order of accuracy were carried out for a 60-mile-long deep-water channel in the Gulf of Kutch, for safe passage of very large crude carriers to be used at the deep-water off-shore oil terminal at Salaya. The specifications of this survey required location of under-water obstructions less than 30-m deep in the vicinity of the approach channel and the delineation of a safe channel. For this purpose, 2 Hi-Fix chains were spread to cover the entire Gulf of Kutch. Geodetic control for the Hi-Fix stations was established using Wild T3 theodolites and MRA-3 Tellurometers. These Hi-Fix chains were serviced by a helicopter. Modern echo-sounders, e.g. the Atlas Deso 10 AN 2021, were used for examination of the bottom. Tidal observations over the entire area were made for construction of cotidal charts for reduction of soundings. The quality and nature of the bottom were also examined in detail; and current, wave and meteorological observations were conducted at various crucial positions. Recommendations were also made for marking the entire length of the channel and provision of radio navigation aids.

During 1973/74, one of the Indian naval surveying ships was employed on a multidisciplinary oceanographic

expedition in the north-eastern Arabian Sea in which almost all the maritime research agencies in the country participated. The large amount of extremely valuable oceanographic data thus gathered is being utilized productively.

The production of new navigation charts and the maintenance of existing charts were continued. The charts were extended to the entire northern Indian Ocean; 49 new charts, 3 new editions and 59 reprints were published. All charts are maintained by the bi-monthly issue of "Notices to mariners and radio navigational warnings". Approximately 400 notices and 500 radio warnings were issued annually.

Under a charting agreement with the Hydrographic Department of the United Kingdom of Great Britain and Northern Ireland, in March 1973, India supplied repromats for 12 Indian charts in exchange for 20 British Admiralty charts. Extension of this agreement is under consideration.

The Indian contribution of two International Charts on the scale 1 : 3,500,000, covering the Arabian Sea and the Bay of Bengal in accordance with the specifications drawn up by the International Hydrographic Organization, was completed. Five countries have produced facsimile reproductions of these charts from repromats supplied by India. Similarly, India produced five International Charts during the period under review.

Modern cartographic techniques are being employed for the production of charts. The charts are compiled from source material on film positives. The fair-drawing is carried out in two stages. All letter and figure work is obtained by photographic means with a Morisawa photo typesetting machine. These photographic materials are affixed in position on the stick-up original. All line work is executed by scribing on specially coated dimensionally stable films. Colour-separated negatives are prepared from peel-coat scribing material.

India is to contribute 19 sheets of the General Bathymetric Chart of the Oceans (GEBCO) on the scale 1 : 1,000,000 for the collection of bathymetric data on a global scale. Nine of these sheets were produced earlier and the remaining 10 sheets have been in progress.

The first bathymetric chart produced by the relief contour method, covering the Bay of Bengal, was produced in 1975.

The charts produced in 1975, though incorporating all the essential information, show a realistic density of soundings, simplified symbolization and better depiction of water, intertidal and land details.

Publication of the Indian edition of the Nautical Almanac was commenced in 1975. The Indian Nautical Almanac is identical to that produced by the United Kingdom and the United States of America and is brought out under arrangement with Her Majesty's Stationery Office in the United Kingdom.

### Research and development

No scientific department can make any significant headway without continual research. In India great importance is attached to this aspect of the science of mapping and a special branch has been added to the Survey of India to undertake such studies. Some of the important projects completed and under study are listed below:

(*a*) Development of computer programmes for geodetic problems;

(*b*) Calibration of electronic distance-measuring (EDM) instruments employed for geodetic surveys and determination of their zero and cyclic errors;

(*c*) Fabrication of EDM instruments, auto-set levels and tide-gauges;

(*d*) Introduction of analytical block triangulation techniques by modification, development and testing of the Bundles Adjustment Programme, written in Fortran IV-G-level language and installation of the same on an IBM 370 computer;

(*e*) Installation on the same computer system of a programme (obtained from the United States of America) for simultaneous block adjustment by independent models as units;

(*f*) Installation of the Stuttgart University Programme Package for Aerial Triangulation with Independent Models (PAT M-43), including Airborne Profile Recorder (APR) data, for adjustment of aerial triangulation by independent models as units;

(*g*) Experiments on aerial triangulation adjustment with simulated data;

(*h*) Programme for analytical relative orientation for all the models of an entire block at one time;

(*i*) Field-work for the establishment of a test field, with a view to evolving suitable specification for the optimization of aerial photography and the required ground control for a photogrammetric survey system;

(*j*) Technique for high-precision calibration of regular mathematical surfaces by close-range angular measurements;

(*k*) Development of an electronic co-ordinate-recording device;

(*l*) Quality control of aerial photography and a photogrammetric mapping system;

(*m*) Investigations in the field of in-flight camera calibration and a calibration procedure for cameras used in close-range photogrammetry;

(*n*) User trial of polyester-base film, scribe and peel-coats manufactured indigenously;

(*o*) Testing of dimensional stability of indigenously made paper film;

(*p*) Studies for evaluation of the various systems of automated cartography in order to determine their suitability to Indian working conditions;

(*q*) Experiments to print continuous-tone orthophoto maps by offset printing-press in multiple colours;

(*r*) Production and adoption of feasibility studies of state-of-the-art cartography;

(*s*) Experiments with satellite imagery for small-scale mapping;

(*t*) Development of a library of programmes of survey interest;

(*u*) Study of electronic data-processing as related to a cartographic data bank.

### Meetings

The Survey of India sent representatives to various seminars, symposia and conferences held in India and abroad. These meetings included the Second United Nations Conference on the Standardization of Geographical Names (Geneva, 4–22 September 1967), Symposium of Significant Results Obtained from Earth Resources Technology Satellite-I; Seventh International Conference on Cartography, Symposium on Problems Related to Redefinition of North American Geodetic Network, symposium on "Terrestrial electromagnetic distance measurements" and "Atmospheric effects on angular measurements", Symposium on Recent Crustal Movements, Seventh International Gravimetric Commission, International Symposium of the ISP Commission III, Seminar of the Commonwealth Association on Surveying and Land Economy, sixth session of the United Nations Group of Experts on Geographical Names (New York, 5–26 March 1975), Commonwealth Survey Officers Conference and XVI General Assembly Meeting of the International Union of Geodesy and Geophysics.

Representatives of the Survey of India also attended the International Symposium on Surveying and Surveying Education in India and other Commonwealth Countries, which was held under the auspices of the Institution of Surveyors and the Commonwealth Association of Surveying and Land Economy; and the All India Cadastral Survey Conference, seminar on "Role of surveyors in developing countries", on the occasion of the Silver Jubilee Celebrations of the Institution of Surveyors.

### Survey of India maps

The following Survey of India maps are available for sale:

(*a*) Map of India and adjacent countries, scale 1:2,534,400 (1 inch to 40 miles), in four sections, multicoloured, showing political divisions down to districts and general information. The map includes several insets illustrating density of population, minerals, rainfall etc.;

(*b*) Road map of India, scale 1:2,500,000, in two sections, multicoloured, indicating road communications and their classifications, and information useful to motorists and tourists. The map contains a list of important places for quick location;

(*c*) Railway map of India, scale 1:3,500,000, multicoloured, showing different zonal railways, gauges and names of railway stations;

(*d*) Political map of India, scale 1:4,500,000, multicoloured, showing political divisions down to districts with their headquarters;

(*e*) Physical map of India, scale 1:4,500,000, multicoloured, showing physical characteristics of the country;

(*f*) State maps, scale 1:1,000,000, multicoloured, for administrative use and for use by the general public;

(*g*) International Map of the World (IMW) Series, scale 1:1,000,000, multicoloured and layered, prepared in accordance with the specifications laid down by the United Nations Technical Conference;

(*h*) World Aeronautical Charts, scale 1:1,000,000, multicoloured, prepared in accordance with specifications laid down by the International Civil Aviation Organization (ICAO).

## ROLE OF CARTOGRAPHY IN DEVELOPING COUNTRIES*

*Paper presented by India*

When considering the role of cartography in developing countries, one has to take into account the problems facing those countries, namely, widespread poverty, low levels of literacy, unemployment, lack of financial resources and acute shortage of skilled manpower. Above all this, economists throughout the world are concerned about the menace of population explosion and the resultant continual depletion of natural resources, leading gradually but unmistakably to the time when mankind's very existence on the earth would be threatened. The threat is not so acute to the few developed countries of the world, but it is of immediate significance to the various developing countries of Africa, Latin America, and South-East Asia, where subnormal levels of living are prevalent. These countries have not only to arrest their population growth but to make all possible efforts to create conditions whereby the fullest exploitation of their existing natural resources would become possible. Immediate and rapid planning and implementation of systematic development programmes are needed if the multifarious problems of a developing economy and population explosion are to be tackled effectively.

### Scope of cartographic needs

The economic growth of a country is, to a large extent, dependent upon exploitation of its natural resources. The land is the primary asset of man and all economic growth

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in the spheres of energy, agriculture, forestry, mineralogy and industry can be traced to it. The development of a country, therefore, largely depends upon the extent to which land development programmes and tapping of natural and other resources existing on the land have been executed.

Land surveying is one of the oldest professions in the world, which in itself would imply that it is a basic requirement for any developmental activity. In fact, it is fundamental to exploitation of the resources of a country. No economic planning can ever be executed successfully without the basic land surveys.

Land surveying and cartography can be described as the art of depicting, on maps, plans or charts, all natural and artificial features of the earth in such a form that it can be used by different user agencies as a first step towards further specialised studies. The importance of maps for any developmental activity cannot be underestimated, as without these aids no resource planning can be done on a sound basis. Without the maps, it is not possible to depict in a scientific way such diverse data as the size and shape of a country, its mineral and geological resources, soil types, forest wealth, water resources, communication systems, crop patterns, urban expansion etc. In fact, a series of maps at intervals would give a true idea of the development of a country over a given period of time.

## Mapping scale

With the increase in tempo of developmental activities, time has become the most important factor. As time goes on, the demand for maps from the planners becomes more and more exacting.

The maps and the survey data available in a country serve as an index of its developmental growth. The larger the basic scale of topographic maps of a country, the larger is its developmental growth.

Thus far, in India 1:50,000 is the basic scale of topographic mapping of the country, except for certain selected areas of economic importance where the basic mapping scale of 1:25,000 is adopted. However, considering the rate of developmental activity in the country, it has been found expedient to adopt 1:25,000 as the basic topographic mapping scale of the country.

## Need for organization of the profession

A map, which is such an important tool in the hands of planners, cannot be produced out of thin air. It needs an organisation properly equipped and staffed with trained surveyors to do the job. The surveyors have not only to provide the basic primary network of control of geodetic accuracy to which subsequent surveys can be tied but to cover the entire terrain systematically on suitable scales to ensure that no detail which might help the planners shall be omitted from the map.

A survey organisation has to provide not only basic topographic coverage on the primary scale for use by its defence forces, administrators and planners in general, but large-scale surveys for development plans. In fact, a major part of the organisation in a developing country has of necessity to be earmarked for development surveys.

The survey technology practised by any country has to be related to its resources. Satellite geodesy, electronic computers, photogrammetry and automated cartography are being widely used by the developed countries. The developing countries, which cannot afford all these sophisticated methods have to make a judicious selection of technical methods to be employed in executing a project, keeping in view the time/cost factor and the accuracy desired. But even a developing country cannot fail to take full advantage of the benefits that modern photogrammetry can offer to survey technology. Aerial photographic coverage of an area for project survey, with some limited ground control, can be rapidly processed for accurate surveys by the use of photogrammetric machines.

A survey organization cannot keep pace with the increased demands placed on it unless its machinery is fully geared to the tasks it has to execute. Project surveys can be very costly for a developing country, but it must be remembered that it is only a fraction of the total outlay on a project, generally varying from 0.5 to 1 per cent of the total cost.

No country, much less a developing country, can afford to neglect its survey organisations. Just as in war and peace the defence forces of a country have to be kept in perfect training to face any situation, the surveyors have to be ready at all times to accept any task projected on them by the planners. It is better to have the surveyors waiting for the task rather than slow down the tempo of development for want of proficient surveyors.

The role of cartography is thus very important, especially in a developing country. The various government agencies responsible for planning must give it due recognition and set aside the necessary funds, out of their outlay meant for development projects, for surveys so that the development of the country is not delayed.

## Survey education and training

The developing countries are thus faced with the problem of finding sufficient skilled manpower to cope with the tremendous survey requirements of varied types and on different scales of their rapidly growing developmental activities; and inadequate local facilities for survey education and training further aggravate the situation.

At first, in order to make progress in the planning and execution of development programmes to meet the urgent need of improving the levels of living of the people, the developing countries have no choice but to enlist the support of professionals and technicians from other countries and to send their own technicians and professionals for training to outside countries where such arrangements exist; but they must take immediate steps to provide the necessary facilities for professional and technician level courses in their local universities and polytechnic institutes. It takes considerable time, say from four to six years, to train a surveyor before he is

productively useful. Therefore, any slackening of this effort is bound to affect the developmental growth ultimately. Not only because the outside assistance involves greater finances but because the demand is of permanent and increasing nature, it must of necessity be met from a local base. Then will remain the need to send a few professionals abroad for training in advanced courses and for participation in the various professional associations in order to remain in tune with technological advancements taking place elsewhere in the profession.

### Establishment of professional society

It is therefore evident that a strong indigenous profession must be developed so that cartographic needs of the developing countries with regard to land administration and development can be met both qualitatively and quantitatively. To achieve this goal, every country needs to have a rigorous and strong professional society which will provide a common forum for mutual exchange of ideas among like-minded persons by way of seminars and symposia held at frequent and regular intervals. That professional society should also hold examinations at different levels and award appropriate diplomas and degrees which should be recognized by the Government for providing better employment. Such a programme would also serve as incentive to the concerned persons. Thus, the society would be directed towards fostering professional advancement locally and making contributions to international associations in any sphere of the profession in which the society has made significant progress.

In some countries, the cartographic requirements are tackled only by government surveyors; but there are other countries where the profession is also practised by private surveyors. In the latter case, it is important to have registration of the profession, which implies that no person is qualified to carry out any of the specified functions unless he is admitted to the prescribed register provided by constitutional enactment by the Government of that country. The objective of registration is to provide protection to the public. If a person is registered as a professional, it would imply that he has attained the required competence, by knowledge and experience, to perform his professional work. This function of registration could be easily discharged by the local professional society.

Further, considering the importance and vast potentialities of the professsion, it would prove more beneficial also to have the planners and administrators survey-oriented; for that purpose, specially designed short-term courses could be provided.

The professional societies must endeavour to bring home the role and importance to all planners responsible for development. Unless those responsible for development projects and the earmarking of funds understand fully the importance of surveys, the profession is likely to be neglected and the interests of the country will thus suffer.

### Research and development

No profession or technology can progress unless research and development are in-built and form its integral part. No doubt a developing country with very limited resources may not be able to afford research in basic science; but it must take heed to have it in its applied field at the earliest time when resources permit.

Research and development activity will make it possible to streamline current procedures to achieve better performance results and will increase know-how in the technological field, gradually resulting in greater self-reliance and less dependence upon foreign technology. Self-reliance in science and technology should not, however, mean that one would become isolated from the international scientific community or refuse to absorb whatever is useful in the achievements made in other countries. Such self-reliance will naturally receive a further development in fields responding to specific needs and priorities of the country. It is no doubt desirable to employ indigenous technology, but it is also not wise to discard any technology on the sole ground that it is foreign and involves foreign exchange. What is needed, therefore, is a judicious mixture of both, with objective of deriving best and maximum results in the least time.

### Conclusion

Considering that land survey is a prerequisite of any developmental activity to improve the lot of the people, any pains taken in the organization and development of the survey profession will prove ultimately rewarding. Most of the developing countries are poor and for them to become rich, they must develop their available resources. To ensure that development, they must first take inventory of their natural resources, which entails cartographic demands. Any delay in surveying and mapping would ultimately cause considerable delay in the development of the country. There is, therefore, urgent need to lay due stress on development of and to accord due recognition to the profession of surveying and cartography. The profession deservedly merits better recognition than it has received.

# MAPPING IN INDIA: A BRIEF REVIEW*

*Paper presented by India*

This paper deals briefly with the development of survey and mapping in India as it is known from the year 1767, when the East India Company appointed Major James Rennel as the first Surveyor General of Bengal and commissioned him to prepare a "vast map of Bengal" as desired by Robert Orme, the historian. The first authoritative map of India was, however, published by D'Anville in 1752, when the exploration of the then unknown India was still largely in French hands. It had been compiled from routes of solitary travellers and from rough charts of the coast. Even earlier, a rough map of India had existed. It had been prepared by the Greek geographer Ptolemy in A.D. 160. From the Greek manuscript copy and with many additions and alterations, the map was brought out in A.D. 1400.

## Earlier history

In addition to the department in Bengal mentioned above, survey departments were set up in the Bombay and Madras Presidencies in 1796 and 1810, respectively. These appointments were needed for surveying the new territories and ceded districts. The knowledge of geography at that time was vague and beyond the main roads scarcely any information was available. Thus, during the period when the East India Company was acquiring district after district as a result of wars with the various rulers in northern and southern India, the need for maps was very acutely felt for military operations. The earlier maps are therefore route maps surveyed during the marching of the engineers who accompanied the troops and few details were picked up beyond the marching routes. Most of the maps were based on reconnaissance and subsequently on chain surveys. Thus, these maps did not possess the accuracy which is expected from the control based on accurate triangulation, but they are of much historical importance.

In 1815, the East India Company, with a view to economising on expenditures, appointed Colonel Colin Mackenzie as the first Surveyor General of India, with headquarters at Calcutta. A bit earlier, in 1800, an independent trigonometrical survey was formed under the control of the Madras government, with Lieutenant Lambton in command. It was transferred in 1818 to the control of the Central Government, under the designation the "Great Trigonometrical Survey", with Lambton as the first Superintendent. He died in 1823 at the age of 70 at Hinganghat, while he was marching from Hyderabad to Nagpur.

Captain George Everest (who later became Surveyor General), an able assistant to Lambton, was then placed under the orders of the Surveyor General as the successor to Brevet Lieutenant Colonel Lambton. Under his guidance, highly accurate triangulation was carried out throughout the country.

## Earlier maps

Before 1802, all the maps had been based on chain surveys and on astronomically fixed points. Triangulation was begun in Madras in 1802; and, subsequently, during the period 1823–1905, a network of highly accurate triangulation and levelling was established throughout India and Burma. Colonel Sir George Everest himself observed many triangles and supervised the selection of sites for observation stations when he was Superintendent of the Great Trigonometrical Survey (1823–1825) and later (1830–1843) when he held the dual posts of Surveyor General and Superintendent of the Great Trigonometrical Survey. He was so much engrossed in completing the triangulation net (specially measuring the great arc) that he was usually absent from the Surveyor General's headquarters, which at times invited adverse comments from his superiors.

It was during the period 1823–1905 that the height of Mount Everest (named after Colonel Sir George Everest) was calculated; and it was ascertained that it was the highest mountain in the world, its height being 29,002 ft. The discovery of Mount Everest was the work of a team of observers and computers, and no one person can lay claim to its discovery. Subsequently, in 1953, the height was recalculated after fresh observations and ascertained to be 29,028 ft (8,848 m).

During the period 1802–1905, surveying and mapping were carried out on an *ad hoc* basis rather than on any organized system. India was surveyed for the Indian Atlas series on the scale $\frac{1}{4}$ inch to 1 mile, the layout of which was 1° latitude × 2° longitude, the hill features being shown by hachures. This survey was completed around the end of the nineteenth century. Since at that time there were no reproduction facilities in India, the maps were engraved and printed in England. These maps were in one colour, namely, black.

Maps were also required during that time for revenue purposes by the district authorities of the newly ceded districts. Surveying was done on the scales 4 inches to 1 mile and 2 inches to 1 mile. These maps also were in one colour (black) with the hill features shown by form-lines.

Subsequently, based on the above-mentioned revenue maps, topographic maps on the scale 1 inch to 1 mile were compiled. The layout of these maps was 15′ latitude × 30′ longitude; and they also were published in black only, with the hill features shown by form-lines.

Some of the areas of India which were not under British rule were surveyed on the scale $\frac{1}{2}$ inch to 1 mile. The format of the maps was 30′ latitude × 1° longitude.

* The original text of this paper, prepared by M. K. Chatterjee, Superintending Surveyor, Survey of India, appeared as document E/CONF.68/L.127.

In addition, maps for forest departments were prepared on the scale 4 inches to 1 mile.

All the maps mentioned above were based on triangulation, which itself was based on the co-ordinates of the Madras Observatory.

The lettering of the maps was hand-written, no fair-drawing was done and field surveys were used as originals for reproduction. The reproduction of these maps commenced at Calcutta in 1889, where stone was used as printing-plates (metal plates were introduced later). Hence, the Calcutta printing office was later called the "Photo Litho" office.

The maps on the scales 1 inch to 1 mile and 1 inch to 2 miles, which were surveyed and printed up to 1905, though in black only (colourings to emphasize special features used to be done by hand) provide a wealth of information. The hill features were so accurately surveyed that when these maps were later used for revisional surveys, the hill features currently depicted by contours exactly fitted with the earlier form-lines.

In 1905, the revenue survey was separated from the Survey of India and formed part of the duties of the governments of the British provinces.

### Modern maps

In 1905, during the deliberation of the Survey Committee appointed by the Government of India, it was decided that topographic mapping of India should be done on a standard scale of 1 inch to 1 mile, and the format 15′ latitude × 15′ longitude was adopted. A degree sheet would cover the area of 16 such 15′ × 15′ sheets. Topographic maps of the princely states would be surveyed on the scale 1 inch to 1 mile if the rulers of those states agreed to meet the expenses of the surveys. It was also decided that maps on the scales 1 inch to 1 mile and $\frac{1}{4}$ inch to 1 mile should be in colours; up to 1905, they were shown only in black. The hill features which had previously been shown by form-lines were to be depicted by contours in brown colour.

For reasons of economy, it was decided in 1913 that smaller scale mapping on the scale $\frac{1}{4}$ inch to 1 mile would suffice for certain remote regions and other areas where the population was less then 50 per square mile. Surveys on the scale $\frac{1}{2}$ inch to 1 mile were adopted for areas with population of less than 150 per square mile.

At the time of Independence (August 1947) the Survey of India had published 3,355 maps on the scale 1 inch to 1 mile, and 266 maps at $\frac{1}{2}$ inch to 1 mile, based on post-1905 surveys, that is, covering more than half of the country.

India adopted the metric system on 1 October 1956. Prior to that time, all topographic maps were on the foot-pound-second (FPS) system. The scales 1 inch to 1 mile and $\frac{1}{4}$ inch to 1 mile on the FPS system were to be accordingly replaced by 1 : 50,000 and 1 : 250,000 scale maps, respectively, by rounding of the representative fraction. Maps on the scale $\frac{1}{2}$ inch to 1 mile were to be replaced by 1 : 50,000 maps.

India is covered by 5,084 map-sheets on the standard scale of 1 inch to 1 mile (now 1 : 50,000 scale). Of this member, about 2,200 maps have been published and many more maps are at different stages of mapping and printing. Similarly, out of 394 degree sheets covering India, nearly half (about 190 maps) have been published; and the remaining sheets are at different stages of mapping and printing. These figures show the progress up to 31 August 1976.

In addition to the two scales mentioned above, maps at 1 : 25,000 scale have recently begun to be processed for areas which are of importance for development etc. A few hundred maps on that scale have already been published by the Survey of India.

### Organisation and role

The organisation that was initiated in 1767 to provide a few route maps to meet the requirements of military operations and to prepare *ad hoc* revenue maps for the district administrators currently has the role of maintaining and updating the national series of maps (on the scales 1 : 25,000, 1 : 50,000 and 1 : 250,000); some of the 1 : 50,000 maps have been updated by three editions since 1958. Apart from preparing geographical maps of the different states and general maps of India, and maintaining the series of the International Map of the World on the Millionth Scale (IMW) and charts of the International Civil Aviation Organization (ICAO), the Survey of India is also called upon:

(*a*) To survey international and state boundaries;

(*b*) To survey and supply maps on large scales (e.g., 1 : 15,000 and 1 : 10,000) for execution of several projects for various departments. These maps include forest and cantonment surveys, riverain and irrigation surveys, railway and city surveys and surveys of tea-gardens and mining areas;

(*c*) To survey at 1 : 15,000 scale forest maps for the Forest Departments of different states;

(*d*) To supply all types of topographic and geodetic data required by the different agencies for the development of natural resources.

### Geodetic work

Geodetic work was begun in 1823, as mentioned above. At that time, it consisted mainly of triangulation and levelling; and subsequently, of tidal predictions and publication of tide-tables for 38 ports in the Indian Ocean between Suez and Singapore, magnetic surveys, observation of the direction and force of gravity; astronomical observations to determine latitude, longitude and time; and seismographic and meteorological observations were also taken up.

### Exchange of technology

Exchange of technology is an important aspect recognized in modern times. For some years, the Survey of India has been increasingly called upon to send experts to developing countries to assist them in various branches of geodetic and topographic surveys; and officers of the Survey have thus been to various countries of Africa and the Middle East, and to Afghanistan, Bhutan and Nepal.

The Survey of India possesses the necessary know-how and experience (both traditional and modern) in all branches of geodetic and topographic surveys to participate effectively in joint ventures on development projects.

## Modernization problems of developing countries

In attempting to modernize the surveying and mapping techniques in developing countries, one encounters special problems which are sometimes not understood appropriately. These problems relate to recurring materials, supporting equipment (e.g., a computer), accessories, spares, maintenance facilities, specialization training, production procedures and local environment.

Although at first glance it appears difficult, the initial procurement of modern surveying, mapping and map-printing equipment may not be a major problem and often, bilateral and United Nations aid would be available. In practice, the problem relates more to the recurring materials, accessories and spares, and repair facilities, for which it is not a sound proposition to depend permanently upon aid. Thus, when importing capital equipment (to last a lifetime), the organization should carefully consider to what extent the recurring materials and supporting facilities can be met indigenously, currently or in the near future. It is not essential that a developing country should undertake outright modernization in every sense, nor is it advisable. The degree and coverage of modernization and sophistication must be selective and regulated. Often, very intricate machines are developed in technically advanced countries to compensate for a lack of manpower, whereas, in developing countries, the modernizing equipment should be chosen with emphasis on different considerations, such as mechanization to relieve mass handling and repetitive drudgery, to rationalize cumbersome manual procedures and to improve efficiency and speed of manual operations. Hence, a blend between the traditional and modern would be suggested.

Developing countries procuring modern equipment must steadily build up trained personnel of their own to operate and maintain the equipment themselves by the time the foreign experts depart. This task may not always be very difficult if the practical problems are appropriately foreseen and innovations planned, which should be done also by the experts. Unless the equipment is specially designed to suit the circumstances (rarely the case), innovation of mapping procedures is often required to suit the local environment, including manpower and state of industries.

## Modernization of mapping techniques in India

With the gradual change-over to photogrammetric machines over the past two decades and the introduction of cartographic scribing and of high-speed map-printing machines, the tempo of mapping activities in India has also increased manifold. India has been successful in manufacturing scribing instruments indigenously, and a beginning has been made to produce coated polyster sheets. It is expected that cartographic scribing will soon replace conventional fair-drawing methods so as to decrease the heavy load in reproduction offices and save man-days utilised in colour-separation work.

## Training and development

Training has been carried out within the Survey of India for decades, to meet its own basic requirements. Training facilities have been augmented and enlarged; and on 6 May 1967 the Centre for Survey Training and Map production was established at Hyderabad as part of the Survey of India, with assistance from the United Nations Development Programme. The Centre provides training in basic, refresher and advanced courses in all aspects of surveying, mapping and map-printing, and is well equipped with a large variety of both traditional and modern equipment. The Centre also imparts specialized training to officers of other developing countries and caters for pilot production (based on modern methods and innovation to suit) and other research and development activities. The Centre has also made a small beginning in digital and automated cartography.

## Conclusion

Cartography, which began with rudimentary techniques in ancient times, has advanced into an important branch of science. The developments have, however, been most spectacular in the past few decades. A unique property of the map is its ability to portray all types of resource data in an integrated form, and another unique feature of the map is the ease of comprehension, facilitated both for the layman and the specialist. Maps form an indispensable basic tool for a variety of disciplines concerned with developmental activities, and mapping has become a highly service-oriented field with close interrelations with other fields. Map-makers, therefore, cannot merely know how to survey and draw maps but must broaden their knowledge in a multidisciplinary sense.

# CARTOGRAPHIC ACTIVITIES IN INDONESIA, 1973–1976*

*Paper presented by Indonesia*

This report summarizes the cartographic activities in Indonesia during the period 1973–1976.

## MAPPING ORGANIZATIONS

Responsibility for production of the national topographic base map series with related activity in geodesy and for aeronautical charting is assigned to the National Co-ordination Agency for Surveys and Mapping (Badan Koordinasi Survey dan Pemetaan Nasional: BAKOSURTANAL); activities in hydrography and oceanography are undertaken by the Naval Hydro-Oceanographic Service. BAKOSURTANAL is also responsible for the regional resource surveys utilizing multistage sampling techniques, including satellite remote-sensing for natural resource inventory and evaluation, as well as the production of national atlases. Inherent in the above-mentioned task is the establishment of a national resources information system, in which BAKOSURTANAL plays a role.

The Armed Forces Surveys and Mapping, in addition to having its own mission as a military mapping organization, renders assistance to BAKOSURTANAL in the execution of most of the national mapping projects, particularly in Sumatera and Irian Jaya, where Australia grants technical assistance for the mapping operations. This organization co-ordinates the Army Topographic Service, the Naval Hydro-Oceanographic Service and the Air Force Aerial Photographic Service.

Among the other agencies involved in cartographic activities are the following: Directorate General of Agrarian Affairs of the Ministry of Home Affairs, for cadastral and land-use mapping; Soil Research Institute of the Ministry of Agriculture, for soil surveys and mapping; Directorate of Geology of the Ministry of Mining, for geological mapping and geophysical surveys; Ministry of Public Works and Energy for large-scale mapping for engineering purposes.

BAKOSURTANAL is also responsible for the co-ordination of activities on geographical names and for the survey and demarcation of the national boundaries both on land and at sea.

In addition to a State-owned aerial company, P. N. Aerial Survey (PENAS), quite a few private survey and mapping firms, national as well as foreign, are taking part in various development projects in the field of aerial surveys, mapping and cartography, particularly in mineral and oil explorations, forestry and public works projects.

## GEODETIC ACTIVITIES

### *Doppler observations and datum definition*

In 1974, the first Doppler position-fixings were made in Sumatera at six primary triangulation stations (see figure 29 in pocket[1]) using Geoceivers in conjunction with the Sumatera basic mapping at 1 : 50,000 scale. The six stations, which stretch from the northernmost tip (Banda Aceh) to the southernmost part of Sumatera (Gunung Dempo), are meant to strengthen the scale and azimuth of the existing Sumatera triangulation, which was undertaken during the years 1895–1936. Comparison of spheroidal distance and azimuth between the stations Banda Aceh and Gunung Dempo for co-ordinates derived by the triangulation and by Dopplers yielded accuracies of 1:920,000 in distance and 0.16″ in azimuth, indicating that the triangulation, despite its age, was of high quality.

The other objective of Doppler observations in Sumatera is to tie the separated Riau-Bangka triangulation system with that of Sumatera and, at the same time, to connect the Malaysian and Sumatera geodetic systems by including two Malaysian triangulation stations in the Doppler operations. One of the stations, Pulau Pisang, has been adopted by Malaysia and Indonesia as the common datum point for the purpose of joint surveys and charting in the Straits of Malacca.

An important decision was made regarding the datum definition for Sumatera mapping, which was based on Doppler satellite position-fixing methods. For this purpose, the geodetic co-ordinates of Padang Base Point 1884 derived from Doppler observations on NWL-9D datum were adopted as the geodetic co-ordinates on the computational surface having parameters of the Geodetic Reference System of 1967 (GRS-67) with its orientation towards the pole of Conventional International Origin (CIO). The new datum for Sumatera is called the Padang Datum; it will permit the unification of all geodetic surveys in Indonesia and will make it possible to take full advantage of the extensive Doppler satellite positioning programmes planned for the area.

In Irian Jaya, 76 Doppler position-fixings were made in the course of 1976 (see figure 30), using Geoceivers for the purpose of establishing control for the national systematic mapping of the area on the scale 1 : 100,000 and for selected areas at 1 : 50,000 scale. This undertaking was carried out in co-operation with Australia.

### *Trilateration and traversing*

In North Sumatera, two triangles and one quadrangle

* The original text of this paper, prepared by the National Co-ordination Agency for Surveys and Mapping (Badan Koordinasi Survey dan Pemetaan Nasional), Indonesia, appeared as document E/CONF.68/L.76.

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figures 29 and 31–33 are in this pocket.

were measured to fix one secondary and two tertiary stations. The distances of an average length of approximately 45 km were measured with Tellurometer MRA-3 and the angles with a Wild T3 instrument.

In West Kalimantan, a Tellurometer reading of 340 km was measured from Gunung Majau to Gunung Jerup, consisting of nine stations.

*Astronomical observations*

During this period, first-order longitudes, latitudes and azimuths were observed in Sumatera at two Doppler stations, Bukit Serati and Padang Base Point 1884. The results were to serve as an evaluation of the Doppler observations.

In West Kalimantan, first-order latitudes, longitudes and azimuths were observed at Gunung Datu and Gunung Jerup, to conclude the traverse adjustment running from these Laplace stations to the previously established Laplace station at Gunung Serindung Base Point-A.

*Levelling*

Second- and third-order levellings have been carried out in Jawa, Sumatera, Kalimantan and Sulawesi for various irrigation, tidal rice cultivation and other public works projects. In Aceh, Bengkulu and Jambi, third-order levelling and barometric heighting were undertaken to provide control for the base mapping of Sumatera at 1 : 50,000 scale. Laser airborne altimetry (Airborne Profile Recorder: APR) has been used for fixing the vertical control in Irian Jaya, where ordinary levelling would be a tedious and time-consuming job (see figure 30). It was intended to cover the whole of Irian Jaya with APR lines to serve as vertical control for topographic mapping at 1 : 100,000 scale in 1976; however, due to adverse weather conditions, only 430 of APR lines were measured, with the technical assistance of Australia.

## Map production

For West Kalimantan, 66 new topographic base mapsheets on the scale 1 : 50,000 (see figure 31) have been published. With the other 30 sheets already published, as reported during the Seventh Conference, the total number of sheets of West Kalimantan is now 96, covering an area of 65,000 km$^2$. The sheet size is 15′ × 15′ presented in the Universal Transverse Mercator (UTM) grid system. In South Sumatera and Lampung, 87 new UTM series of topographic base maps at 1 : 50,000 scale have been printed. In Aceh, 51 new series of UTM maps at 1 : 50,000 are being plotted and field-checked.

Thirty-eight sheets of Sumatera and 29 sheets of Kalimantan on the scale 1 : 250,000 (see figure 32) have been produced; the sheet size is 1° × 1° 30′ presented in UTM grid system.

For maps on the scale 1 : 500,000, the following results have been obtained: 12 sheets covering Jawa and the Lesser Sunda Isles have been produced; and 11 sheets covering West and East Kalimantan have been colour-separated.

Five sheets of the International Map of the World on the Millionth Scale (IMW), covering the island of Kalimantan, are still at the scribing stage.

Map revision has been undertaken for 16 sheets of the topographic maps of Jawa, Bali and South Sulawesi on the scale 1 : 50,000.

## Aerial photography

During the period reported in this paper, high-altitude aerial photography on the scale 1 : 100,000, using super-wide-angle camera RC10, was taken in Sumatera (see figure 33) and about 85 per cent of the island of Sumatera is completed. Due to cloud conditions, aerial photography at larger scale has yet to be taken for the remaining area.

In Irian Jaya photography on scales ranging from 1 : 80,000 to 1 : 100,000 has been carried out for a length of 8,884 km. Spot photography of all 76 Doppler stations also was made.

For the study of watershed in connexion with the survey and demarcation of the international boundary between Indonesia (Kalimantan) and Malaysia (Sabah and Sarawak), aerial photography was made along 600 km of the border area, which is about 30 per cent of the total length of the boundary.

## Training and education

To cope with the increasing activities in surveys and mapping in the coming decade and future developments in research, science and technology, manpower development at all levels has long been the focus of concern. A beginning has been made with a School for Photogrammetric and Cartographic Operators, established in 1975 with the technical assistance of the International Institute for Aerial Surveys and Earth Sciences (ITC), at Enschede, the Netherlands. The School, attached to the Bandung Institute of Technology, is under the auspices of BAKOSURTANAL. Its purpose is to fulfil the need for operators for government mapping agencies, i.e., BAKOSURTANAL, the Army Topographic Service, the Cadastral Survey and the Mapping Centre of the Ministry of Public Works and Energy. The annual output is about 20 photogrammetric operators and 20 cartographic technicians divided among the four above-mentioned agencies. When a vacancy is available, the School is open for other government agencies or private survey firms, and even for countries in South-East Asia. As an example, this year, two students from the National Mapping of Malaysia are pursuing courses at the School.

Another activity comprises the training courses in photo-interpretation conducted as a joint effort of BAKOSURTANAL and the Gajah Mada University at Yogyakarta. It is the intention that a permanent School for Image Interpretation, including remote-sensing techniques and integrated surveys, will be set up at Yogyakarta, since both aerial photographs and remote-sensing imageries, including those of

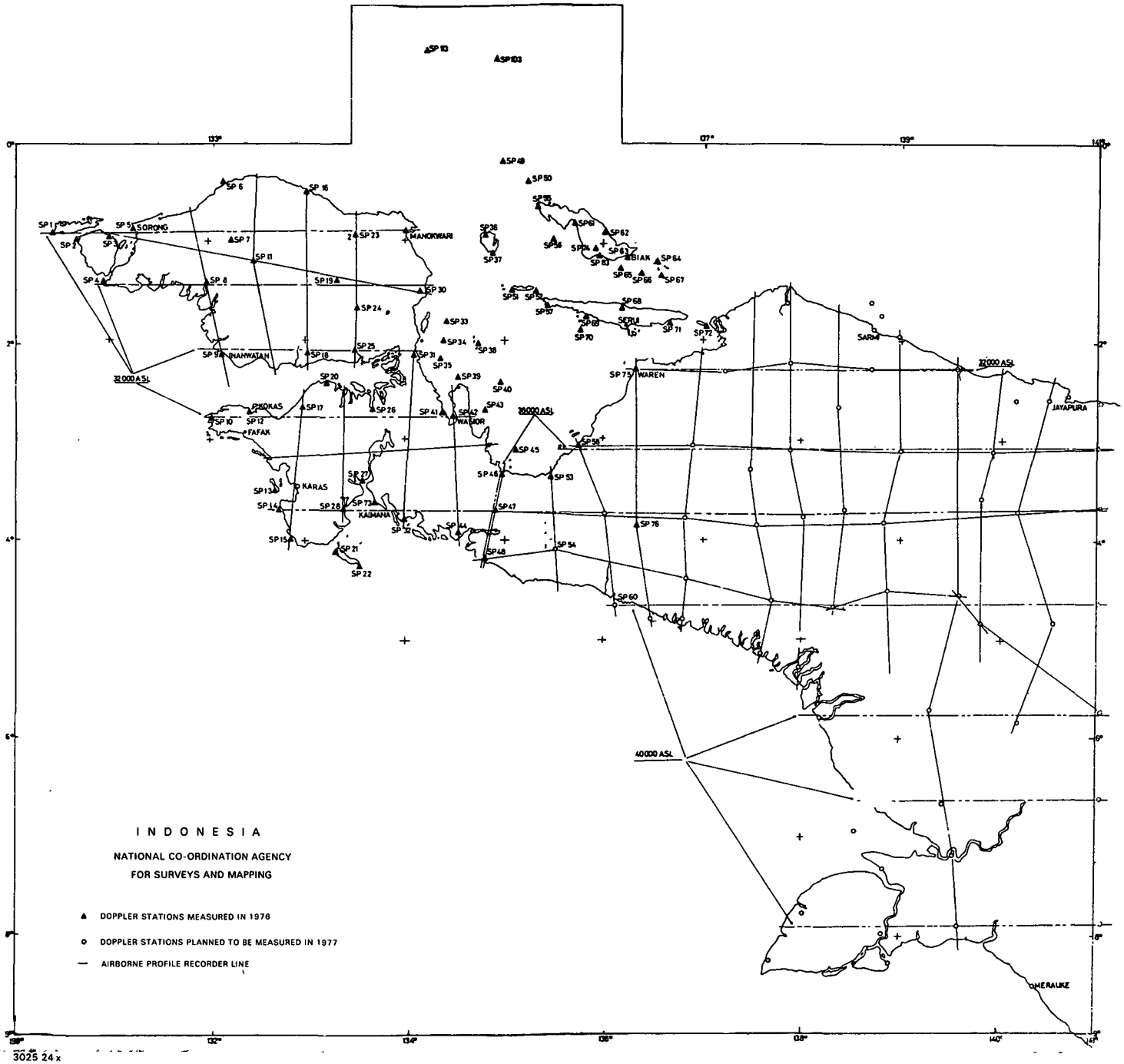



*Figure 30. Indonesia: Doppler stations measured, 1976*

LANDSAT-1, are available and widely accepted as tools for resources inventory and study.

Quite a few students have been sent to ITC in the Netherlands, from various government mapping organizations, to pursue courses in photogrammetry, data processing in photogrammetry, photo-interpretation, aerial photography and integrated surveys.

Courses in geodesy and photogrammetry are offered by two universities, the Bandung Institute of Technology and Gajah Mada University at Yogyakarta; courses in geography are appeared at Gajah Mada University, as mentioned earlier, and at the University of Indonesia at Jakarta.

BAKOSURTANAL currently employs 60 persons, including 21 professionals and 21 technicians. To carry out effectively its co-ordination functions and to fulfil operational responsibilities related to the National Resource Survey and Mapping Project, financed by the World Bank, staffing and training programmes would have to be substantially expanded. The proposed manpower plan indicates that by 1980–1981, a total of about 220 staff, including approximately 90 professionals, would be required. About 50 per cent of the staff would be engaged in geodetic survey, photogrammetric plotting, and chart and map production and reproduction. Staffing requirements would be unlikely to diminish after completion of the national 1 : 50,000 base-map series, because of the need for continuous updating, for addition of contour lines to the planimetric (orthophoto) base and for subsequent production of larger scale base maps (e.g., 1 : 25,000) for more developed regions.

### Conclusion

The Government of Indonesia would like to thank all countries and organizations, as well as individuals, who have contributed to and assisted in the development of Indonesia, particularly in development of the national capabilities in mapping and charting, in resources inventory and evaluation, and in geodesy and photogrammetry, without which the national development plan could not be carried out properly and successfully. Much remains to be done in the coming decade. The future development of Indonesia depends critically upon its ability to make the best possible use of its natural resources, with a minimum of waste and for the benefit of the greatest number of people.

It is of particular importance that constant close co-operation be kept between developed and developing countries so as to minimize the gap in the light of technological advancement. It is well known that today, more than ever, questions and problems may be solved by the possibility of supplementing information. Only through the co-operation of all those concerned will it be possible for the most important task of science and technology—to make life more livable for mankind—to take effect.

## THE NATIONAL RESOURCE SURVEY AND MAPPING PROJECT IN INDONESIA*

*Paper presented by Indonesia*

Indonesia is the world's largest and most populous archipelago, consisting of about 3,000 islands extending approximately 5,000 km along the equator. Nearly two thirds of the population of over 130 million inhabit Jawa, Madura and Bali, at densities which rival the highest in the world. Other regions, including Irian Jaya (western part of the island of New Guinea), Kalimantan, Sulawesi and Sumatera, are sparsely populated with important natural resource potentials which are not yet fully utilized.

Resource-based industries, particularly agriculture, forestry, fisheries and extraction of petroleum, gas and hard minerals play a vital role in the Indonesian economy. Besides providing employment to the great bulk of population, these industries account for almost all of Indonesian exports and for over 60 per cent of gross domestic product and of government revenues. The revenues derived from extraction, processing and export of natural resources have enabled the Government to implement a rapidly expanding investment programme while raising the level of living of its people.

Most of the resource development efforts of both government agencies and private firms have been directed to the development of land and forest resources and mineral deposits, and to the rehabilitation and modernization of large elements of public infrastructure, such as ports, irrigation systems, highways and communication systems, and of mining and commercial agriculture establishments. As the backlog of such investment in the traditional sectors and the more developed areas has been reduced, and the attention of government planners has shifted to less-developed regions, serious deficiencies in the availability of information on the natural resources and physical environment of Indonesia have become apparent.

Efforts to evaluate and map the topography, soils, hydrology, forests and other resources in proposed project areas have in turn revealed that up-to-date base maps, aerial photography and geodetic controls are almost non-existent except for small areas of the country which are historically the most developed. In general,

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information about the resource endowment of Indonesia is clearly inadequate to meet the needs of national, regional and project planning.

### Towards the integration of national mapping and resource evaluation

The existing situation in the mapping and resource survey fields is due in part to inadequate funding of geodetic and base-mapping work and specialized resource survey and mapping activities, but it is due also to excessive fragmentation of effort in those fields and a resultant low efficiency and inconsistency of work. With this situation prevailing in the country, the Government, through Presidential Act No. 27/1975, established the National Committee for Inventory and Evaluation of Natural Resources, which is an interministrial committee presided over by the Minister of State for Research. The National Co-ordination Agency for Surveys and Mapping (Badan Koordinasi Survey dan Pemetaan Nasional; BAKOSURTANAL), established in 1969, acts as the secretariat of the Committee.

The Committee is a forum to implement co-ordination, synchronization and integration among government agencies in order to formulate public policies regarding the inventory, evaluation, processing, development and preservation of natural resources.

The Working Group on Integrated Information System, which will bring together both physical and socio-economic data in a system of information management has been established under the auspices of this Committee. With this end in view, a system to integrate mapping and data has been proposed, using Universal Transverse Mercator (UTM) grid cells as its storage and retrieval base.

It is clear that a substantial investment in aerial photography, geodetic control, equipment and facilities for the production of base maps and other mapping materials is required in order to accelerate and co-ordinate the generation of information on the natural resources base of Indonesia. In addition, regional resource surveys should be complemented and assisted by the interpretation of satellite imagery and large-scale aerial photography, which would require investment in equipment and facilities as well as in basic materials.

Although requirements in the short term are for specific tasks to be performed and for certain materials to be produced, the long-term need is for institutionalization of the process of base mapping, resource survey and resource inventory and evaluation.

Base mapping is a continuous operation which should respond to demands for updating, revision and large-scale presentation as development proceeds; thus, it demands a permanent institutional commitment. Although resource survey work is, in general, best performed by specialized agencies possessing the required technical expertise, the synthesis, evaluation and presentation of the detailed data generated by these agencies in a form which will assist economic planning and policy making is a task best performed by a single agency.

The Government of Indonesia desires to use an accurate national series of base maps to promote the standardization and co-ordination of resource survey and mapping work by all government agencies and by both private and international organizations working in Indonesia, and it has accordingly allocated the responsibility for both base-mapping operations and resource inventory and evaluation to a single agency.

For this purpose, the National Resource Survey and Mapping Project, financed by the World Bank, is designed to strengthen and equip this agency to play its designated role.

### The implementing agency

The National Co-ordination Agency for Surveys and Mapping is, by the Government's decision, the implementing agency of the project. The project would provide BAKOSURTANAL with the capability and technical assistance required to undertake two major tasks which are prerequisites of the acceleration and co-ordination of natural resource inventory and evaluation in Indonesia. The first task is the completion of an accurate series of geodetically controlled base maps for the entire land area of the country, which in turn requires substantial geodetic field-work and small-scale aerial photography. The second task is the initiation of a national resource inventory and evaluation effort which would utilize the new base maps and small-scale photography, earth satellite imagery covering large blocks of the country and large-scale aerial photography of specific areas, as well as conventional field-survey methods. A subsidiary programme to improve aeronautical and navigational charts is also included in the project.

### Project components

The project consists of several interrelated components which may be grouped into two broad parts. Part I, the foreign exchange costs of which would be financed by the World Bank, consists of items (*a*)–(*g*) of the following paragraph, and would establish a strong indigenous institutional capability in mapping and resource survey. Part II, which would be financed by the Government of Indonesia, possibly with bilateral assistance, consists of items (*h*)–(*j*) and would provide the cartographic materials and data necessary to complete the base mapping of Indonesia.

The main components of the project are as follows:

(*a*) Construction of headquarters for BAKOSURTANAL, including suitable facilities for printing and cartographic shops and photographic laboratories;

(*b*) Procurement of cartographic, printing, imagery interpretation and other equipment required for both map production and reconnaissance resource evaluation;

(*c*) Procurement of remote-sensing imagery, including earth satellite output;

(*d*) Aerial photography, on the scales 1 : 50,000 and over, of approximately 300,000 km$^2$ to support detailed mapping of specific areas for project planning and charting purposes;

(*e*) Technical services to be executed by qualified survey firms, including geodetic control, photo processing and reproduction, and contact map production for delimited areas;

(*f*) Engagement of individual experts to provide technical assistance to BAKOSURTANAL in geodesy, aerial photography, cartography, printing processes and resource evaluation;

(*g*) Training in Indonesia and overseas of senior technical and professional staff of BAKOSURTANAL, and training in Indonesia of staff technicians;

(*h*) Aerial photography on the scale 1 : 100,000 of approximately 950,000 km$^2$;

(*i*) Extension throughout Indonesia of the primary, secondary and tertiary geodetic control network to a density required for mapping at 1 : 50,000 scale;

(*j*) Aerial triangulation of all areas flown.

### Mapping and resources survey operations

The project was initiated in January 1976. The envisaged plan within the coming five years is to produce planimetric orthophoto base maps at 1 : 50,000 scale from the 1 : 100,000 scale super-wide-angle aerial photography and control data provided by Doppler observation techniques for horizontal positions and laser Airborne Profile Recorder (APR) for vertical control. When needed, contoured orthophoto maps will be produced since height information will be stored during the scanning process for the orthophoto. The areas covered in this plan are Sulawesi, Maluku, Nusa Tenggara, the unmapped portion of Kalimantan, Jawa and Bali, since West Kalimantan, Sumatera and Irian Jaya have been covered by the joint Indonesia-Australia mapping co-operation which began as early as 1969.

Doppler observation techniques will be utilized first to unify the separate geodetic data into a unified national geodetic datum; and, secondly, to provide controls for aerial triangulation to be processed using large blocks (Programme Package for Aerial Triangulation with Independent Models: PAT-M).

For regional resources surveys, a multistage sampling technique will be applied, utilizing earth satellite imageries in conjunction with the over-all coverage of small-scale and the selected large-scale aerial photography, and for which multispectral photography will be of great assistance for interpretation purposes. Field surveys appear to be required to generate the more detailed data needed to identify project possibilities and to delineate favourable project areas. The plan will be executed in a multidisciplinary approach by multiagency teams in full co-operation with the specialized departments, research institutes and universities. The surveys would cover natural geographical regions, primarily in the outer islands, which appear favourable for transmigration and land settlement, irrigation, agriculture development, mineral extraction and lumbering, or transport infrastructure investment. Surveys on Jawa would be primarily oriented to the assessment of deforestation, erosion, flooding patterns and other forms of ecological deterioration, and to the determination of suitable resource conservation policies and programmes.

### Closing remarks

The plan herein envisioned is still at the first stage of its implementation and preparations have been undertaken to construct the buildings for the photogrammetric and cartographic laboratory to house the needed equipment, which still must be procured. The full-fledged operation could be expected as early as 1978, however, and regional resource surveys will be initiated earlier for areas where data are available from the previous aerial photography and the available earth resources imageries.

Additional training of staff and technical personnel is of primary concern so as to foster successful implementation of the project in the future. Manpower development is still a slow process. All foreign assistance to facilitate training for Indonesian personnel to keep abreast with modern technology is highly appreciated.

## APPLICATION OF CONVENTIONAL AERIAL PHOTOGRAPHY FOR SOIL SURVEYS IN INDONESIA*

*Paper presented by Indonesia*

### Background information

#### *Subjects for interpretation*

The subjects for interpretation from aerial photographs are literally "under the ground". The phenomena to be interpreted are largely "invisible", for the most part due to vegetative or land use coverage. The essential characteristics can only be studied in the soil profiles varying in depths from 0.5 to 10 m below the surface. Recognition and identification of soils directly from the photo-image can only provide a very small part of the essential information.

The interpretation will largely depend upon a good understanding of the relationships between the soils and the different elements of the landscape that can be identified. A good knowledge of the local factors of soil formation and the soil-forming processes is essential. A soil, as a three-dimensional body, is a piece of landscape

* The original text of this paper, prepared by the Soil Research Institute, Ministry of Agriculture, Bogor, Indonesia, appeared as document E/CONF.68/L.78.

with its own surface and landform, as well as soil profile and internal characteristics. The interpretation from the photo-image as applied is usually carried out indirectly through physiographical analysis, because among all the elements of the landscape, the physiographical setting is often the determinant factor of soil distribution. Therefore, photo-interpretation is generally less concerned with the identification of the soil *per se*, but rather with their spatial distribution.

*Classification of the soils*

The placement of the soils in the classification scheme should be done after examinations of the soil profiles, supported by chemical, physical and mineralogical analysis in the laboratory. The category in which they are placed will depend upon the level of survey or the scale of the soil map.

*Essentials for interpretation*

For a good interpretation, it is essential that the photo-interpreter has the appropriate techniques of handling aerial photographs, besides a good reference level (background knowledge). The best procedure, therefore, is to have the photo-interpretation and field-work intimately connected by having them carried out by the same person.

*Availability of aerial photographs for soil survey*

Soil survey and mapping activities in Indonesia are entrusted to the Soil Research Institute of the Ministry of Agriculture. The entire area of Indonesia is not yet covered by aerial photographs. The existing photographic coverage varies in scale, quality, year and sometimes in size. The photographs were made for different purposes. The old photographs usually have no negatives.

Currently, most of the areas to be developed and accordingly to be surveyed have no good base maps and no photographic coverage. All survey activities, including soil survey require new aerial photographs. Aerial photography should be planned some years ahead.

USE OF CONVENTIONAL AERIAL PHOTOGRAPHS IN SOIL SURVEYS

*History*

The Soil Research Institute first used aerial photographs in 1948, almost one decade after Kint published his first experiences in the tropical mangroves in 1934. This first application was connected with reconnaissance soil survey in some plains on Flores and Timor islands for mechanized ground-nut cultivation.

Although still without a good methodology, the result obtained from the above-mentioned surveys provided the real beginning for the direct application of aerial photographs for all survey and mapping activities in the coming years. After the return of a senior staff member from the International Institute for Aerial Surveys and Earth Sciences (ITC) in the Netherlands, in 1953, some improvements were made in methodology, facilities and manpower within the Soil Research Institute. The most notable progress came after 1972, when the United Nations Development Programme (UNDP) and the Food and Agriculture Organization of the United Nations (FAO) began to provide technical assistance.

*Aerial photographs as an essential tool*

Aerial photographs are now considered an essential tool for routine soil surveys. Especially in outer Jawa, where no good topographic maps exist, the use of aerial photographs is a prerequisite of such surveys. At the beginning of the second five-year plan in 1974, there was a common problem in that most of the regions to be developed in Sumatera, Kalimantan and Sulawesi, and in Nusa Tenggara, were not covered with aerial photographs or were only partially covered. It was commonly thought that without good base maps development could not be carried out properly. Systematic aerial photography is one of the quickest solutions.

*Activities with aerial photographs*

After the collection of the appropriate aerial photographs, the actual activities with these photos begin as part of the soil survey procedures. Aerial photographs are used both in the preparation and in the execution of field operations.

The preparation procedure consists of the simultaneous production of base maps and interpretation maps. The base map is prepared by the slotted-templet method, usually followed by the assembling of a semi-controlled mosaic. The preparation of this base map is usually carried out by the Soil Research Institute, as time does not allow the Institute to wait for the availability of the cartographically superior base maps prepared by the photogrammetrists.

The thematic features of the base map, consisting of roads, villages, reference points, heights and names of streams, places, hills, mountains etc., should be further checked and corrected in the field; new names might be added eventually. If in the surveyed area a good topographic map is available, then the photographic base map should be adopted first; this is true in hilly and mountainous regions where relief distortions are too large.

The interpreters, together with the soil surveyors, stereoscopically analyse the aerial photograph for the following elements of the landscape, each of them related to geomorphology/physiography, to hydrology, to land-cover/land-use pattern and to specific human activities. All these details on the aerial photographs are transferred on to the above mentioned base map by sketchmaster or radial line plotter. Three maps are produced: a physiographic map; a hydrographic map; and a land-use map. The hydrographic map is provided with a network of roads and villages.

From the study and comparison of the different elements of analyses described above, tentative soil boundaries are delineated on the photographs. These boundaries should be checked during the field operation. Within each unit boundary the necessary observations are made from soil profiles and borings, their relation with vegetative cover and land-use pattern or other physical features.

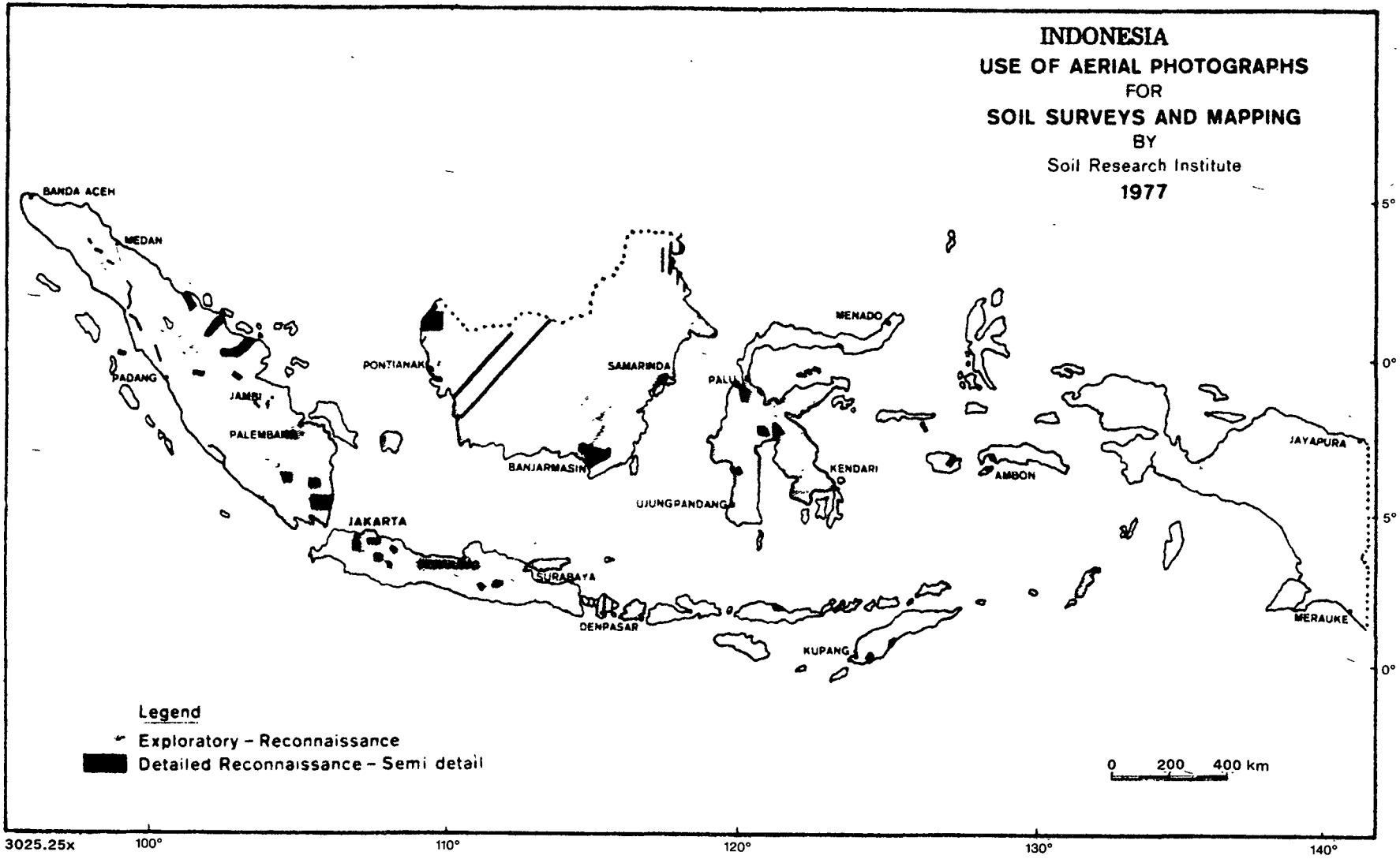



*Figure 34. Indonesia: use of aerial photographs for soil surveys and mapping*

At the final stage of the preparatory work a proper planning of the field operation is made, and where needed, traverse lines also are projected.

The next step consists of checking the legends of the produced maps described above by using the respective aerial photographs as a base map during the field operation. A tentative soil-mapping legend should be established giving the tentative soil units, their physiographical setting, land use and other hazardous physical land features.

Soil samples are collected and brought to the laboratory to be analysed for their chemical, physical and mineralogical characteristics. The respective tentative soil units should be checked against these laboratory features so that the definitive soil units are established with the correction of the appropriate boundaries on the maps.

At the end of the survey, all the exact or corrected boundaries of the respective elements, especially the soil boundaries, are reported on a base map or on a semi-controlled mosaic.

*Checking boundaries and scale of soil maps*

The above-mentioned procedures vary with the scale of the soil map or the level of intensity of the survey, especially with respect to the delineation of the boundaries against the required reliability of the soil map. For small-scale (reconnaissance) soil maps (1:100,000) almost all the boundaries are drawn in the office with few checkings in the field. On the other hand, on detailed soil surveys (1:10,000) almost all the boundaries have to be delineated based on field observations. in this detailed survey, aerial photographs will mainly serve as a base map. Such physical features as rocks, stones, sand and depths of layers can only be observed in the field and, accordingly, the delineation of their boundaries.

The required scale of aerial photographs will depend upon the purpose of the soil survey. In this case, the Soil Research Institute follows the general agreement with regard to the standard requirements of observations for the different level of surveys.

## Achievements

*Aerial photographs used by the Soil Research Institute*

To date, a total area of about 120 million ha has been surveyed, comprising exploratory, reconnaissance, detailed reconnaissance, semi-detailed and detailed soil surveys. Hence, only a small part covering several detailed reconnaissance and semi-detailed surveys made use of aerial photographs (see figure 34).

Most of these aerial photographs were obtained from the national firms assigned as contractors by the respective governmental agencies (transmigration, public works etc.). For the South-East Sulawesi survey aerial photos taken by the International Nickel Company (INCO) were made available through FAO.

In 1969 aerial photographs on the scale 1:50,000 covering an approximate area of 11.5 million ha, worth $400,000, were obtained as an FAO/UNDP aid. Unfortunately, the projected areas to be photographed were only about 90 per cent completed due to bad weather conditions. Another FAO/UNDP aid worth $100,000, to fly the remaining area in South Sumatera and to cover several promising regions in Sumbawa, Flores, and Central and North Sulawesi had to be suspended because of financial difficulties.

From the aerial photographs provided by FAO/UNDP, several maps have been produced (soil and land use) covering the southern part of South Sumatera Province, almost the whole of Lampung Province, the entire Cimanuk watershed and the upper Solo watershed. A semi-controlled base map on the scale 1 : 100,000 was produced for Lombok Island.

The most intensively used are the Cimanuk watershed photographs, especially by the Land Capability Project for land-evaluation purposes.

*Supporting activities*

The newly established cartographic and printing unit annex to the Soil Research Institute permits the Institute to print three-colour maps of the respective surveyed areas. Photo-mosaics serving as background for the soil and capability maps also have been produced since 1974.

Reports and figures are now printed with Itek and Gestetner printers at reasonably low cost.

*Working facilities and equipment*

Since 1972, the working facilities of the photographic section have been expanded to accommodate 6–10 interpretation units and the assembly of two sets of photo-mosaics.

The necessary equipment has been completed or updated for orientation, interpretation, transferring data and slotted-templet/radial triangulation purposes.

*Manpower*

The manpower has been expanded with three university graduates and two technicians. Two of these personnel obtained additional training at ITC in the Netherlands.

All of the existing 30 soil surveyors are obliged to take an active part in photo-interpretation as a part of the whole survey procedure.

## Other activities

In 1973, the Soil Research Institute took an active part in integrated research on the application of multispectral analyses for survey purposes, with the island of Bali as a case study. An interpreter and a senior soil surveyor were assigned for the soil and land-use studies. The results are still unpublished, but a part of the results was drafted as a supplement to the paper on "Application of remote-sensing technique to soil investigation", prepared by A. Suroto and J. P. Malingreau.

On the occasion of the Regional Seminar on Remote Sensing Applications, held at Jakarta from 19 to 28 November 1975, the above-mentioned paper was presented as a joint contribution of the Soil Research Institute and the FAO project at Bogor.

# REPORT ON THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION*

*Paper presented by the International Cartographic Association*

After nearly 20 years of existence, during which it has demonstrated a rapidly expanding activity, the International Cartographic Association (ICA) requires only a brief introduction. ICA is a non-governmental organization which has the following aims: (*a*) to advance the study of cartographic problems; (*b*) to spread cartographic knowledge; and (*c*) to co-ordinate cartographic research involving co-operation between countries. Membership in ICA is open to any country that pursues a cartographic activity. The Association currently has 52 member countries, most of which are represented as a member by a national society or a committee for cartography.

ICA tries to realize its goals by organizing technical conferences and by establishing special commissions and working groups for the execution of important tasks. Nine commissions are currently in action, concerned with, respectively: (1) education; (2) terminology; (3) automation; (4) communication in cartography; (5) technology; (6) natural resources mapping; (7) oceanic cartography; (8) base maps for global international thematic map series; and (9) history of cartography. The activities of these commissions have resulted in a series of publications, one of the most important of which undoubtedly is the *Multilingual Dictionary of Technical Terms in Cartography*, published in 14 languages in 1973. A second edition is in preparation. Of all the definitions in this dictionary, that of the term "cartography" is of particular importance for the participants of this Conference.

A series of eight publications is planned for the next four years, among which is the "Multilingual manual in elementary cartography", financially assisted by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The first chapter of this manual, which is primarily intended for developing countries, was presented to the Eighth ICA Conference in Moscow in August 1976. Translations of the manual into Arabic, Hindi, Japanese and Thai are envisaged.

ICA now has a programme for developing countries, which will begin with seminars on automation in cartography in Kenya and on natural resources mapping in Nigeria, both planned to take place in 1978.

The Ninth ICA Conference will be held at College Park, Maryland, United States of America, in 1978; the Tenth Conference is envisaged to be held in Japan in 1980.

Apart from the satisfaction of contributing to the development of cartography, ICA also has its concerns. A point of great concern is the fragmentation of global conference activity in the field of cartography. Besides ICA, the following bodies currently operate on a broad international scale: (*a*) the United Nations, which organizes regional cartographic conferences for Africa, the Americas, and Asia and the Far East; (*b*) the Pan American Institute of Geography and History (PAIGH), a part of the Organization of American States (OAS), with national representations in each of the member States and regular consultations; and (*c*) the African Association of Cartography, which was established at Addis Ababa in 1975, under the umbrella of the Economic Commission for Africa.

The usefulness of these organizations and their contributions in promoting cartography and mapping programmes is not questioned. Nevertheless, it will be obvious that their over-all annual output of conferences, seminars, symposia and consultations can easily lead to duplications, congestion and confusion, the more so as these programmes are not co-ordinated; and, in most cases, the same cartographers are called upon for participation, the same Governments have to pay and the same commercial enterprises have to exhibit their equipment. Co-ordination between the various cartographic bodies working on an international scale appears to be the solution.

As a first step of co-ordination between professional associations, mention should be made of the liaison between the International Cartographic Association and the International Photogrammetric Society (IPS). At the Eighth Conference at Moscow in 1976, it was decided that interassociation working groups should be established to study, respectively: (1) education, (2) automation, (3) cartography; and (4) photo maps. Both associations were represented by their own experts in these working groups.

Lastly, an interassociation working group was established to deal with environmental atlases, as a similar joint venture of the International Cartographic Association and the International Geographical Union (IGU).

* The original text of this paper appeared as document E/CONF.68/L.117.

# CARTOGRAPHIC WORK IN JAPAN 1973–1975*

*Paper presented by Japan*

Most cartographic works in Japan are controlled by governmental organizations and are classified into two categories—the national fundamental survey and public surveys. The national fundamental survey is executed by the Geographical Survey Institute (GSI); public surveys are carried out by other governmental or public organizations, such as the Forestry Agency, the National Land Agency, Japanese National Railways, the Japan Highway Public Corporation and other local government offices.

## NATIONAL FUNDAMENTAL SURVEY

The national fundamental survey is executed in accordance with the second ten-year plan and the third ten-year plan which began in 1974.

### *Geodetic works*

The Geographical Survey Institute conducts the fundamental geodetic work, including maintenance and revisional surveys of existing control points and the establishment of new minor control points for areas where large-scale mapping or cadastral surveys are planned. Revisional surveys are undertaken to detect deformations of the earth's crust as well as to maintain the current geodetic network. Studies on the crustal deformation are very important in Japan, for they are considered to be the most effective means of predicting earthquakes.

*Triangulation and precise geodetic network*

The fundamental framework of the triangulation network was established for the entire land area of Japan and was completed in 1913. It consists of 330 principal first-order, 620 supplementary first-order, about 5,000 second-order and about 33,000 third-order stations. Since then, only local revisional surveys have been carried out for areas disturbed by destructive earthquakes.

The first revisional survey of all principal first-order triangulation stations was begun in 1947 and was completed in 1967 for most of the country. The second revisional survey was initiated in 1968 from the Kyushu district, the south-western part of Japan, and covered about one third of the whole network up to 1973, but it was replaced by the "precise geodetic network" project as described below.

From the results of the revisional survey of the principal first-order triangulations, the following conclusions were derived:

(*a*) Crustal movements accompanied with earthquakes are very severe in many parts of the country;

(*b*) As a result, of course, the co-ordinates of triangulation stations of lower order, which were determined up to 1913 and are still being used, have not necessarily maintained the accuracy required for practical purposes;

(*c*) Information on the horizontal movement of the crust obtained from revisional surveys is very useful for predicting the occurrence of huge earthquakes;

(*d*) The principal first-order triangulation network is too rough to permit detection of the precursors of destructive earthquakes of magnitude 7. The lower order triangulation stations should also be resurveyed at the same time.

In these circumstances, GSI decided in 1973 to begin a project to establish a precise geodetic network throughout Japan. The network includes all existing triangulation stations, and the co-ordinates of the stations are to be newly determined. The survey is performed mainly by distance measurements using electro-optical instruments, such as the laser Geodimeter, and supplementally by angle measurement. The work is divided into primary and secondary steps. The primary network consists of about 6,000 triangulation stations which include existing first- and second-order stations, and the average distance between two adjacent stations is about 8 km. The primary network should repeatedly be revised with as short a time interval as possible, because its objective is to find useful information on crustal movements for predicting the occurrence of earthquakes. After the preliminary work in 1973, this project began with the survey in the Boso Peninsula, South Kanto, in 1974. Up to the end of 1975, about one tenth of the entire land area was covered by the primary survey and $1-2\cdot10^{-6}$ in relative accuracy was obtained.

The secondary network corresponds to the existing third-order network of which the average side length is about 4 km. The main purpose of the secondary network is to give accurate co-ordinates for practical use, and the survey will be repeated when necessary. For the time being, however, revisions are made only in areas where the land has been disturbed by earthquakes or other causes.

In order to establish base lines for satellite geodetic work, three observation stations in Japan were connected with two arcs of precise traverse survey by using the laser Geodimeter up to 1972. These arcs form a long traverse line along the Pacific coast of the country and are about 2,000 km in total length. Another arc is being settled along the Japan Sea coast, and six shorter arcs across the Japanese islands had been measured up to 1974, to

* The original text of this paper, prepared by the Geographical Survey Institute, Ministry of Construction; and the Hydrographic Department, Maritime Safety Agency, Japan, appeared as document E/CONF.68/L.16 and Add. 1.

connect both coastal arcs according to the Geodynamics Project. Repetition of these shorter arcs will detect the crustal deformation perpendicular to the Japan island arc. A loop of these arcs, 1,120 km in length, was formed and the closing error was about $1 \cdot 10^{-6}$. These arc measurements will serve for the primary network.

The computer analysis of the crustal deformation characterized by three kinds of horizontal strains, dilatation, principal axes and maximum shear has been made through the comparison of the new data and those previously obtained, using an improved universal programmme.

Since 1951, minor control points have been established by fourth-order triangulation and second-order traverse survey around cultivated areas and their vicinities. Recently, the traverse survey by high-precision electronic distance-measuring instruments had been utilized more frequently than triangulation because of its high efficiency. Establishment of some minor control points, including the primary and secondary control points, are being carried out by private surveying firms under contract with the Geographical Survey Institute.

The geodetic works performed during 1973–1975 are summarized below in table 1.

**Table 1. Japan: geodetic works 1973–1975**

| | *1973* | *1974* | *1975* |
|---|---|---|---|
| Primary control stations | 23(10)[a] | 188 | 220 |
| Secondary control stations | 75 | 118 | 157 |
| Geodynamics Project high-precision traverse surveys: | | | |
| Number of lines | 18 | 13 | 18 |
| Total kilometres | 574 | 531 | 518 |
| Laplace stations | — | 2 | 2 |
| Astronomical stations | 12 | 11 | 10 |
| Satellite triangulation | 1 | 1 | 1 |
| Quadrilateral base-line measurements (lines) | 9 | — | — |
| Fourth-order stations including precise Geodimeter traverse stations | 1 949 | 1 672 | 1 474 |
| Second-order traverse stations | 36 | 63 | 56 |

[a] Figures in parentheses indicate first-order triangulation stations.

*Levelling*

Since 1947, all routes of the first-order levelling network in Japan have been revised continuously. In 1975, the land area of Japan, excluding the Hokkaido district, was covered by the fifth revisional survey, which had been begun in 1968.

The seventh revisional survey was begun from the southern part of the Kyushu district in 1976 and is in progress in the central part of the Kyushu district. In the Hokkaido district, the fourth revision was commenced in 1974 and is still in progress. In addition to the general revisional survey, more frequent revisions are performed in the "special observation area" in the Earthquake Prediction Project of Japan. The southern part of the Kanto district is specified as the "observation intensified area" in the project and the repetition of about 600 km of precise levelling has been carried out annually on the peninsulas of Boso and Miura and in their vicinities.

Recently, ground subsidence in urban areas has been one of the serious social problems in Japan, because many large cities have been built on alluvium layers along the coast and have suffered damage due to ground subsidence. For this investigation, precise levelling of 13,000 km is carried out each year in those areas through the co-operation of GSI, local governments and other bodies.

Second-order levelling has been carried out in various parts of the country to establish a supplementary levelling network.

Table 2 shows the working records of the first- and second-order levelling executed by GSI. Tidal stations are maintained by several governmental organizations.

**Table 2. Japan: levelling work, 1973–1975**
*(Kilometres)*

| | *1973* | *1974* | *1975* | *Total* |
|---|---|---|---|---|
| Revised first-order levelling | 2 186 | 2 209 | 1 987 | 6 382 |
| Established second-order levelling | 976 | 773 | 255 | 2 004 |

*Astronomical and satellite observations*

Since 1947, 162 Laplace stations have been established by the first-order astronomical survey at suitable first- and second-order triangulation stations. The second-order astronomical survey was re-commenced in 1974 to determine the vertical deflection; 312 triangulation stations, including Laplace stations, have been covered. The observations were made with astrolabes equipped with the electronic transit detector developed by the Institute. The astrolabe used for observations was calibrated at the Kanozan Geodetic Observatory.

In order to control the geodetic network in Japan and that connecting it with the networks of other parts of the world, the Geographical Survey Institute, in co-operation with the Hydrographic Department, the Maritime Safety Agency and the Tokyo Astronomical Observatory, is working to establish their own satellite laser ranging instrument and is currently conducting experiments. In addition, the Institute and other related organizations are planning to develop a new balloon type of geodetic satellite which will permit laser ranging as well as photographic observation.

*Gravity survey*

With the co-operation of the Academy of Science of the Union of Soviet Socialist Republics, the Geographical Survey Institute completed a series of gravimetric connexions of Tokyo, Moscow, Potsdam and Paris in 1974, using three LaCoste and Romberg gravity meters.

For the domestic survey, the repetitional measurements at four fundamental gravity stations have been carried out with the GSI pendulum apparatus. Through the precise observation of multiple LaCoste and

Romberg gravity meters, four first-order gravity stations have been newly established and 38 have been re-occupied. The total number of first-order stations was 102. Combining the results of the fundamental and the first-order stations, a new gravimetric network, named the Japan Gravity Standardization Net 1975 (JGSN 75), was established, and new gravity values at 122 stations were determined on the basis of International Gravity Standardization Net 1971.

In 1974, the second-order observations covered the entire area of the country and about 9,000 stations, including most of the existing bench-marks, were occupied by a LaCoste and Romberg gravity meter in all areas but Hokkaido, where there are old observations with other types of gravity meters.

Observations at triangulation stations are in progress and at least one station in an area of 50 $km^2$ has been established for about one third of the land area of the country.

In connexion with the Geodynamics Project, 36 second-order gravity stations have been established in the south-western archipelago.

Precision measurements for detecting the gravity changes related to crustal movements and seismic activities are conducted in several specific areas by many institutions, including GSI and several universities.

The Ocean Research Institute, the University of Tokyo and the Hydrographic Department conducted a sea gravity survey in the Pacific Ocean and in the Japan Sea.

*Magnetic survey*

Various types of magnetic surveys of the first and second order and aero-magnetic surveys have been conducted by GSI. Since 1949, 105 first-order magnetic stations have been established, among which 20 stations were selected as the standard and have been reoccupied every other year; 16 stations which are considered to be important for earthquake prediction and 6 stations near active volcanos have been reoccupied every year; the remaining first-order stations have been reoccupied at intervals of four years.

In connexion with the geodynamics project, 17 second-order magnetic stations were newly established in the southern islands and in the south-western archipelago of Japan.

By combining the results of the first- and second-order magnetic surveys, isomagnetic charts of declination, inclination, horizontal, vertical and total force reduced to the epoch 1970.0 were compiled in 1973.

Measurements of total force were carried out with an airborne apparatus in the northern and south-eastern areas of Japan from 1973 to 1975.

In order to study the geomagnetic secular changes at sea, the development of an undersea magnetometer is now in progress.

*Geodesy in hydrographic work*

*Satellite geodesy*

Optical and Doppler observation of artificial earth satellites have been conducted continuously on the isolated islands in the western Pacific. Since 1973, these observations have been performed as a five-year subproject of the Geodynamics Project, in order to study a geoid around Japan as well as to connect those islands to the Tokyo Datum.

The Hydrographic Department, in co-operation with GSI, has manufactured an experimental laser ranging system of the second generation. The set is under test operation.

*Overseas levelling and observation of vertical deflection*

Overseas levelling is being continued among the Izu Islands and on the Izu peninsula as one of the earthquake prediction programmes. This project was begun in 1967 in order to obtain basic data for study of the crustal structure of that region, which is geologically one of the most active regions.

Observations of vertical deflection are also in continuous progress by means of astronomical methods in the Izu Islands and in the western Pacific, related to the two projects mentioned above.

*Astronomical observations*

Observation data of occultations of stars by the moon are constantly accumulated at the three astronomical observatories of the Hydrographic Department at Sirahama, Simosato and Kurasiki. Results of reductions have been used in compilation of nautical almanacs.

An expedition was dispatched to Australia for observation of the total solar eclipse on 23 October 1976.

*Gravity measurements at sea*

Gravity measurements at sea have been carried out by the Hydrographic Department for the Basic Map of the Sea, continental-shelf series; and free-air gravity anomaly charts on the scale 1 : 200,000 have been produced.

*Geomagnetism in hydrographic work*

Magnetic charts for the epoch 1975.0 are in preparation, based on magnetic surveys carried out in 1974 and 1975 at 15 land stations in the whole of Japan and along 30 tracks on the sea, by aircraft, within 800 nautical miles from the Coast.

Geomagnetic absolute and variation observations of three elements and total magnetic force are being carried out at Simosato Hydrographic Observatory, thus forming part of the network of world magnetic observations.

*Topographic mapping at 1 : 25,000 scale*

Topographic mapping on the scale 1 : 25,000 has been carried out since 1964, and the project is nearly completed. The entire area of the country, including several isolated islands, approximately 370,000 $km^2$, is covered by the new base map of 4,450 sheets.

These maps are revised at intervals of 3, 5 or 10 years, according to the amount of changes in the map content. Recompilation of the maps is carried out after three or four revisions. Table 3 shows the amount of work accomplished during the past three years.

**Table 3. Japan: topographic mapping at 1 : 25,000 scale**

| | 1973 | 1974 | 1975 |
|---|---|---|---|
| New edition.... | 310 sheets (25 804 km²) | 274 sheets (23 751 km²) | 176 sheets (15 109 km²) |
| Recompilation.. | — | — | 16 sheets (1 552 km²) |
| Revision..... | 406 sheets (35 162 km²) | 412 sheets (31 331 km²) | 362 sheets (30 104 km²) |

*National large-scale mapping*

The national large-scale mapping project consists of cyclical aerial photography at three-year intervals for urban areas and five-year intervals for the remainder, 1 : 2,500 and 1 : 5,000 large-scale mapping and fourth-order triangulation.

Recently, GSI has emphasized the mapping at 1 : 2,500 scale. The progress of this project is shown in table 4.

**Table 4. Japan: area covered by national large-scale mapping**
(*Square kilometers*)

| | Scale | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Photographic coverage... | 1 : 10 000 | 384 | 151 | 2 386 |
| | 1 : 20 000 | 29 579 | 30 422 | 22 295 |
| New edition..... | 1 : 5 000 | 4 119 | 3 343 | 2 905 |
| Revision..... | 1 : 5 000 | 677 | 1 066 | 1 034 |
| Photo mapping..... | 1 : 5 000 | 596 | 229 | 317 |

*Aerial colour photography*

Aerial colour photography has been carried out since 1974. The objective is to cover the entire country within four years. This coverage will form the first link in the chain of the National Land Information Service System planned by the National Land Agency.

Photographic scales are 1 : 8,000 for flat terrain and 1 : 10,000–1 : 15,000 for hilly and mountainous regions. During the fiscal years 1974 and 1975, about 158,900 km² were covered with these colour photographs.

*Compilation and revision of small-scale maps*

*Topographic maps at 1 : 50,000 scale*

The topographic maps on the scale 1 : 50,000, which cover the entire country with 1,257 sheets, are compiled from the new topographic maps at 1 : 25,000 scale. By the end of fiscal year 1975, this method had been used to compile 1,032 sheets.

In addition, the topographic maps at 1 : 50,000 scale are regularly revised and approximately 150 sheets are revised each year in accordance with the revision of the topographic maps at 1 : 25,000 scale.

*Regional maps at 1 : 200,000 scale*

The series of regional maps at 1 : 200,000 scale consists of 129 sheets, and 51 sheets of this series were recompiled by revisional surveys during 1973–1975.

*District maps at 1 : 500,000 scale*

The series of district maps on the scale 1 : 500,000 consists of eight sheets; two editions of these maps have been reproduced. One edition has layer tints; the other does not.

*Maps of Japan at 1 : 1,000,000 scale*

Maps of Japan on the scale 1 : 1,000,000 are compiled in accordance with internationally standardized specifications. The maps on the scales 1 : 200,000 and 1 : 500,000 are used as base maps, and the series covers the entire country with three sheets. One edition for domestic use was revised in the period 1973–1975.

*Composite topical maps*

The urban land-use map of Osaka on the scale 1 : 25,000 was compiled in 1973–1975. On the reverse side of the sheet, several small-scale regional maps were laid out to show changes that had occurred over past years. The urban land-use map was compiled as an experimental project for the development of a new map design. On this basis, the city map of Tokyo and the map of Hakone were experimentally compiled on the scale 1 : 25,000 during 1973–1975.

## Cadastral surveys

The cadastral survey in Japan is carried out by the National Land Agency in conformity with the National Land Survey Law. The main purpose of the Law is to clarify the natural characteristics of the country by cadastral surveys, including establishment of control points for cadastral surveys, land-classification surveys and water resources surveys. Table 5 shows the cadastral work done during the period 1973–1975.

**Table 5. Japan: cadastral surveys, 1973–1975**

| | 1973 | 1974 | 1975 | Over-all total |
|---|---|---|---|---|
| Control point survey (points) ..... | 1 207 | 1 292 | 1 200 | 33 352 |
| Cadastral survey (square kilometres) ..... | 4 324 | 3 954 | 3 788 | 49 785 |

## Public surveys

Public surveys comprise a considerable part of the cartographic work and a large number of maps have been made for public use on scales ranging from 1 : 500 to 1 : 10,000. These surveys have usually been carried out by private firms in compliance with requests from various public organizations. The number of firms registered by the Survey Law and the number of employees are shown in table 6.

**Table 6. Japan: number of private firms undertaking public surveys for cartographic works and number of their employees**

| | 1973 | 1974 | 1975 | Remarks |
|---|---|---|---|---|
| Number of private firms. | (35)[a] 4445 | (47)[a] 5006 | (54)[a] 5438 | |
| Number of employees... | 147532 | ... | ... | Total |
| | 14563 | ... | ... | Registered surveyors |
| | 13580 | ... | ... | Registered assistant surveyors |
| | 119389 | ... | ... | Assistant surveyors |

[a] Figures in parentheses indicate the number of firms that can perform photogrammetric work.

The quantity of photogrammetric equipment available in Japan is shown in table 7.

**Table 7. Japan: photogrammetric equipment available**

| | 1973 | 1974 | 1975 |
|---|---|---|---|
| Aircraft for taking aerial photographs | | | |
| Government | 2 | 3 | 3 |
| Private | 41 | 48 | 78 |
| Cameras | | | |
| Government | 11 | 13 | 14 |
| Private | 47 | 66 | 81 |
| First-order instruments | | | |
| Government | 7 | 7 | 7 |
| Private | 30 | 34 | 40 |
| Second-order instruments | | | |
| Government | 34 | 35 | 35 |
| Private | 182 | 229 | 253 |
| Third-order instruments | | | |
| Government | 48 | 48 | 48 |
| Private | 12 | 21 | 23 |
| Comparators | | | |
| Government | 1 | 1 | 1 |
| Private | 12 | 14 | 17 |

Public surveys executed during the period 1973–1975 are shown in tables 8 and 9.

**Table 8. Japan: areas photographed for public surveys, 1973–1975**
*(Square kilometres)*

| | Photographic scale | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Forestry survey | 1:10000 | — | — | — |
| | 1:20000 | 30335 | 23795 | 29013 |
| | 1:30000 | — | — | — |
| Other public surveys | 1:10000 | 25458 | 7950 | 11810 |
| | 1:20000 | 24085 | 22345 | 17080 |
| | 1:30000 | 6290 | 4011 | 4136 |

**Table 9. Japan: areas mapped for public surveys, 1973–1975**
*(Square kilometers)*

| | 1973 | 1974 | 1975 |
|---|---|---|---|
| Forestry contour map | 9952 | 15634 | 13132 |
| City-planning map | 17095 | 12144 | 11025 |
| Road-planning and improving map | 2383 | 2125 | 2657 |
| Railway-planning map | 1253 | 3574 | 4155 |
| River-improving map | 1795 | 2958 | 2385 |
| Farm-improving map | 8937 | 3160 | 2122 |

## Thematic maps

### *Land-use maps*

In connexion with the National Land Information Service, which supplies the data necessary for national and regional land-use plans under the provisions of the National Land-use Planning Act, the National Land Agency in co-operation with GSI began the production of land-use maps in the fiscal year 1975. The maps will cover the main habitable areas of the entire country, estimated to be about 90,000 km$^2$, within four or five years. In the fiscal year 1975, 158 sheets were completed. The scale of the map is 1 : 25,000 (see figure 35 in pocket[1]) and importance is attached to the classification concerned with city and village areas.

### *Land-classification maps*

The National Land Agency established the specifications for the land-classification surveys after 20 years of experience. The land-classification map series consists of three thematic maps—land classification, subsurface geology and soil—on the scale 1 : 50,000, together with detailed explanatory text.

In 1970, the National Land Agency began production of a new series on the scale 1 : 50,000 as the basic materials for each regional project based on the New Comprehensive Development Plan. This new series is a continuation of the above-mentioned series. To date, 150 sets of these maps have been compiled with the co-operation of the local governments concerned; and 150 sets are planned in the future.

The National Land Agency is also compiling the land-classification map series at 1 : 200,000 scale for each local governmental area. As of March 1975, the map series of 46 prefectures had been completed. The entire series should be completed in 1978. This map series consists of the following thematic and overlay maps: geomorphological classification map; subsurface geological map; current land-use map; land-use capability classification map; relief energy; valley density overlay; slope-classification overlay; subsurface geological overlay; soil productive capability classification overlay.

### *Land-condition maps*

The Geographical Survey Institute compiles land-condition maps to clarify the land condition of various areas for the purpose of preventing natural disasters and for regional land development.

Land-condition maps of four districts at 1 : 25,000 scale and of three districts at 1 : 10,000 scale have been compiled.

### *Topographic maps and land-condition maps of coastal areas*

The Institute produces topographic maps and land-condition maps of coastal areas in order to clarify the land and sea-bottom condition of those areas.

Eight sheets of the topographic maps and the same number of sheets of land-condition maps of Ise Bay, Hiroshima Bay etc. were issued during the period under review.

### *Lake charts*

Five charts of the 1:10,000 series for three lakes were compiled by GSI in the report period and two sheets covering a part of Lake Biwa were revised.

### *Water-use maps*

Since 1965, water-use maps on the scale 1 : 50,000 have been prepared by the National Land Agency, in co-operation with GSI, for several important river systems in Japan. Eighteen sheets covering four districts were completed during the period 1973–1975.

### *Geological maps*

Geological maps of Japan are mainly produced by the Geological Survey of Japan (GSJ).

As for the basic standard geological maps in the series on the scale 1 : 50,000, compilation has been carried out since 1950 by GSJ; 15 sheets with their explanatory texts were published during the period under review. In total, the area covered by the maps on the scale 1 : 50,000, together with those areas covered by maps on the scales 1 : 75,000 and 1 : 100,000, constitute almost half of Japan. The geological map series on the scales 1 : 200,000 and 1 : 50,000 are compiled from the above-mentioned maps and other data; five sheets of the former series and one sheet of the latter have been published.

In addition to the above-mentioned basic maps, many types of geological maps have been prepared by GSJ. Maps prepared during the period 1973–1975 are as follows:

(*a*) One sheet of the mineral deposits of Japan series on the scale 1 : 2,000,000;

(*b*) One sheet of the tectonic map series on the scale 1 : 500,000;

(*c*) Two sheets of the geological map of the coal-fields of Japan on the scale 1 : 25,000;

(*d*) Three sheets of the hydrogeological maps of Japan on the scales 1 : 25,000–1 : 50,000;

(*e*) Three sheets of the marine geological maps on the scale 1 : 200,000;

(*f*) Twenty-four sheets of the aeromagnetic maps series on the scale 1 : 200,000.

### *Vegetation maps*

The Agency for Cultural Affairs is preparing vegetation maps which show the distribution of the types of vegetation formations and dominant species, covering the entire area of Japan according to a plan which was formulated in 1967. The compilation of these maps on the scale 1 : 200,000 covering 37 prefectures were completed before the end of fiscal year 1975; the remaining nine prefectures, excluding the Hokkaido region, are scheduled to be completed within the next two years.

In addition, during the period 1973–1975, two other

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figure 35 is in this pocket.

types of vegetation maps were prepared for every prefecture of the country by the Environment Agency. These maps are as follows:

(*a*) 53 sheets of the actual vegetation map on the scale 1 : 200,000, having approximately 50 classified vegetation regions; and (*b*) 53 sheets of the natural grade map on the scale 1 : 200,000, having 10 classified regions between natural and artificial vegetation grades.

*Population maps and population-related maps*

The Bureau of Statistics of the Office of the Prime Minister has prepared various maps of national interest based on statistical data from the national census taken every five years.

During the fiscal years 1973–1975, the Bureau of Statistics published 10 sheets of the population maps on the scale 1 : 300,000, manifested by the standard mesh system, based on results of the 1970 population census; and the maps of population distribution by landforms on the scale 1 : 1,000,000, consisting of three sheets, also were prepared on the basis of the same data. In addition, the map showing the percentage of population that moved after 1965, on the scale 1 : 1,500,000, was prepared by the Bureau of Statistics in 1973. Furthermore, based on the results of the 1970 population census, several maps, using the computer printer, were produced as statistical maps on the grid-square basis.

*Soil maps*

Soil maps of Japan are roughly classified into two categories. One type is specified for cultivated lands and the other for forest lands. They are prepared, respectively, by the corresponding organizations in the Ministry of Agriculture and Forestry.

The 1 : 50,000 series of soil types and their products for cultivated lands has been prepared by the Agricultural Administration Bureau since 1959; and the entire area of cultivated lands, 60,000 km$^2$, was covered by this series up to 1975.

The 1 : 20,000 series of soil types for national forests has been prepared by the Forestry Agency since 1947. About 70 per cent of the national forests, corresponding to 80,000 km$^2$, was covered by this series at end-1975. The Agency also has prepared the 1 : 50,000 series of soil types for private forests in the 10-year project since 1969. About 50 per cent of the private forests, corresponding to 70,000 km$^2$ or more, was covered by this series as of end-1975.

*Traffic-volume maps*

The traffic-volume map of Japan on the scale 1 : 1,200,000, and similar maps for the Tokyo, Nagoya and Osaka region on the scale 1 : 200,000, were issued in 1974. These maps have been compiled every three years since 1962.

These traffic maps were prepared by the Road Bureau of the Ministry of Construction in co-operation with GSI, to be used as fundamental data for road administration.

## HYDROGRAPHIC WORK

*Hydrographic surveying and charting activities*

The number of various hydrographic surveys carried out from 1973 to 1975 is given in table 10.

**Table 10. Japan: hydrographic surveys, 1973–1975**

| *Type of survey* | *1973* | *1974* | *1975* |
|---|---|---|---|
| Harbour survey | 10 | 12 | 7 |
| Updating survey | 206 | 195 | 180 |
| Passage survey | 4 | 2 | 3 |
| Coastal survey | 1 | 1 | 0 |
| Oceanic survey | 1 | 1 | 1 |
| Survey for Basic Map of the Sea | 6 | 7 | 8 |
| Survey for Earthquake Prediction Programme | 1 | 1 | 1 |

Results of these surveys were utilized in the production of nautical and other charts, as shown in table 11.

**Table 11. Japan: charts produced, 1973–1975**

| *Type of chart* | *1973* | *1974* | *1975* |
|---|---|---|---|
| *New charts:* | | | |
| Nautical | 11 | 11 | 12 |
| Miscellaneous | 10 | 8 | — |
| Basic Map of the Sea | 30 | 38 | 46 |
| Aeronautical | 1 | 1 | 1 |
| *New editions:* | | | |
| Nautical | 39 | 13 | 26 |
| Miscellaneous | 5 | 14 | 10 |
| Basic Map of the Sea | — | — | — |
| Aeronautical | 2 | 1 | 2 |
| *Reprint* | — | 3 | 1 |
| TOTAL | 98 | 89 | 98 |

*Nautical charts*

The changes in hydrographic information for ports and harbours have been remarkable in recent years due to harbour construction works and dredging operations on shipping routes. Updating of these charts is done by issuing new charts and new editions of existing charts, as well as by correcting them with correction chartlets promulgated by Notices to Mariners.

With the commencement of service of the Tohoku Decca system, 12 Decca charts are to be issued to cover the service area; seven of them have already been published.

In accordance with the resolution of the International Hydrographic Organization (IHO), international charts of the western Pacific, six in the series at 1:3,500,000 scale and two in the series at 1 : 10,000,000 scale, will be published. Three of the first series have already been published.

*Basic Map of the Sea*

The Basic Map of the Sea series, produced since 1967, has as it objective the provision of fundamental data for sea-bottom researches and ocean development other

than for navigational purposes. Preparation of this series is currently a major function of the Hydrographic Department, together with nautical charting. The outline of the Basic Maps of the Sea is shown in table 12.

**Table 12. Japan: Basic Map of the Sea series**

| *Series* | *Scale* | *Coverage* | *Size* | *Type* |
|---|---|---|---|---|
| Basic Map of the Sea, coastal areas | 1 : 10 000<br>1 : 50 000 | Coastal areas within 12 miles of the coast | Full | Bathymetric chart<br>Submarine structural chart |
| Basic Map of the Sea, continental shelf | 1 : 200 000 | Continental margin | One half | Bathymetric chart<br>Submarine structural chart<br>Total magnetic intensity chart<br>Gravity anomaly chart |
| Basic Map of the Sea, ocean areas[a] | 1 : 50 000 | Ocean | Full | Bathymetric chart<br>Submarine structural chart<br>Total magnetic intensity chart<br>Gravity anomaly chart |

[a] To be published beginning in fiscal year 1977.

*Charts on issue*

The charts on issue as of March 1976 are listed below in table 13.

**Table 13. Japan: charts on issue**

| *Type of chart* | *Number of charts* |
|---|---|
| *Nautical:* | |
| General chart | 24 |
| Sailing chart | 130 |
| General chart of coast | 164 |
| Coastal chart | 260 |
| Habour plan | 409 |
| Sub total | 987 |
| *Miscellaneous:* | |
| Current chart | 10 |
| Tidal current chart | 15 |
| Meteorological chart | 8 |
| Chart showing positions of set net-fisheries | 16 |
| Position-plotting sheet | 32 |
| Pilot chart | 12 |
| Others | 28 |
| Sub total | 121 |
| *Basic Map of the Sea:* | |
| Continental shelf | 145 |
| Coastal areas | 82 |
| Other | 49 |
| *Aeronautical chart* | 19 |
| TOTAL | 1 403 |

## *Oceanography*

*Oceanographic observations*

For the purpose of determining the status of currents in the adjacent seas of Japan, oceanographic observations were carried out quarterly by the Hydrographic Department in co-operation with the Japan Meteorological Agency, the Fisheries Agency and other organizations. In addition, observations of the Kuroshio variations were carried out twice a month over the Kuroshio region, using aircraft and vessels. Results of these observations are published as *Charts Showing the Status of the Sea around Japan*; and, in particular, the Kuroshio observations are disseminated through radio broadcasts and similar methods in addition to the Notice to Mariners.

Observations of sea ice have been carried out every winter along the coast of Hokkaido.

Integrated oceanographic observations were carried out by the Hydrographic Department in the East China Sea, Kii Suido and Tugaru Kaikyo, in co-operation with the Japan Meteorological Agency and the Fisheries Agency.

Observations of ocean waves were carried out by means of the floating type of wave meters and shipborne wave meters.

Continuous tidal observations are carried out at some 100 tidal stations throughout the country. Data obtained are being utilized in tidal predictions, determination of datum level of charts and monitoring of crustal movements in the country. In particular, data obtained from the stations located at the islands in southern Honsyu are also used for the study of the Kuroshio variations.

*Monitoring of marine pollution*

Monitoring of marine pollution by oil, heavy metals, polychlorylephenyls (PCB) and radio-activity in the adjacent seas of Japan was carried out by the Hydrographic Department, in co-operation with other organizations concerned, at 68 stations in 1973, 57 stations in 1974 and 88 stations in 1975, as well as in five areas especially designated as the dumping-ground for industrial wastes.

*Japan Oceanographic Data Centre*

The Japan Oceanographic Data Centre (JODC) is now functioning as the National Data Centre as well as the Kuroshio Data Centre, the latter being a regional data centre for the Co-operative Study of the Kuroshio (CSK) under the International Oceanographic Commission (IOC).

As of 30 June 1976, the Kuroshio Data Centre had received the data of 454 cruises and 17,726 stations from the countries participating in CSK. These data and information are processed and are then compiled and published as the *Data Report of CSK*, the *CSK Newsletter*, the *CSK Atlas* and the *Existing Oceanographic Station Data in the South China Sea*, all of which are widely distributed both to the organizations participating in CSK and to those concerned with oceanography in many countries.

From domestic organizations, such as the Maritime Safety Agency, the Japan Meteorological Agency, the Fisheries Agency and universities, oceanographic data are sent into JODC, where they are processed and preserved in the form of punched cards and magnetic tapes for distribution in compliance with internal and external requests. Thus far, the serial station data of about 110,000 stations and the current data of about 80,000 stations have been processed.

Furthermore, a number of statistical studies, analyses and compilations, are conducted for various oceanographic elements in the north-western Pacific Ocean.

In January 1976, the Japan Hydrographic Association published a portion of these results as an atlas entitled *Marine Environmental Atlas, North-western Pacific Ocean*.

The JODC has served to work on the Report of Observations/Samples Collected by Oceanographic Programmes (ROSCOP) and other similar active programmes concerned with compilation of the primary information concerning oceanographic observational cruises and their data, such as the international catalogue of ocean data stations and international geological/geophysical cruise inventory, within the framework of IOC.

## Recent cartographic activities

*National Atlas of Japan*

Compilation of the National Atlas of Japan was commenced by GSI in 1971, in compliance with long-standing requests and demands from governmental, educational academic and business societies; it was scheduled to be completed in 1976. In early 1977, it will be published by the Japan Map Centre. The standard of the National Atlas of Japan is as follows:

*Size*: 84.1 cm × 59.4 cm (when open);

*Volume*: 380 pages;

*Number of colours used*: from 5 to 12;

*Scale*: for thematic maps, 1 : 2,500,000, 1 : 4,000,000 and 1 : 8,000,000; for regional maps and city maps, 1 : 1,000,000 and 1 : 100,000, respectively;

*Language*: edition for domestic use in Japanese; edition for international use in English;

*Map projection*: oblique conformal secant conic projection;

*Binding*: solid binding.

*National land information*

With a view to establishing a data bank of land information, GSI has been undertaking research on methods to prepare and store the data, including a digital method, on the basis of the national standard grid system which was established for the entire country in 1969; it began the project to complete the national land information programme in 1974.

Several items of land information, among them area, ground elevation, landforms, surface geology, soil, legal zones and coastal zones, have been completed. Land use is in process of digitization.

*Geographical names on maps and charts*

Since 1960, GSI and the Hydrographic Department have been co-operating to unify the representation of geographical names on their topographic maps and nautical charts.

During the period under review, almost all of the geographical names for the recompiled edition of the district maps at 1 : 500,000 scale have been unified. Discussions are under way to determine the unified geographical names for the coastal charts on the scale 1 : 200,000.

## Other activities

*Remote sensing*

Research is remote sensing in Japan is conducted by the Science and Technology Agency of the Office of the Prime Minister. Several governmental institutes and universities undertake research in remote sensing in many fields. Airborne multispectral seamen (MSS) and multiband photographs, as well as satellite imagery, are used for interpretation. The Remote-sensing Technology Centre of Japan was established in 1975 in order to promote investigations and research concerning remote sensing. Several private firms have shown strong interest in the remote-sensing field and have established their own systems for processing remote-sensing data.

*Overseas technical co-operation*

The Government of Japan has carried out the education and training of engineers from developing countries since 1954, as overseas technical co-operation under the Colombo Plan. Governmental organizations concerned with cartographic work, such as the Geographical Survey Institute, the Hydrographic Department and the Geological Survey of Japan, have received engineers from those countries through the sponsorship of the Japan International Co-operation Agency (JICA). The training subjects and total number of engineers trained are shown in table 14.

**Table 14. Japan: training subjects and number of engineers trained**

| *Training course* | *Since* | *Total number of students* |
|---|---|---|
| *Geographical Survey Institute* | | |
| Geodesy | | |
| Topography | 1963 | 99 |
| Cartography and printing | | |
| *Hydrographic Department* | | |
| Hydrographic survey | 1971 | 70 |
| Physical oceanographic survey | | |
| *Geological Survey of Japan* | | |
| Search for coastal mineral resources | 1967 | 196 |
| Development of ground-water resources | | |

Since 1971, GSI has also given technical assistance in surveying and mapping work to the developing countries of Asia and to other countries through JICA. The Institute is also gradually increasing the dispatching of experts in surveying and increasing the number of countries that receiving such mapping aid. Technical co-operation of the Government of Japan with developing countries in the surveying field is treated in a technical paper.[2]

### Earthquake prediction

Under the national programme of earthquake prediction, the Geographical Survey Institute has been investigating the crustal activity related to precursors of earthquakes, through the repeated survey of the geodetic networks in Japan. The observed data are analysed in the Geodynamics Department of the Institute and the results are submitted to the Co-ordinating Committee for Earthquake Prediction, which is made up of various national organizations and universities concerned with the study of earthquake prediction. The main events in the period 1973–1975 were the earthquakes off Nemuro (1974), the abnormal ground upheaval in Kawasaki of the metropolitan area, and the seismic and crustal activity of the Izu peninsula. In those areas, in addition to regular revision of the geodetic networks, several kinds of special surveys, such as a precise-strain survey using the new electronic distance-measuring instruments and a combined survey of levelling and gravity, have been carried out at brief repeated intervals.

Recently, remarkable crustal movement around the Suruga Bay area has been noticed in relation to a further major Tokai earthquake; therefore, GSI is planning to intensify the research of crustal movement in that area.

Furthermore, basic researches for studying a method of detecting the active faults under the thick alluvium and classifying their activity by means of geodetic and aerophotographic interpretation techniques, have been begun in the southern Kanto and Tokai districts, in co-operation with the Geological Survey of Japan, the National Research Centre for Disaster Prevention and the Kakioka Geomagnetic Observatory.

[2] See "International technical co-operation by the Geographical Survey Institute", under agenda item 11.

## ESTABLISHMENT OF A NEW GEOGRAPHIC CENTRE IN JORDAN*

*Paper presented by Jordan*

Maps of all kinds are a basic requirement of any development project. This demand has been increasing in Jordan in the past few years as a direct result of the national development plans and it is anticipated that the pressure will accelerate as the five-year development plan is implemented.

Every project—of any nature—requires accurate and up-to-date mapping on a particular scale; these scales vary from one project to another. Thus, it is foreseen that the volume of work needed to meet the increasing demand will become larger as the execution of various projects proceeds, and any delay in commencing mapping activities in Jordan will cause a bottle-neck in development activities and obviously lead to economic losses.

It was therefore considered imperative to establish an organization which would use the most modern technological and scientific methods available to provide Jordan with the capabilities, human and otherwise, needed to produce the required mapping for the various needs of the country at the instant they are needed.

The Jordan National Geographic Centre (JNGC) project was undertaken for that purpose. A Royal Decree issued on 1 October 1975 approved the establishment of the Centre.

### Definition of the project

The project was defined as the setting-up of a semi-governmental centre in which all capabilities, manpower and equipment, which would be available in all departments, should be organized in a suitable manner to meet the cartographic requirements in Jordan. Additional equipment and well-trained and specialized engineers and technicians should be acquired as soon as possible. New buildings should be constructed to meet all technical specifications in order that the centre would be able to carry out its commitments in mapping the country, and might be able to offer this service to neighbouring Arab countries, where such service is not available.

* The original text of this paper appeared as document E/CONF.68/L 123.

## JUSTIFICATION OF THE PROJECT

### *Primary geodetic network*

The geodetic network of any country is the basis of all triangulation networks of lower orders and the basis from which all survey and cadastral works are initiated. The primary triangulation network that covers Jordan was based on the survey of Palestine. The network was prepared by the armed forces of Australia, New Zealand and the United Kingdom of Great Britain and Northern Ireland during the Second World War. Thus, it was made under war conditions and by different teams which had no real co-ordination, the result of which was that many points have two or more different values.

This network sufficed for those military purposes, but a new network must be built to serve the pressing need for more accurate information.

### *Aerial photography*

While preparing for the execution of the development projects mentioned above, it was realized that consultants would need aerial photography and maps in order to study each project. To meet those requirements, the Government had to give much of the work to foreign contractors, due to the lack of a specialized Jordanian organization. The amounts paid to foreign contractors for such tasks almost equalled the cost of establishing a survey organization to provide the country with all those services.

Aerial photographs are crucial to the security and development of any country and awarding such work to foreign contractors will invariably lead to this valuable information being conveyed to foreign Powers which may be hostile to that country. The danger of security leaks will definitely be diminished, if not wholly eliminated, once the Jordan National Geographic Centre begins operations.

### *Jordan capabilities specialized in map production*

There are a number of trained personnel working in the different departments of the Government who would be able, if gathered into one administration, to meet the needs of the country, thus eliminating foreign help in aerial photography and/or map production. Therefore, it is important to bring these trained personnel into one organization to attain the necessary security and to provide a source of income by opening a new field of co-operation with neighbouring Arab countries.

### *Shortage of maps*

Topographic maps are available at the military survey unit on scales 1 : 50,000 and smaller. Larger scales, such as 1 : 25,000, are available only for some parts of the country. However, these maps do not serve all development purposes. Other specialized maps, such as geological, agricultural and environmental maps, are urgently needed.

### *Updating of maps*

The updating of different maps is an important process which reflects both natural and man-made changes so as to be useful for development, transportation, city planning and other purposes. The maps currently available in Jordan were produced in the 1950s or earlier.

Therefore, it is time to begin updating and revising those maps for the different purposes and on different scales.

### *Geographical information*

Jordan, under the leadership of his Majesty King Hussein, has become an active member in the international forum and has developed relations which extend across the world in a magnitude that exceeds all expectations and can never be compared with any other country with the same size, population and natural resources.

Therefore, complete geographical information about all countries is needed and the centre would like to begin collecting such information by all available means, including the exchange of information with all friendly countries to serve all governmental purposes.

### *Development in the Arab countries*

All Arab countries, especially the oil-producing States, are developing rapidly, which necessitates the availability of all types of maps. In the absence of geographical centres in most of these countries, foreign firms have taken advantage of this market, which has resulted in the leakage of geographical, economic and other strategic information to those foreign countries; in addition great financial losses are incurred by the Arab countries. These reasons compel the Government of Jordan to move forward in all possible ways to develop its capabilities and to serve other Arab countries for the good of all, taking advantage of its unique relations with other Arab countries and its vast educational programmes.

### *Training*

The low standard of available technicians in Jordan and in other Arab countries, excluding those who have been trained abroad at great expense, necessitates the establishment of a training centre to meet the needs of Jordan and other Arab countries for well-trained technicians in a comparatively short time.

## OBJECTIVES OF THE PROJECT

The objectives of the Jordan National Geographic Centre are:

(*a*) To establish a modern geodetic network in Jordan;

(*b*) To undertake continuous updating of all maps;

(*c*) To produce topographic maps on all scales for civilian and military purposes;

(*d*) To prepare maps for all ministries and governmental departments;

(*e*) To provide all ministries and governmental departments with all survey information necessary for development projects.

(*f*) To furnish the Lands and Survey Department with the basic maps necessary for cadastral registration;

(*g*) To carry out aerial photography according to required scales for all ministries and governmental departments and according to the priorities given by the National Planning Council;

(*h*) To advise all ministries and governmental departments with regard to the provision, use and training of technicians in all matters related to survey work and map production;

(*i*) To carry out research and studies to develop surveying and map production techniques;

(*j*) To set up a map library to include all necessary geographical information;

(*k*) To train technicians to meet the needs of the centre and other governmental departments;

(*l*) To carry out research in the cloud physics field;

(*m*) To carry out research in the use of remote sensing of photography taken from aircraft or satellites for the benefit of all interested bodies;

(*n*) To carry out various research programmes in geophysics by co-operating with the Natural Resources Authority;

(*o*) To guard the security and safety of all survey information.

### Organization

Two vital issues had to be decided in organizing the Jordan National Geographic Centre: what its duties were to be, i.e., its relationship with the Lands and Survey Department; and whether it should be a military or civilian organization. These two questions were discussed at length in all official and semi-official quarters of the country.

It was decided that an ideal solution for Jordan would be that outlined below:

(*a*) The Lands and Survey Department will continue to be responsible for land registration and cadastral matters. The Centre will be responsible for first-, second- and third-order surveys, but the Lands and Survey Department will continue to be responsible for fourth-order surveys. Thus, co-operation between the Centre and the Department is crucial for the good of the country;

(*b*) Military control of JNGC was seen as essential at the current stage, but civilian needs are imperative for the development of the country; therefore, the Upper Committee was formed for the Centre, composed of 11 members, six of whom are civilians representing the ministries and departments that most need the services of JNGC (see figure 36). In addition to the regular members of the Committee, associate members are drawn from universities and other scientific centres for consultations, but they do not have the right of vote. The Upper Committee is headed by the Prime Minister, who is traditionally the Minister of Defence and thus gives the centre its dual role in meeting both civilian and military needs.

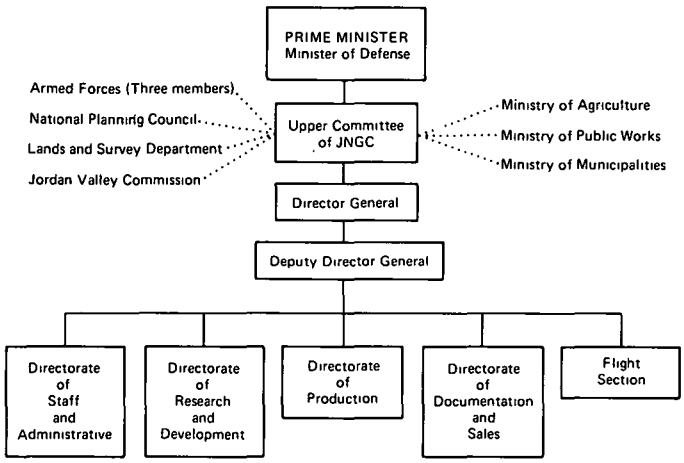



*Figure 36. Composition of Upper Committee of Jordan National Geographic Centre*

### Co-operation agreement between Jordan and France

The co-operation agreement between Jordan and France is summarized below.

The obligations of France under the agreement are:

(*a*) To train 104 Jordanian engineers and survey technicians in France for periods of from two to six years;

(*b*) To train 162–200 Jordanian survey technicians locally in Jordan and to provide two permanent experts for local training throughout the period of the agreement. France is also to provide up to 25 French experts for short periods of three or four months throughout the period of the agreement (75–100 man-months);

(*c*) To execute all projects needed in Jordan for the production of all types of maps, with the co-operation of JNGC;

(*d*) To make use of all available personnel and equipment at JNGC in order to lower the cost of the projects and to provide an additional opportunity for training Jordanian students locally;

(*e*) To carry out all projects at the same prices agreed upon for the mapping of southern Jordan in 1973, with an escalation of those prices as shown in the price indexes published by agencies officially recognized by the French or Jordanian authorities concerned;

(*f*) To make its best effort to assist in financing up to 80 per cent of any project given to France to perform.

The obligations of Jordan under the agreement are:

(*a*) To provide the necessary equipment and location for local training at the Military Survey Centre;

(*b*) To construct new, modern buildings for the Centre during the period of the co-operation agreement;

(*c*) To purchase the equipment needed for JNGC within the specified time-limit;

(*d*) To provide the French experts with accommodation and local transportation within the standards deemed reasonable by JNGC and to exempt those experts from all taxes, customs duties and other fees;

(*e*) To co-operate with other foreign mapping organizations on projects in Jordan only if those projects are not financed by Jordan.

## Five-year internal plan of the Centre

### *Personnel*

*Manpower requirements*

It is estimated that 420 employees in various trades and disciplines will be required for the Centre:

(*a*) The personnel needed for services, e.g., drivers, mechanics and chain-men, who can be recruited locally without special training, will account for 145 of the total;

(*b*) There are a number of military technicians and some survey specialists from the cadastre and other departments who would be useful after going through conversion courses in their particular specialties. From 21 to 42 technicians (7.5–15 per cent of the total technical staff) are already available;

(*c*) It is necessary to plan for additional personnel requirements because of failures, other circumstances and future needs which will result in the loss of trainees or the need for more trainees. For this purpose, 10 per cent of the total number of technical staff has been approved in the plan for the next period of from five to seven years;

(*d*) The number of personnel (286–306) to be trained in France and Jordan over the coming period of from five to seven years will be distributed as follows:

*France*: 46 engineers and 58 assistant engineers;

*Jordan*: 162 assistant engineers and 20–40 technicians who would take conversion courses.

*Employment plan*

A plan was formulated for the organization of recruiting programmes in order to show the stages of employment at the Centre. The recruiting schedule is given below in table 15.

**Table 15. Recruiting schedule for Jordan National Geographic Centre**

| *Type* | *1975* | *1976* | *1977* | *1978* | *1979* | *1980* | *1981–1984* |
|---|---|---|---|---|---|---|---|
| Engineer | – | 2 | 6 | 4 | 3 | 1 | 38 |
| Assistant engineer and technician | – | 20 | 62 | 56 | 73 | 29 | – |
| Students | | | | | | | |
| Jordan | 43 | – | 60 | – | 60 | Reserve | |
| France | 18 | 38 | 44 | | | | |
| Miscellaneous (non-technical) | 13 | 12 | 22 | 26 | 30 | 48 | Reserve |
| TOTAL | 74 | 72 | 194 | 86 | 166 | 72 | 38 |

### *Buildings*

The Centre will need specially designed buildings to meet the different requirements of each department. The total area required is estimated to be approximately 10,000 $m^2$ (useful area).

The cost is estimated to be approximately 1 million Jordanian dinars. A precasting system will be used and thus the estimated duration of construction activities will be reduced to 18 months.

### *Training*

Table 16 shows the training schedule for JNGC personnel, both in France and in Jordan.

Graduates will begin serving the Centre at the end of 1977.

**Table 16. Training schedule for personnel of Jordan National Geographic Centre**

| *Type* | *1975* | *1976* | *1977* | *1978* | *1979* | *1980* |
|---|---|---|---|---|---|---|
| Engineers—France | 18 | 21 | 7 | | Reserve | |
| Assistant Engineers—France | – | 17 | 41 | | Reserve | |
| Assistant engineers and technicians—Jordan | 43 | – | 60 | – | 60 | – |
| TOTAL | 61 | 38 | 107 | – | 60 | – |

# THE STATE OF CARTOGRAPHIC SERVICES IN THE LIBYAN ARAB JAMAHIRIYA*

*Paper presented by the Libyan Arab Jamahiriya*

## Background information

A national cartographic agency for the Libyan Arab Jamahiriya was established only in February 1968. At that time, it took the form of a small Surveying Office within the authority of the Ministry of Planning and Development. After it had been in existence one year, the Surveying Office was functioning slowly with the help of three technical staff members, but this number was increased gradually to 20 by the second anniversary of the establishment of the office.

The main duties of the Surveying Office were defined as follows: (*a*) to recruit technically qualified personnel at different levels; (*b*) to set long-term plans for the buildup of a competent Surveying Department; (*c*) to train nationals; (*d*) to supervise cartographic work done for the Government by private firms; (*e*) to execute small surveying jobs; and (*f*) to offer cartographic services and advice to different governmental agencies.

When the Surveying Office had been in operation 42 months, with fewer than 40 technical staff members, it became the Surveying Department of Libya. According to law, the Department consists of four technical divisions and one administrative and financial division, plus a research and planning office. The technical divisions are concerned with geodesy, photogrammetry, cadastre and cartography, respectively. The Cadastral Division, however, was left under the authority of the Department of Land Registration until the Surveying Department could build up an organization capable of carrying out the cadastre. Since its formation, the Surveying Department has undertaken the duties assigned to its precedent office, but with increased surveying activities and cartographic services. Efforts are continuously made by the Department in order to meet the increasing requirements for cartographic services in a rapidly developing country such as the Libyan Arab Jamahiriya.

The total area of the Libyan Arab Jamahiriya is approximately 1,775,500 km$^2$; its population is slightly over 2.5 million. Relatively populated areas, consequently, are limited to a narrow band along the coast of a width less than 100 km. The remaining area is a vast desert with scattered towns, villages, settlements, oilfields and oases.

Population distribution undoubtedly controls most of the development projects; consequently, it governs the type and location of base needed.

## Base maps

Since the early 1960s, the coastal band of the Libyan Arab Jamahiriya has been covered by topographic maps on the scale 1 : 50,000 (see figure 37), comprising 240 sheets of standard format sized 15′ × 15′. These maps were compiled from aerial photographs at 1 : 60,000 scale taken in 1956.

The same photographs were used for the compilation of the maps at 1 : 250,000 scale for the area north of latitude 28°. Each map has a standard format of 1.0° × 1.5° latitude and longitude increments, respectively.

Further, the entire country was covered by old Italian reconnaissance maps on the scale 1 : 400,000, as well as by the International Map of the World on the Millionth Scale (IMW).

On the large-scale side, all main cities and villages were covered by maps at either 1 : 1,000 or 1 : 2,000 scale for town-planning purposes, compiled from large-scale photographs taken during 1965.

The topographic maps at 1 : 50,000 scale were considered to be base maps of the country and they satisfied most of the needs. However after 1969 great changes took place and altered almost all aspects of life. Agricultural and industrial development projects began to spread everywhere, especially in remote areas. These projects are changing the face of the country, because they are accompanied by new roads, schemes, power-lines, stations, buildings and new settlement areas.

Accordingly, it was decided to initiate a topographic base map series on the scale 1 : 25,000, in order to cover the populated areas of the coastal belt, and to update the existing topographic maps at 1 : 50,000 scale.

Of the maps at 1 : 50,000 scale, 63 sheets have been updated and 16 new sheets of orthophoto maps with contour lines have been prepared.

## Geodetic net

The main horizontal ground control of the Libyan Arab Jamahiriya is a triangulation net which extends along the coastal belt, about 1,800 km in length (see figure 38). The net is computed on the International Ellipsoid and is connected to the European Datum. It was established by the United States Army Map Service in the late 1950s and includes 14 base lines which were direct sides of the net. Laplace points were sufficiently distributed along the net at approximately 200-km intervals.

A number of electronic distance-measuring (EDM) traverses cross the country, mainly from north to south; and three traverse loops cover the area of the southern borders. The sides of the Tellurometer traverses were kept below 40 km, with few exceptions, but never below 5 km, in order to have a uniform positional accuracy, astronomical azimuth was observed at every 100 km of progress.

Approximately 10,000 km of levelling lines are distributed throughout the country (see figure 39).

*The original text of this paper, prepared by the Surveying Department of the Libyan Arab Jamahiriya, appeared as document E/CONF.68/L.95.

For a number of reasons, however, efforts must still be made to improve the current situation of ground control. Such reasons include:

(*a*) The main horizontal ground control net is not strongly connected to the European Datum; consequently, accuracy is not uniform throughout the lengthy net;

(*b*) Some of the first-order trigonometrical stations and many of the lower order stations need to be recovered and strongly monumented;

(*c*) Many bench-marks have been destroyed because of the enlargement of roads;

(*d*) The main horizontal net is not strongly connected to neighbouring countries.

Accordingly, current plans have the following objectives:

(*a*) The establishment of a super-horizontal control network of uniform accuracy over the entire country (see figure 40);

(*b*) The establishment of horizontal control points of second- and third-order accuracy at 5-km intervals along the coastal band;

(*c*) The establishment of horizontal control points of second-order accuracy in the main cities at 2-km intervals with additional points of third-order accuracy at intervals not exceeding 500 m;

(*d*) The establishment of permanent bench-marks of first-, second- and third-order accuracy in the coastal belt in such a way that no location shall be more than 5 km away from a bench-mark, with dense bench-mark distribution in major cities.

All the above-mentioned objectives—probably exclud ing the first objective—appear to conform to the normal practice of surveying departments throughout the world. For a number of years, however, it has been thought that a unified accurate geodetic system would be beneficial because the astronomical fixing of different positions in the southern part of the country could produce relative errors of a few hundred metres in many cases, due to differences in the vertical deflection. There is no accurate geodetic connexion with neighbouring countries.

The super-horizontal control net will consist of 45 points spaced throughout the country at distances of 200–450 km. Each will be observed and positioned by the Doppler translocation method in the hope that an accuracy of less than a decimetre can be attained.

To control this accuracy, a first-order classical traverse of 3,000 km is being established to link the Doppler points. A report will be made on the accuracy and practicality of this method after completion of the project, probably later this year.

For the time being, 16 points needed for navigational aids for civil aviation have been established by the same Doppler translocation method; evaluation of the 1-m accuracy is in progress.

In remote areas, 115 new points will be determined by the Doppler translocation method, for use in the new mapping project at 1 : 250,000 scale.

### Grid system

The Universal Transverse Mercator (UTM) with a 6° zone width, a 0.9996 central scale factor and a 500,000-m easting constant has been in use in the country since 1956. This UTM grid system is adequate for medium- and small-scale mapping; but the scale distortion and the arc-to-chord ($t$-$T$) corrections at the edges of a UTM zone are too great for engineering surveys, cadastral surveys or large-scale mapping.

In order to avoid having two grid systems in the country—one for geodetic work and another for large-scale mapping—the Surveying Department decided to adopt a Transverse Mercator grid system with a 2° zone width, an initial scale factor of 0.9999, an easting constant of 200,000 m and a 15-km overlap area on both sides of any zone. The width of the overlap area is about 25 km. Some of the advantages of the newly adopted grid system are given below:

(*a*) Scale distortion never exceeds 1 : 10,000;

(*b*) The arc-to-chord is ($t$-$T$) correction for a line 1 km in length, even at the limits of the zone, is less than 1 sexagesimal second, a value which is smaller than the required accuracy for most observations of engineering or cadastral surveys; hence, it can be neglected;

(*c*) Variation of scale within the zone is less than 3 parts per million (ppm) and less than 6 ppm at the limits of the overlap area;

(*d*) The maximum error in an area, which is computed directly from grid co-ordinates, will not be more than 1 : 5,000. This error can be eliminated, however, by applying a simple correction factor for the district which includes the area considered.

The advantages of the new grid system will make the task of engineering surveys, cadastral surveys and large-scale mapping simpler within the frame of a unified grid system.

### Aerial photography and photogrammetry

Aerial photography has been used extensively for almost all mapping purposes, excluding some engineering project surveys of limited extent and the cadastral surveys taken to date. Figure 41 shows the main areas photographed in the past three years, minor areas of special projects are not shown. The photography scales primarily used are 1:25,000 and 1:40,000. From the cartographic point of view, the first photography scale will be adopted for plotting of the medium-scale base maps. To date, the other scale has been used for the purposes of photo-reading, photo-interpretation and mosaics at 1 : 50,000 scale (see figure 42).

Aerial photography on the scales 1 : 4,000, 1 : 6,000 and 1 : 15,000 also exist and were taken for such mapping purposes as town planning, harbour and airfield design, road design and agricultural reform studies.

All the aerial photography produces black-and-white 9 × 9 inch wide-angle photographs. Simultaneous photography of black and white and infra-red, however, is a normal practice for areas where hydrogeological studies or soil studies or classifications are needed.

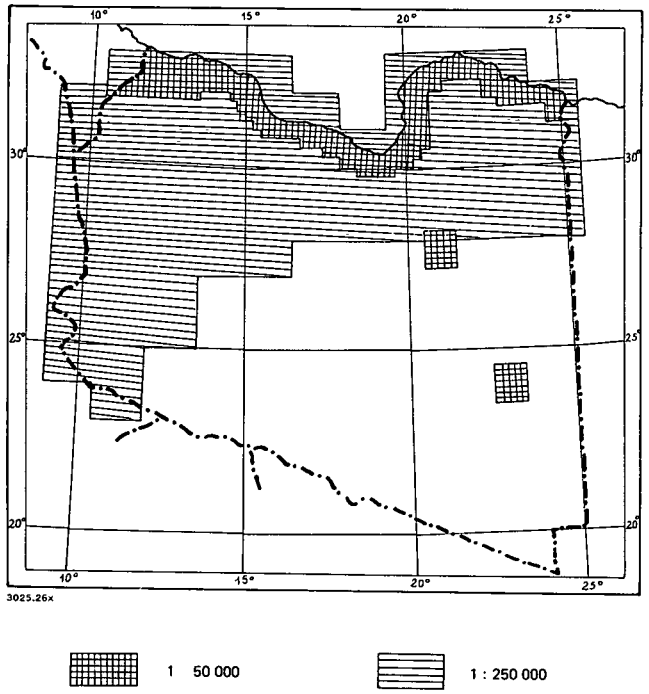



*Figure 37. Libyan Arab Jamahiriya: index of topographic maps*

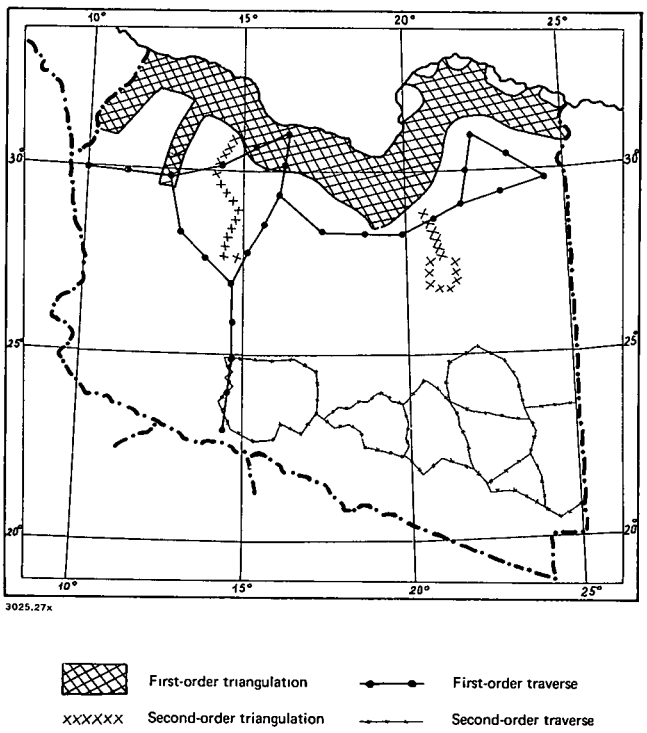



*Figure 38. Libyan Arab Jamahiriya: index of triangulation and traverse net*

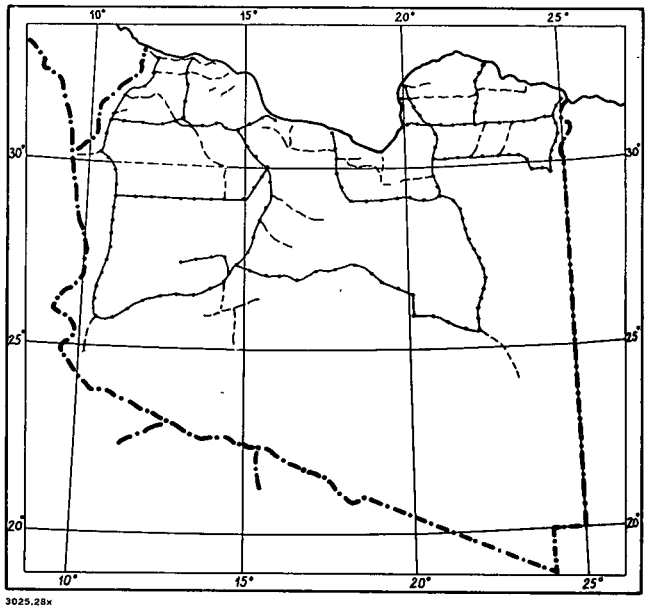



*Figure 39. Libyan Arab Jamahiriya: index of levelling net*

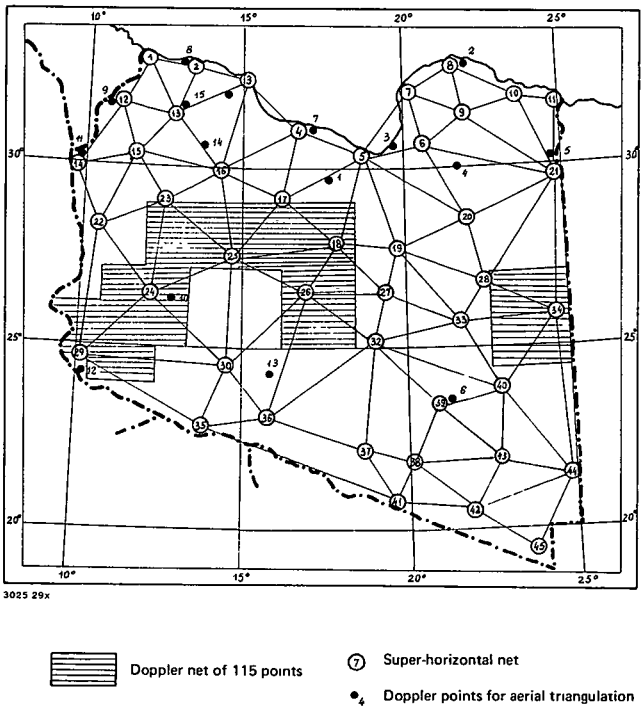



*Figure 40. Libyan Arab Jamahiriya: index of Doppler net including super-horizontal net*

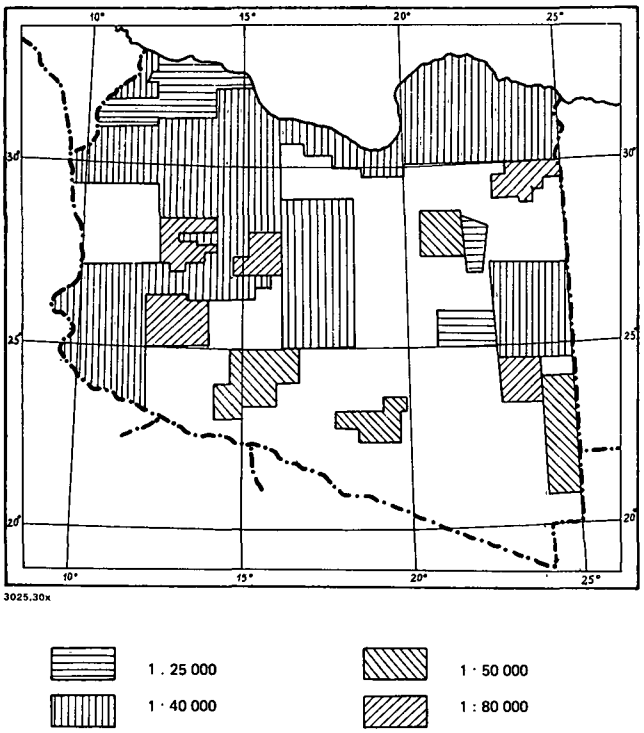



*Figure 41. Libyan Arab Jamahiriya: index of aerial photography*

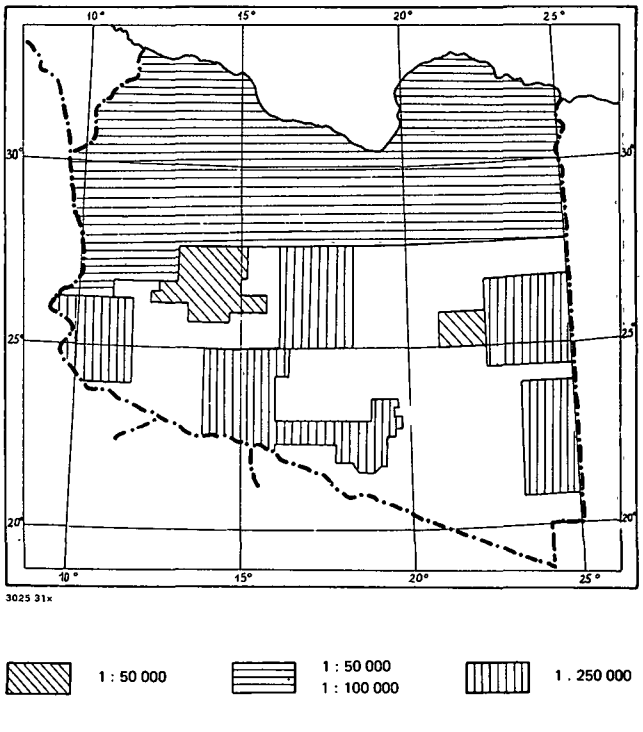



*Figure 42. Libyan Arab Jamahiriya: index of controlled mosaics*

Photographic missions have been carried out by private firms under the supervision of the Surveying Department of the Libyan Arab Jamahiriya and according to the specifications set by the Department.

Exposed films are processed at Tripoli in the laboratory of the Department.

Most of the photogrammetric plotting has been undertaken by private firms under the supervision of the Surveying Department. The photogrammetric division of the Department, however, has been equipped with the following instruments: 2 Wild A10 precision stereoplotters; 4 Zeiss Planimats; 2 Planicarts; 2 Kern PG 2 stereoplotting instruments; 1 Wild B8S topographic stereoplotter; 1 Wild STK-1 stereocomparator; 1 GZ-1 Gigas-Zeiss orthoprojector.

The first-order plotters are equipped with automatic registration devices such as typewriters and punch-card machines. Automatic registration was thought to be essential for aerial triangulation and the digitization of plotted maps, bearing in mind the possible automatic updating of maps.

Since the beginning of 1974, the Photogrammetric Division has been undertaking the following tasks:

(*a*) Testing and adoption of the most suitable solutions for the aerial triangulation strip-and-block adjustment;

(*b*) Updating of the urban maps at 1 : 1,000 scale using photographs at 1 : 4,000 scale taken in 1973 and 1976;

(*c*) Plotting of new topographic maps at 1 : 25,000 scale;

(*d*) Studying and testing of new numerical cadastral mapping methods on the scale 1 : 1,000 for suburban areas.

### Map-printing facilities

The map-printing facilities include: (*a*) a Klimsch cartographic camera with necessary accessories; (*b*) a two-colour Roland offset printing-press with accessories, such as a paper conditioner and cutter; (*c*) a small one-colour offset printing-press for forms, reports and small maps; and (*d*) Cromaline colour-printing facilities.

### Computation

The Computation Section of the Surveying Department is responsible for all computations for the Geodetic, Photogrammetric and Cadastral Divisions.

It has access to the IBM 370 computer of the Ministry of Planning and has acquired its own Programmable Data Processor (PDP 11/45) with 128,000-bit capacity.

The Surveying Department has begun to build up its own FORTRAN IV computer programming library which will meet all computational requirements of the Department.

### Remote sensing

Being well aware of the importance of remote-sensing for the inventory of natural resources, the Government

has set up the National Committee on Remote Sensing. The primary goal is to find practical applications for remote-sensing technology in the Libyan Arab Jamahiriya; and secondly, to follow up scientific and technological developments in this field. The Committee is publishing a journal, *Remote Sensing – Information*, to give those persons who are involved or are expected to be involved in the application of remote-sensing technology theoretical knowledge about remote sensing and to inform them about the experience of other countries in these fields.

The Surveying Department has been selected to participate in the LANDSAT follow-on programme No. 2815 designed to compare geophysical and satellite remote sensing in the southern part of the Libyan Arab Jamahiriya. This project will compare the results of field geology, aerial photo-interpretation and airborne geophysics with the use of space imagery over the same area. It is hoped that this study will contribute to the advancement of the application of remote-sensing technology in similar areas and will promote the application of remote-sensing techniques for the inventory of the natural resources of the Libyan Arab Jamahiriya.

The remote-sensing library of the Surveying Department already contains LANDSAT imagery covering the entire country, both in black and white and in colours, as negatives and as paper prints on different scales. The Department has a standing account with the data centre of the Earth Resources Observation System (EROS) to receive regularly new space imagery taken over the Libyan Arab Jamahiriya. In the near future, it is planned to develop the remote-sensing section and to provide it with the necessary equipment for processing and evaluating space imagery.

### Atlas

The Libyan Arab Jamahiriya will publish its first comprehensive national atlas which will consist of more than 100 pages. The atlas will be published in both Arabic and English and will be available late this year.

### Technical personnel and training

The technical staff of the Surveying Department comprises more than 100 qualified employees plus technical workers who are employed as helpers in the laboratories. Graduates of the civil engineering departments of the two universities in the country, who have had a reasonable amount of surveying courses, are attracted by construction jobs rather than surveying works.

The Surveying Department, however, adjusted itself to the national situation and hired graduates in mathematics and geography. Plans were drawn up to provide graduates in mathematics with special practical and educational training programmes in order to qualify them as photogrammetric and geodetic engineers and programmers. The graduates in geography, on the other hand, were given another training programme which incorporated both on-the-job training and formal education, in order to prepare them to specialize in either cartography or photo-interpretation.

On the lower technical level, the Department has hired graduates of the Institute of Applied Engineering of Tripoli, which is a four-year programme after preparatory school (i.e., after grade 9). Thus far, the Surveying Department has sent 51 students abroad for training and university studies: 28 to the United States of America; 7 to the Netherlands; 6 to the Federal Republic of Germany; 5 to Egypt; 3 to the United Kingdom of Great Britain and Northern Ireland; and 2 to Nigeria.

## CARTOGRAPHIC ACTIVITIES IN MALAYSIA, 1973–1976*

*Paper presented by Malaysia*

The Directorate of National Mapping of Malaysia, headed by the Director of National Mapping, is responsible for topographic and geodetic surveys, as well as the production and maintenance of topographic, political, town and road maps of the country for defence and development purposes.

The successful implementation of the second Malaysia development plan, 1971–1975, marked the outstanding role played by the Directorate in providing the base maps, plans and aerial photographs required both at the planning stage and in its implementation. It was estimated that 83 per cent of the land development target, equivalent to about 1 million acres, has been met.

With the launching of the third Malaysia plan, 1976–1980, the Directorate was expected to double its previous efforts and output. A sum of approximately 5 million Malaysian dollars ($M) has been allocated for the purchase of instruments and supportive equipment to help achieve this goal.

### Joint projects

A project to survey and demarcate the common international boundary between Malaysia and Thailand was undertaken jointly by the Directorate of National Mapping of Malaysia and the Royal Thai Survey Department. The task, divided into four phases, was begun in 1973; currently, approximately 96 km of the 576-km common land boundary have been surveyed and demarcated.

A similar project was also undertaken jointly by the

* The original text of this paper, prepared by Paul Foo, Director-General of Survey, Peninsular Malaysia/Director of National Mapping, Malaysia, appeared as document E/CONF.68/L.62.

Directorate of National Mapping of Malaysia and the Co-ordinating Board for National Survey and Mapping of Indonesia. It concerns the survey and demarcation of the approximately 1,800-km common land boundary of Malaysia (Sabah and Sarawak) and Indonesia (Kalimantan Timur and Kalimantan Barat). The task commenced in September 1975; and up to October 1976, approximately 216 km of the common boundary had been surveyed and demarcated[1].

In the field of cartography, the Directorate of National Mapping of Malaysia also participated in a regional joint project, namely, the compilation and publication of a nine-colour map of South-East Asia. This project was undertaken in connexion with the proposals made by members of the United Nations Divisional Group of Experts on Geographical Names, Asia South-East Division, of which Malaysia is the divisional representative.

### Triangulations

In Peninsular Malaysia, the existing triangulation network was considered adequate for current mapping purposes. Consequently, no major project was carried out to improve or strengthen the existing network. Furthermore, no proper analysis had yet been carried out to test the strength of that network. However, if the pace of development mapping permits, such an analysis will be made.

For the purpose of the Malaysia-Thailand border demarcation survey, extension of the existing network was carried out to fix major controls. Thus far, Phases I and II have been successfully executed based on the extension of the Fort Connexion.

As is well known, it is expensive to establish a triangulation network in a country and, therefore, it is of vital importance that the network be maintained because it is a national asset. Consequently, a considerable amount of work had been carried out to refix and reobserve the existing triangulated points which had been found to be either missing or destroyed.

A Geoceiver station was established at the Western Hill, Penang; and another was set up at the fundamental point and common datum of Peninsular Malaysia and Indonesia, at Pulau Pisang, Malaysia.

Each state in Peninsular Malaysia has its own co-ordinate system based on the Cassini-Soldner projection, but national mapping is based on that of the rectified skew orthomorphic projection. In order to have a unified system throughout the country, steps have been taken to work out all the transformation parameters for each state from the Cassini-Soldner projection to conform to the rectified skew orthomorphic projection.

[1] For a complete report on the project, see "A joint report on Indonesian and Malaysian activities in connexion with the survey and demarcation of the border between Indonesia (Kalimantan) and Malaysia (Sabah and Sarawak)", under agenda item 7(*a*).

### Geodetic surveys

No large-scale geodetic surveys of first-order accuracy have been undertaken. Work has been mainly concentrated on the breakdown from the primary stations for the purpose of regional mapping and other local uses.

For the survey of the international boundary between Sarawak and Kalimantan, three minor first-order control schemes were extended to the border. The control survey in the country was generally done by traversing, using electronic distance-measuring (EDM) equipment. However, the method of triangulation was also applied where convenient. A total of 591 stations were established, of which 426 stations were for short traverse lines of about 0.5 mile each along the main roads.

In Sabah, 248 second- and third-order stations were established. EDM equipment was used to measure 12,533 lines covering 3,503 miles.

### Levelling

Peninsular Malaysia is covered by a network of precise levels (geodetic double-line levelling), which consists of two lines of precise levels running the entire length of the country, one on the west coast and the other on the east coast, joined by an east-west line through the middle of the country. Precise levelling was begun in 1912 and was completed in 1967. Currently, most of the bench-marks have either been lost or destroyed; and hence investigations are under way to study the feasibility of relevelling the routes with possibilities of including new precise levelling routes.

The mean sea level was based on a datum at Port Kelang (Port Swettenham) in 1912. A new tide-gauge is being constructed at Chenering, Terengganu, on the east coast; and it was envisaged that more tide-gauges would be installed in the near future, some on the west coast and others on the east coast of Peninsular Malaysia.

The Tanjung Kidurong tide-gauge station in Sarawak had been in operation for only a few months when it was totally destroyed in the exceptionally heavy sea in December 1973. However, a reasonable mean sea level had been derived from the readings.

Another automatic tide-recording station has been constructed at Pulau Lakei in Sarawak. A total of two and one half years of recording is currently available; but the tide data have not yet been processed.

Second-order precise levelling networks have been completed in most of the major towns in Sarawak. Connexions were completed between Kuching and Sibu by way of Simanggang and Sarikei, and between Miri and Bintulu.

In Sabah, 569 bench-marks covering 366 miles were established. Primary tide-gauges were constructed in Kota Kinabalu and Sandakan, and secondaries in Labuan, Lahat Datu, Tawau and Semporna. Data were collected from 1976 and were not processed.

### Aerial photography

In 1974–1976, aerial photography at 1:25,000 scale was undertaken to cover most of Peninsular Malaysia. In

addition, photography at 1:10,000 scale was done for various towns. For land development projects, a total area of approximately 294,875 acres was photographed on the scales 1:20,000 and 1:25,000. Photographs were taken also for special projects, e.g. the Muda Dam project, the Johor Barat development project and Wilayah mapping, on scales ranging from 1:10,000 to 1:5,000.

The Lands and Surveys Department of Sarawak continues to charter an aircraft for a period of from six to seven months a year for its aerial photography programme. During the three-and-one-half-year period, nearly 60,000 square miles of photography were covered. The photography was flown at scales ranging from 1:3,000 to 1:40,000, to suit various purposes, such as mapping, land use, forest studies, planning, security and other general usage.

The Lands and Surveys Department of Sabah has covered 5,921 square miles at scales varying from 1:6,000 to 1:42,000.

### Map compilation

In Peninsular Malaysia, work is concentrated mainly on the mapping of the capital city of Kuala Lumpur—a Federal Territory. There are altogether 384 sheets on the scale 1 inch = 2 chains (1:1,584). Photogrammetric plotting has been intensively undertaken; 10 machines and 25 personnel have been employed in two shifts. A transparent overlay of cadastral information was also prepared for every sheet compiled by means of an automatic electronic plotter, the EAI 430 data plotter; 82 sheets covering approximately 28,700 acres were completed during the period under review.

The compilation of the maps (series L.905) of 44 towns in the first phase was completed. Preliminary work for compiling maps of 64 more towns in the second phase has begun. At the same time compilation work on 42 sheets of town maps in series L.808 has continued.

Compilation of several special development maps for the federal land development projects, the Muda Dam project and the Johor Barat development project on scales ranging from 1:5,000 to 1:10,000, also has continued.

During the period under review, Sabah mapped 1,361.3 square miles of its territory at 1:12,670 scale with 20–25-ft contour intervals; 63.5 square miles at 1:3,168 scale with 5–20-ft contour intervals; and 17.9 square miles at 1:792 scale with 5-ft contour intervals.

Work has also been undertaken for the mapping of military complex sites on the scale 1:1,584; an aerodrome obstruction chart at 1:10,000 scale; form-line mapping on the Malaysia-Indonesia boundary at 1:12,500 scale; and mapping of the Lahad Datu-Bakapit road at I:2,500 scale.

As for Sarawak, the general output of mapping since 1973 has increased tremendously, amounting to 1 million acres each year. A further 4.2 million acres have been drawn, mostly on the scales 1:25,000 and 1:10,000. The former scale was generally required for development purposes, and the latter was designed to cover the main towns and village settlements. Although most of these maps were only available in black-and-white drawings, they are to be printed under series T.834 and T.931 in future.

### Electronic Services Division

The Electronic Services Division was set up in 1969. An IBM 1130 computer was installed in December 1969. In 1973, the Division acquired an automatic plotter, the EAI 430/200 data plotter driven by an EAI PACER 100 computer with 16,000 bits of core memory. Other peripherals are a card-reader, a teletype terminal, a magnetic-tape deck and a digitizer. The main task then was to assist in clearing the backlog of cadastral plan drawing as well as in expediting the drawing of topographic and other maps. A cadastral plotting programme package was developed by the Division and the automatic plotting system was implemented in the same year. By the end of 1974, a total of 11,850 lots had been drawn by the machine.

In 1975, it was found necessary to enhance the EAI PACER 100 computer. An additional 16,000 bits of core memory were acquired. Additional peripherals are one off-line plotter, another magnetic-tape deck, two disc drives, a line-printer and another terminal with a graphic display unit. The enhanced system played an important part in the mapping of the Federal Territory of Kuala Lumpur.

Thus far, the Division has done cadastral computation for 220,500 lots, drawn 24,100 lots on cadastral plans and prepared 360 sheets of cadastral overlays for the Federal Territory (covering the entire area). It has begun work on the plotting of cadastral standard sheets covering the whole country.

### Map production

Map production is the responsibility of two divisions in the Directorate of National Mapping of Malaysia. The Cartographic Division is responsible for all cartographic work, from the stage of compiling source materials and data to the stage of preparing repro-mats for printing; the Photo-lithographic Division is responsible for all photo-lithographic work, including binding and mounting.

The two divisions also provide assistance to other government and statutory bodies in the production of thematic maps. The volume of map-sheets produced during the period under review is given in table 17.

### Equipment

A new building designed to house photogrammetric equipment under tough tropical conditions was scheduled for completion by mid-January 1977. A list of the additional computer, electronic, photogrammetric, cartographic and printing equipment acquired since the previous report[2] is given in table 18.

[2] "Report on Malaysia", *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*; vol. II, *Technical Papers* (United Nations publication, Sales No. E. 74.I.25), pp. 58–61.

**Table 17. Malaysia: map-sheets produced by Cartographic Division and Photo-lithographic Division April 1973–November 1976**

| | *Cartographic Division* | | *Photo-lithographic Division* | | | |
|---|---|---|---|---|---|---|
| | *Number of new map-sheets completed* | *Number of map-sheets revised* | *Number of new map-sheets printed* | *Number of revised map-sheets printed* | *Number of map-sheets reprinted without revision* | *Total number of copies printed* |
| Series L.7010 and L.707 1:63,360 | 8 | 36 | 8 | 36 | 197 | 1 496 900 |
| Series L.8010 1:25,000 | 22 | – | 22 | – | 47 | 158 700 |
| Series T.735 1:50,000 | 14 | 30 | 14 | 30 | 45 | 462 687 |
| Series L.905 and T.931 town maps, and L.808, various scales | 14 | – | 14 | – | 15 | 84 150 |
| Miscellaneous maps and charts | 2 | 25 | 2 | 25 | 100 | 386 530 |
| Thematic maps for other departments | 15 | – | 15 | – | – | 36 750 |

**Table 18. Malaysia: additional equipment acquired since March 1973**

| *Name of equipment* | *Number of units* | *Name of equipment* | *Number of units* |
|---|---|---|---|
| Wild DI3 Distomat | 6 | Hewlett-Packard 9820A electronic computer | 2 |
| AGA Geodimeter 76 | 8 | Flexowriter 4301 | 2 |
| Kern DM-1000 electro-optical distance counter | 4 | Burroughs L4112 computer | 1 |
| Kern PG-2 stereo plotting instrument | 2 | International Computer Ltd. 1028 paper-tape punch verifier | 4 |
| Wild PPO-8 orthophoto equipment | 1 | Morisawa MC 507 phototypesetting machine | 2 |
| Zeiss contact printer | 1 | Haag-Strait M6241 co-ordinatograph | 1 |
| Kern ER-1 co-ordinate read-out | 4 | Durst M700 enlarger | 1 |
| Macbeth reflection densitometer | 1 | Pakorol Super G.48-1 film processor | 1 |
| Zeiss aerial film processor | 1 | Precision line-up table | 1 |
| Zeiss aerial film dryer | 1 | Agfa Gaevert Repromaster 2000 and processor | 1 |
| Klimsch Sekant film cutter | 1 | Hasler-Signal film dryer | 1 |
| Zeiss radial secator | 1 | Statfile Rotray print-drying machine | 1 |
| Zeiss KG-30 contact printer | 1 | Rotaprint R30/90 offset printing machine | 1 |
| Radial line-plotter | 2 | Rotaprint plate-maker | 1 |
| Zeiss aerial film processor | 1 | Heliostar printing machine | 1 |
| Wild aerial film processor | 1 | Microfilm camera | 1 |
| Wild VG 1 enlarger | 1 | Microfilm reader | 1 |
| Wild RC 10 universal film camera | 1 | Multiplex reduction printer | 1 |
| Electronic Associates Incorporated Pacer 100 computer (with two 16,000-bit core memory banks) | 1 | U-Bix copier | 1 |
| Electronic Associates Incorporated 430/200 data plotter | 2 | | |
| Hewlett-Packard 9100B electronic computer | 1 | | |

## NATIONAL REPORT FOR NEPAL*

*Paper presented by Nepal*

Nepal has been divided into four development regions—the eastern, central, western and far-western regions—with the objective of providing equal opportunities to the people so that they may share equally in the fruits of development. Each region has launched various plans and programmes for its social and economic development. Therefore, since the Seventh Conference, the Survey Department of Nepal has been very active in the field of surveying and mapping in order to meet the demands for maps from the four development regions. The Topographic Survey Branch has been established within the existing Survey Department, with United Nations technical assistance; and the activities of the Geodetic Survey Branch (formerly the Trigonometrical Survey Branch) also have been expanded so as to be self-sufficient in the field of surveying and mapping.

* The original text of this paper, prepared by A. B. Basnyat, Director of Surveys, H.M.G. Survey Department, Kathmandu, Nepal, appeared as document E/CONF.68/L.111.

The Survey Department is composed of the Geodetic Survey Branch, the Cadastral Survey Branch, the Topographic Survey Branch and the Survey Training Centre.

## Geodetic Survey Branch

The Geodetic Survey Branch currently consists of three divisions: the Trigonometrical Division; the Astronomical Division; and the Levelling Division. The Branch is planning to establish a fourth—the Gravity Division—in the near future.

### *Trigonometrical Division*

*National grid system*

The Trigonometrical Division established the national grid system on the basis of the Universal Transverse Mercator (UTM) projection.

For cadastral purposes, the 3° belts were accepted, with central meridians of 81°, 84° and 87° East, using nomenclature of 44.0, 44.5, and 45.0 and with the scale factor 0.9999. For international connexions, the 6° belts were accepted, with central meridians of 81° and 87° East, using nomenclature of 44.0 and 45.0 and with the scale factor 0.9996. The metric system has been adopted for all purposes.

*Computation*

When the Division was established in 1969, there was no time to begin from the first-order network, which had been established mainly to supply control points for the cadastral survey.

The Survey of India had done triangulation work in Nepal in the 1950s, when making the topographic map on the scale 1 inch to 1 mile. The Survey of India had given assurances that the accuracy of the trigonometrical stations established by them in Nepal was sufficient for a breakdown into lower order stations for cadastral purposes, but the accuracy proved to vary from place to place. Occasionally, it fits quite reasonably, but sometimes it differs beyond the limit up to 20 m. A major problem in the computation work has been to find the best possible solution.

*Basic first-order network*

As Nepal is in need of a more modern and accurate triangulation network, a basic first-order network has been planned for the entire country. It consists of 39 stations, including 14 azimuth stations and 7 Laplace stations. Thirty stations had already been monumented, including Laplace and azimuth stations. Astronomical observations have been carried out since November 1976 (see subsection on astronomy). Measurements of distance have already been begun for the first-order network, using the laser Geodimeter model 8. As concerns angle observations, the branch is planning to have required the manpower and extra equipment in the near future.

In the basic first-order net, the distance varies from 32 to 61 km, and the height varies from 1,281 to 5,394 m.

*Equipment used*

For observing directions, the theodolites listed in table 19 will be used for the various orders of the network.

**Table 19. Nepal: theodolites used by Trigonometrical Division**

| *Theodolite* | *Order* |
|---|---|
| Wild T3 | Basic first-order framework<br>Second-order network |
| Wild T2 | Third-order network |
| Wild T16 | Fourth-order network and cadastral points |

Desk calculators are used for small calculations and Hewlett-Packard 1098A computers are used for complex calculations.

*Progress*

The progress made in setting up the trigonometrical survey is shown in table 20.

**Table 20. Nepal: progress in establishing trigonometrical stations**

| *Field season* | *Second- and third-order stations* | *Fourth-order stations* | *Total number of stations* |
|---|---|---|---|
| 1970–71 | 97 | 901 | 998 |
| 1971–72 | 223 | 2 830 | 3 053 |
| 1972–73 | 209 | 4 928 | 5 137 |
| 1973–74 | 273 | 5 313 | 5 586 |
| 1974–75 | 175 | 5 381 | 5 556 |
| 1975–76 | 187 | 5 530 | 6 057 |

### *Astronomical Division*

The Astronomical Division was recently established. The entire division is situated at Nagarkot, where the geodetic observatory is located (height, 2,166 m).

In the observatory, the Astronomical Division has installed an instrument called a "Circumzenithal", which is made in Czechoslovakia. The function of this instrument is just like that of a prismatic astrolabe. The Division expects to have the following additional equipment in the very near future: (*a*) an Omega chronograph with printer; (*b*) a Hewlett-Packard calculator model 67 (programmable, pocket-sized); (*c*) a radio for time signals.

Preliminary observations from the observatory have already begun, using manual chronometers for sidereal time and local time.

A geodetic expedition team of four experts from Czechoslovakia came to Nepal in November 1976, for a period of about five months. The expedition resulted from a bilateral agreement between the Government of Nepal and the Government of Czechoslovakia, concerning the provision of aid to Nepal. The expedition brought all the necessary equipment, including a Wild T4 theodolite.

The objective of the expedition is mainly to train the Nepalese counterparts for the geodetic observatory; and,

of course, to give the geodetic and astronomical co-ordinates, deviation of verticals, geodetic and astronomical azimuths, etc.

The expedition has completed half its work and it is expected to complete the field observation within another three months. The results of the observations are to be handed over to the Government of Nepal in September 1977.

*Levelling Division*

The Survey Department established the Levelling Division in 1974. Prior to that time, there were no first-order bench-marks in the country. For this reason, the Geodetic Survey Branch has established two first-order bench-marks as datum stations at two points on the Nepal-India border: Birgunj (longitude 84° 51′ 07″; latitude 27° 01′ 22″), height, 80.9 m; and Bhairawa (longitude 83° 27′ 10″; latitude 27° 30′ 22″), height, 104.6 m.

Through the co-operation of the Survey of India, these two points are now already connected to the Indian first-order network.

*Plan and progress*

The Levelling Division of the Geodetic Survey Branch has already completed the first-order levelling traverse from Birgunj up to Kathmandu (200 km) along the Tribhuvan Raj Path Highway. The plan calls for the traverse to be made along another alignment towards Bhairahawa, another given datum station for closing.

The Levelling Division also wishes to connect the network up to the Great Himalayas and plateau region in the north to the border of Nepal.

*Equipment*

In the levelling survey, the instrumentation and field procedure adopted are those outlined by the International Union of Geophysics and Geodesy (IUGG). The instrument used is the WILD N3 spirit-level with double-graduation invar staves.

*Corrections*

Apart from the well-known levelling corrections, the importance of the influence of levelling refraction and tidal corrections on levelling lines has been realized by the most countries. However, there are many controversies about this fact, and the Levelling Division is following the proposal of a Finnish geodesist, using refraction and tidal corrections only.

For field-book checking and making corrections, a Hewlett-Packard 9810A desk computer has been used.

CADASTRAL SURVEY BRANCH

The cadastral survey plan and programme have been systematically implemented since 1964, when the land reform programme was launched in Nepal for its economic development.

Nine survey parties work according to districts, each under a survey officer (gazetted officer). In each survey party, there are 80 surveyors as well as other supervisors; these surveyors are divided into the required number of teams according to the area of the district and the time needed to complete the survey.

*Working procedure*

The cadastral mapping-sheet is made of a plastic called "Permatress". The standard size of the sheet is 50 × 50 cm and its thickness is 0.003 inch. In each field-sheet, the Trigonometrical Division of the Geodetic Survey Branch provides from three to five plotted co-ordinates, depending upon the relief of the area.

These sheets are intended for use in the field by the cadastral survey teams; and after the survey is completed and checked, this field-copy will be traced in 0.002-inch thick Permatress. For all purposes, this trace copy will be used, and original field-copies will be stored for future reference if needed.

The branch, does not have any microfilming devices for storage of the field-copies and field-books, as there is no current need.

Classification of land is carried out simultaneously during the field survey and is recorded in the field-book. This task is done in presence of the local farmers who know the land well, as defined in the Land Survey and Measurement Act of 1963.

After completion of all the field-work, an ownership register and certificate will be prepared, and certificates will be issued to the landowners. This certificate is a guarantee of their ownership.

The scales of the cadastral plans vary from 1 : 500 to 1 : 2,500, according to land values and parcel areas.

*Objectives and Progress*

The goal of the Cadastral Survey Branch is to complete the survey of the 75 districts of the country, including the Tarai, the Inner Tarai, the Kathmandu Valley and the mountain region, by 1987. Thus far, the branch has completed the cadastral survey in 32 districts.

*System of registration*

In land transactions the land registration system is adopted where the cadastral survey has been completed. But private conveyancing and registration of deeds are still in practice in those areas of Nepal where the cadastral survey has not been completed.

*Equipment*

Watts microptic alidades and other necessary accessories for plane-table surveying are used for cadastral mapping.

*Topographic Survey Branch*

The Topographic Survey Branch was officially established in 1975 to carry out all the topographic activities in Nepal. The United Nations Development Programme (UNDP) appointed the project manager in 1975 to prepare a project document and to establish the Topographic Survey Project under the Survey Department, and to provide major equipment and expert services in all phases of topographic mapping.

*Past mapping activities*

The mapping and topographic surveying activities formerly were rather unco-ordinated and were carried

out in a piecemeal manner. Complete map coverage of the country for planning and administrative purposes was available only in two sheets from the 1924–1926 series at 1 : 506,880 scale (1 inch to 8 miles) and 19 sheets of the series on the scale 1 : 250,000.

In order to obtain a modern basic medium-scale topographic map coverage of Nepal, arrangements were made in the early 1950s under the Columbo Plan for the Survey of India to undertake the survey and publication of topographic maps of Nepal on the scale 1 : 63,360 (1 inch to 1 mile). The field-work was completed 15 years ago. The entire area of Nepal will be covered by 270 map-sheets, each sheet covering a 15′ × 15′ area. Up to January 1977, only 213 sheets (250 copies of each sheet) had been received. Revisions of these maps are badly needed for areas where development activities have accelerated over the past 15 years.

Six map-sheets of the Himalayan region on the scale 1 : 50,000 were compiled and published for mountaineers, by Kartographische Astalt Freytag-Berndt Und Artaric, Vienna, Austria. Limited copies of these maps are available locally at high prices.

Large-scale maps for irrigation, town planning, hydroelectric production and other development projects were prepared on the scales 1 : 2,000, 1 : 5,000 and 1 : 30,000; but they were made in an uncoordinated manner, with varying standards of accuracy. The surveying and instrumentation were all done in the same manner by the national and international private mapping organizations.

Thematic maps, such as forest maps, geological maps and soil maps, have been compiled by the respective government departments. However, complete coverage of the country does not exist. Some map-sheets have been printed by the local commercial press at Kathmandu.

*Current activities of the Topographic Survey Branch*

The main work of the Topographic Survey Branch is to meet the pressing demands of the country for basic topographic mapping at various scales; the Special Fund of UNDP is to provide $941,000 to assist in this project during the period 1975–1979.

Construction of the building for the Branch is nearly completed; currently, 3 United Nations personnel, 4 foreign volunteers and 85 national personnel are engaged in the Topographic Survey Branch.

Although procurement of major items of equipment from UNDP funds has been delayed, the Branch does have the following equipment; 17 theodolites; 5 levels; 8 alidades; 4 tacheometers; 2 desk-top programmable calculators; 1 Wild DI 35 electronic distancer; 2 stereoplotters; 2 plan variographs; 1 co-ordinatograph; 1 point transfer device; 1 electronic contact printer; 1 contact printer and other minor items. It is expected that, by the end of 1980 the Topographic Survey Branch will have all the other equipment required for mapping of the country.

*Map compilation*

To meet the need for administrative maps of the country, the following provisional administrative map-sheets have been published in Devanagari script:

(*a*) Regional maps at 1 : 500,000 scale, 4 sheets;

(*b*) Zonal maps at 1 : 250,000 scale, 15 sheets;

(*c*) District maps at 1 : 125,000 scale, 8 sheets;

(*d*) Map of Nepal at 1 : 100,000 scale, 1 sheet;

(*e*) Large-scale topographic plan at 1 : 2,500 scale, 25 sheets.

The small-scale maps were compiled from available medium-scale maps. Major roads, canals and administrative boundaries were updated by field revision, using satellite imageries.

The place-names were transliterated and verified with the Royal Gazette and with local authorities.

Large-scale mapping has been carried out by the traditional field-survey method, using traverse, trigonometrical control and plane-table and tacheometric surveying.

Maps are printed by a commercial press at Kathmandu. Drafting and colour-separation techniques are modified at the press.

The photogrammetric method of map compilation will be used in 1977 for training and experimental mapping on the scales 1 : 50,000, 1 : 25,000 and larger.

Some map-sheets at 1 inch to 1 mile will be revised in 1977. The Branch will be capable of providing aerial photographic service, topographic service, cartographic service and map-printing service to the Government of Nepal by the end of 1978. It is expected that by 1980 Nepalese personnel alone will be able to undertake any topographic mapping project in the country.

*Problems in current mapping*

The following problems have arisen with regard to current mapping:

(*a*) *Inaccurate maps*: inaccuracy has been noticed in the high Himalayas when the maps are compared with satellite imageries. River courses have changed in the south-eastern plains;

(*b*) *Map data exchange*: in order to compile atlases for schools and for the general public, it is essential to exchange maps and relevant data;

(*c*) *Control data*: as Nepal does not touch on a sea, it would expedite Nepalese mapping activities if height information were readily available near the border.

*Land-use mapping*

The Government of Nepal is expected to undertake land-use mapping of the country with the assistance of the Government of Canada. This project will be launched in three phases: aerial photography; land-use mapping of the far-western region; land-use mapping of the remainder of the country. The first phase of the project is expected to begin in October 1977.

## Survey Training Centre

The Survey Training Centre was established in 1967, in order to make proper arrangements for the training of personnel in survey techniques and methods, and then to

meet the requirements for skilled-technician level personnel.

The centre teaches three courses: the Recruit (*amin*) Course; the Junior Surveyor's Course; and the Senior Surveyor's Course. For advanced courses in surveying, Fellows are sent abroad.

Two instructors at the Survey Training Centre are provided by the Survey of India under the Colombo plan; the other staff members are Nepalese.

*Course discriptions*

The Recruit (*amin*) Course (C1) covers all that a field surveyor of a cadastral survey team should know. The trainees are taught large-scale plane-table surveys, establishment of property boundries from survey and other records, tracing of plans, measuring areas, classifying land, preparation of land registers and registration laws. This is an eight-month course which is scheduled twice a year, from 1 November to 30 June and from 15 July to 14 March. The entrance qualification for this course is class X completed with mathematics. In each term, 75 trainees are taken into the course.

In the Junior Surveyor's Course (C2) trainees are taught minor triangulation, tertiary traversing and levelling, chain surveying, large- and medium-scale plane-table surveys, contouring and draftsmanship. The entrance qualification for this course is matriculation or completed equivalent examination with mathematics, or a completed recruit course and five years of service in a survey organization. Approximately 30 trainees are admitted to this course. It is scheduled once a year, from 1 November to 31 October. The aim of this training is to enable one to act as a field-survey team leader of the cadastral survey, to be an observer of the trigonometrical field-survey team.

In the Senior Surveyor's Course (C3), training is given in various branches of surveying such as triangulation, traversing, levelling, medium- and small-scale plane-table surveys, contouring, aerial surveys, field astronomy and triangulation computation. This training enables them to act as field-team leaders or as assistant executive field-survey officers. The prerequisites of this course are completed intermediate science with mathematics or the Junior Surveyor's Course and the possession of stereoscopic vision. About 10 trainees are admitted to this course, which also is a one-year course, lasting from 1 November to 31 October.

The following equipment is used for training: Wild theodolites T1, T2 and T16; Watts telescopic alidades; plane-table; Indian clinometer; simple levels; rectangular plotting machine; parallax bar; slotted-templet machine.

## CARTOGRAPHIC ACTIVITIES IN NEW ZEALAND, 1973–1976*

*Paper presented by New Zealand*

This paper sets out the responsibilities for map and chart production in New Zealand and gives an indication of progress and development since the Seventh Conference in 1973.

### Cartographic activities of Department of Lands and Survey and Department of Scientific and Industrial Research

The Department of Lands and Survey, as the national survey and mapping organization, is responsible for:

(*a*) The Land Survey System, including all plan records, cadastral mapping, and maintenance and development of the network of ground marks;

(*b*) Triangulation and urban and rural control surveys, including precise levelling and selected earth deformation surveys;

(*c*) Topographic mapping for engineering purposes as well as for basic mapping;

(*d*) Aerial photography, with emphasis on regular coverage and the national index;

(*e*) Aeronautical charting;

(*f*) General mapping, including mapping for other government departments and agencies; thematic and special-purpose maps.

The Department of Lands and Survey is strongly decentralized, with 12 district offices and four suboffices spread throughout New Zealand. Attached to the head office are three branches providing specialized services in photogrammetry, cartography and computing, as well as a photo laboratory and a map holding and distribution centre. In addition, the cartographic staff of the Department are seconded to the Department of Scientific and Industrial Research, the organization responsible for the preparation and publication of geological, geophysical, oceanographic and soil surveys.

Mapping work related to forestry and forest management in New Zealand is undertaken by the New Zealand Forest Service, as detailed in the second section of this report; and hydrographic surveys and hydrographic charting are carried out by the Hydrographic Branch of the Royal New Zealand Navy, as described in the third section.

Most of the 14,000 plans added each year to the land survey records of the Department of Lands and Survey are produced by private practising surveyors, who undertake work for the State as well as for private land-holders.

* The original text of this paper, prepared by the Department of Lands and Survey, New Zealand, appeared as document E/CONF.68/L.36.

*Land survey system*

The conduct of cadastral surveys in New Zealand is defined or governed by survey regulations which are regularly updated to meet the changing needs of the land survey system. The introduction of a microfilm system and the change to the two-plan system provided an opportunity to update the regulations. With the more widespread use of computers and electronic distance-measuring (EDM) equipment in the private sector, the need to regulate the standards of measurement and to update survey practices is continuously under investigation.

*Triangulation and control surveys*

The development and introduction of new equipment and methods has permitted the basic triangulation system to be improved and extended more rapidly (see table 21) and economically. An increase in density of control has been necessary to allow large forest development and irrigation projects to proceed. The extension and upgrading of existing control in urban areas continues to receive high priority to meet heavy construction programmes in development; and intensified rural land use, road upgrading and special projects have intensified the need for upgraded and extended rural control in the form of precise traverses connected to existing triangulation.

The need for accurate height control continues and the precise-levelling programme has given priority to areas of national importance while striving to complete the network which will allow computation of a precise datum for New Zealand. This goal is now much closer; and with the new methods and improved equipment which have recently become available, improved progress is forecast.

Because of its fault patterns, New Zealand has a unique opportunity to participate in any projects which could help in the prediction of earthquakes or contribute to the study of earth deformation. To this end, the Department of Lands and Survey, in conjunction with the Department of Scientific and Industrial Research and the Royal Society, is co-operating to investigate a worthwhile number of patterns throughout New Zealand. Involvement of the Lands and Survey Department is in the establishment and regular monitoring of a series of narrow-belt first-order triangulation patterns throughout New Zeland and the measurement of a series of circuits or lines of precise levels across known active fault areas. Work has commenced on one narrow first-order triangulation belt across the centre of the North Island, between Raglan and Gisborne; and another major traverse is planned for completion in March, between Te Anau and Dunedin on the South Island. Further traverses are programmed later in 1977.

Precise-level circuits in the Rotorua Taupo region have been blocked and levelling is proceeding rapidly. New equipment, field techniques and computer facility have combined to give impetus to the work. Other traverses are scheduled in 1977, to consolidate an effective basis for monitoring in the volcanic and earthquake prevalent regions of the North Island. The Department of Lands and Survey has also participated in measuring several local earth deformation patterns over small active faults and monitoring of these faults will continue.

**Table 21. New Zealand: details of survey control for years ending 31 March**

| | *1974* | *1975* | *1976* |
|---|---|---|---|
| Triangulation (square kilometres) | 11 287 | 22 724 | 20 010 |
| Rural control traverse (kilometres) | 602 | 276 | 336 |
| Urban control traverse (kilometres) | 614 | 381 | 358 |
| Precise levelling (kilometres) | 388 | 381 | 421 |

*Basic mapping*

The basic topographic mapping of New Zealand at 1 inch to 1 mile has been completely published.

Metric mapping specifications have been prepared for an integrated series of topographic maps and cadastral records designed to upgrade existing maps to standards adequate to meet the needs of the future. The scales selected for the maps are 1 : 250,000; 1 : 50,000 and 1 : 10,000, with contour intervals of 20 m for the 1 : 50,000 series and 5 m for the 1 : 10,000 series. The 1 : 50,000 mapsheets will cover an area 30 × 40 km and are bled to the edge north and east.

The new maps are patterned on the New Zealand map grid which permits both the North and the South Island maps to be compiled on a single projection and co-ordinate system. Some 44,000 km$^2$ of new photogrammetric mapping has been completed at 1 : 25,000 scale and final drawing has commenced on maps on the scales 1 : 50,000 and 1 : 250,000.

*Engineering mapping*

Most project mapping requirements for all government agencies are now produced by photogrammetric methods. Scales range from 1 : 500 to 1 : 10,000. There has been special emphasis on hydroelectric investigation and irrigation schemes. To carry out this task and basic mapping work, five additional photogrammetric plotters have been purchased, as well as a stereocomparator. To further aid the programme, orthophoto equipment is on order.

*Cadastral maps*

New Zealand, with full cadastral coverage, has found value in having a counterpart cadastral map to match the topographic map at 1 inch to 1 mile. This principle is continued with the metric 1 : 50,000 and 1 : 10,000 maps. In urban areas, the cadastral record sheets break down to the scales 1 : 2,000 and 1 : 1,000. The larger scale cadastral record-sheets are subject to daily revision and will not be published, but plan prints of the revised sheet or of the line drawings only are available to the public in the new series throughout one third of the country. In the new metric cadastral series at 1 : 50,000 scale, 251 of the 312 sheets covering New Zealand either have been published or are well advanced in production.

With a sophisticated survey system and the ability to identify any property in New Zealand in terms of the New

Zealand map grid, the opportunity exists to establish a comprehensive computer-based land data information system and investigations towards this end are proceeding.

*Aerial photography*

The Department of Lands and Survey handles and co-ordinates aerial photography for all government needs. With full coverage achieved, the objective in recent years has been to recover rural areas at least every 10 years and urban areas every five years. Within that framework, priority is given to areas where new photography meets the greatest number of requirements, as ascertained from all government departments and public bodies. Some economy has been achieved by including non-Crown-copyright photography in the index of photography. As part of the metric change, the current scales for interpretation or resource photography are 1 : 50,000 and 1 : 25,000 for rural areas and 1 : 10,000 for urban areas.

*Remote sensing*

As an adjunct to the normal photogrammetric activities, the Department is investigating more sophisticated remote-sensing techniques utilizing both aircraft and satellite-borne sensing systems.

Through the Department of Scientific and Industrial Research, which is the central New Zealand agency for collaboration with the National Aeronautics and Space Administration (NASA) of the United States of America, New Zealand is participating in the LANDSAT-2 satellite programme. The LANDSAT imagery is being used in production of a new series of relief maps at 1 : 250,000 scale.

By applying the data received from such platforms in a quasi-operational programme of research, the Department of Lands and Survey is currently using satellite data to improve its small-scale revision techniques. Aircraft and satellite imagery is further being investigated as a data source for the land-use series of maps.

*Aeronautical charts*

All approach and landing charts are currently produced in an A5 size flip format. Separate publications are produced and maintained on a monthly basis for instrument, visual and South Pacific flight guides, as well as a flight guide for the Royal New Zealand Air Force. The period has been characterised by the large amount of joint civil/military charting. The 1 : 500,000 series has been redrawn to specifications of the International Civil Aviation Organization (ICAO) and features the military low-level routes as an overprint of the parent aeronautical chart.

*General, thematic and special-purpose maps*

During the period under review, a programme has been developed for maps to cover the area of interest of New Zealand in the South-western Pacific. The project includes both small-scale and large-scale maps and involves close liaison with Governments of Pacific islands and other authorities.

Small-scale maps of the Pacific Ocean and of the South-western Pacific have been published, and a number of Pacific islands having close ties with New Zealand have been mapped.

The land inventory mapping of New Zealand at 1 : 63,360 scale has not progressed and has been replaced by a more comprehensive land resources survey which is proceeding in specified regions of New Zealand. The publishing scale is generally 1 : 100,000.

A major series of geological and soil maps produced for the Department of Scientific and Industrial Research has in the past been on the scale 1 : 63,360. Because of the change to the new metric map grid, production has begun on a new series of maps on the scale 1 : 50,000. As an interim help to geologists wishing to identify localities of fossil finds and rock outcrops, all of the old NZMS.1 sheets have been overprinted with NZMS.260 sheet numbers, and metric grid and master copies are held for reference at the Science Information Division of the Department of Scientific and Industrial Research.

The National Resources Survey published by the Ministry of Works and Development has been discontinued.

Considerable cartographic effort was put into the New Zealand Atlas which was recently published by the Government Printer.

## Cartographic activities of New Zealand Forest Service

Mapping activities of the New Zealand Forest Service are primarily restricted to providing a wide range of services for departmental administrative, planning, scientific and publicity purposes.

The maps produced by the Department of Lands and Survey are utilized as the base for Forest Service publications wherever possible.

One map series, that concerning forest parks, is compiled jointly by agreement by both the Department of Lands and Survey and the Forest Service; all other map series are compiled variously in seven Conservancy Offices, the Forest Research Institute and the Head Office.

*Basic mapping*

Basic topographic stereoplots on the scale 1 : 10,000 are produced by the Department of Lands and Survey from survey controls established by either the Forest Service or the Department survey staff. Final map compilation is carried out in Conservancy Offices, and these maps form the basis for most departmental map records.

*Slope mapping*

An important quantitative parameter in forest planning is land slope. For forest management purposes, it is considered important to classify slopes in the ranges 0°–15°, 15°–25°, 25°–35° and over 35°.

A technique has been developed whereby land can be so classified accurately and quickly at the stage of compiling contour maps using photo-mechanical means. The method developed is sufficiently versatile to allow the calculation of any slope factor.

The same equipment can also be used to enhance finely drawn maps for reduction by photographic methods.

*Scientific mapping*

In scientific mapping emphasis is currently placed on the classification of all indigenous forest into 18 ecological classes and the publication in bulletin form of ecological-class maps on the scale 1 : 250,000. Twenty-six maps will cover New Zealand, and to date nine have been published.

A more detailed series on the scale 1 : 63,360, first commenced some 10 years ago, has been suspended in favour of completion of the 1 : 250,000 series.

Two maps on the scale 1 : 1,000,000, illustrating the ecological classification of indigenous forest grouped into eight "super" types, was published for the National Development Conference in 1973.

*Administration maps*

The main map of the administration map series is the conservancy map on the scale 1 : 250,000, illustrating cadastral information important to Forest Service activity.

Other maps in this category cover regional management proposals for forest development and communications and fire control maps. The compilation of maps of the latter category is being upgraded.

The need to examine fully and in detail the optimum land use, particularly in environmentally sensitive areas, when planning large-scale forestry projects has led to the development of "sieve planning" techniques.

*Public information maps*

The development of multiple-use forestry for recreation and other purposes has led to a need for public information maps, including forest park maps. Small brochure maps also are in demand for exotic forests being used for recreational purposes.

*Aerial photography*

Almost all forest maps and records are compiled from and maintained by aerial photography.

*Remote sensing*

The Forest Service is using a combination of LANDSAT imagery and 70-mm infra-red aerial photography to monitor desiccation of wind thrown forests on the Canterbury Plains, to assess the vigour of forest stands damaged by fire and to map the extent and distribution of disease (particularly *Dothistroma pini*) in forests.

HYDROGRAPHIC CHARTING

The Hydrographic Office of the Royal New Zealand Navy is responsible for the following activities:

(*a*) Hydrographic surveys of New Zealand coastal waters and adjacent ocean areas;

(*b*) Preparation and publication of navigational charts;

(*c*) Collection and publication of random sounding data from international sources for a large part of the South Pacific Ocean as part of the International Hydrographic Organization (IHO) General Bathymetric Chart of the Oceans;

(*d*) Production of international charts for areas of the South Pacific Ocean;

(*e*) Issuance of Weekly Notices to Mariners and promulgation of Long-range Navigational Warnings (NAVAREA 14);

(*f*) Distribution of New Zealand charts throughout the world and British Admiralty and Australian charts on an agency basis;

(*g*) Maintenance of national hydrographic and tidal archives;

(*h*) Maintenance of records of territorial waters and fishing zones, and publication of definitive charts.

The major survey unit is a replacement vessel, HMNZS *Monowai* (3,200 tons displacement), currently fitting out. This vessel has the full range of coastal and off-shore surveying equipment, with automated data-logging and plotting facilities. Two 72-foot survey motor launches are also employed on the in-shore surveys. The survey vessels have full capability for precision hydrographic surveys and the major unit has capacity for collection of selected geophysical data.

Since 1973, the Hydrographic Office has published 18 new charts and has revised and reprinted 110 charts. A chart correction service is maintained to ensure that all charts shall be corrected from Notices to Mariners, up to the date of issue. Charting is co-ordinated with Australia and the United Kingdom of Great Britain and Northern Ireland, in order to maintain integrated world coverage. Cartography is in accordance with the requirements of this arrangement and is generally in agreement with IHO resolutions.

Reproduction material is supplied to the United Kingdom Hydrographic Department in terms of the charting arrangement and internationally for those charts produced under the International Chart Scheme.

# CARTOGRAPHIC ACTIVITIES IN THE PHILIPPINES, 1973–1976*

*Prepared by the Philippines*

This paper presents the significant developments and progress in the cartographic activities of the Philippines since the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, held in 1973. It includes a brief statement on the preparatory meeting for the formation of the South China Sea Hydrographic Commission held at Manila.

## National Committee for Surveying and Mapping

Relevant to ever-changing social and economic conditions, surveying and mapping activities in the Philippines must necessarily keep up with and be responsive to the surge of development activities. One of the steps the Government has taken to execute the massive programmes for national development and to ensure economic progress is the institution of the integrated reorganization plan. Specifically, in the field of cartography, a national committee to co-ordinate and standardize surveying and mapping activities was organized and was directed to become an active participant in the task of nation-building.

The National Committee is composed of the Director of the Bureau of Coast and Geodetic Survey as chairman and the heads of 11 other government agencies with varying surveying and mapping capabilities as members. The committee members include representatives of the Department of Agrarian Reforms, Philippine Air Force, Office of the Chief of Engineers, Armed Forces of the Philippines and their mapping centre, National Irrigation Administration, Bureau of Forest Development, Bureau of Lands, Bureau of Mines, Department of Public Highways, Bureau of Public Works, Bureau of Soils and University of the Philippines Training Centre for Applied Geodesy and Photogrammetry.

The private surveying and mapping agencies also are represented on the committee and contribute substantially in the government programme for economic development. Involvement and co-ordination of both government and private sectors in regional development plans as well as in national economic programmes are indeed attributes mutually benefiting both sectors while in turn enhancing social and economic growth.

The principal advantages realized from the objectives of this arrangement are:

(*a*) Unity of effort in attaining the achievement of national goals;

(*b*) Greater flexibility in and better utilization of limited resources, giving rise to efficiency and economy;

(*c*) Better control and close adherence to adopted specifications and procedures resulting in the production of better quality charts and maps;

(*d*) Minimization of duplication of functions, resolution of divisive and interagency rivalries; enhancement of exchange of better ideas and transfer of technology; and maximum utilization of technical data.

## Geodesy and ground control

The primary triangulation network in the Philippines is of second-order accuracy and covers most parts of the country. However, there have been co-ordinated and continuing efforts, though limited in scope, to densify the horizontal controls for mapping purposes, in addition to extending controls, especially in regions selected for development. Moreover, coastal surveys in pursuance of bathymetric hydrographic activities and other control surveys executed in connexion with special mapping are, in most cases, linked to second- or third-order triangulation nets.

Plans are being prepared to connect the second-order triangulation network of the Philippines to the Unified World Geodetic Datum. In pursuance of this objective, the Philippine Government entered into a co-operative agreement with the Defense Mapping Agency of the United States of America, for the observation of selected stations by Geoceivers using the Doppler method of satellite observations. Existing and easily accessible triangulation stations were occupied by a team including an observer from the United States Naval Oceanographic Office, and officers and men from the Philippine Bureau of Coast and Geodetic Survey. Thus far, 31 stations have been occupied and observed in central and southern Luzon.

## Development projects

The importance of detailed surveys and large-scale maps has never before been so appreciated. A number of these surveys have been completed for infrastructure projects, flood control, irrigation, highways, resettlement; complex site, ports and harbour development; and off-shore exploration.

The Bureau of Coast and Geodetic Survey, in cooperation and co-ordination with other government agencies, has completed the extensive survey and mapping of the Bicol River basin and Laguna Lake shore area development projects. The areas surveyed cover approximately 150,000 ha (544 square (statute) miles). The objective of these multipurpose projects is to integrate all socio-economic plans and programmes for the agro-industrial development of the two regions. The survey and mapping activities in these two projects, which took more than three years to complete, involved horizontal and vertical control surveys, photo mapping and stereo compilation of large-scale topographic maps. Considered one of the significant contributions of the Bureau to the economic development of the country, these extensive projects integrate productive utility of land for agricul-

* The original of this paper, prepared by the Philippine Coast and Geodetic Survey, appeared as document E/CONF.68/L.60.

ture and industry, and water resources for irrigation and hydroelectric power.

The first phase of development work conducted in the Bicol River basin project was a massive combined operation of different survey and mapping activities. At first, for the horizontal control of the selected and identified photo-control points, the triangulation net in the area was densified, extended and connected to primary horizontal controls. First-order levelling was extended to Bato, Camarines Sur, Polangui in Albay and Basud in Camarines Norte from Naga City, which provided the vertical controls for the area. The navigable portion of the Bicol River was likewise surveyed for the study of its potential utility in the area development.

Similarly, the Laguna Lake shore development project was surveyed in the same manner, as the operation proved expeditious under existing conditions. Triangulation networks were extended to cover the entire shore area for the horizontal control of aerial photograph points. Vertical control was provided by the precise levelling running through the towns bordering the lake.

In both projects, the topographic mapping was undertaken using photogrammetric methods, and field checking and editing were conducted to verify the finished map compilations.

Hydrographic surveys of a number of harbours were also undertaken for enhancing industrial development. The revision survey of Mariveles harbour in Bataan facilitated the development of the export-processing zone and expansion of the shipbuilding, repair and dry-docking facilities of the harbour. The surveys executed at Villanueva, Misamis Oriental, facilitated the construction of a pier and a sintering plant and enhanced the development of an industrial complex in the area. The revision surveys of the port of Davao paved the way for the expansion of Sasa wharf and the improvement of the Santa Ana piers. Surveys were also conducted at Looc, Samar, for determining a suitable site for a ferry landing linking the Pan Philippine Highway. The surveys conducted in Coral Bay and in the Tuba River approaches at Bataraza, Palawan, aided the development of ports and harbour facilities in the area and the exportation of the nickel and other minerals mined in the region.

Other hydrographic and oceanographic surveys of varying magnitudes but of no less significance to national interest were conducted with respect to marine pollution, development of aquatic resources, sea-bed and subsoil explorations, nuclear power-plant site, lay-up sites for supertankers and oceanographic investigations for ecological studies.

### Aerial photography and photogrammetry

The 7,000 islands of the Philippines, with a total land area of 30 million ha, are about 90 per cent covered by aerial photography of good cartographic quality. Modernization paid off in dividends in making it possible for these photographs to be utilized in surveying for specific purposes, such as irrigation, flood control and other infrastructure projects. Currently, these aerial photographs are widely used in connexion with the "operation land transfer" of the national land reform programme. Thousands have already been benefited from this innovation in mapping. It is for this reason that parcellary mapping of landed estates is being pursued for distribution to tenant farmers. Parcellary maps are drawn at 1:4,000 scale, showing graphically the relative positions, shapes and area of farm lots. In addition, with over a million patents issued for 4.6 million ha, the Government has released vast tracts of idle alienable lands for productive use.

### Mapping for irrigation

For irrigation projects, the National Irrigation Administration (NIA) has completed aerial photography on the scale 1:8,000 of about 842,000 ha of arable land. Topographic surveys of the irrigation project area have been completed on the scale 1:4,000 with 1-m and 0.5-m contour intervals for irrigation service areas; on the scale 1:2,000 with 2-m contour intervals for dam areas; and on the scale 1:4,000 with 5-m contour intervals for reservoir areas. All were produced by photogrammetric processes, using recent aerial photographs on the scale 1:8,000 and Department of Agrarian Reform aerial photographs on the scale 1:15,000 for a total coverage of about 581,700 ha.

By the ground or the conventional method of topographic mapping, NIA has completed a total area of about 180,000 ha at 1:4,500 scale. All horizontal and vertical ground controls established were of third-order accuracy to meet NIA mapping requirements.

### Cadastral surveys

The cadastral survey of the Bureau of Land has been progressing satisfactorily and issuance of land patents has been accelerated tremendously in consonance with the objectives of the land reform programme. The cadastral surveys completed during the past three years totalled about 241,770 parcels covering an area of some 301,317 ha in 36 municipalities. Cadastral surveys totalled 356,108 parcels with a coverage of about 451,887 ha in 49 municipalities. The surveys undertaken for public-land subdivisions include 61,535 parcels with an area of 79,056 ha in 14 municipalities. Secondary controls were also executed by the Bureau of Lands, and 3,786 *barrio* boundary monuments were laid out and 619 municipal boundary monuments were established.

The Bureau of Lands is committed to produce 10,000 sheets of photo maps on the scale 1:4,000 covering 4 million ha of tenanted rice and corn lands. Of this total, 1,671 sheets were produced for the first 10 months ending June 1976.

The Department of Agrarian Reform has completed land-capability and land-classification mapping of a project area in central Luzon. Covering an area of approximately 789,000 ha, the project calls specifically for the original compilation of map data showing physical, social and economic land uses to effect the implementation of the various aspects of the agrarian reform programme. To meet the demands of the project expe-

ditiously, photogrammetric processes have been applied to advantage. Aerial photographs on the scale 1 : 15,000 were used in the stereo compilation. The photo-interpretation technique as applied to the study of soil type, slope drainage patterns, current land use and agricultural capability was further supplemented by extensive field investigation and verification.

### South China Sea Hydrographic Commission

In August 1976, the Government of the Philippines, through the Bureau of Coast and Geodetic Survey, hosted the preparatory meeting for the formation of the South China Sea Hydrographic Commission. Its objective is the co-operative charting of the South China Sea by the countries of South-East Asia which border that body of water. This meeting was considered significant in that it laid the groundwork for the early formation of the commission. It was anticipated that the commission would open an era in co-operative venture for joint surveys or projects beneficial to the developing countries of the region in order to facilitate international shipping, safety in navigation, exploitation of marine resources and studies of allied disciplines.

Since the inception of this commission in 1964 when it was presented at the Fourth United Nations Regional Cartographic Conference for Asia and the Far East, it did not again receive serious attention until 1967 and 1970. At the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, held at Tehran in 1970, resolution No. 28 was adopted for the formation of the Commission. It is in pursuance of this resolution that the early formation of this commission is being worked out. More importantly, the pressing needs of the millions of people in this part of the world demand that the sea and its resources be tapped and utilized for the amelioration of the living conditions of the people in the region. Preparations are under way for the first conference and inaugural meeting of the South China Sea Hydrographic Commission to be held at Manila in the early part of 1977.

## CARTOGRAPHIC ACTIVITIES IN MACAO*

*Paper presented by Portugal*

### The territory of Macao

Since the end of the sixteenth century, this Chinese territory has been under Portuguese administration; it currently comprises the small peninsula of Macao with an area of 5.4 $km^2$, and the islands of Taipa (3.5 $km^2$) and Coloane (6.6 $km^2$).

In the beginning, such a small territory did not require the terrestrial cartographic studies capable of providing it with large-scale charts and plans. It was necessary, however, to prepare successive hydrographic charts as the ports are constantly silted due to the situation of Macao in the delta of two important rivers—the Pearl River (Chu Kiang) and the West River (Si Kiang)—which bring in large quantities of sediment.

### Activities

Therefore, cartographic activities in Macao never had the support of an organized, well-equipped department for such objectives. These works were undertaken by the Navy, the Army or the Public Works Department.

Under these conditions, each body was concerned only with its own immediate or specific interests; and the current Government decided to establish a department to meet all the requirements of Macao.

This department will also be responsible for the training of topographic staff, the study of the deformation of bridges and dams, and renewal of the local geodetic network.

### Historical notes

The oldest chart found dates back in 1772 and was prepared by Custodio de Azevedo Rendo. Subsequent hydrographic surveys were done in 1796, 1829, 1865, 1883, 1904, 1907, 1920, 1928, 1935, 1946, 1948 and 1954.

In 1965, a more complete work was undertaken in which the geodetic network, established in 1907 and reformed in 1956, was redone on the scale 1 : 2,000 to assist the survey of Taipa and Coloane islands.

In 1938, two naval air pilots, Freitas Ribeiro and Correia de Barros, made the photographic coverage of Macao, using the Nistri camera, type AGR and the focus distance of 210 mm, size 131 × 8. The approximate scale of this photography is 1 : 5,000, and it was taken by a lateral superposition of 25 per cent and longitudinal of 50 per cent. However, the photography was not used.

### Current plans

Towards the end of 1975, the current Government of Macao began to organize a department and to equip the Escola de Topografia e Cadastro (Topography School) which was formed at the time. The first course began in October of the same year. At the end of October 1976, after an intensive one-year course, there were 13 topographers, one who will be sent to Switzerland to study at the Swiss School for Photogrammetric Operators.

In 1976, The Topography School began two courses—one in Portuguese and the other in Chinese and English for Chinese citizens.

The preparation can be considered good, except in the field of photogrammetry, where the lack of material

* The original text of this paper appeared as document E/CONF.68/L.106.

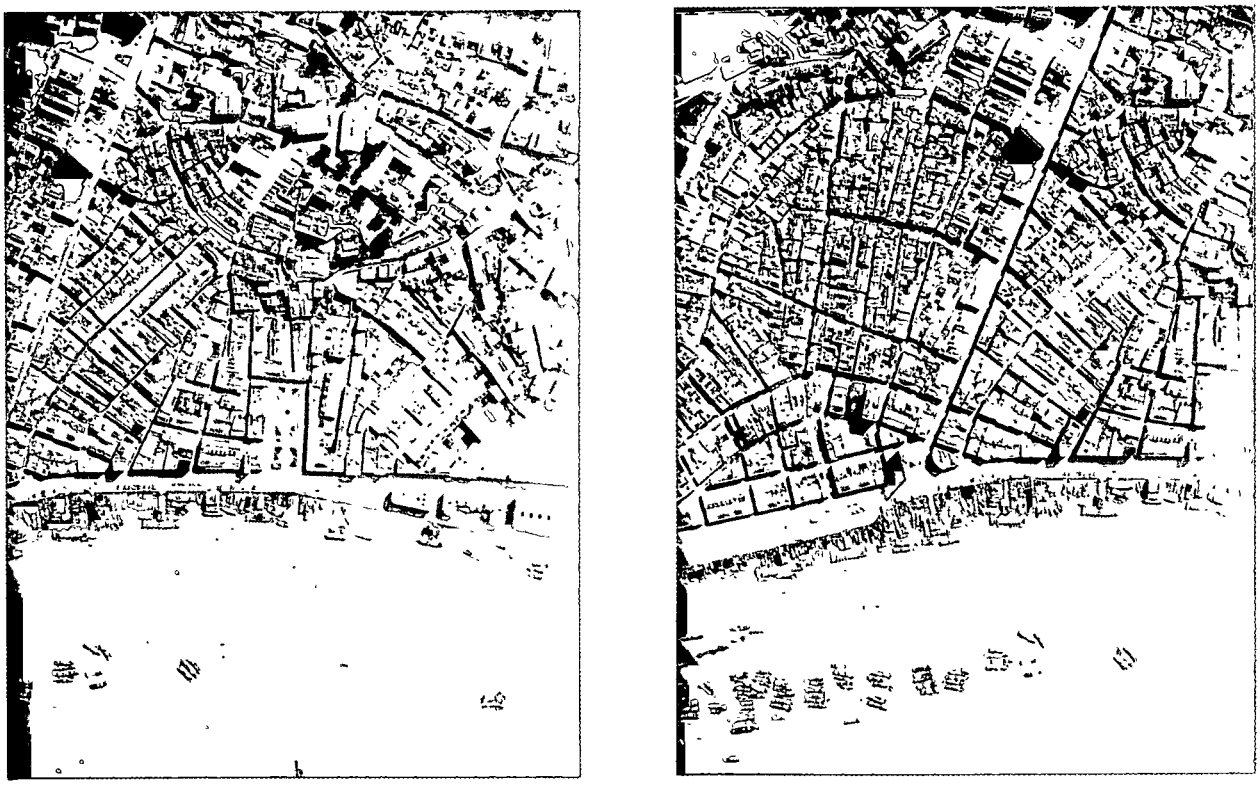


*Figure 43. Portugal/Macao: stereo-photographic pair of Macao harbour*

means does not permit the school to give more than a general idea, with slight training in stereoscopic vision and photo-interpretation.

## Geodesy

The geodetic network was remade and improved from corresponding sides to second and third orders. Two geodetic points are shown in figures 44 and 45.[1] The accuracy of the connecting side of the figure of amplification base to the network was only $\pm 0.04$.

Although such accuracy may have been sufficient for the works of that time, it is no longer adequate, as it does not guarantee the necessary accuracy for the calculation of the support vertices of a new network, having in mind the urbanization plans and the study of the behaviour of the bridges and dams.

In these conditions, these sides are being remeasured with a Wild DI3S which will guarantee its accuracy within the desired limits for a city of about 300,000 inhabitants, that is, with errors less than 1 cm per kilometre.

The origin of the co-ordinates is a point of the ocean south-west of Coloane; in this way, the entire territory is situated in the first quadrant of the considered axis system.

Because of the small dimensions of the territory, the system was considered equivalent to a equidistant azimuthal projection, therefore, it does not have corrections due to deformation of the projection.

It would be of great interest to Macao to connect this small network to the geodetic network of China.

Everything is prepared for the photogrammetric charts on the scale 1 : 1,000, bearing in mind the execution of new urbanization plans and expecting at all times to find the solution of the overflying problem.

As concerns altimetry, after a period in which the adopted origins varied with the executants, all the altitudes were referred to the sea level, which was not difficult as since 1925 there has been an excellent tide-gauge which has always been kept in perfect order. From 1925 to 1964, the monthly and annual mean level was thus calculated.

This tide-gauge was moved to a more suitable place on the wharf and the altimetric connexion between its former and its new position has already been made.

The tides in Macao are of a semi-daily type which is very similar to the mixed type.

But the altimetric connexions of Macao with Taipa and Coloane were never made perfectly. Only after the construction of the Macao-Taipa Bridge was it possible to

[1] Certain unnumbered figures have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figures 44 and 45 are in this pocket.

complete the altimetric connexion of Macao and the islands by levelling of geometrical accuracy.

It would be very advantageous to complete these studies, either by planimetry or altimetry. Even those related to the continental platform had to be done with the co-operation of the authorities of China.

It was the intention of the Government to make gravimetric observations which would be connected to the universal network through the Hong Kong mark, but to date it has not been possible.

## SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH: INFORMATION REPORT OF THE WORKING GROUP ON GEODESY AND CARTOGRAPHY*

*Paper presented by the Scientific Committee on Antarctic Research*

The Scientific Committee for Antarctic Research (SCAR) is a special committee of the International Council of Scientific Unions (ICSU).

For a number of years, SCAR has had nine active permanent working groups: Biology; Geodesy and Cartography; Geology; Glaciology; Logistics; Meteorology; Oceanography; Solid Earth Physics; and Upper Atmosphere Physics. A new working group, Human Biology and Medicine, was formed in 1974.

Each working group conducts its work mainly by correspondence through an elected secretary. The groups have autonomous powers of internal organization, including election of officers and appointment of subcommittees. As a general rule, working groups meet at the times of regular SCAR meetings; periods between the meeting of working groups vary, but are normally at from four- to six-year intervals, that is, every second or third SCAR meeting. Copies of circulars issued by working group secretaries to their members are sent to the secretariat of SCAR, and reports of activities are submitted to SCAR meetings.

The working group discussed in this paper came into being at the third meeting of SCAR, at Canberra in March 1959, with George R. Laclavere of France as Chairman and Bruce P. Lambert of Australia as Secretary. After comprehensive discussions on mapping techniques and specifications, co-ordination of activities, interchange of source material and standardization of map symbols, the working group made certain recommendations which were formally approved by SCAR.

Those recommendations have since been modified and amplified at succeeding working group meetings, which have been held at Cambridge, United Kingdom, 1960; Wellington, New Zealand, 1961; Paris, France, 1964; and Oslo, Norway, 1970. At the meeting in 1960, the word "geodesy" was added to the name of the working group.

In 1962, the working group's map symbols were accepted by the United Nations Technical Conference on the International Map of the World, which specified:

> "In polar or similar regions, and particularly within the area covered by the Antarctic Treaty, i.e., south of 60° south latitude, symbols and content should conform to the specifications of the Special Committee on Antarctic Research (SCAR)."[1]

The Secretary of the working group publishes, on behalf of SCAR, a catalogue of topographic maps, aeronautical and hydrographic charts produced by member countries. The catalogue is kept up to date by periodical issues of lists of new maps and charts and revised editions. A fourth edition of the catalogue was published in 1974 and revised in May 1976.

The secretary also prepares, at five-year intervals, general reports of the group's survey and cartographic activities and specifically reports at four-year intervals, to the assemblies of the International Association of Geodesy, on geodetic activities in Antarctica.

### Progress in geodesy and cartography

Although topographic mapping of Antarctica was not included in the official programme of the International Geophysical Year (1957), a considerable amount of survey work was done by the countries that took part in Antarctic research. This work was inevitable, as accurate and detailed maps were found to be necessary for the planning of scientific studies and for navigation of aircraft and field parties operating at a distance from their bases. Since that time, there has been much cartographic and geodetic activity.

Extensive mapping operations have been undertaken in Antarctica by Australia, Japan, New Zealand, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America. Most of the remaining SCAR member countries have made some contributions to the mapping of the continent and of the sub-Antarctic islands.

By the end of 1959, large areas of the continent had been photographed from the air and reconnaissance-type maps were available for most of the major features. To this stage, geodetic survey activity in Antarctica consisted

* The original text of this paper appeared as document E/CONF.68/L.92.

[1] *United Nations Technical Conference on the International Map of the World on the Millionth Scale, Bonn, 1962*; vol. II, *Specifications of the International Map of the World on the Millionth Scale (IMW)* (United Nations publication, Sales No. 63.I.20), p. 15.

mainly of independent astronomical determination of geographical positions to establish mapping control (often by daylight star observations). The relatively very small extent of rigid triangulation accomplished by the late 1950s was largely confined to the environs of scientific bases. Transportation at this time was mainly by dog-sled and snow-tractor.

In the course of topographic mapping, considerable use has been made of aerial photography (vertical and oblique), both from fixed-wing and from rotary aircraft, but the applications of satellite technology to the mapping of Antarctica has been advanced by the advent of the LANDSAT satellites which have been programmed to yield high-resolution imagery, providing basic data for planimetric mapping of most of the continent, at small and medium scales. The imagery is particularly valuable in the mapping of sea-ice conditions and of large areas of relatively inaccessible regions of the continent. A number of members of the working group are now using the imagery for mapping operations at 1 : 250,000 and smaller scales.

Aerial photography and airborne terrain profiling are both still being used to supplement this mapping from satellite imagery and to provide vertical information for contouring to varying degrees of accuracy. However, future satellites that are planned to provide altimetry may make a significant contribution to the portrayal of relief.

In recent years, extensive airborne surveys have been undertaken using radio methods for penetration of the ice surface and production of terrain profiles of the land surface beneath the ice mass. The Scott Polar Institute (United Kingdom) has been very active in these surveys with the aid of considerable air transportation provided by the authorities of the United States of America.

Several countries have produced or are producing an Atlas of the Antarctic, notably the USSR and the United States.

Since 1960, extensive use has been made of electromagnetic distance-measuring equipment to establish survey control by traversing and trilateration; and with the increased use of aircraft support for field parties, geodetic networks have been established over extensive coastal regions and mountainous areas of the hinterland of Antarctica. The United States of America has extended survey control from Oates Land along the full length of the Trans Antarctic Mountains, in the coastal regions of Ellsworth Land, in Marie Byrd Land and in other isolated areas. The United Kingdom has covered most of the Antarctic peninsula. The Soviet Union has completed a traverse survey from Mirny to Vostock, to the Pole of Inaccessibility, to Molodezhnaya. Australia has surveyed from Davis through the Prince Charles Mountains to Mawson, thence to Enderby Land and Molodezhnaya. Local control surveys and mapping have been undertaken by France, Japan and South Africa; and in earlier days, by Belgium and Norway.

These geodetic and mapping control surveys have been supplemented by a great number of geophysical (gravity and seismic) traverses that have literally criss-crossed the continent. Most member countries have participated and contributed in varying degrees to the determination of the elevation of the ice surface and of the sub-ice land surface.

The advent of satellite geodesy in Antarctica occurred in 1969, with the setting-up of four United States geodetic satellite observation stations on the continent to link Antarctica with the world-wide network of stations. Following the important first step towards the creation of a geodetic network over the whole of the continent, continuing programmes of satellite observations have been maintained. Technology has now progressed to the development and practical application of Doppler satellite equipment of the United States Navy Navigation Satellite (NAVSAT), capable of establishing the precise geographical position and elevation in good or adverse weather conditions. Use of this technique is rapidly expanding and its potential for mapping control, and for geophysical and glaciological investigations in Antarctica, suggests that it will eventually come into widespread use. The USSR is undertaking a programme of optical observations of satellites for geodetic purposes.

A limited amount of hydrographic charting and oceanographic survey in Antarctic waters has been completed, with contributions coming from Argentina, Belgium, Chile, Japan, New Zealand, the Soviet Union, the United Kingdom and the United States of America.

## The future

The existence of SCAR in combination with the Antarctic Treaty has brought about very practical co-operation between the countries that are carrying out scientific operations within the Antarctic region. Specifically, worthwhile progress has been achieved in geodesy and cartography, and a very significant degree of co-ordination has been achieved with an absolute minimum of administrative effort. The members of the SCAR Working Group on Geodesy and Cartography look forward confidently to the time when their cumulative efforts will produce the first complete topographic map of Antarctica. The advent of satellite techniques should make this a reality within the foreseeable future.

## CARTOGRAPHIC ACTIVITIES IN SINGAPORE, 1973–1976*

*Paper presented by Singapore*

Since the Seventh Conference, cartographic activities in Singapore have mainly been concerned with the production of maps at larger scales.

Thanks to the experience gained in the publication of the 1 : 50,000 series, less trouble was encountered during the preparation of the maps at 1 : 25,000 scale.

One Wild A10 precision plotter was acquired by the Mapping Unit in the beginning of 1976, with the intention of generating a series of topographic maps on the scale 1 : 1,000 to supplement the cadastral plans on the same scale.

Other activities include metrication, revision of road maps, preparation of a series of geological maps for the Director of the Public Works Department and the preparation of an airfield obstruction chart for the Department of Civil Aviation.

### Revision of topographic mapping at 1 : 25,000 scale

Many changes in specifications were incorporated in the new edition of the topographic maps at 1 : 25,000 scale to make the appearance more pleasing as well as to economize on procedures.

The controls for plotting were determined by strip adjustment, using a Hewlett-Packard 9830 calculator with co-ordinates scaled from independent models on the Wild B8 plotter.

Due to lack of proper equipment, many improvisations had to be made to obtain the model co-ordinates. Despite various odds, the standard errors of the adjusted co-ordinates were found to be about ±6 m, which were quite tolerable at this scale.

### Metrication

The original series of topographic maps of Singapore at 1 : 2,500 scale was plotted on a chain grid with 10-ft contour intervals. The Mapping Unit is in the process of recasting the sheet-line in accordance with the even numbers of the 1 : 1,000 cadastral sheet and converting the contour to 5-m intervals.

### Topographic maps at 1 : 10,000 scale

The series of topographic maps at 1 : 10,000 scale was compiled from the 1 : 2,500 plots and revised on the basis of aerial photography taken in 1974. A colour series is expected to be produced in the near future.

### Geological survey

A comprehensive geological survey was carried out by the Geological Unit of the Public Works Department, with the assistance of the United Nations Office of Technical Co-operation and the New Zealand Geological Survey.

The topographic maps on the scale 1 : 10,000 were used as the base map for the survey. The final maps are to be published on the scale 1 : 25,000 and will be printed by the Mapping Unit.

* The original text of this paper, prepared by the Mapping Unit, Public Works Department, Singapore, appeared as document E/CONF.68/L.17.

## CARTOGRAPHIC ACTIVITIES IN THE SUDAN, 1973–1976*

*Paper presented by the Sudan*

For the purpose of easy reference and for the benefit of the members of the Conference, this report has been compiled to overlap with the previous report (E/CN.14/CART/301) to the Third Regional Cartographic Conference For Africa, held at Addis Ababa in 1972, and to cover the period up to date.

The Sudan Survey Department (SSD) is the principal cartographic organisation of the country. During the period under review, SSD activities included geodetic, cadastral and topographic surveys and mapping. These surveys were carried out to meet the requirements of the projects of the five-year development plan.

SSD is also responsible for planning and co-ordinating aerial photography and for publication of tidal, trigonometrical and levelling data for the Sudan.

### Geodetic surveys

#### *Triangulation*

The Department has made every effort to complete sufficient first- and second-order triangulation nets in order to meet regional obligations and to provide control for high-priority mapping areas.

* The original text of this paper, prepared by Muhammad Al Baqir Khalifa, Director General of Sudan Survey Department, appeared as document E/CONF.68/L.67.

*First-order triangulation*

The central and north-eastern parts of the country are fully covered with first-order triangulation. Recently, work has been concentrated in the west. Apart from the arc of the 12th parallel and two second-order chains, two first-order chains have been completed, bringing the total number of first-order chains so far observed to 800 first-order stations.

*Second- and third-order triangulation*

In second-order arcs, all stations are marked with tertiary concrete pillars. Over the years, 21 chains of second-order triangulation bridging 4,000 km and containing 411 stations have been observed according to second-order standards, including two chains done during the period under review.

*Supernetwork*

Modern techniques of satellite geodesy were introduced in the Sudan in 1974, with the aid of a team of experts from the United Kingdom of Great Britain and Northern Ireland. Doppler observations were carried out at 11 trigonometrical stations situated in different parts of the country. More observations will be carried out in 1977–1978.

*International links*

The Sudan is linked with Chad and Ethiopia through the arc of the 12th parallel. It is also connected with Egypt and Uganda by the chain of the 30th meridian.

*Base measurements*

Thirty bases totalling 484 km were measured by Geodimeter and 10 bases totalling 91 km were measured by invar tape.

*Precise levelling*

The precise lines were run along triangulation chains and across mapping areas. During the period under review, 3,485 km were double-levelled, bringing the total achieved over the years to 14,698 km.

*Tidal stations*

In 1960, an automatic tide-gauge was installed in the Port Sudan harbour. Since then, it has been functioning satisfactorily. Its records are being kept up to date. It is worth mentioning that preliminary computations revealed that there was no appreciable difference in mean sea level between the Mediterranean Ocean at Alexandria and the Red Sea at Port Sudan. By 1979, the gauge at Port Sudan will mature, and then levels could be referred to the Port Sudan datum instead of to Alexandria.

*International links*

The levelling survey of the Sudan is tied to four of its neighbours, namely, Egypt, Ethiopia, Uganda and Chad (plate 1[1]).

*Gravity measurements*

The distribution of pendulum and gravity stations in the Sudan is shown in plate 2. The pendulum observations were begun by the Survey of Egypt in 1911, and then by SSD in 1935–36. In 1950, the Department of Geology of the University of Washington (United States of America) established an international pendulum station at the University of Khartoum, relating it to the Washington station on their tour for connecting gravity fundamental bases of the world. It was further occupied in the years 1954, 1955 and 1958.

*Coverage for geodetic purposes*

During the period under review, 142 gravity base stations were observed covering most of the railway stations. More than 170 bench-marks, along triangulation chains, have also been observed.

With the help of the Army Map Service of the United States of America, 21 gravity bases were observed. These bases were mostly airport stations and were referred to Khartoum fundamental stations.

*Coverage for prospecting purposes*

Parts of the Khartoum, Kordofan and Red Sea provinces were covered with gravity and magnetic surveys (plate 2).

## Cadastral surveys

Heavy pressure was put on the staff of the Cadastral Administration both in the field and in the office, in response to the government policy which is directed to providing residential plots in urban areas to meet the rise in population and agricultural land to meet the national plan for self-sufficiency in food products.

To achieve this objective, the Cadastral Administration executed 117,750 plots in the housing plan and 1,662,500 *feddans* in the field of agriculture during the period under review (plate 3).

## Topographic surveys

As a result of the five-year development plan and the increasing demand for mapping, the Topographic Administration must continuously meet urgent requests for special maps required by various departments and ministries. In addition to those requirements, the Administration is responsible for the compilation and maintenance of the standard map series on the scales 1 : 100,000 and 1 : 250,000. Other small-scale maps of the Sudan on the scales 1 : 2,000, 1 : 4,000 and 1 : 8,000 were corrected in respect of internal boundaries, railways and names from the new classified photographs.

*Aerial photography*

In 1976, to meet the high demand for mapping in the Sudan, SSD purchased a new Twin Otter series 300 aircraft equipped with a Wild NF2 navigation sight, a Decca Survey Doppler, a Wild RCIO super-wide-angle camera and a Wild RC8 wide-angle camera. During the period under review, two areas were covered on the scale 1 : 40,000; this coverage involved part of the south-western region (Nuba and Nyala areas) of the country

[1] The colour illustrations referred to in this paper (plates 1–4) may be obtained from the Director General, Sudan Survey Department, Ministry of Defence, P.O. Box 306, Khartoum, Sudan.

and the eastern region (Red Sea Province). The second area was executed jointly by the Directorate of Overseas Surveys (DOS) and Ministry of Overseas Development of the United Kingdom and by the Sudan Survey Department. In addition to the above-mentioned areas, the new aircraft has contributed in the coverage of three small areas on the scale 1 : 25,000 in the southern Region, the Roseires Dam and Red Sea Province, totalling approximately 23,000 km (plate 4).

*Photogrammetry*

The main task of this section during the period under review has been confined to the compilation of the map series at 1 : 100,000 scale for prospecting significance.

Compilation from super-wide-angle photography has been introduced, utilizing the Wild AIO for independent model triangulation and the Wild B8S for plotting.

The computerized block adjustment using the Elliott 803B, which is relatively slow compared with modern standards, has improved the speed and efficiency of obtaining photogrammetric co-ordinates, which previously had been determined by the Zarzyckis graphical adjustment method. SSD is currently using an IBM 360 for computations and is contemplating the use of a more advanced system in co-ordination with the expected national computing centre.

*Topographic mapping*

*Standard series at 1 : 100,000 scale*

Of the 18 sheets covering the area between latitudes 18° and 19° North and longitudes 36° and 39° East, 10 sheets have been printed and published under the auspices of the United Nations Development Programme (UNDP). DOS is compiling 14 maps.

*Series at 1 : 250,000 scale*

During the period under review the series at 1 : 250,000 scale which covers the entire country, was revised for the provincial boundaries and for railways.

*Series at 1 : 1,000,000 scale*

All 16 sheets of the series on the scale 1 : 1,000,000 have been revised for the new internal boundaries and railways.

*Series at 1 : 2,000,000 scale*

The three sheets of the map at 1 : 2,000,000 scale received minor corrections and amendments; and an overprint showing the major agricultural schemes was added.

*Series on the scales 1 : 4,000,000 and 1 : 8,000,000*

The two series on the scales 1 : 4,000,000 and 1 : 8,000,000 are used only as bases for thematic maps. They also received minor amendments.

*Use of LANDSAT-1 imagery*

In a development project for rain-fed farming in the south-western part of the Sudan, the International Institute for Aerial Surveys and Earth Sciences (ITC) of the Netherlands made use of LANDSAT-1 imagery for basic data collection, planning of future survey activities and proposals for follow-up studies in the selected areas. The results were most encouraging. Hence, the Sudan, with its limited resources for mapping, is looking forward to receiving more assistance in this domain for revising its old series at 1 : 250,000 scale covering the entire country (171 maps).

PRINTING AND REPRODUCTION

All the maps compiled and drawn in the Sudan are printed by the Sudan Survey Department. During the period under review, the printing section has witnessed considerable development and improvement in its equipment. Two single and one double colour electronic offset printing presses and a new automatic camera have been installed.

EQUIPMENT

The main items of surveying and mapping equipment acquired during the report period are listed in table 22.

**Table 22. Sudan: equipment acquired during the period 1973–1976**

| *Name of equipment* | *Number of units* |
|---|---|
| Wild RCIO universal film camera | 1 |
| Decca Doppler type 72 | 1 |
| Wild NF2 navigational sight | 1 |
| Wild AIO stereoplotter | 1 |
| Wild B8S Aviograph stereoplotter | 4 |
| Wild E4 rectifier enlarger | 1 |
| Wild T2 theodolite | 20 |
| Wild NK2 level | 18 |
| Tellurometer set | 6 |
| Distomat | 2 |
| Film dryer | 5 |

MISCELLANEOUS TOPICS

SSD has recently submitted to the competent authorities the draft statute of the Sudan National Geographical Names Committee for favour of study and approval.

An agreement is being made with DOS to provide assistance to SSD in the compilation and reproduction of a first edition of the Sudan National Atlas and an updated edition of a map catalogue originally published in 1956.

# MAPPING ACTIVITIES AT THE SURVEY OF SWEDEN*

*Paper presented by Sweden*

By western European standards, Sweden, with a total area of 449,000 km² and a population of 8,240,000, is sparsely populated. Large areas of the country are mountainous or forest covered with a population density of fewer than 10 persons per km²; between 60 and 70 per cent of the population live in urban areas.

As late as the 1930s, the country was still basically an agrarian society. Since the middle 1940s, the rate of economic development has been very high; and Sweden currently must be considered one of the most highly industrialized countries in the world. Prior to the mid-1960s, however, progress in the field of surveying and mapping had in no way kept pace with the general rate of development. Consequently, many of the mapping problems in Sweden can be relevant in developing countries.

A fundamental requirement for a national development strategy is an effective mapping programme. The development of water resources, forestry, agriculture, soil erosion control, transportation, mineral prospecting, urban and rural planning and environmental control is, to a very high degree, dependent upon the availability of good-quality maps.

There are two main series of official maps in Sweden: the land-use map series which, for the greater part of the country, is published on the scale 1 : 10,000; and for the more sparsely populated areas, on the scale 1 : 20,000; and the topographic map series, which is generally published on the scale 1 : 50,000 except for the mountainous areas of western Sweden, where the scale 1 : 100,000 has been adopted.

## Land-use map series (Economic map series)

The land-use map (economic map series) is based on a photo map which, up to 1966, was made as a controlled photo mosaic, but which, since then, has gradually been replaced by an orthophoto map. The map-sheets are printed in four colours using offset methods: green for the photo-map background; black for planimetric detail and names; brown for contours; and yellow for arable areas.

## Topographic map series

Production of the topographic map series is generally carried out using the land-use map series as a base.

Topographic map-sheets are published in four colours by offset methods: planimetric detail, together with the greater part of the text and neat lines, are shown in black; hydrographic features in blue; contours and marsh areas in brown; and forest areas in green. On certain of the mountain sheets, hill shading is used. According to current plans, the final sheets in these two series will be published during 1978.

The production cycle for the first editions of both series from aerial photography through geodetic field work and cartographic reconnaissance to the printed map-sheet is normally from three to four years.

## Aerial photography

Aerial photography is carried out by camera crews from the Survey of Sweden using the Survey's cameras and ancillary equipment mounted in four Aero-Commander aircraft leased both from a government agency and from a private firm. Two of the aircraft are fitted with turbo engines and can therefore be used for high-altitude photography. A Lear jet aircraft has also been used for this purpose. The standard flying height for high-altitude photography is 9,200 m. The volume of high-altitude photography has steadily increased over the past few years. The six Wild RC8 and RC10 wide-angle cameras are fitted with either the early type of Universal Aviogon lens system or the UAg II system. The focal length is 15 cm and the standard negative size 23 × 23 cm.

For standard mapping purposes, the flying altitude is 4,600 m with a fore and aft overlap of 60 per cent and a lateral overlap of 30 per cent, and an approximate negative scale of 1 : 30,000. Normally, the strips are oriented in a north-south direction and are centrally placed in relation to the map-sheet lines. For navigational purposes, the aircraft are fitted with Zeiss NT-1 navigation telescope aids.

In addition to the Wild camera equipment, the Survey of Sweden has two Hasselblad camera "packets", each comprising four synchronized cameras. The two packets can be combined to form a synchronized eight-camera packet. These systems are primarily used for multispectral photography.

To date, the entire area of Sweden has been photographed one or more times from 4,600 m. Rephotography is carried out according to a running plan to maintain a photographic coverage which is nowhere older than seven years in the southern and central parts of the country and not older than 10 years in the remainder of Sweden. Approximately 70,000 km² are photographed annually.

All photographic processing is carried out in the laboratories of the Survey of Sweden. The processing includes development, contact printing, production of diapositives and copying on plastic materials. Available equipment includes Versamat film processors, Hostert Automata colour-film processors, Kodak Supermatic paper processors, colour analyzers and automatic contact-printing equipment, Klimsch reproduction cameras and a Homrich horizontal reproduction camera.

* The original text of this paper, prepared by Ian Brook, National Land Survey of Sweden, appeared as document E/CONF.68/L.39.

## Ground control surveys

All ground control is supplied by the Geodetic Services Division. The Division is currently engaged in the remeasurement and readjustment of the national triangulation network. Field-work was begun in 1968; and by 1980, 449,000 km² will have been covered by a homogeneous area network of uniform accuracy with distances of approximately 10 km between triangulation stations over 60 per cent of the country and 30 km between stations over the remainder.

The field-work is based on trilateration methods using laser Geodimeters and portable, telescopic aluminium towers. A total of six laser Geodimeters, 40 portable towers and 500 Geodimeter prisms, together with ancillary equipment and classical optical instruments, is available.

The new network has been built up around the skeleton formed by the existing loops of first-order triangulation as the quality of the old observational material is high. Preliminary studies which were carried out prior to beginning the new programme indicated that a uniform standard accuracy of 1 : 300,000 in the measured distances could be attained. Results of adjustments so far carried out confirm that this figure was in no way over-optimistic.

Prior to 1975, all first-order, second-order and third-order levelling was carried out using classical methods. During the 1974 field season, a motorized levelling party was established with a view to testing methods developed in the German Democratic Republic. A motorized party comprises four surveyors with one surveyor in each of the staff cars and two in the instrument car. A Zeiss Jena Ni-002 instrument, which was developed for motorized levelling, has been used together with standard two-scale invar staffs. Mounting systems for the staffs and instrument have been developed at the Survey of Sweden.

Field results from the 1975 and 1976 surveys indicate that production per day can be increased by approximately 75 per cent, with a decrease in costs of approximately 20 per cent. These improvements have been accompanied by an improved accuracy.

Except for well-defined objects, such as churches and water-towers, all triangulation stations that are to be used as ground control are pre-marked with four 80 × 80-cm white masonite or plastic sheets, before aerial photography is carried out.

## Block adjustments and orthophoto mapping

The relatively sparse geodetic ground control is densified by block triangulation in order to obtain the necessary control points for orientation of the photogrammetric models and for assembling the orthophoto negatives. Transfer and control points are marked in the diapositives with the help of a point-transfer device.

The computer programme used for block adjustment, which works with the photogrammetric model as a unit, can handle 100 models. To adjust a greater number of models, two or more models must be connected using relative orientation by dependent models and scale transfer. At least four geodetic height control points are needed in each model or coupled model.

The general geodetic control requirement is 0.5–1 points per 100 km² in plan and 10 points per 100 km² in height. The achieved accuracy is 1.5 m in plan and 1.0 m in height.

For production of the orthophoto maps, two Gigas-Zeiss orthoprojectors with scanning units, optical interpolation devices and electronic contour-liners are available. Orthophoto projection is carried out off line, guided by profiles scribed on glass plates.

The time required for orthoprojection of a map-sheet with format 0.5 × 0.5 m is about four hours. Profiling is carried out in stereoplotters mainly of the Stereometrograph type. Contours are normally generated using the electronic contour-liner; but in areas of difficult topography, they are drawn in stereoplotters.

## Field reconnaissance and revision

The use of a photo-map background makes it possible to carry out cartographic field reconnaissance with relatively simple tools. A red-toned photographic copy of the photo-map including contours is made on shrink-proof material as part of the standard production procedure for the land-use map. Prior to the field-work, property and other boundaries together with public roads, certain parts of the drainage pattern, property names and register numbers, are drawn on a separate sheet of shrink-proof material at same scale as the red-toned copy. These two sheets are then used together for field reconnaissance purposes.

Reconnaissance for both the land-use and the topographic map series are, whenever possible, carried out simultaneously using this base material.

After completion of the first production run of the two map series, a revisional programme will begin.

Experimental revision has been carried out with a view to developing suitable revision procedures. The experimental work, which embraced 20 sheets, indicated, amongst other things, that it should be possible to use old ortho storage plates of an age of up to 15 years without any significant loss in geometrical quality. It was also found that the cost of assembling 0.5 × 0.5 m orthophoto negatives could be lowered from about $100 for the first production run to about $50 for the second.

## Printing

The Survey of Sweden does not print its own map-sheets. The final stage in the production cycle is, therefore, the preparation of the reproduction originals. For the land-use map, there are three or four originals (black, brown, green and yellow) and for the topographic map, normally four (black, brown, blue and green). For the mountain sheets in this series, for which hill shading is employed, the number of originals is increased to seven

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# CARTOGRAPHIC ACTIVITIES IN SWITZERLAND*

*Paper presented by Switzerland*

### ACTIVITIES OF FEDERAL AGENCIES

#### *Topographical Survey of Switzerland*

The main tasks of the Topographical Survey of Switzerland are the establishment and maintenance of the geodetic network of higher order and the production and updating of topographic maps on the scales 1 : 25,000, 1 : 50,000, 1 : 100,000 and 1 : 500,000. The completed national topographic map series at 1 : 25,000 scale is the base map from which smaller map series have been derived.

In 1969, a new general map series on the scale 1 : 200,000 was initiated. It consists of four sheets, of which the last has recently been completed.

Revision of the national map series begins with the revision of the 1 : 25,000 sheets. Smaller scale maps are revised in accordance with the revised maps at 1 : 25,000 scale, after appropriate generalization.

The Topographical Survey of Switzerland is continuously searching for more efficient methods to improve the tremendous task of map revision.

The country has recently been subdivided into six revision regions; one per year is rephotographed on the scales 1 : 25,000–1 : 30,000. Mapping of the areas under revision is done directly on the Wild A7/A8 Autographs.

The efficiency of the restitution phase has been increased by approximately 30 per cent with the introduction of an additional optical observation system between plotting-table and operator, which enables the operator to observe the stereo image of the autograph and the image of the map-sheet side by side and at the same scale.

The complete national map series on scales ranging from 1 : 25,000 to 1 : 500,000 is revised every seven or eight years.

Eight instalments of the Atlas of Switzerland have been completed. The ninth and last instalment will be completed in 1977.

#### *Swiss Federal Directorate of Cadastral Surveys*

The general map series on the scales 1 : 5,000 and 1 : 10,000 has been completed to 95 per cent.

For future revisions of these maps, orthophoto techniques are currently being studied. Of the large-scale cadastral maps, 75 per cent have been completed; they are updated continuously, especially in areas of prime importance. However, 20 per cent of those maps were produced before 1912 and currently serve only as "provisional cadastre".

The maps in remaining 25 per cent are for mountainous areas (instruction zone III) where, for the time being, the general maps on the scales 1 : 5,000 and 1 : 10,000 serve as the base for cadastral surveys and information.

### ACTIVITIES BY PRIVATE ORGANIZATIONS

The achievements mentioned above must be attributed to a considerable number of the approximately 235 private organizations (13 have photogrammetric capabilities) because the Swiss Federal Directorate of Cadastral Surveys does no work of its own other than photographic flights, but performs mainly legislative, managing and supervising functions.

In recent years the private sector has, apart from other engineering survey tasks, been extensively engaged in surveying and mapping work for the design of a superhighway network.

### ACTIVITIES IN RESEARCH AND DEVELOPMENT

A tremendous amount of research has been undertaken by federal agencies, universities and private organizations for the compilation of data for the Atlas of Switzerland.

A comprehensive paper by E. Huber, Director of the Topographical Survey of Switzerland, on "Thematic mapping in Switzerland"[1] is available for distribution during the Conference.

* The original text of this paper appeared as document E/CONF.68/L.70.

[1] This paper will appear in *World Cartography*, vol. XV, currently being prepared for publication by the United Nations.

The Swiss Geodetic Commission, in co-operation with the Swiss Institute of Technology, the Topographical Survey of Switzerland and other agencies, is engaged in geodetic problems and tasks, such as establishment of additional Laplace points, determination of the geoid, satellite geodesy and surveys of glaciers. Many of these activities are carried out in co-operation with other countries.

## CARTOGRAPHIC ACTIVITIES IN THAILAND*

*Paper presented by Thailand*

Interest in mapping problems did not develop in Thailand until after 1875. Even though no strict cartographic programme existed, mapping of the city of Bangkok and charting in the area of the Gulf of Thailand was carried out by a mapping division, first established in Thailand in 1875.

Cartographic activities in Thailand have been entrusted to the Royal Thai Survey Department since its formation as a department by the Royal Decree in 1885.

Up to 1954, topographic surveying was done by plane-table methods, and maps on various scales ranging from 1 : 5,000 to 1 : 50,000 were produced covering about 42 per cent of the country.

Although mapping from aerial photographs was introduced in 1930, the photogrammetric method for producing new topographic maps has come into use only recently.

The purpose of this report is to present a general review of the over-all mapping activities performed by various governmental agencies in Thailand, as well as their progress in the surveying and mapping concerned. Even though cartographic activities in Thailand have been performed by various governmental agencies, the responsibility placed upon any agency other than Royal Thai Survey Department is confined to the requirement of its own mission pertaining to country development project.

Activities of the following organizations are discussed in this report:

(*a*) Royal Thai Survey Department, Supreme Command Headquarter, Ministry of Defense;

(*b*) Hydrographic Department, Royal Thai Navy, Ministry of Defense;

(*c*) Department of Lands, Ministry of Interior;

(*d*) Department of Land Development, Ministry of Agriculture;

(*e*) Royal Forest Department, Ministry of Agriculture;

(*f*) Royal Irrigation Department, Ministry of Agriculture;

(*g*) Department of Mineral Resources, Ministry of Industry;

(*h*) National Energy Administration, Office of the Prime Minister.

* The original text of this paper appeared as document E/CONF.68/L.58.

### ROYAL THAI SURVEY DEPARTMENT

The Royal Thai Survey Department had an impressive, if modest, beginning in 1873, when His Majesty King Rama V became aware of the advantages of mapping during a tour which included the East Indies, the Malay Peninsula and India. To launch the programme in Thailand, the King appointed as his private advisor Henry Alabaster, former British Ambassador to Thailand. After recommending the establishment of a mapping division, Mr. Alabaster proceeded in 1875 with the mapping of the city of Bangkok and the surveying for the laying of telegraphic cables from Bangkok to Battambang in the Republic of Khmer and for charting in the area of the Gulf of Thailand.

The new Survey Department gained another influential member in 1880, when the Survey of India extended the triangulation network towards Burma and to the Chao Phraya River. At the request of Mr. Alabaster, one of the project's surveyors, James McCarthy, gained the King's approval and joined governmental service of Thailand.

In 1883, the King ordered the foundation of a Survey School in the vicinity of the Grand Palace, under the responsibility of His Royal Highness Prince Damrongrajanubhap, then Commander of the Royal Guard. Two years later, on 3 September 1885, the Survey Department was officially established, still attached to the Royal Guard. Its first chief, was Phra Wibhak Bhuwadol (James McCarthy).

The Department developed under several parent organizations before attaining its current stature. In 1892, it was transferred to the Ministry of Agriculture, with headquarters at Saprathum Palace (now known as the National Stadium). The scope of mapping activities was extended to various provinces.

On 1 October 1909, the Survey Department was attached to the Ministry of Defense, and its headquarters was moved to Pak Khlong Talat. It was moved again in mid-1931 to the current site, near the Ministry of Defense.

About that time, Survey Department officials became concerned that topographic map production at 1 : 50,000 and various other scales could not fully satisfy the requirements either for general development of Thailand or for military use. To meet the increasing demand, the Survey Department conducted the first aerial mapping in the area of Changwat Surin, but the project proved so expensive that it was set aside. In 1950, the Government

approved resumption of aerial mapping to assist various ministries and departments who needed maps at 1 : 50,000 scale covering the country for development planning and military purposes.

When the Aerial Mapping Organization was established, its headquarters was in a building in front of Chulalongkorn University. It was subsequently moved to a new structure on Ratchadamnoen Nok Avenue near the Chulachomklao Royal Military Academy. In 1951, it was elevated to department level and attached to the office of the Under-Secretary of the Ministry of Defence. Three years later, it was incorporated into the Survey Department, with responsibility for photogrammetric mapping. Close co-operation and assistance provided by the Government of the United States of America have enhanced this programme since 1952.

The Royal Thai Survey Department, as such, assumed its current status on 26 March 1963, when the Thai Government approved its new name and transferred the Department to the Supreme Command Headquarters; working units within the Department were reorganized at the same time.

To provide it with sufficient capacity and to fulfil the ever-increasing mapping demands of the Ministry of Defense, other governmental agencies and public requirements, the Royal Thai Survey Department was reorganized again on 19 October 1973, and its personnel strength was also augmented.

*Mission and activities of Royal Thai Survey Department*

The Royal Thai Survey Department conducts both ground and aerial surveys for the production of land maps for official use. In addition, the Department provides surveying engineers and produces mapping for various governmental units and carries out geodetic and geophysical activities.

Geodetic and geophysical activities, under the administration of the Royal Thai Survey Department as assigned in its mission, have been conducted successively in Thailand since 1906. As a result, networks of geodetic and geophysical control are distributed in various parts of Thailand. In addition to their direct advantage for the mapping of the country, these networks also provide data for various studies of earth sciences conducted by the international scientific associations of which Thailand is a Member.

Although there has been dense geodetic and geophysical control in Thailand, there is still need both for improvement of accuracy and for additional distribution of density. Therefore, the programmes of the Department have been scheduled as described below.

*Geodetic survey*

Since the beginning in 1906 up to the present, the following geodetic survey has been established: 7 base lines; 362 first-order triangulation stations; 40 first-order astronomical observation stations; 8,110 first-order levelling bench-marks (covering 13,414 km); and 1,500 gravity stations.

The gravimetric survey was conducted at gravity stations located approximately every 10 km along various routes in the country. The Royal Thai Survey Department has made a plan for the density increase of land gravity stations in every part of the country and expects to have a density distribution of about 40 stations per $1^\circ \times 1^\circ$ square, so that the gravity anomaly map of Thailand can be compiled.

*Geophysical survey*

*Geomagnetism*

Geomagnetic data have been observed at a total of 90 magnetic stations located in the northern, central, eastern and southern parts of Thailand. That survey was a repetition of observations at the former magnetic stations, for the purpose of determining data variation values with respect to the geomagnetism in the five-year cycle.

*Earth-tide measurement*

In addition, the Royal Thai Survey Department and the Observatoire Royale de Belgique co-operated in carrying out the earth-tide survey according to the Trans World Tidal Gravity Profile, observing earth tides at the Royal Thai Survey Department station at Bangkok, utilizing Geodynamics gravimeter No. 084 of Observatoire Royal de Belgique; and at the seismological station at Chiang Mai, using Askania gravimeter G. S. 15 No. 226 of the Royal Thai Survey Department and Geodynamics gravimeter No. 084. The results of both stations were remitted for computation and research at the Observatoire Royal de Belgique and they will be indicated in the report of the working group on the Trans World Tidal Gravity Profile.

It is expected that an additional earth-tide measurement will be undertaken in the southern region in 1979.

*Aerial photography*

Aerial photography for mapping in Thailand has been conducted in earnest since 1952, after the joint mapping agreement between Thailand and the United States of America in the mapping assistance project became effective.

In the first phase, aerial photography of Thailand was conducted with the assistance of the Government of the United Kingdom of Great Britain and Northern Ireland, and the Government of the United States. This assistance provided the aerial photography coverage throughout Thailand from 1952 to 1959. The Government of the United States again assisted in aerial photography from 1966 to 1970. The photographs taken in 1966–1970 were utilized in the map revision programme and in the compilation of series L 7017 in the area below latitude 7° North down to the border of Thailand and Malaysia.

In the meantime, the Government had realized how advantageous and necessary aerial photography was and gave approval to the Royal Thai Survey Department to procure photographic aircraft and equipments. Since then aerial photography has successfully been developed. The need for aerial photography to expand development projects in the country has induced the Royal Thai Survey Department to develop the capability to support those projects. Thus far, the Royal Thai Survey

Department has acquired six well-equipped aircraft for aerial photography.

In connexion with photographic reproduction phase, the photo laboratory of the Royal Thai Survey Department has been provided with all necessary equipment, including two electronic dodging printers, four Zeiss SEG V rectifiers, two Wild VG1 enlargers, two Kodak process densitometers and one densichron electronic densitometer.

The Royal Thai Survey Department is currently conducting aerial photography for two purposes: support of departmental mapping programmes; and support of the national development projects of various governmental units.

In the first phase of the five-year programmes aerial photography was scheduled for the support of topographic mapping by the Department on the scales 1 : 50,000 and 1 : 25,000, and city mapping on the scale 1 : 12,500.

An important, high-priority activity in support of other governmental units is the conducting of aerial photography and the provision of its products for the issuance of Land Use Certificates by the Department of Lands. The Royal Thai Survey Department was assigned to fly aerial photography at 1 : 15,000 scale and to produce aerial photographs which would be enlarged to the scale 1 : 5,000 throughout the country within five years, from fiscal year 1973 to 1978, about 85,000 km$^2$ per annum.

*Mapping*

Topographic mapping utilizing photogrammetric methods is the most important activity of the Royal Thai Survey Department; the objective is to produce topographic map coverage of the entire country.

Topographic mapping at 1 : 50,000 scale was begun in 1952, under the Joint Mapping Agreement between Thailand and the United States of America.

During the course of 15 years, up to 1967, through the co-operation of both countries, activities for mapping and related fields of the Royal Thai Survey Department were expediently and widely developed, resulting in the following topographic map series:

(*a*) Map series L 708 on the scale 1 : 50,000, format 10′ × 15′; complete coverage of Thailand totalling 1,161 sheets (excluding the southern area from latitude 7° North down to the Thailand-Malaysia border, for which the aerial photography was found unfavourable for mapping). This map series has become obsolete;

(*b*) Map series L 509, on the scale 1 : 250,000; this series has been superseded by map series 1501 on the same scale;

(*c*) City map series L 9013 on the scale 1 : 12,500, covering selected urban areas.

The results and experience derived from implementation of the Joint Mapping Project between the Royal Thai Survey Department and the Defense Mapping Agency Topographic Center of the United States Army Map Service led the Government of Thailand to realize the importance of mapping. It is necessary to work ceaselessly in order that Thailand may have perfect coverage with completely up-to-date maps reflecting the rapid changes taking place in the country. Therefore, the Royal Thai Survey Department received approval to continue and broaden its mapping projects, which resulted in a long-range project, extending into a five-year programme. The Royal Thai Survey Department is currently undertaking its first five-year programme, from fiscal year 1974 to fiscal year 1978, which comprises the activities described below.

*Revision of maps at 1 : 50,000 scale*

Because of the rapid growth and development of the country, data obtained 8–15 years ago are mainly obsolete. After the Government approved a 10-year project in fiscal year 1964, the revisional programme was carried out by the Royal Thai Survey Department to update map series L 708 on the scale 1 : 50,000, for which the data had been obtained from aerial photographs taken during the period 1952–1959.

The programme was conducted solely by the Royal Thai Survey Department for four years; in 1967, the United States of America joined it. In addition to expediting the original revision programme, the joint effort undertook to recast the 10′ × 15′ format of the existing map-sheet to 15′ × 15′.

Subsequent to recasting, the map series was redesignated as series L 7017, and the coverage has been extended to include the entire area of Thailand. The series comprises a total of 830 map-sheets.

*Recompilation*

In the evaluation of map series L 7017, it was found that 25 per cent of the coverage of the north-eastern part of Thailand and about 9 per cent of the coverage of the Thailand-Burma border area were below the class C category of standard accuracy set forth by the United States of America.

The Royal Thai Survey Department therefore set up a recompilation project for those sheets, which number about 262, to improve their standard accuracies. The project is divided into three phases, from fiscal year 1974 to 1988.

*Mapping at 1 : 25,000 scale*

For map series L 8019 on the scale 1 : 25,000, bilingual topographic mapping has been undertaken since 1970. The areas covered by these maps are specified in accordance with the need of some particular purpose. To date, 163 sheets have been published; during the report period, 114 sheets were produced.

Mapping on this scale is obviously costly and time-consuming; therefore, it must be carried out as a long-range programme.

*City mapping at 1 : 12,500 scale*

Production of the City map series L 9013 on the scale 1 : 12,500 has been carried on concurrently with the 1 : 50,000 mapping project. This map series will cover only the vicinity of various *changwats* (primary administrative) and *amphoes* (secondary administrative), and some other selected populated areas. As of 1976, 71

*changwats*, 79 *amphoes* and 2 populated areas had been mapped.

Because of the rapid development of the country, the currency of the map has to be maintained, which necessitates the continuation of the revisional programme for this map series. The revisional programme will be set up as successive five-year programmes.

*City map of Bangkok*

The map of the metropolitan area of Bangkok on the scale 1 : 20,000 will consist of 20 sheets, of which nine sheets have so far been printed.

*Thematic mapping*

The Royal Thai Survey Department has worked on three atlas projects: the National Resources Atlas of Thailand; the Regional Economic Atlas of Asia and the Far East; and the Topographic Atlas of Thailand. These projects are described below.

The National Resources Atlas of Thailand is important for the development of the country as well as for the exploration and utilization of national resources. It is of high interest among international mapping authorities. The Survey Department realized its importance and began compiling the first national resources atlas in 1961. It consisted of nine topics and was designed on the scale 1 : 1,000,000. The first revision was published in 1964; it consisted of 16 maps of various topics and was designed on the uniform scale 1 : 2,500,000. After that revision, several revised edition of the atlas were printed, and a few topics were added. The edition of 1972 was a volume 54 × 77.5 cm in size which contained 19 themes on a uniform base map on the scale 1 : 2,500,000, it included many additional pages with statistics and texts in Thai and English. The most recent revised edition of the atlas consists of three sections dealing with natural, human and economic resources, it has been compiled since 1973. The current revised atlas will be 37 × 50.5 cm in size and will be in loose-leaf form. It will not contain text pages. For the most part, two standard scales have been used: 1 : 2,500,000 on a folded double page; and 1 : 4,000,000 on a single page. The base maps were accurately compiled from the most recent topographic maps. A few other scales also were used when it seemed appropriate. The world maps were newly calculated and designed to show the location, trade and transportation of Thailand. The atlas will cover 54 topics, of which 20 have already been published.

The Regional Economic Atlas of Asia and the Far East was proposed to the third United Nations Regional Cartographic Conference for Asia and the Far East. In resolution 12[1] of the Conference, Government of Thailand was assigned to carry out the compilation of the economic atlas in this region. The atlas project was accepted as a task of international co-operation. Due to insufficient data and other obstacles, however, only two maps of the Regional Economic Atlas have been presented to the United Nations Regional Cartographic Conference: a population density map; and a map of the climatic regions (Koppen classification). The Royal Thai Survey Department also worked on a new base map for which the layout had been presented to the Seventh Conference in Tokyo, in order to replace the inaccurate and inadequate old base map. This new base map was compiled from various sources by the Department in 1973 and 1974. The six sheets of the new base map have been used for the compilation of three new maps of the atlas: a map of the transportation network and facilities; a map of forest resources and their exploitation; and a map of population distribution around 1970.

The Topographic Atlas of Thailand will be the first atlas of its type in Asia. It mainly comprises 114 carefully selected sections of various types of topographic maps of Thailand, with interpretive and explanatory texts in Thai and English. The maps are extracted from the most recent maps on the scales 1 : 12,500 (6 maps), 1 : 50,000 (98 maps) and 1 : 250,000 (4 maps). Six older maps and nautical charts were also included.

The landscapes and towns of the northern part of Thailand are shown on 26 maps; those of central Thailand from Sukhothai to Khlong Yai, Trat are given on 36 maps. The essential elements of the north-eastern part of Thailand are portrayed on 27 maps; and those of the southern part are shown on 25 maps. The maps and texts can be regarded as a first regional geography of Thailand.

In addition to the regional section, the atlas will have two other parts. The introduction is a short history of cartography and the spatial concepts of Thailand with sections of old maps on six pages. The final atlas section explains the basics of map reading and map interpretation with illustrative maps: scale; signatures; relief representation; and typical landforms of Thailand.

The atlas will be a bound volume sized 22.5 × 30.5 cm. Most map sections are ready for printing. The texts, however, have not been completed as the acquisition of detailed information is necessary and requires some time. Then, the text will not only explain the maps but will point to areas of further geographical research.

*Map reproduction*

Map reproduction activities are the last phase of mapping. Maps of various types and scales are to be printed from reproduction materials prepared by divisions concerned for the stock requirements.

In addition to the maps of various types and scales that the Royal Thai Survey Department has directly produced for the three branches of the armed forces and for official uses, other military maps are also reproduced from materials provided by other sources, for example, Joint Operation Graphic series 1501 and series 1501 A, maps of foreign countries and other special maps. Therefore, the high capacity and promptness of map reproduction must be insured by the Royal Thai Survey Department.

Regarding the support of other governmental units, the Royal Thai Survey Department is the sole agency

[1] *Third United Nations Regional Cartographic Conference for Asia and the Far East, 27 October – 10 November 1961, Bangkok, Thailand*, vol. I, *Report of the Conference* (United Nations publication, Sales No. 62.I.14), p. 10.

capable of reproducing standard maps. Requests are constantly received to reproduce special-purpose maps for those governmental units, which is an additional workload on the Department.

The above-mentioned workload has caused the map reproduction programme to become a long-range programme of the Royal Thai Survey Department. Beginning in fiscal year 1974, with the main expenditure for materials and equipments utilized to improve various phases of map reproduction, it has acquired capability in the reproduction of large-size maps rapidly and in large quantities.

*Education and training*

The Survey School is responsible for providing education and technical training in surveying and mapping sciences to the students and personnel of the Royal Thai Survey Department and to surveyors from other governmental agencies.

The Survey School was first established in Thailand in 1883. Its curriculum and course of study have from time to time been revised according to the background knowledge of the student, together with the suitability and technical progress.

There are currently two categories of education and training in the Survey School: one for non-commissioned officer student and cadets; the other for in-service personnel students. Both categories are divided into two levels, the commissioned officer level and the non-commissioned officer level, according to their educational background.

Each year, the Survey School of the Royal Thai Survey Department produces, for the cadre of Armed Forces non-commissioned officers as well as for the staffs of other governmental agencies, a group of surveying and mapping technicians who have completed a two-year course of study. A survey engineering course for the Department's commissioned officers, including surveying and mapping engineers for other governmental services, has also been given for the additional two years to cadets who have completed three years of study at Chulachomklao Royal Military Academy.

In order to disseminate advanced knowledge among department personnel, refresher courses are given, e.g., Surveying Course for Senior Survey Corps Master Sergeants, Advanced Surveying Course for Officers, Survey Navigation Course, Photo-Interpretation Course, Geography Course, Cartography Course, etc. These courses are occasionally offered owing to the necessity and requirement of the Department.

*Map Information Centre* (MIC)

On 1 December 1966, the Royal Thai Survey Department set up the Map Information Centre (MIC) as an official unit within the organization of the Department, in accordance with resolution 5[2] of the Third United Nations Regional Cartographic Conference for Asia and the Far East, in which the Conference accepted the recommendation of the Government of Thailand to establish this centre at Bangkok.

Since its establishment, MIC has been provided with numerous maps, information, documentations and other relevant materials by various States Members of the United Nations. The co-operation cordially rendered by those countries has made possible the fundamental map collection. MIC has so far collected about 2,500 map-sheets from 30 countries and approximately 1,000 other related documents.

To handle maps and documents obtained by MIC, at first the filing system used by the United States Army Topographic Command was adapted, and the catalogue compiled according to the adapted system was published and given to the participants in the Sixth United Nations Regional Cartographic Conference for Asia and the Far East held at Tehran in 1970. Currently, however, MIC is using a new filing system that it developed and the new catalogue reflecting that system has been published and will be distributed at the Eighth Conference.[3]

HYDROGRAPHIC DEPARTMENT

*History and development of maritime charts in Thailand*

Like other maritime countries, Thailand, which has a coastline of about 1,500 nautical miles, established a hydrographic service in order to procure and to disseminate to the naval services all necessary hydrographic and oceanographic information, including charts, sailing directions and nautical instruments.

More than a century ago, in 1856, the first hydrographic survey was made in the Gulf of Thailand by a survey team from the British Admiralty. In 1871, the work was resumed; a Thai naval vessel under the command of the two British naval officers was used. That work progressed for a period of 15 years and was then suspended for several years until 1906, when the Hydrographic Division was established by the Royal Thai Navy.

The first organized survey of Thai waters was began in 1912. This first systematic survey was carried out at Bangkok Bar under the supervision of the two Danish naval officers. Thai naval officers were trained to be familiar with the techniques of hydrographic survey, but during this period original charts could not be drawn nor reproduced. All were sent to be reproduced by the Royal Danish Hydrographic Office in Denmark. It was not until 1921 that the first chart, compiled and constructed by Thai naval officers, was produced on a flat-bed press at the Royal Survey Department of the Royal Thai Army.

In 1922, His Majesty the King was graciously pleased to proclaim the establishment of the Hydrographic Department (Krom Utoksastr). In the same year, the Hydrographic Department was provided with modern instruments to make it possible to construct and reproduce charts and maps by itself. Since that date, the Hydrographic Department has been responsible for all maritime charts in Thailand.

[2] *Ibid.*, p. 9.

[3] For additional information, see "Organization principles of the map catalogue", under agenda item 6.

*Chart production*

The task of chart production in the Hydrographic Department of the Royal Thai Navy is the responsibility of three divisions: Surveying Division; Cartographic Division; Oceanographic Division.

The Hydrographic Department produces nautical charts, aeronautical charts and oceanographic charts.

Nautical charts, on varying scales, are published to meet specific navigational requirements. The area to be charted is selected to provide maximum navigational use consistent with the limitations of scale and of paper size. The Mercator projection is used for nautical charts.

The source material consists principally of the results of original and revisional surveys, oceanic soundings, foreign nautical charts and publications, topographic maps, aerial photographs and report from maritime agencies. The normal method of chart compilation is to prepare a manuscript drawing on a vinylite sheet, indicating all the details which are to appear on the finished chart.

After the compilation is completed, an exhaustive examination is made to ensure that all hydrographic and topographic details shall be complete and correct. Standard international symbols (standardized by the International Hydrographic Bureau) and abbreviations are used on nautical charts. Charts are reproduced by photo-lithographic processes. After the final negatives have been made from the originals, a separate negative is made for each colour. Charts are printed on an offset printing-press. Proofs from printing-plates are carefully examined at various stages of reproduction, to ensure a proper standard of accuracy.

In order to gain a better knowledge of the seas around Thailand and to make navigation safer in Thai waters, the Hydrographic Department of the Royal Thai Navy endeavours continuously to expand and modernize its facilities.

*Printing and distribution of charts*

All nautical and aeronautical charts are produced in accordance with the requirement of the Royal Thai Navy. These charts are distributed to vessels of the Navy, to the merchant marine and to other government agencies through the Maritime Security Division.

*Chart production in future*

The Hydrographic Department plans to produce three small-scale nautical charts. One chart will cover the Gulf of Thailand on the scale 1 : 1,550,000, and the other two will cover Thai waters in the Andaman Sea on the scale 1 : 240,000. After completion of this project, all the British Admiralty charts, which cover part of Thai waters and are still being used, will be replaced by Thai charts.

## Department of Lands

Since 1903, when cadastral surveying and mapping began in Thailand, the Department of Lands has used a rectangular system of co-ordinates for drafting maps. In previous years, 28 co-ordinate systems had been set up, so that each territory was covered by just one system. The origins of these systems were, at first, the tops of mountains, of pagodas, etc.; and later, the points of intersections of meridian and parallel, so that the position of cadastral map-sheets can be located on the topographic maps of Thailand on the scale 1 : 50,000.

The method selected by the Department of Lands, for the production of cadastral line maps prepared by conventional field survey may be summarized as follows:

(*a*) The traverse is run to establish the control points used to tie with property corners of a piece of land. Each property corner has its own co-ordinates; the area of a piece of land can be determined by these co-ordinates;

(*b*) An offset is made from traverse lines by using a chain survey to locate the position of the property corners; by this method, the area of a piece of land can be determined by the graphic method;

(*c*) The boundary of a piece of land is plotted on each cadastral map-sheet by an automatic plotter on the scales 1 : 500, 1 : 1,000, 1 : 2,000 and 1 : 4,000.

As mentioned before, the method cannot enable the Department of Lands to issue land titles to landowners more rapidly. In 1964, the Division of Cadastral Surveying and Mapping of the Department of Lands, which is responsible for the technical aspects of this matter, decided to use a series of graphic cadastral photo maps on the scales 1 : 4,000 and 1 : 2,000 as a basis for the issuance of land titles and at approximately 1 : 5,000 scale as a basis for the issuance of certificates of land use (temporary land certificate).

The production of a series of graphic cadastral photo maps may be summarized as follows:

(*a*) Photographic flight is undertaken in the form of a pin-point strip over the centres of the future map-sheets, using 6-inch Pleogon and Aviogon wide-angle lenses, $9 \times 9$ inch negative size. The photographic scale is 1 : 15,000; flying height, 2,300 m; 80 per cent end lap, 42 per cent side lap; distance between adjacent flight lines, 2 km;

(*b*) Four control points per map-sheet (4 $km^2$) are determined for plotting by aerotriangulation of independent models, using the C-8 Stereoplanigraph and the A8 Autograph; and automatic recording of co-ordinates on punched cards by means of electronic recording units;

(*c*) A minimum number of ground control points are observed for block adjustment of aerotriangulation (size of blocks about 400–10,000 $km^2$ = 100–2,500 map-sheets) by the electronic distance-measurement;

(*d*) Block adjustment of control points required for photogrammetric restitution is performed, using data-processing installations with high capacity;

(*e*) For photogrammetric restitution in flat terrain, the photo map is produced by rectifying individual photographs in a semi-automatic SEG V rectifier. In rolling and mountainous terrain, this method is not sufficiently accurate. True-scale photo-maps of these areas are therefore produced by the orthophoto technique with the aid of the GZ-1 orthoprojector. In addition, the orthoprojector automatically provides elevation data on the configuration of the terrain;

(*f*) The photo-maps for the issuance of certificate of

land use are produced by enlarging individual photographs at approximately 1 : 5,000 scale with the SEG V rectifier. The index of cadastral photo maps-sheets is followed by the index number of the topographic map on the scale 1 : 50,000 and is related to the index of cadastral photo map-sheets for the issuance of land titles;

(*g*) After reproduction, this continuous-tone photo map can be used by the staff of the Department of Lands in order to determine and mark the property boundaries and to issue the land title or the certificate of land use.

Thus far, the Department of Lands has issued land titles to landowners at the following rates: 20 per cent of the entire developed area of the country; 43 per cent for the issuance of certificates of land use; and 37 per cent, unissued.

The Department of Lands has published cadastral maps prepared from various methods, as mentioned above. The maps are available to other government organizations. With the permission of the Director-General of the Department of Lands, private firms may purchase these published maps for several purposes.

## Department of Land Development

### *Development and organization of Soil Survey Division*

The Soil Survey Division of the Department of Land Development is responsible for almost all soil survey activities in Thailand. A soil survey is a scientific inventory of the soils and area which provides information concerning the location, extent and characteristics of each kind of soil. It consists of a map and report. The soil map shows the distribution of soil-mapping units in relation to other prominent physical and cultural features of the earth's surface. Soil survey work for agricultural planning has been carried out by the Department of Agriculture since 1963. By 1963, soil survey work was scattered throughout the Agriculture, Rice and Royal Irrigation Departments. By cabinet decision in September 1963, soil survey responsibilities were transferred to the new Soil Survey Division within the Department of Land Development.

At first, a reconnaissance survey was made using aerial photographs as field maps with aerial photo-interpretation occasionally being attempted by means of a pocket stereoscope. On completion of field-work, the transfer of soil boundaries, cultural and hydrological features was done free-hand from aerial photographs onto topographic maps. Soil maps were compiled, by means of tracing and the diazo printing process. The increase in demand for soil survey work in the country lead to an intensification of field surveys and, consequently, a greater demand for efficient, high-quality production of maps and reports. During the period 1961–1967, with the assistance of the United Nations Development Programme (UNDP) and the Food and Agriculture Organization of the United Nations (FAO), soil survey and classification experts and cartographic experts were provided to co-ordinate and correlate soil survey activity; and to supervise the installation of equipment and the setting-up of a complete cartographic section; to organize the production of maps, reports and other materials; and to train national technicians in the map production. Modern techniques, such as aerial photo-interpretation, scribing work, photo reproduction and multicoloured map and printing processes are being used in the Soil Survey Division. The Division is currently able to handle all map production for soil survey work.

The organization of map production in the Soil Survey Division is shown in figure 46.

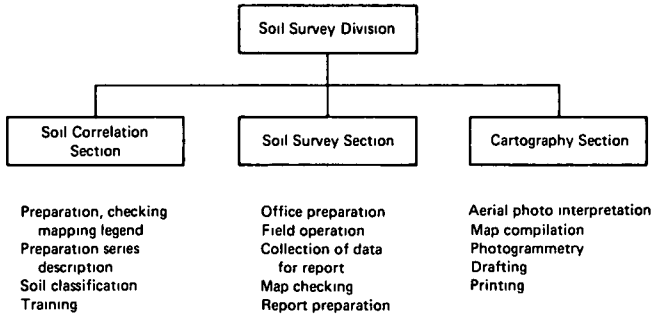



*Figure 46. Thailand: organization of Soil Survey Division*

### *Types of maps produced and work procedure*

Currently, most of the maps produced in the Soil Survey Division are used for agricultural planning. The map type depends upon the type and purpose of the work. The maps can be divided into five groups: soil maps; land-capability maps; land-suitability maps; land-use maps; miscellaneous thematic maps.

The work procedure is shown in figure 47.

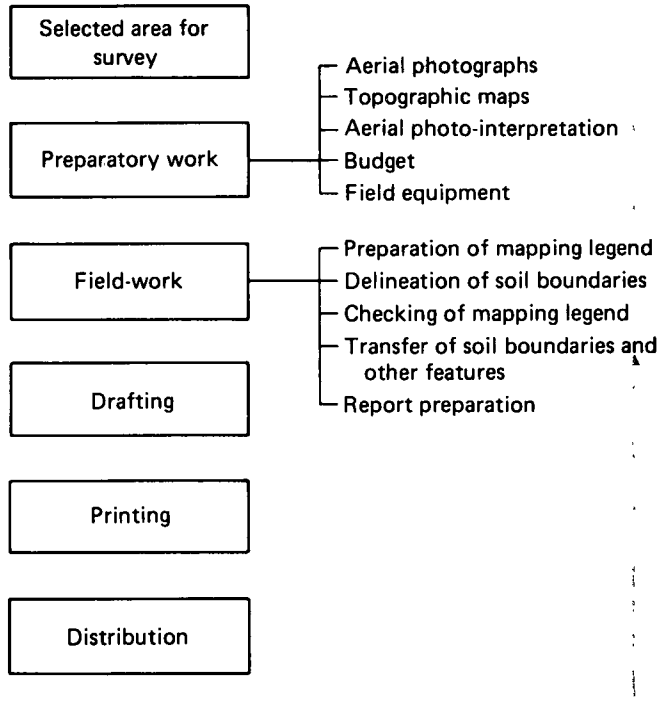



*Figure 47. Thailand: work procedure for map production in Soil Survey Division*

*Printing and distribution*

Maps and reports produced by the Soil Survey Division are mostly for local use. They are distributed to the persons or organizations engaged in programmes related to soil and soil utilization in Thailand and also are available free of charge to anyone who is interested in a particular publication. From 300 to 500 copies of maps and reports for each area are printed.

*Planning*

Most soil surveys in Thailand are detailed reconnaissance surveys of provinces with a publishing scale of 1 : 100,000. Surveys of this intensity are most useful in regional planning. In order to meet the growing development needs, detailed reconnaissance surveys which serve as a basis for selecting promising areas have to be accelerated and are expected to cover the entire country by 1981. Future activities of the Soil Survey Division will increasingly concentrate on highly detailed and specific surveys (as opposed to current predominantly generalized reconnaissance surveys), for use in farm planning, irrigation and drainage design, and urban and engineering planning.

## Royal Forest Department

At one time, almost all forestry maps were produced in the form of "sketch maps". Later, after the Royal Surveys Department had produced maps of the entire country at 1 : 200,000 scale, the Royal Forest Department used those maps as base maps for allocation of forest areas to be prescribed as reserved forests, for a working-plan circle for cutting operations and for other field-checks. In 1961, the Royal Forest Department, the Department of Lands and the Department of Administration collaborated to conduct land-classification surveys throughout the country, and land-classification maps on the scale 1 : 50,000 have been produced since that time. Cadastral surveys and boundary marking for the forest reserve maps also were begun during this period.

In 1955, the application of aerial photographs for forestry work was introduced in Thailand by F. Loetsch, an FAO expert on forest inventory. Photo-interpretation for delineation of various types of forest and compilation of forestry maps from aerial photographs were done at that time. Currently, since the Royal Thai Survey Department has produced topographic maps on the scales 1 : 250,000 and 1 : 50,000 which are available for all government agencies to use for their own purposes, the Royal Forest Department also purchases these types of maps for use as base maps. In addition, the Royal Forest Department has been compiling a forest types map from photo-interpretation results. The master map-sheets of such interpreted work have been sent for printing with conventional colours corresponding to different types of forest, so that the Royal Thai Survey Department can produce a complete forest types map on the scale 1 : 50,000. Existing forest maps and forest land-use maps are compiled from data of the Earth Resources Technology Satellite (ERTS-1) and of LANDSAT-2.

However, because of the limitations of budget and equipment, the Royal Forest Department still must rely on the Royal Thai Survey Department whenever it is necessary to produce a large number of maps for forestry application. The Forest Management Division of the Royal Forest Department is directly concerned with map-making, purchasing and distributing maps to all forestry units in Thailand. It is hoped that the Royal Forest Department will be able to compile fresh data concerning forestry activities in all aspects in order to produce up-to-date maps for various applications by the Department in the future.

## Royal Irrigation Department

*Establishment of Topographic Survey Division*

The Topographic Survey Division is responsible for the surveying and mapping for over-all water resources development projects of the Royal Irrigation Department. This responsibility includes topographic survey, route survey and cadastral survey. Such work requires close co-operation with the Royal Thai Survey Department in order to obtain basic control survey network and aerial photographs. In fact, at the time the Division was set up, many of the staff came from the Survey Department, bringing with them a wide experience in the planning and execution of survey work in the field.

Up to 1973, the Topographic Survey Division, which had no photogrammetric equipment, was only able to produce line maps at large scales prepared by conventional topographic survey. At that time, this capability was sufficient to meet the mapping requirements for irrigation projects carried out by the Royal Irrigation Department. On the rare occasions when a photogrammetric map was needed, the Royal Thai Survey Department and/or a contractor were appointed.

*Modernization of Topographic Survey Division*

Since 1973, in order to meet the ever-growing need for high-quality maps for the study and implementation of irrigation projects, an attempt has been made to strengthen and modernize the Topographic Survey Department, with the final aim of making this agency self-sufficient in all types of surveying and mapping. In particular, an aerial mapping section was established within the Division. In 1973, the Division received four stereoplotters (three Wild B8S and one Wild B8) and one set of co-ordinates recorders (Wild EK8 digitizer and IBM typewriter) for aerial triangulation.

*Current Situation*

*Staffing and Equipment*

The staff of the Topographic Survey Division currently comprises 35 engineers, more than 500 trained technicians and 120 draftsmen. The organization of the Division is shown in figure 48.

The Aerial Mapping Section was almost completely equipped when a Wild A8 stereoplotter and a PPO8 orthoprojector were purchased in February 1976.

*Types of maps produced*

Maps produced by the Division must meet the highest standards of accuracy: an altimetric error, even if it is small and localized, may result in very serious consequences to the project realization. These maps have to be made at very large scales in order to show all planimetric features and to facilitate the design work without the constraint of a graphic error.

To conciliate these requirements with the need to reduce to a minimum the delay in getting the project under way, two types of maps are generally prepared:

(*a*) For feasibility studies a line map on the scale 1 : 10,000 or 1 : 20,000 with 1-m or 2-m contour intervals, entirely prepared by stereo compilation;

(*b*) For design and construction, a photo map on the scale 1 : 4,000 together with a contour overlay at 25-cm intervals.

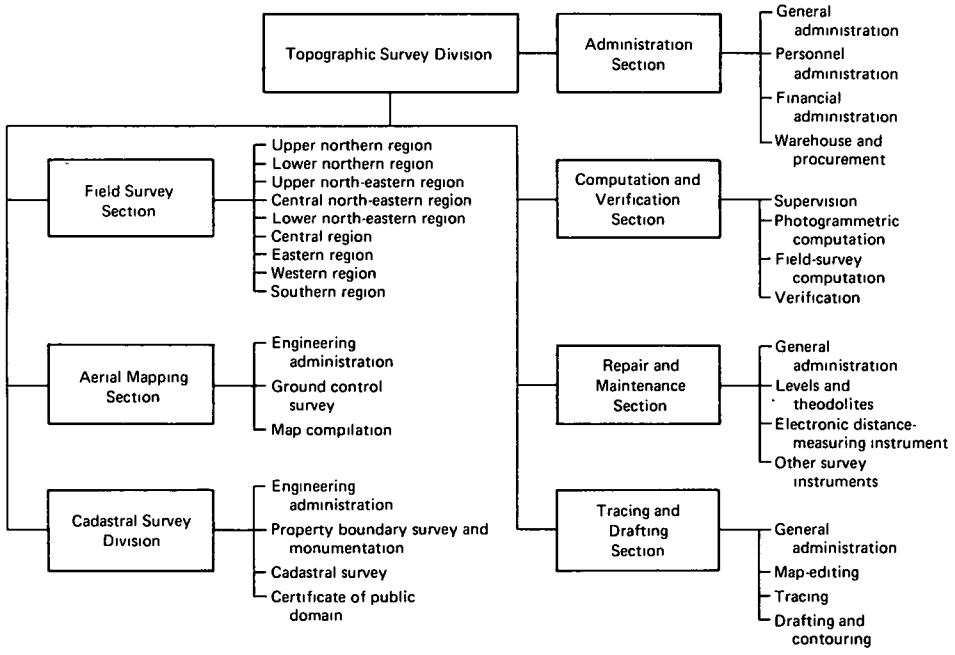



*Figure 48. Thailand: organization of Topographic Survey Division*

The photo map can be either a rectified photo map or an orthophoto map. A rectified photo map is prepared when the ground is practically flat. As the Topographic Survey Division does not yet possess a rectifier, the rectification is performed on the equipment of the Survey Department and/or the Land Department. An orthophoto map is prepared when land consolidation is necessary. In this case, the Division produced the orthophoto map, using the PPO8 orthoprojector.

As for altimetric features, taking into account that it would require exceptionally low-flown photography to plot 25-cm contour intervals accurately with the existing stereoplotter and as 80 per cent of the project area is usually open fields, the contours are plotted after completion of a spot height survey.

The total production of the Aerial Mapping Section since 1973 is as follows: topographic line maps, 4,800 km$^2$; rectified photo maps, 2,200 km$^2$; orthophoto maps, 400 km$^2$. The average output is about 1,800 km$^2$ per annum, i.e., twice as high as before 1973.

*Procedures*

*Aerial photography.* Aerial photographs used for map preparation are generally on the scale 1 : 15,000 taken by the Royal Thai Survey Department for the Land Department. When necessary, the Survey Department is requested to provide some aerial coverage on the scale 1 : 8,000 or 1 : 10,000.

*Ground control.* Ground control points are related to the basic network established by the Royal Thai Survey Department. As the irrigation project areas generally have no relief, it is difficult to carry out triangulation; preference is therefore given to traverse techniques for planimetric basic ground control. Traverses are performed with 1″ class theodolites and electronic distance-measurement equipment such as the AGA Geodimeter or Cubic Tellurometer. Altimetric ground controls are determined by second- or third-order levelling lines which, at the same time, constitute the network for spot heights survey, profiles and cross-sections.

*Aerial triangulation.* Aerial triangulation is performed for planimetric control only, by independent models, using a Wild B8S equipped with an EK8 digitizer.

*Stereo compilation.* Compilation of line maps is carried out with the Wild B8 and Wild B8S. In future, the Wild A8 stereoplotter, which has until now been used jointly with the PPO8 orthoprojector, could replace the B8 or

B8S when high altimetric accuracy is required.

*Spot heights surveying.* Until recently, the Division used the grid method for spot heights surveying, but this method is not particularly well adapted to the physical and climatic characteristics of the country. In the past, field-work was hampered, if not paralysed, during the rainy season. Therefore, the grid method has been almost abandoned in favour of a more flexible method which consists essentially of selecting and identifying all the spot heights on the aerial photos. This method can easily be used year-round without risk of damaging crops.

*Cadastral survey.* Although issuance of land titles to farmers is the main task of the Land Department, the Topographic Survey Division is very frequently obliged to survey the property boundaries, which constitute an important factor in the choice of the most adequate layout. Surveying of property boundaries has become more efficient through the use of photo-identification techniques instead of the classical methods used solely in the past.

*Mapping.* Because of the lack of more modern equipment, stereo-compiled line maps are reproduced by hand-tracing and are printed by the diazo process for supplying to the users. In case of on-farm development projects, for which the requirements are increasing considerably, photo maps together with topographic and cadastral information are needed for design and construction. Some experiments have been made to print the result of both the topographic and the cadastral survey on to the photo map. As the results were very poor, it was decided to use special cadastral and contour overlays on which the main planimetric features are redrawn. The designers are provided with blueprints which are used jointly with the photo map showing only grid, toponymy and marginal information.

*Future performances and planning*

*Programme*

The Topographic Survey Division still must strive to meet all the mapping requirements of the Royal Irrigation Department. According to the fourth national economic development plan (1977–1981), a total area of approximately 8,000 $km^2$ per annum must be mapped on large scales.

*Improvements of staffing and equipment*

In order that the above-mentioned programme may be successfully completed, the Division needs 10 additional officers with a Bachelor of Science degree and 50 more well-trained technicians. Furthermore, the following equipment is needed: 15 theodolites; 13 electronic distance-measuring instruments; 60 automatic levels.

The equipment of the Aerial Mapping Section must be completed by the setting-up of a photo-laboratory and the installation of a rectifier. A second orthoprojector, an Orthosfom 9300, provided by bilateral technical co-operation from the Government of France, will be operational in a few months, and the acquisition of another first-order stereoplotter has been proposed.

*Improvement in work method*

In order to reduce the manpower and time devoted to planimetric ground control, it is envisaged to use two aerial coverages, one at medium and one at large scale, and to generalize the adjustment by blocks for aerial triangulation.

In the field of cartography, the Topographic Survey Division hopes to experiment with the scribing process, in order to increase its production, using the same number of draftsmen.

*Conclusion*

Under the pressure of an increasing need for accurate maps for irrigation, the Topographic Survey Division, which originally almost emanated from the Royal Thai Survey Department and had very limited activity, has grown and made impressive progress. However, the Division is seeking to use more modern techniques in the field of surveying and mapping, such as the digital terrain model and automated cartography. In this connexion, more qualified personnel, modern equipment and other relevant supports are needed for further development.

## Department of Mineral Resources

The Department of Mineral Resources of Thailand is responsible for the following tasks:

(*a*) Geological mapping of the country at various suitable scales;

(*b*) Levelling and cadastral surveying, as well as topographic surveying and mapping for mineral prospecting, mining concessions and mining development;

(*c*) Preparation of manuscript maps and production of maps of various types which results from the works mentioned above in (*a*) and (*b*).

Since 1966, the Department of Mineral Resources has been undertaking the geological mapping of Thailand on the scale 1 : 250,000, and more than 60 per cent of the entire area of the country has been systematically mapped;

That mapping programme was planned for co-operation of the entire country in 1971. However, the progress of work has been much hampered by insurgency and it is doubtful whether the work will be completed as scheduled.

In 1977, the Department of Mineral Resources is beginning detailed geological mapping programme on the scales 1 : 50,000 and 1 : 25,000. Areas with extensive mineralization have been chosen for commencement.

Thus far, the following geological maps of Thailand have been published and are available to the public:

(*a*) Geological map of Thailand at 1,000,000 scale;

(*b*) Geological map of Lampang, sheet, at 1 : 250,000 scale;

(*c*) Geological map of Uttaradit, sheet, at 1 : 250,000 scale;

(*d*) Geological map of Nan, sheet, at 1 : 250,000 scale.

Ten mineral distribution maps of Thailand on the scale 1 : 250,000 have been published and are available to the

public. These maps cover the distribution of the following minerals, respectively: antimony; barite; clay minerals; copper–lead–zinc; feldspar–quartz–silica sand; fluorite; iron; manganese; tin; tungsten (wolfram).

### National Energy Administration

*History and development of map production*

The National Energy Administration (NEA) has been responsible for carrying out hydroelectric investigations since 1954. At first, the small-scale maps made available by the Royal Thai Survey Department were used for study at the initial stage of the implementation of each project. After the preliminary investigations had been completed, the aerial photography and topographic mapping were done. The topographic maps provided by the office were normally on large scales ranging from 1 : 500 to 1 : 20,000, because detailed resource surveys for small areas (up to 5 km$^2$) are needed for economic purposes and effective use. Maps for reservoirs, dam sites, power-plants and waterways have been prepared by NEA. When large area maps are needed, such as for the large reservoirs, the aerial photography and mapping will be carried out by private firms under the supervision of NEA with the approval of the Royal Thai Survey Department. This procedure is in compliance with the national security regulation which states that all aerial photography must be done by the Royal Thai Survey Department. To date, about five firms have received approval from the Ministry of Defence to perform aerial photography and mapping in Thailand.

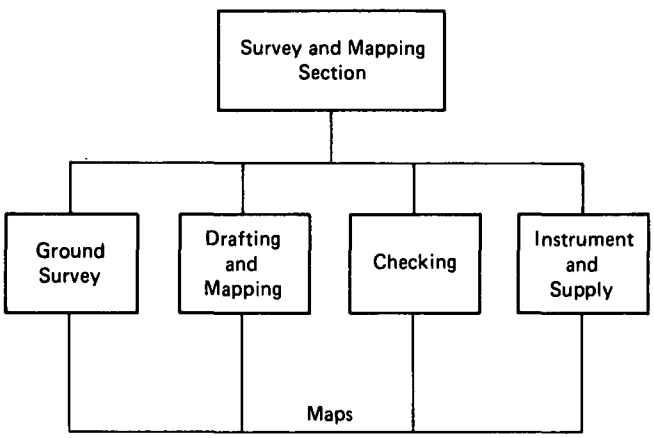



*Figure 49. Thailand: organization of Survey and Mapping Section of National Energy Administration*

*Types of maps and map production procedure*

Of the many types of maps available, those primarily used by NEA are line maps. These maps are not widely used, however, as they mainly stress contour lines to serve engineering purposes. They are effectively used for some specific small areas, up to 500 km$^2$. NEA produces maps by two methods—ground survey and aerial photogrammetric survey. All maps are produced as blueprints.

*Map production in future*

As mentioned above, the maps prepared by NEA will be basically used for the study and planning of national power resources. The maps required for the investigations of the NEA development programme are at 1 : 1,000 with 1-m contour invervals and at 1 : 10,000 scale with 5-m contour intervals. As those maps are mostly related to particular small areas, the use of such maps has some limitations. They are appropriate for detailed study of the projects and for engineering purposes. Each year, from two to five local maps are prepared, not for general purposes, but particularly for the power resources development project under that responsibility only. The production of maps in future is expected to follow the same trend.

### Progress report on cartographic activities, October 1973–October 1976

*Royal Thai Survey Department*

*Geodetic and geophysical survey*

During the report period, the Royal Thai Survey Department conducted the geodetic and geophysical surveys described below.

*Triangulation*

The existing first-order triangulation in the central part of the country was extended to link with the existing network in the northern and north-eastern parts in the area between latitudes 14°50′ and 15°30′ North and longitudes 101°30′ and 103°15′ East, and between latitudes 16°00′ and 18°00′ North and longitudes 100°00′ and 100°45′ East (see figure 50 in pocket[4]).

This extension of the triangulation network will result in 33 additional first-order triangulation stations in Thailand.

*Astronomical observations*

Laplace stations were determined at the first-order triangulation network in the central, north-eastern and southern parts of the country, totalling 11 stations.

*Levelling*

First-order levelling has been carried out in the central, northern and north-eastern regions (see figure 51); and 162 primary bench-marks and 634 secondary bench-marks have been established for a distance of 1,434 km.

*Land gravity survey*

The expansion of land gravity stations has been carried out in the central and north-eastern regions (see figure 52). The result was that 226 new stations were obtained. The elevation of 287 existing gravity stations in the central, eastern and north-eastern regions also was determined during the report period.

*Geomagnetic survey*

During the period under review, 43 geomagnetic stations in the central, northern, eastern and southern regions were reobserved according to the five-year cycle

[4] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figures 50–53 are in this pocket.

(see figure 53). This survey is made to provide data for the variations of the geomagnetic elements.

*Earth-tide measurement*

The Royal Thai Survey Department has participated in the earth-tide measurement according to the Trans World Tidal Gravity Profile. The full co-operation of the Observatoire Royal de Belgique made it possible to complete the measurement at two earth-tide stations at Bangkok and at Chiang Mai with a very satisfactory result.

*Aerial Photography*

Aerial photography has been taken by the Royal Thai Survey Department, using Wild RC8, Wild RC10 and Zeiss RMK-A cameras, for 27 national development projects under the responsibility of 10 governmental agencies on scales ranging from 1 : 4,000 to 1 : 30,000 and covering approximately 294,370 km$^2$. For mapping purposes under the responsibility of the Royal Thai Survey Department, aerial photography has been flown for eight different mapping projects on scales ranging from 1:10,000 to 1:40,000; the areal coverage was about 69,100 km$^2$.

To increase its capability for serving various governmental agencies, the Survey Department had procured one additional Rockwell Turbo-Commander 690 A by the end of 1976.

*Mapping*

*Standard topographic maps*

A bilingual topographic map series (L 7017) on the scale 1 : 50,000, covering the entire country, was produced. The total coverage of the series, which consists of 772 sheets with the format of 15′ ×15′, was completed in 1973. In the evaluation made after completion of the series, certain numbers of the sheets were found to be under United States standard accuracy of class-C category. The five-year project (1974–1978) for recompilation of those 125 sheets was carried out in 1974. Thus far, 10 sheets have been completed.

*Other topographic maps*

Bilingual topographic mapping at 1 : 25,000 scale has been performed since 1970. The areas covered by these maps are specified in accordance with the requirements for some particular purposes. To date, 163 sheets have been published. During the report period, 114 sheets were completed.

A bilingual city map on the scale 1 : 12,500, covering the urban areas of all 71 *changwats* (primary administrative divisions) throughout the country, as well as 79 *amphoes* (secondary administrative divisions) and 2 populated areas, has been published. These maps have been updated from time to time, resulting in the publication of 12 revised sheets out of the total number within the period under review.

Thirty-nine sheets of the bilingual topographic map on the scale 1 : 250,000, covering the area north of latitude 7° North, were revised by the United States Defence Mapping Agency Topographic Center. Four sheets covering the area south of latitude 7° North, produced by the Ordnance Survey of the United Kingdom, have been revised by the Royal Thai Survey Department.

*Thematic Maps and Atlases*:

The National Resources Atlas of Thailand has been revised and the size of the volume reduced to only 1:10,000 to 1:40,000; the areal coverage was about 69,100 km$^2$.

1 : 2,500,000 on a folded double page; and 1 : 4,000,000 on a single page. The base maps were accurately compiled from the most recent topographic maps. A few other scales were used where it seemed appropriate. The world maps were newly calculated and designed to show the location, trade and transportation of Thailand. During the report period, bilingual maps covering 20 topics of natural, human and economic resources were published.

Work has continued on the Regional Economic Atlas for Asia and the Far East project which was accepted as a task of international co-operation and for which two maps were reported at the sixth and seventh Conferences. Six sheets of the new base map which was calculated in 1973 by the Institut für Angewandte Geodäsie, Frankfurt (Federal Republic of Germany) are being used for the compilation of three new maps of the atlas: the transportation network and facilities; forest resources and their exploitation; population distribution around 1970.

The Topographic Atlas of Thailand, a new type of atlas for Asia, contains 114 sections of various types of topographic maps of Thailand, with interpretive and explanatory texts in Thai and English. The maps in the atlas are extracted from new maps on the scale 1 : 12,500 (6 maps), 1 : 50,000 (98 maps) and 1 : 250,000 (4 maps). A few older maps and nautical charts (about six maps) are also included. The atlas will be a bound volume of 22.5 x 30.5 cm size. Most of the map sections are ready for printing. The texts, however, are not complete as the acquisition of detailed information is necessary and requires some time.

*General-purpose maps and road maps*

The city plan of Bangkok metropolis, on the scale 1 : 20,000, will consist of 20 sheets; only nine sheets have been published.

Road maps on the scale 1 : 2,000,000, showing the road network throughout the country, were renewed during the report period.

*Map reproduction*

The new map reproduction plant of the Royal Thai Survey Department is the largest in Thailand. It serves the main needs of governmental agencies at the final stage of map production. During the report period, approximately 3.9 million copies of various types of maps were published. Of this amount, 80 per cent were maps at different scales which had been compiled by the Department.

The capability of the plant has been increased from time to time by its development. Additional equipment has been procured, including a Miller Convertible Offset TP 36, size $25\frac{1}{2} \times 36\frac{1}{4}$ inch, multicolour offset printing press (five colours).

*Geographical names*

Thailand, with the co-operation of the United States Defense Mapping Agency Topographic Center, has been preparing a new geographical name gazetteer of Thailand based on map series 1501 on the scale 1 : 250,000. The preparation of the preliminary list of names has been done by Thailand since 1975. Final compilation of the gazetteer is under way at the United States Topographic Center and completion was anticipated in 1976.

Thailand hosted a meeting for the United Nations Divisional Group of Experts on Geographical Names, Asia South-east division; and also participated in another four similar meetings held by other countries in the Division.

*Education and training*

The Survey School of the Royal Thai Survey Department is accredited by Supreme Command Headquarters to offer various courses, which have resulted in the graduation of 12 classes: three classes (30 graduates) of the five-year survey engineering course for military cadets; three classes (97 graduates) of the two-year course for non-commissioned officers; two classes (41 graduates) of the advanced surveying course for commissioned officers; one class (42 graduates) of the associate basic surveying course for commissioned officers; two classes (44 graduates) of the surveying course for sergeant-majors; and one class (6 graduates) of the survey navigation course for commissioned officers.

The Survey Department has received assistance in the form of scholarships from various countries, for example, Japan, the Netherlands, the United Kingdom and the United States of America. As a result, 21 officers of the Royal Thai Survey Department have been trained abroad in the following courses: cartography (1); photogrammetry (2); aerial photography and survey navigation (3); integrated surveys for development (1); surveying and mapping (4); mapping, charting and geodesy (2); map reproduction (1); off-shore prospecting (1); surveying and mapping instruments (2); languages instructor (4).

Training aids, such as geodetic and photogrammetric instruments and equipment, have also been procured for the Survey School, in order to eliminate interference with the working schedule of the Department.

*Hydrographic Department*

*Hydrographic surveys*

Hydrographic resurveys were carried out in the eastern coast of the Gulf of Thailand in order to renew the nautical charts which had been surveyed since 1923.

During 1975, some area in Sattahib Bay were surveyed and studied for the sedimentation.

In 1976, off-shore surveys using the electronic positioning system, TORAN P-100, were introduced in the Gulf of Thailand and in the Andaman Sea. The project will last for three years and will provide useful hydrographic data for the reproduction of small-scale nautical charts, which will cover all parts of the Gulf of Thailand and some parts of the Andaman Sea.

*Nautical and aeronautical charts*

During the past three years, three new nautical charts were published and 19 charts were revised.

Two new aeronautical charts on the scale 1 : 500,000 were produced. Two existing aeronautical charts were revised.

*Department of Lands*

From October 1973 to October 1976, the Department of Lands issued land titles to the owners of 44,102 pieces of land covering the developed area amounting to 240,204 *rai*, 1 *ngan* and 37 *wah*;[5] and also issued certificates of land use for 2,362,365 pieces of land covering the developed area totalling 18,698,927 *rai*.[6]

*Department of Mineral Resources*

During the report period, the Department of Mineral Resources published the following maps:

(*a*) Six sheets of geological maps covering some particular areas on the scale 1 : 250,000;

(*b*) Mineral distribution maps of Thailand on the scale 1 : 250,000, on the following 10 topics: antimony distribution; barite distribution; clay minerals distribution; copper-lead-zinc distribution; feldspar-quartz-silica sand distribution; fluorite distribution; iron distribution; manganese distribution; tin distribution; tungsten (wolfram) distribution.

*Royal Forest Department*

*Forest maps production*

About 40 per cent of the total area of Thailand is covered by forest. All forested area belongs to the State. These forest areas are classified into several types, such as evergreen, mixed deciduous, dry dipterocarps, mangrove and pine forests. The boundary of each forest type is derived from the interpretation of aerial photographs.

Forest type maps have been printed by the Royal Thai Survey Department on the scale 1 : 50,000:

(*a*) In 1974, the forest type maps were printed in series L 708, 50 sheets;

(*b*) In 1975, the same type maps were printed in series L 7017, 24 sheets;

(*c*) In 1976, series L 708, 50 sheets; and series L 7017, 32 sheets, were printed.

All the maps are of areas in the northern region of Thailand.

In addition to these forest type maps prepared from conventional aerial photographs, the Royal Forest Department has used the LANDSAT 1 and 2 imageries with ground-truth data to prepare maps of existing forest areas in all five regions of the country. These maps, which are on the scale 1 : 500,000, were completed in 1974. They show general patterns of the forest and non-forest areas of the entire country.

Another useful application of satellite imagery is the designation of particular land for catchment forest areas.

[5] Equivalent to 38,433 hectares, 4 ares and 148 $m^2$, respectively.

[6] Equivalent to 2,991,828 hectares.

A watershed map for the northern area of Thailand was completed in 1976. This project will continue to check and collect ground-truth data to locate forest watershed areas in the eastern and western regions.

Thus far, the Royal Forest Department has reproduced the national reserved forest maps, the national parks map, the wildlife sanctuary map and the forest working-plan map. These maps are available not only for departmental purposes but for all government agencies.

Budget limitations and old equipment force the Royal Forest Department to rely on the Royal Thai Survey Department for large amounts of map production. If the Department could get support in terms of equipment and staff training, it would be able greatly to improve current map production. The Forest Management Division of the Royal Forest Department is directly concerned with map-making, procurement and distribution to all the forestry units in the country.

## Report on matters that formed the basis of the resolutions of the Seventh Conference

In pursuance of the resolutions of the Seventh United Nations Cartographic Conference for Asia and the Far East, the activities described below have been undertaken.

### *Resolution 11: Training*

In spite of the fact that there have been quite a few educational facilities in cartography in Thailand, the courses of which lead to the degree as well as the diploma, they are not really appropriate for foreign students because they are taught in the Thai language. Therefore, a special arrangement must be provided in order that foreign students may possibly be admitted.

At the Survey School of the Royal Thai Survey Department, a course in cartographic drafting and topographic surveying at technician level used to be designed under the special programmes whenever appropriate. However, persons enrolled in this course must be properly familiar with the Thai language.

### *Resolution 12: Geographical names*

Thailand participated in the sixth session of the Group of Experts at the United Nations Conference on the Standardization of Geographical Names, and represented the Asia South-East Division at the second and the third sessions of the United Nations Divisional Group of Experts on Geographical Names.

Thailand also hosted the first meeting of the Working Group of Experts on Geographical Names, Asia South-East Division, in April 1976.

### *Resolution 14: Thematic maps and national atlases*

In accordance with the recommendation (*a*) of resolution 14, the Royal Thai Survey Department has designed, compiled and published a new set of thematic maps as the most recent revised edition of the National Resources Atlas of Thailand, with the short series title Atlas of Thailand.

The National Resources Atlas of Thailand was first published by the Department in 1961. The subsequent revisions, as well as the addition of topics, were done in 1964, 1968, 1969 and 1972. The current renewed edition of the atlas has been compiled since 1973. Of the total of 54 topics, 20 have been published.

In accordance with recommendations (*b*), (*c*), (*d*) and (*e*) of resolution 14, the Royal Thai Survey Department has compiled and will publish the new topic of the Regional Economic Atlas of Asia and the Far East on the new six-sheet rectangular format, the layout of which was presented to the Seventh Conference. The Conference recommended that the topic be the population distribution on the new base map.

In compiling the population distribution map for the areas of the Asian part of the region served by the Economic and Social Commission for Asia and the Pacific (ESCAP) according to recommendation (*c*) of resolution 14 of the Seventh Conference, the Survey Department was faced with difficulties in securing and collecting source materials and relevant data. Such necessary data could scarcely be obtained directly from the Asian part of ESCAP region countries. The data could be collected mainly from various divisions of the ESCAP, but they are not complete because some countries are very reluctant to release sufficient economic information. Therefore, the data for compiling population distribution maps had inevitably to be indirectly determined from other types of economic maps, for instance, maps of transportation networks, maps of forest resources and maps of administrative and census divisions.

That drawback, however, did not always bring about an entirely negative result; in this particular case, it unexpectedly made it possible for the Survey Department to compile two additional topics of the economic atlas of the region: a transportation map; and a forest resources map as a by-product. The Survey Department hopes to present sample sheets of these maps, if not the complete map, to the Eighth United Nations Regional Cartographic Conference for Asia and the Far East.

In order to avoid a disputed boundary in some countries, the international boundaries will not be shown on these maps.

### *Resolution 15: Satellite geodesy*

The Doppler method of satellite observations in Thailand has been used by the satellite monitoring teams of the United States of America, accompanied by the Royal Thai Survey Department.

These observations are made to provide basic geodetic information which will greatly contribute to improvement in the large- and medium-scale mapping programmes of Thailand. In addition, the stations would be part of a world-wide net of geodetic observation points which would observe low-altitude Doppler-equipped earth satellites.

### *Resolution 16: Levelling surveys*

Since the Seventh Conference, the vertical control established by means of first-order and third-order levelling has been expeditiously carried out for mapping projects, as well as for every field of engineering activities.

During a period of three years, the above-mentioned levelling was run in many parts of the country. The result was that 2,268 vertical control points at the distance of 6,958 km were obtained.

The Royal Thai Survey Department also planned a five-year project (1979–1983) to renew the geodetic levelling in the Bangkok area. First-order levelling will be run to determine the precise elevation of various existing points scattered throughout Bangkok and areas in the vicinity, totalling approximately 100 points. The elevation of the points will be reobserved annually in order that the vertical movement of the Bangkok area may be investigated.

*Resolution 17: National seaward boundary limits*

Thailand is in agreement as to the importance of relating the geodetic datum in order to establish the national seaward boundary limits.

The horizontal control points in hydrographic surveying currently are extended from geodetic stations of the Royal Thai Survey Department which use the Indian Datum, Everest Spheroid, as a reference. It is possible to tie a triangulation network in Thailand to the world geodetic datum, and the Royal Thai Survey Department is responsible for this programme.

*Resolution 18: Financing of hydrographic assistance*

The hydrographic surveying capability of Thailand has been gradually expanded. However, assistance is needed to accelerate the growth of capability in various hydrographic fields.

*Resolution 19: Membership in the International Hydrographic Organization*

Thailand has been a member of the International Hydrographic Organization since 1921.

*Resolutions 20 and 21: Remote sensing and satellite imagery*

The Thailand National Programme of the Earth Resources Technology Satellite (ERTS) was initiated in September 1971, when the Cabinet approved the appointment of the National Co-ordinating Committee which is composed of representatives from various government agencies interested in the application of satellite data for national development planning. A working sub-committee was appointed, and the proposal for the Thailand National Programme of the Earth Resources Survey by ERTS-1 was prepared and submitted to, and subsequently approved by the United States National Aeronautics and Space Administration (NASA). ERTS data have been regularly transmitted to Thailand from NASA, for analysis and interpretation in the fields of interest of participating agencies. Research development and findings have been reported to NASA as well as in international workshops and symposia.

Thailand has also participated in the Skylab programme; and land-use/forest classification of the areas taken by the earth terrain camera S102B was attempted and verified by ground-truth data.

When LANDSAT-2 was launched in January 1975, Thailand was also approved by NASA to participate in the follow-on programme. Full coverage of Thailand by LANDSAT-2 was completed and various agencies have been using LANDSAT data in their work, some at the quasi-operational stage and some at the research and development stage. A working sub-committee on automatic data-processing was initiated and plans are being prepared for acquiring capability in Thailand for automatic data-processing of LANDSAT computer-compatible tapes. The Thailand programme is being expanded, since the completion of new facilities in December 1976, to cover wider areas of application, such as regional planning and environmental monitoring, as well as to provide training and promotion of research in remote sensing.

*Resolution 22: Topographic mapping*

The Royal Thai Survey Department has established, topographic mapping capacity and experience for its own sake. No assistance has been provided by or to the Department through the United Nations.

The Survey Department has undertaken to fulfil the needs of many government agencies for topographic maps, thus providing to those agencies the benefits that will accrue from the resultant ability properly to assess and manage the national resources of Thailand. Special and definite topographic maps have been produced by the Survey Department for such agencies as the National Energy Administration, the Department of Land Development and the Royal Irrigation Department.

*Resolution 23: Urban mapping*

The Royal Thai Survey Department has produced large-scale city maps, which are used for multiple purposes. The Department has also, from time to time, conducted urban mapping for particular purposes according to the requirement of other governmental agencies.

*Resolution 25: Aerial photography and photogrammetry*

The Royal Thai Survey Department has conducted the aerial triangulation in obtaining model control and geodetic point positioning referenced to the national geodetic control.

The Department has mainly used wide-angle photography for photogrammetric purposes. Super-wide-angle photography has never been used for mapping.

Both the use of photo maps and orthophoto maps as an interim substitute for conventional line maps and the use of photo maps have been practised.

# ORGANIZATION PRINCIPLES OF THE MAP CATALOGUE*

*Paper presented by Thailand*

The Map Information Center (MIC) of the Royal Thai Survey Department has been established in accordance with resolution 5[1] of the Third United Nations Regional Cartographic Conference for Asia and the Far East. The main responsibilities of MIC are: (*a*) the collection of maps, documents and other informative materials of the topographic and thematic mapping of Asia and the Far East; and (*b*) the procurement of information from mapping agencies of the region about mapping activities within the region and their results. The main branches of MIC are accordingly the Documentation Branch and the Information Branch.

## Documentation branch of Map Information Centre

The major tasks of the Documentation Branch of MIC are: (*a*) acquisition of maps and related documents; (*b*) recording and categorizing of the accessions in catalogues, files and/or index maps; (*c*) storage of those materials in such a way as to make all the information they contain readily available for consultation and use; and (*d*) keeping the collection up to date. All activities of the branch are centred on the map collection and the catalogue.

### *Map collection*

The MIC map collection does not comprise only topographic maps, but includes maps of various topics, various scales, various regions and various forms or types. To keep the storage space and equipment to a minimum, as well as to ensure the availability of the maps to the many various users, different classification and reference systems had to be considered and used.

#### *Area classification system*

As the portrayal of the spatial relationship of objects is the basic purpose of maps, the spatial extent of the maps can be regarded as the basic concept of a map collection. The setting up of an area classification is the basis both of any code system for a map catalogue and of the storage system for the map collection.

The area classification should establish a hierarchy of regions to fit all orders of geographical magnitude and scale. The order should be reflected in a code system of letters which can be easily remembered.

Table 23 gives an example of the area classification system used for the MIC collection. The code system consists of one capital letter for the global and hemispheric areas and two letters for continental areas, with a third letter which can be added after a full stop to indicate a country within a region.

**Table 23. Thailand: example of area classification system used for Map Information Centre collection**

| *Code* | *Area* |
|---|---|
| X | Space, celestial sphere |
| XM | Moon |
| XP | Other planets |
| G | Globe, earth, world |
| O | Oceans |
| OA | Atlantic Ocean |
| OP | Pacific Ocean |
| OI | Indian Ocean |
| E | Eastern hemisphere, Old World |
| EU. | Europe |
| EUN. | Northern Europe |
| EUN.DA | Denmark |
| EUN.FI | Finland ( = Suomi) |
| EUN.IC | Iceland |
| EUN.NO | Norway |
| EUN.SW | Sweden |
| EUW. | Western Europe |
| EUW.AN | Andorra |
| EUW.BE | Belgium |
| EUW.EI | Eire ( = Republic of Ireland) |
| EUW.FR | France |
| EUW.LU | Luxembourg |
| EUW.NL | Netherlands |
| EUW.UK | United Kingdom of Great Britain |
| EUC. | Central Europe |
| EUC.AU | Austria |
| (EUC.GG) | Germany |
| EUC.GC | German Democratic Republic |
| EUC.GE | Federal Republic of Germany |
| EUC.LS | Liechtenstein |
| EUC.SZ | Switzerland ( = Helvetia) |
| EUE. | Eastern Europe |
| EUE.AL | Albania |
| EUE.BU | Bulgaria |
| EUE.CZ | Czechoslovakia |
| EUE.HU | Hungary |
| EUE.PL | Poland |
| EUE.RO | Romania |
| EUE.YO | Yugoslavia |
| EUS. | Southern Europe |
| EUS.CY | Cyprus |
| EUS.GR | Greece |
| EUS.IT | Italy |

#### *Scale classification system*

The extent of the area shown on a map determines the scale of the map. On the other hand, the scale can determine the accuracy of the spatial information, and the amount and details of the substantial information of a map. The number of the scale nominator can be used as a number code. The last three digits can be omitted because they usually consist of three zeros. Thus, the scale

* The original text of this paper, prepared by the Map Information Centre of the Royal Thai Survey Department, appeared as document E/CONF.68/L.59.

[1] *Third United Nations Regional Cartographic Conference for Asia and the Far East, 27 October – 10 November 1961, Bangkok, Thailand*, vol. II, *Report of the Conference* (United Nations publication, Sales No. 62.I.14), p. 9.

1 : 50,000 will be coded as 50, the scale 1 : 2,500,000 as 2500 without a comma.

*Subject or topic classification system*

The number of objects that can be represented in their spatial distribution and relationships on maps is innumerable. For this reason, a general subject classification can only attempt to give a layout of the topics which have been mapped in many areas and in detail, and which appear to be of scientific or practical importance. However, the layout should be open to further additions. In connexion with regional and national atlases, lists of topics have been prepared. The lists have been evaluated by scientists in some handbooks on thematic mapping in which general subject classifications have been proposed. These sources have been consulted for the subject classification system of MIC as listed in table 26 (see annex). The topics are coded in a numerical system which allows additions to and subdivisions of the main topics.

*Form or type classification system*

The form of the map is of importance to the storage of the map collection, as well as to the reference system of its catalogue. The most common map forms are:

I. The single map which shows a distinct topic in a distinct area, either as a desk or a wall map. The map could have been reproduced by print, sun-print, photography or other map reproduction methods. The map can be an original draft, in which case the reference system should indicate it (D for draft). The reference system also should point out those maps which require specific storage equipment or space, such as rolled wall maps (R for rolled);

II. The part of a single map, either an inset map or the portion of an (old or large) map that could not be totally acquired;

III. The map of a map series or of a set of maps. Most large-scale topographic maps belong to this group;

IV. The single map of an atlas or book that does not exceed a limited convenient size. In general, the storage facilities for these maps differ from those of the other map forms. The catalogue card should state the title of the atlas, book or journal from which the single map has been extracted;

V. The atlas, the systematic arrangement of various maps in a bounded form. The catalogue should list at least the most important topical maps of each atlas of the collection.

The forms or types of the maps are included in the reference code system (see table 27 in annex) of the MIC collection by using the Roman numerals listed above. The exceptions are marked by the additional letters D (original draft map) or R (rolled wall map).

To include publications other than maps in the form classification, the following category was added:

VI. Book-Category form publications:
- VI.Y Bibliography;
- VI.M Technical manual;
- VI.C Catalogue;
- VI.B Book;
- VI.R Report, journal, periodical;
- VI.D Document, pamphlet;
- VI.G Gazetteer, table;
- VI.S Miscellaneous

*Authority classification system*

Map production is carried out by many persons and institutions. Very often, various persons and agencies participate in the production of a single map as author, cartographer, printer and/or publisher. In general, only the author and/or the publisher are cited in catalogues. In the MIC catalogues, they are cited by their full names, as a code system cannot be applied to the great variety of names in different languages.

*Language classification system*

Each collection of maps covering different regions entails the problem of transcription or transliteration of the various languages into the map collector's language. In general, the title of a map and the names of the author and publisher are cited, the title in the original language as well as in the map collector's language, one of them in brackets. A catalogue reference must quote the original title and its translation, as well as the script that is used for the map lettering. For international map collections, English and/or French, which are official languages of the United Nations, should be used as reference languages. The map collection of MIC and its catalogues are based on the English language.

*Time classification system*

Map production is a time-consuming procedure. Therefore, each map carries two dates: the date of the survey; and the date of publication. On some maps, the date of the survey is included in the title; on some, the date of publication is only to be found in a shorthand code in the printer's note. A catalogue should indicate both dates, if possible. In some cases, the number of the edition can be helpful as a substitute for these dates or as additional information.

*Other classification systems*

Many more classification systems can be used to group and arrange the various maps. It is possible to think of map classifications using the accession number of the collection, the size of the map-sheets, the number of colours of the map, the method of graphic representation (predominant types of signatures), the intended purpose of the maps etc. However, only a few of those classifications appear to be of practical significance. Their data can be included in a catalogue reference, if required. The arrangement and the storage of the maps can follow only a few classification systems in a certain order as, in general, not more than one map can be acquired. The technical requirements of the storage facilities propose the application of the form or type classification as the most suitable system. Within each form group, the maps can be arranged according to other classification systems. For storage of the maps, MIC will use the following sequence of classifications: (1) form or type; (2) area; (3) subject; (4) time classification system.

*Catalogues of the Map Information Centre*

The acquisition of one copy of each map and the technical requirements of the map storage systems restrict the use of the complete informational content of the maps. To facilitate easy access to the maps and to make the regional and factual data of the maps readily available to the map-users, it is necessary to organize several map catalogues based on various map classification systems.

A map catalogue consists of catalogue cards, which have been arranged according to one of the classification systems mentioned above. In general, two map catalogues appear to be sufficient: a regional catalogue (area classification as shown in table 24) and a topic catalogue (subject classification as shown in table 25). MIC has set up those two catalogues for consultation. An additional catalogue (authority = publisher classification) is used by MIC only for the internal purpose of map-exchange control.

**Table 24. Thailand: sample page of map catalogue of Map Information Centre—reference by area**

| *Area* | *Topic Code* | *Authority* | *Accession No.* | *Full code* |
|---|---|---|---|---|
| Globe, Earth | 2.0 | TCI | 2478 | G –2.0 –V |
| World Oceans | 4.3.2 | NGS | 0001 | O –4.3.2–IV –50000 |
| Atlantic Ocean | 4.3.2 | NGS | 0138/1–24 | OA –4.3.2–I –20000 |
| | 4.3.2 | GSA | 1339/1–2 | OA –4.3.2–I |
| | 4.3.2 | NGS | 1862 | OA –4.3.2–IV –30412 |
| Pacific Ocean | 4.3.2 | NGS | 0008 | OP –4.3.2–IV –36432 |
| | 3.2 | NGS | 0150 | OP –3.2 –I –27500 |
| | 4.3.2 | NGS | 0242 | OP –4.3.2–IV –36432 |
| | 4.1.3 | NZOI | 2310 | OP –4.1.3–IV –25000 |
| | 4.1.3 | NZOI | 2311 | OP –4.1.3–IV –25000 |
| | 4.1.3 | NZOI | 2312 | OP –4.1.3–IV –25000 |
| | 4.1.3 | NZOI | 2313 | OP –4.1.3–IV –25000 |
| | 4.1.3 | NZOI | 2314 | OP –4.1.3–IV –25000 |
| | 4.1.3 | NZOI | 2315 | OP –4.1.3–IV –25000 |
| | 4.1.3 | NZOI | 2316 | OP –4.1.3–IV –25000 |
| | 2.5 | NZMS | 2388/1–2 | OP –2.5 –I –20000 |
| | 4.3.2 | NGS | 0015 | OI –4 3.2–I –15459 |
| | 4.3.2 | GSA | 1341 | OI –4.3.2–I |
| Europe | 9.4 | NGS | 0146/1–2 | EU –9.4 –I –7500 |
| | 9.4 | DS | 0283 | EU –9.4 –III –5000 |
| | 3.4 | PPWK | 1962 | EU –3.4 –I –3000 |
| Northern Europe | 2.5 | AMS | 0025 | EUN –2.5 –III –4000 |
| | 9.4 | NGS | 0068 | EUN –9.4 –IV –3041 |
| | 9.4 | NGS | 0203 | EUN –9.4 –I –2500 |
| Western Europe | 9.4 | NGS | 0252 | EUW –9.4 –IV –2154 |
| France | 2.4 | IGN | 0315 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0316 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0319 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0325 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0327 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0331 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0356 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0384 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0385 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0389 | EUW.FR –2.4 –III –500 |
| | 2.4 | IGN | 0390 | EUW.FR –2.4 –I –1000 |
| | 3.1 | IGN | 0393 | EUW.FR –3.1 –III –500 |
| | 3.1 | IGN | 0396 | EUW.FR –3.1 –III –500 |
| | 3.1 | IGN | 0397 | EUW.FR –3.1 –III –500 |
| | 3.1 | IGN | 0399 | EUW.FR –3.1 –III –500 |
| | 3.1 | IGN | 0401 | EUW.FR –3.1 –III –500 |

**Table 25. Thailand: sample page of map catalogue of Map Information Centre—reference by subject**

| *Area* | *Topic code* | *Authority* | *Accession No.* | *Full Code* |
|---|---|---|---|---|
| Aeronautical chart | AS | ACIC | 0288 | AS -3.1 -III -1000 |
| | AS | ACIC | 0289 | AS -3.1 -III -1000 |
| | AS | ACIC | 0290 | AS -3.1 -III -1000 |
| | AS | ACIC | 0291 | AS -3.1 -III -1000 |
| | ASA.MY | SD/FM | 0294 | ASA.MY -3.1 -III -2000 |
| | AS | ACIC | 0307 | AS -3.1 -III -1000 |
| | AS | ACIC | 0310 | AS -3.1 -III -1000 |
| | AS | ACIC | 0313 | AS -3.1 -III -500 |
| | ASE.JA | HD/MSA | 0361 | ASEJA -3.1 -I -1000 |
| | ASE.JA | HD/MSA | 0362 | ASEJA -3.1 -I -1000 |
| | ASA | HD/RTN | 0365 | ASA -3.1 -III -1000 |
| | EUW.FR | IGN | 0393 | EUW.FR -3.1 -III -500 |
| | EUW.FR | IGN | 0396 | EUW.FR -3.1 -III -500 |
| | EUW.FR | IGN | 0397 | EUW.FR -3.1 -III -500 |
| | EUW.FR | IGN | 0399 | EUW.FR -3.1 -III -500 |
| | EUW.FR | IGN | 0401 | EUW.FR -3.1 -III -500 |
| | EUW.FR | IGN | 0402 | EUW.FR -3.1 -III -500 |
| | EUW.FR | IGN | 0405 | EUW.FR -3.1 -III -500 |
| | AUI.NZ | NZMS | 2341 | AUI.NZ -3.1 -I -2000 |
| Agriculture map | AUM.AT | DNM | 0046 | AUM.AT -8.1.3-IV -12500 |
| | AUM.AT | DNM | 0047 | AUM.AT -8.1.3-IV -6000 |
| | ASE.JA | GSI | 0526 | ASE.JA -8.1.3-IV -800 |
| | ASE.JA | GSI | 0527 | ASE.JA -8.1.3-IV -800 |
| | ASE.JA | GSI | 0528 | ASE.JA -8.1.3-IV -800 |
| | ASA.TH | DG/CMU | 1583 | ASA.TH -8.1.3-IV.D-2500 |
| | ASA.TH | DG/CMU | 1608 | ASA.TH -8.1.3-IV.D-2500 |
| | ASA.TH | DG/CMU | 1629 | ASA.TH -8.1.3-IV.D-2500 |
| | ASI.ID | ATD | 1807 | ASI.ID -8.1.3-IV -5000 |
| | ASI.ID | ATD | 1815 | ASI.ID -8.1.3-IV -5000 |
| | ASI.ID | ATD | 1818 | ASI.ID -8.1.3-IV -5000 |
| | ASI.ID | ATD | 1819 | ASI.ID -8.1.3-IV -5000 |
| | ASI.ID | ATD | 1820 | ASI.ID -8.1.3-IV -5000 |
| | ASI.ID | ATD | 1821 | ASI.ID -8.1.3-IV -5000 |
| | ASI.ID | ATD | 1822 | ASI.ID -8.1.3-IV -5000 |
| | AUM.AT | DNM | 1905 | AUM.AT -8.1.3-IV -6000 |
| | AUM.AT | DNM | 1939 | AUM.AT -8.1.3-IV -12000 |
| | AUM.AT | DNM | 1940 | AUM.AT -8.1.3-IV -12000 |
| | EUC.GE | IFL&IFR | 2016 | EUC.GE -8.1.3-IV -2000 |
| | EUC.GE | IFL&IFR | 2018 | EUC.GE -8.1.3-IV -2700 |
| | EUC.GE | IFL&IFR | 2019 | EUC.GE -8.1.3-IV -2700 |
| | EUC.GE | IFL&IFR | 2021 | EUC.GE -8.1.3-IV -2700 |
| | EUC.GE | IFL&IFR | 2024 | EUC.GE -8.1.3-IV -2700 |
| Central place maps | ASA.TH | FAO | 2472 | ASA.TH -8.1.3-V -250 |

Each card of the three catalogues contains the same essential data for one map:

Map title (in reference language)
Original map title
Language of the map
Additions to the title (title of book, explanatory notes, documents etc.)
Serial and sheet number
Page and plate number
Map scale
Author
Publisher
Date of survey
Date of publication
Edition
Map type form
Map size
Remarks (accession number etc.)
Information on the map content and the methods of representation cannot be given satisfactorily due to the great variety of the map legends. The data on each card are headed by two codes which are of utmost importance for the arrangement of the catalogues: (1) the catalogue code; and (2) the coded reference to the storage facilities.

The catalogue code is a combination of the codes of (*a*) the area classification (capital letter); (*b*) the subject classification (Arabic numeral with decimals); (*c*) the type classification (Roman numeral); (*d*) the scale classification (Arabic numeral).

By underlining the required code component, these card headings can be utilized to establish the various catalogues. The orientation within the catalogues can be further facilitated by the use of coloured cards. The second code, the storage note, gives the number or designation of the division, room, shelf or drawer in which the map is kept. Figure 54 shows the arrangement of the codes and the map data on a sample catalogue card.

| CATALOGUE CODE | ASA.TH - 2.4 - III - 250 | STORAGE NOTE | A - 2 - 5 |
|---|---|---|---|
| MAP TITLE (IN ENGLISH) : | CHANGWAT CHIANG MAI | | |
| DOCUMENT TITLE: | | | |
| ORIGINAL TITLE : | จังหวัดเชียงใหม่ | | |
| LANGUAGE : | THAI, ENGLISH | | |
| ADDITIONS TO THE TITLE : | INDOCHINA AND THAILAND (THAILAND-BURMA) 1:250,000 | | |
| MAP SERIAL No. : | L 509 | PAGE No. : | |
| MAP SHEET No. : | NE 47-6 | PLATE No. : | |
| SCALE : | 1:250,000 | | |
| AUTHOR : | | | |
| PUBLISHER : | ROYAL THAI SURVEY DEPARTMENT (RTSD) | | |
| DATE OF SURVEY : | 1960 | MAP/DOC. TYPE : | III |
| DATE OF PUBLICATION : | 1964 | MAP/DOC. SIZE (IN CM) : | 72 x 56 |
| EDITION : | 2 - RTSD | | |
| ACCESSION No. : | 2523 | | FOR REMARKS P.T.O. |

*Figure 54. Thailand: sample catalogue card of Map Information Centre*

*Map documentation procedure*

Upon receipt of a map, the catalogues are checked to see whether the map is already held by MIC. If it is not in the collection, the procedure outlined below is followed:

(*a*) The map is stamped with the MIC stamp;

(*b*) It is given an accession number;

(*c*) It is filed in the accession register;

(*d*) It is classified according to the classification systems described above;

(*e*) The catalogue code is written on the map below the stamp;

(*f*) The three catalogue cards are filed with all the map data. The map and its catalogue cards are then passed on to the storage rooms;

(*g*) In the storage facility, the storage reference is given;

(*h*) The storage reference is entered on the catalogue cards and on the map that will be kept;

(*i*) The catalogue cards are returned and filed in the area, subject and authority catalogues, respectively.

If the map is already held by the collection, no catalogue card is written. A notation is made on the existing catalogue cards to show that an additional copy of the map has been added to the collection.

The maps of map series have to pass one more procedure. For a map series, an index map or cover diagram is drawn which shows the extent of each map as well as of the complete series. Each newly acquired map of a series has to be marked on the index map.

The Documentation Branch does not evaluate the information content of the new acquisitions. It only compiles a list of the new arrivals, listing area, subject and scale, that might be distributed by the Information Branch.

*Other documentation activities*

MIC receives not only maps but related printed materials, such as books, periodicals and journals, reports, original documents, and aerial photographs. In general, books, journals and periodicals, and reports are given to the General Library or other divisions (Geography Division, for instance) of the Royal Thai Survey Department. The original documents are generally kept in the Drafting or Reproduction Division, the aerial photographs in the Aerial Photo Library. But notes and/or catalogue cards of the existing materials are filed in the area and topic catalogues of MIC. The Documentation Branch of MIC is restricted to keeping selected gazetteers, glossaries, symbols, books and specifications, catalogues, periodical reports of various mapping agencies and cartographic news-letters.

INFORMATION BRANCH OF THE MAP INFORMATION CENTRE

The major tasks of the Information Branch of MIC are: (*a*) to establish contacts between the Royal Thai Survey Department and the various mapping authorities of Thailand as well as of other countries of the ESCAP region; (*b*) to collect and exchange information on the mapping activities and mapping coverage of the countries of the ESCAP region; and (*c*) to collect information to compile the Regional Economic Atlas of Asia and the Far East and other geographical mapping projects in close co-operation with the Geography Division of the Survey Department.

The contacts between MIC and the various mapping agencies were established in part by a questionnaire and various written requests to the participants of the United Nations Regional Cartographic Conferences. They are recorded in a special catalogue of mapping authorities of the region. These authorities have been listed in the 1970 edition of the MIC map catalogue. Meanwhile, many more contacts had to be made to obtain the necessary information for compilation of the maps of the Regional Economic Atlas.

The exchange of information on the mapping activities of the different agencies within the ESCAP region is restricted by the limited budget of MIC. Such information will be given upon request as completely as it is available in MIC.

MIC is also consulted by other divisions of the Royal Thai Survey Department for the sully of data of special geographical mapping projects.

**Table 26. Thailand: subject classification system of Map Information Centre**

A. SYSTEMATIC ARRANGEMENT

| *Code* | *Subject* |
|---|---|
| 1. *Cartography, theory and practice* | |
| 0.0 | Cartography, theory and practice |
| 0.1 | Institutions, organization, libraries |
| 0.2 | Cartographic surveys |
| 0.2.1 | Geophysical survey, equipment and procedure |
| 0.2.2 | Hydrographic survey |
| 0.2.3 | Geodetic survey, including topographic survey, equipment and procedure |
| 0.2.4 | Photogrammetric survey, equipment and procedure |
| 0.2.5 | Remote-sensing survey, equipment and procedure |
| 0.2.6 | Aerial photo-interpretation, equipment and procedure |
| 0.2.7 | Geographical survey (if not recorded as map) |
| 0.2.8 | Statistical survey (if not recorded as map) |
| 0.3 | Cartographic production |
| 0.3.1 | Cartographic planning, organization |
| 0.3.2 | Cartographic compilation and design Redaction |
| 0.3.3 | Names, transcription |
| 0.3.4 | Cartographic draft techniques |
| 0.3.5 | Cartographic printing techniques |
| 0.3.6 | Legal questions of cartographic production |
| 0.3.7 | Cartographic products other than maps (relief, globe) |
| 0.4 | Cartographic equipment |
| 0.5 | Cartographic training |
| 0.6 | Other cartographic fields |
| 2. *Cartographic products* | |
| 1.0 | Grids and index maps |
| 1.1 | Projections, geodetic grids |
| 1.2 | Geodetic constructions (triangulation, trilateration etc.) |
| 1.3 | Outline maps |
| 1.4 | Distance maps, time-zone maps |
| 1.5 | Index maps |
| 1.9 | Miscellaneous |
| 2.0 | Topographic maps (general maps) |
| 2.1 | Topometric maps, cadastral maps (over 1:10,000 scale) |
| 2.2 | Town plans, city maps |
| 2.3 | Topographic maps, large scale (1:10,000-1:100,000) |
| 2.4 | Topographic maps, small scale (1;100,000-1,000,000) |
| 2.5 | Chorographic maps (scale under 1:1,000,000) |
| 2.6 | Photo maps, picto maps |
| 3.0 | Charts (maps for orientation or navigation) |
| 3.1 | Aeronautical charts |
| 3.2 | Hydrographic charts (open sea), nautical charts |
| 3.3 | Hydrographic charts (inland waterways) |
| 3.4 | Road maps |
| 3.5 | Tourist maps |
| 4.0 | Maps of the natural environment |
| 4.1 | Maps of the lithospheric environment |
| 4.1.1 | Hypsometric maps, marphographic maps, contour maps |
| 4.1.2 | Geophysical maps |

**Table 26 (*cont.*)**

A. SYSTEMATIC ARRANGEMENT (*cont.*)

| *Code* | *Subject* |
|---|---|
| *2. Cartographic products* (cont.) | |
| 4.1.3 | Geological maps, mineral deposit maps, stratigraphic maps |
| 4.1.4 | Pedological maps, soil maps |
| 4.2 | Maps of the atmospheric environment |
| 4.2.1 | Meteorological maps, weather maps |
| 4.2.2 | Climatological maps |
| 4.3 | Maps of the hydrospheric environment |
| 4.3.1 | Hydrographic maps, ground water maps |
| 4.3.2 | Oceanographic maps |
| 4.4 | Maps of the biospheric environment |
| 4.4.1 | Vegetation maps |
| 4.4.2 | Wildlife maps, migration (of animals) maps |
| 4.5 | Miscellaneous |
| 5.0 | Population maps |
| 5.1 | Population distribution maps, density (of population) maps |
| 5.2 | Maps of population development and migrations |
| 5.3 | Anthropological maps, ethnographical maps |
| 5.4 | Language maps |
| 5.9 | Miscellaneous |
| 6.0 | Cultural maps |
| 6.1 | Maps of hygiene and health, medical provision maps |
| 6.2 | Maps of education |
| 6.3 | Maps of religion |
| 6.4 | Maps of recreation |
| 6.9 | Miscellaneous |
| 7.0 | Settlement maps |
| 7.1 | Maps of settlement types and distribution |
| 7.2 | Maps of rural settlements |
| 7.3 | Maps of urban settlements (other than 2.2) |
| 7.4 | Maps of architectural monuments |
| 7.5 | Maps of central places |
| 8.0 | Economic maps |
| 8.1 | Maps of primary economic activities |
| 8.1.1 | Maps of forestry and hunting |
| 8.1.2 | Maps of fishery |
| 8.1.3 | Maps of agriculture; land-use maps, livestock |
| 8.1.4 | Maps of water resources and management, irrigation maps |
| 8.1.5 | Maps of mining industry |
| 8.2 | Maps of secondary economic activities |
| 8.2.1 | Maps of manufacturing industry |
| 8.2.2 | Maps of energy production, electricity |
| 8.3 | Maps of tertiary economic activities |
| 8.3.1 | Maps of transportation and commuting |
| 8.3.2 | Maps of communication |
| 8.3.3. | Maps of the tourist industry |
| 8.3.4 | Maps of trade and banking |
| 8.4 | Maps of the economic characteristics of population |
| 8.9 | Miscellaneous (income, prices, investment etc.) |
| 9.0 | Political maps |
| 9.1 | Maps of political organizations and their boundaries |
| 9.2 | Maps of internal administrative organization |
| 9.3 | Maps of international groupings and their boundaries |
| 9.4 | Geopolitical maps |
| 10.0 | Historical maps (maps of historical events) |
| 10.1 | Political history maps |
| 10.2 | Population history maps |
| 10.3 | Cultural and settlement history maps |
| 10.4 | Economic history maps |
| 10.5 | War history maps |
| 10.6 | Exploration history maps |
| 10.7 | Landscape history maps |
| 10.9 | Miscellaneous |
| 11.0 | Military maps |
| 11.1 | Maps of military organization |
| 11.2 | Maps of military constructions (forts, bases etc.) |
| 11.3 | Maps of military operations (other than 10.5) |
| 12.0 | Maps of spatial planning |
| 12.1 | Town-planning maps |
| 12.2 | Regional planning maps |
| 12.3 | National planning maps |
| 12.4 | Special planning maps |
| 12.5 | Conservation maps (national parks etc.) |
| 13.0 | Other maps, unclassified |

Table 26 (*cont.*)

B. ALPHABETICAL ARRANGEMENT

| *Subject of map* | *Code* |
|---|---|
| Aeronautical charts | 3.1 |
| Agriculture maps | 8.1.3 |
| Anthropological maps | 5.3 |
| Architectural monument maps | 7.4 |
| Atmospheric environment maps | 4.2 |
| Biospheric environment maps | 4.4 |
| Cadastral maps (scale over 1:10,000) | 2.1 |
| Central place maps | 7.5 |
| Charts (maps for orientation or navigation) | 3.0 |
| Chorographic maps (scale under 1:1,000,000) | 2.5 |
| City maps | 2.2 |
| Climatological maps | 4.2.2 |
| Communication maps | 8.3.2 |
| Commuting maps | 8.3.1 |
| Conservation maps | 12.5 |
| Contour maps | 4.1.1 |
| Cultural history maps | 10.3 |
| Cultural maps | 6.0 |
| Density (of population) maps | 5.1 |
| Development (of population) maps | 5.2 |
| Distance maps | 1.4 |
| Economic characteristics of population maps | 8.4 |
| Economic maps | 8.0 |
| Economic history maps | 10.4 |
| Education maps | 6.2 |
| Electricity maps (maps of energy production) | 8.2.2 |
| Ethnographic maps | 5.3 |
| Exploration history maps | 10.6 |
| Finance economy maps | 8.9 |
| Fishery maps | 8.1.2 |
| Forestry maps | 8.1.1 |
| Geodetic constructions | 1.2 |
| Geodetic grids | 1.1 |
| Geological maps | 4.1.3 |
| Geophysical maps | 4.1.2 |
| Geopolitical maps | 9.4 |
| Grids and index maps | 1.0 |
| Ground-water maps | 4.3.1 |
| Historical maps (maps of historical events) | 10.0 |
| Hunting maps | 8.1.1 |
| Hydrographic charts (inland waterways) | 3.3 |
| Hydrographic charts (open sea) | 3.2 |
| Hydrographic maps | 4.3.1 |
| Hydrospheric environment maps | 4.3 |
| Hygiene and health maps | 6.1 |
| Hypsometric maps | 4.1.1 |
| Income maps | 8.9 |
| Index maps | 1.5 |
| Internal administrative organisations maps | 9.2 |
| International groupings maps | 9.3 |
| Investment maps | 8.9 |
| Irrigation maps | 8.1.4 |
| Landscape history maps | 10.7 |
| Land-use maps | 8.1.3 |
| Language maps | 5.4 |
| Lithospheric environment maps | 4.1 |
| Livestock maps | 8.1.3 |
| Manufacturing industry maps | 8.2.1 |
| Medical provision maps | 6.1 |
| Meteorological maps | 4.2.1 |
| Migration (of population) maps | 5.2 |
| Migration (of animals) maps | 4.4.2 |
| Military construction maps (forts, bases) | 11.2 |
| Military maps | 11.0 |
| Military operations maps (other than 10.5) | 11.3 |
| Military organization maps | 11.1 |
| Mineral deposit maps | 4.1.3 |
| Mining industry maps | 8.1.5 |
| Morphographic maps | 4.1.1 |
| National parks maps | 12.5 |
| National planning maps | 12.3 |

**Table 26 (*cont.*)**

B. ALPHABETICAL ARRANGEMENT (*cont.*)

| *Subject of map* | *Code* |
|---|---|
| Natural environment maps | 4.0 |
| Nautical charts | 3.2 |
| Oceanographic maps | 4.3.2 |
| Outline maps | 1.3 |
| Pedological maps | 4.1.4 |
| Photo-map or picto-map | 2.6 |
| Political history maps | 10.1 |
| Political organizations and their boundaries maps | 9.1 |
| Political maps | 9.0 |
| Population development maps | 5.2 |
| Population distribution maps | 5.1 |
| Population history maps | 10.2 |
| Population maps | 5.0 |
| Prices maps | 8.9 |
| Primary economic activity maps | 8.1 |
| Projections map | 1.1 |
| Recreation maps | 6.4 |
| Reference maps (see chorographic maps or topographic maps) | 2.0 |
| Regional planning maps | 12.2 |
| Religion maps | 6.3 |
| Road maps | 3.4 |
| Rural settlements maps | 7.2 |
| Secondary economic activity maps | 8.2 |
| Settlement history maps | 10.3 |
| Settlement maps | 7.0 |
| Settlement type and distribution maps | 7.1 |
| Soil maps | 4.1.4 |
| Spatial-planning maps | 12.0 |
| Special architectural monuments maps | 7.4 |
| Special planning maps | 12.4 |
| Stratigraphic maps | 4.1.3 |
| Tertiary economic activity maps | 8.3 |
| Time-zone maps | 1.4 |
| Topographic maps (general maps) | 2.0 |
| Topographic maps, large scale (1:10,000–1:100,000) | 2.3 |
| Topographic maps, small scale (1:100,000–1:1,000,000) | 2.4 |
| Topometric maps (scale over 1:10,000) | 2.1 |
| Tourist industry maps | 8.3.3 |
| Tourist maps | 3.5 |
| Town plans | 2.2 |
| Town-planning maps | 12.1 |
| Trade and banking maps | 8.3.4 |
| Triangulation maps | 1.2 |
| Transportation maps | 8.3.1 |
| Urban settlements maps (other than 2.2) | 7.3 |
| Vegetation maps | 4.4.1 |
| War history maps | 10.5 |
| Water resources and management maps | 8.1.4 |
| Weather maps | 4.2.1 |
| Wildlife maps | 4.4.2 |

**Table 27. Thailand: type classification system of Map Information Centre**

| *Code* | *Type* |
|---|---|
| I. | Single maps (print) |
| I.D | Single maps, draft |
| I.R | Single maps, rolled |
| II. | Part of a single map |
| III. | Maps as part of a map series |
| IV. | Map as part of an atlas or a book |
| V. | Atlas |
| VI. | Book form publication |
| VI.Y | Bibliography |
| VI.M | Technical manual |
| VI.C | Catalogue |
| VI.B | Book |
| VI.R | Report, journal, periodical |
| VI.D | Document, pamphlet |
| VI.G | Gazetteer, table |
| VI.S | Miscellaneous |

# TOPOGRAPHY, GEODESY AND CARTOGRAPHY IN THE UNION OF SOVIET SOCIALIST REPUBLICS, 1973–1976*

*Paper presented by the Union of Soviet Socialist Republics*

The state astrogeodetic network in the Union of Soviet Socialist Republics meets the requirements of studies of the form and dimensions of the earth, as well as the applied tasks of mapping the national territory and the conduct of local topographic surveys to meet the needs of specific branches of the economy. During the period under review the state geodetic system carried on activities on bridging in specific intensively developing regions. Both theoretical and applied activities have been undertaken in further verification of the astrogeodetic network, in the setting-up of a fundamental astrogeodetic network, in the application of spatial constructions for geodetic purposes in geodetic observations of satellites and in other directions. A number of works have been fulfilled under international programmes.

A vastly developed first- and second-order precise levelling network connects level observations of all the seas surrounding the country. Works on bridging this network and relevelling are being conducted. The levelling network of the USSR is precisely adjusted. Data on the relevelling of lines with a total length of about 70,000 km have been collected and systematized. These data are used in studies of recent vertical movements of the earth's crust.

As was reported at the Seventh Conference in 1973, the map of recent vertical movements of the earth's crust in the Eastern European region, on six sheets at 1 : 2,500,000 scale, was published as a result of these studies. Progress in improving the precision of linear measurements through improvement of geodetic equipment has increased the possibilities for studies of the horizontal movements of the earth's crust. There has been an increase in the volume of geodetic researches and observations conducted in this field in geodynamic test areas (prognosis test areas) in regions of seismic activity, with the objective of working out methods of detecting the forerunners of earthquakes. For this purpose, a vast programme of geodetic research and measurements (relevelling, compilation and reobservations of linear, linear-angular networks and astronomical fixes) is widely spread throughout test areas in the seismically active regions of the country.

New methods and techniques were introduced into geodetic practice in the Soviet Union. The application of helium-neon laser range-finders to high-precision linear measurements has noticeably increased, thus permitting the measurement of considerable distances at night and during the day.

In the northern regions, under heavy weather conditions, Tellurometers have been the most widely used apparatus for linear measurements.

For measurements of extremely long distances as well as water obstacles, the Tellurometer transceivers were located at heights up to 25 m, using the outer antenna rods.

Topographic optical range-finders (SM-3, EOK-200, MSD-1m and others) have been used at geodetic network constructions and bridgings for large-scale surveys, including those in urban areas.

The construction of large hydrotechnical and industrial complexes has focused greater attention on improvement of the accuracy of geodetic level measurements to the degree required for construction purposes as well as for subsequent relevelling.

## Aerial photography

In the USSR, state mapping is conducted on different scales. The commonly accepted map scales are 1 : 10,000, 1 : 2,500, 1 : 50,000 and 1 : 100,000. Corresponding technical instructions are elaborated for all map scales in respect of their contents. Catalogues of standard symbols also are prepared, providing for transition from one scale to another, taking into consideration the necessary generalization of contents. Standard requirements concern also the accuracy of map compilation at each scale and contour interval. As concerned requirements, the same approach applies for large-scale maps and plans (1 : 5,000, 1 : 2,000, 1 : 1,000 and 1 : 500); but in this case, in addition to the general requirements for maps and plans, there are specific needs, depending upon the purposes involved and the expected fields of application. It is mandatory that the inaccuracy of a map or a plan should not exceed a mean error volume of 0.5 mm of the map scale and $\frac{1}{4}$–$\frac{1}{3}$ of a contour interval. In recent years, production of photo maps has increased and production of digital maps has begun. Simultaneously with the work on compilation of new maps on all scales and the conduct of large-scale surveys, great attention is paid to the maintenance of existing maps on modern levels.

Radio-geodetic intersections obtained by aerial Tellurometer (radio-distancer system) for computation of photographic central points in map production are widely used.

From year to year, the volume of large-scale surveys (1 : 500, 1 : 1,000, 1 : 2,000) needed for economic development, land reclamation and agriculture increases. In this case also, the main method for compilation of maps and plans is phototopography.

Research on the use of helicopters for aerial surveys is under way.

Photogrammetric methods are successfully applied in the compilation of large-scale plans for land reclamation projects, for projecting and construction in urban areas, for projecting new roads and for drafting plans with contour intervals of 0.5–1.0 m.

* The original text of this paper appeared as document E/CONF.68/L.101.

In most cases, photo plans and photo maps are in great demand. There is a large volume of topographic-geodetic activities on actualization surveys in both urban and rural regions and on surveys and compilation of underground communications and technical network plans.

### Cartography

The volume of maps and atlases published for mass consumption in the USSR increases each year in order to satisfy more fully the demand from different branches of the economy and population.

Teaching, informational and other types of maps are published for all the republics of the Soviet Union and fully satisfy their requirements.

The themes and production samples of the USSR cartographic service were widely represented at the Eighth International Cartographic Conference of the International Cartographic Association; and at the exhibitions, organized within the framework of that Conference, incorporating the following topics:

(*a*) Cartography as a source for public education;

(*b*) Mapping of nature for environmental protection purposes;

(*c*) Application of remote-sensing data for thematic mapping;

(*d*) Compilation of a world small-scale thematic map series on the basis of international co-operation;

(*e*) Methods of map utilization for scientific research and application;

(*f*) Development of cartography in the Soviet Union.

The characteristic feature of those themes is broad participation in their elaboration of the scientific institutions, ministries and directorates that compile and utilize thematic maps and atlases.

In recent years in the USSR, the following cartographic works were produced: Geological-geophysical Atlas of the Indian Ocean; Europe and world tectonic maps on the scales 1 : 2,500,000 and 1 : 10,000,000, respectively; Atlas of the CPSU History; Geographical Atlas of the World for Secondary Schoolteachers; Teaching Atlas of the World; Atlas of the USSR Areas and Resources of Medicinal Herbs; a series of informational maps on other countries of the world; and other works.

Work is under way on further improvement of map contents and design as well as improvement of map compilation techniques and equipment. Different plastic materials and films are widely used in map publishing.

### Research activities

In order to provide for a continuously increasing volume of geodetic and cartographic works to meet the needs of the national economy and the population, new methods and means are being developed that will substantially increase labour efficiency in all the processes connected with those works.

In recent years, a range of new devices and technological processes has been developed for astrogeodetic, photogrammetric and cartographic purposes. Research is being done on the further introduction of computers at standard geodetic testing grounds to determine the effect of instrumental errors and environmental conditions on the accuracy of geodetic measurements, as well as for use in other fields.

A variety of new aerial cameras has been developed for topographic surveys at different scales: a stereographer; an orthophoto transformer; a differential photo transformer; devices for point identification at overlapping photographs.

A significant advance in the further modernization of aerial photographic surveying was the commencement of commercial production of a special AN-30 aircraft. In photogrammetry, research is being conducted on the further modernization of analytical methods of plotting and computer-assisted equations of spatial block photogrammetric networks to increase the accuracy of photogrammetric fundamental networks for surveying with contour intervals of 1 m and less, and on the modernization of the stereo-topographic method of large-scale surveying.

Work has been done on mapping of the moon and Mars, as well as of the earth's surface, by the use of remote-sensing data and materials, obtained from space craft.

In cartography, scientific research has been carried on with regard to the further mechanization and automation of cartographic processes, on the development of new kinds of thematic maps; and on the improvement of production of thematic, informational, tourist and teaching maps and atlases.

As concerns economics and management in topographic-geodetic and cartographic production, research has been done on the development and application of automatic systems of production control.

# UNITED KINGDOM REPORT ON ACTIVITIES*

*Paper presented by the United Kingdom of Great Britain and Northern Ireland*

This progress report covers the contribution to the surveying, mapping and charting of the countries and seas of Asia and the Far East made by agencies of the United Kingdom of Great Britain and Northern Ireland between June 1973 and the end of August 1976.

Land survey work has been carried out mainly by the Directorate of Overseas Surveys (DOS), a part of the United Kingdom Ministry of Overseas Development, under United Kingdom technical co-operation arrangements. Field-parties worked in Cyprus, the Gilbert Islands, Sabah, Tuvalu and Yemen. Doppler satellite fixes were made by military surveyors at various sites in the regions and by DOS in Yemen. The Royal Air Force flew aerial photography of selected areas of a number of countries as a basis for new or revised mapping. Details of these activities are given below in the first section.

Map production was undertaken by DOS and by the Directorate of Military Survey (DMS); details are given below and in table 28 (see annex I). The use of automated-cartography techniques in the United Kingdom increased greatly during the report period, particularly at DMS. These techniques are used both as an aid to conventional compilation and for the provision of a variety of digital products. To improve further the rate of data capture, a new rapid digitizing system has been designed which is of the automated line-following type. This system was on schedule for delivery to DMS in October 1976. Photo-mapping techniques were further developed at DOS; and this type of map is proving to be particularly effective in the island areas of the Pacific, because of the detailed information that it can provide on vegetation patterns and off-shore features. Hydrographic surveying by the Royal Navy survey ship, HMS *Hydra* has continued; details are given below in the third section and in table 29 (see annex I).

Government agencies have also continued to provide training facilities for overseas personnel in the fields of cartography, photogrammetry, photography and surveying. Such training has been provided both at DOS and at the School of Military Survey for holders of United Kingdom technical co-operation awards, United Nations fellowships and overseas government scholarships. Trainees came to the United Kingdom from Hong Kong, India, Indonesia, Malaysia, Nepal, Pakistan, the Solomon Islands, Sri Lanka and Thailand.

For the first time, considerable assistance was given to countries or areas within the region by the secondment of senior professional and technical personnel to overseas Governments for periods of two years or more. Senior surveyors were seconded to the Solomon Islands, the New Hebrides and Sabah; a survey adviser was appointed to Yemen; and a cartographer was seconded to the Indonesia–United Kingdom Transmigration Project.

During the past 10 years, the United Kingdom has presented a number of technical papers to United Nations regional conferences which are of world-wide and not merely of regional interest; to enable delegates to have access to these reports, a list has been included in annex II.

## TOPOGRAPHIC SURVEY, AERIAL PHOTOGRAPHY AND MAPPING

### *Arabian Peninsula*

In the small-scale mapping of the Arabian Peninsula, six sheets at 1 : 500,000 scale were produced in series 1404 by the Directorate of Military Survey. These sheets cover Qatar (547C), the United Arab Emirates (548C), the United Arab Emirates/Oman (563A), the United Arab Emirates/Saudi Arabia (564B) and Yemen (687A and 668D).

### *Bahrain*

Two sheets of Bahrain at 1 : 50,000 scale (north and south) in series K 7610 were produced by DMS.

### *Brunei*

Aerial photography at a scale of 1 : 25,000 was taken by the Royal Air Force of selected areas of Brunei, for revisional purposes.

### *Burma*

The preparation of geological maps of Burma was undertaken on behalf of the United Kingdom Institute of Geological Sciences. One sheet at 1 : 63,360 scale was published; and at the end of the report period work had been taken up on the Yadanatheingi area (1 : 100,000) and the Kyaukme-Longtawkno area (1 : 125,000) in the northern Shan states.

### *Cyprus*

In June-July 1973, to support the new contoured mapping programme at 1 : 5,000 scale, 4,760 km$^2$ of the southern part of Cyprus were photographed on the scale 1 : 15,000.

Throughout the report period, work continued in the Cyprus Lands and Surveys Department and in DOS on a joint 1 : 5,000 mapping programme. Field survey was carried out mainly by Cyprus, aerotriangulation was done in the United Kingdom and all subsequent stages of map production were undertaken in both countries. Fifty-six sheets have been printed (including 23 in Cyprus) and work was in hand on a further 501 sheets.

DMS produced town plans at 1 : 7,500 scale of Nicosia, Famagusta, Larnaca and Episkopi and also various military range area maps at 1 : 25,000 scale.

* The original text of this paper, prepared by the Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.68/L.18.

*Fiji*

Aerial photography on the scale 1 : 80,000 was taken of the Fiji islands and off-lying reefs by the Royal Air Force in July-August 1973. Coverage at larger scales was also taken of selected areas to assist chart revision.

Photography on the scale 1 : 80,000 was used to revise three 1 : 50,000 sheets of Vanua Levu. The final 12 thematic maps illustrating the land-capability survey of Viti Levu and Vanua Levu were published.

*Gilbert Islands*

A DOS field-survey party completed the task of establishing the framework and mapping control throughout the former Gilbert and Ellice Islands colony in December 1974.

Six sheets at 1 : 2,500 scale, covering part of rural Tarawa, were completed and sent out for dye-line reproduction locally, and five further sheets were awaiting field completion.

Work was begun on a new series of photo maps at 1 : 25,000 scale designed to cover the entire group; in May 1976, mosaics of Beru, Butaritari and Maiana were sent out for field completion.

*Hong Kong*

The 1 : 25,000 contoured mapping and associated military range and training area maps of the area of Hong Kong have been revised by DMS. A new series on the scale 1 : 20,000, to replace the 1 : 25,000 series eventually, is being produced in association with the Hong Kong Crown Lands and Survey Office. This project has required new photography.

The two-sheet geological map covering the entire area at 1 : 50,000 scale was published.

*Malaysia: Sabah and Sarawak*

In July 1973, the DOS field-party completed its programme of establishing control for contoured mapping of Sabah at 1 : 50,000 scale. DOS also completed its current topographic mapping programme for Sabah and Sarawak in 1976, having published 31 sheets of Sarawak at 1 : 50,000 scale and 26 sheets of Sabah during the period under review. DMS continued its routine production of the series on the scale 1 : 50,000.

Ten sheets at 1 : 250,000 scale showing soil associations have been completed and published for the Sabah Regional Soils Survey; and in 1976, work was taken up on a similar series depicting land capability.

*Maldives*

As concerns Maldives, the mapping of Malé at 1 : 1,000 scale in nine sheets has been completed and the reproduction material dispatched to the World Health Organization.

*Nepal*

DOS monitored a contract let to Hunting Surveys Ltd. for the production, from local material, of topographic, land-use and administrative maps of the Katmandu valley in Nepal.

*New Hebrides*

Two maps at 1 : 1,000,000 scale of the entire Condominium were published: one showing relief by hill-shading; and one showing geology.

Work was taken up on the contoured mapping at 1 : 2,500 scale of Port Vila and of Luganville/Santo using aerial photography flown by the Institut géographique national (IGN) and control established by the Condominium Survey Department. By the end of the report period, all 56 sheets had reached the printing stage and reproduction material had been dispatched to the New Hebrides.

Geological maps at 1 : 100,000 scale were published of Efaté, Erromango, the Central Islands and Torres; and were in production for Pentecost, Ambrym and Santo.

*Oman and United Arab Emirates*

Some aerial photography of Oman and the United Arab Emirates was taken by the Royal Air Force, covering selected areas to support mapping undertaken by DMS. This work included the routine revision of series K668 on the scale 1 : 100,000, the production of 11 sheets on the scale 1 : 50,000 of the coast of Zufar; and town plans of Daba, Masqat and Matrah, and Al Buraymi, together with mapping at 1 : 10,000 scale of RAF Masirah.

*Singapore*

Aerial photography of the entire island of Singapore at 1 : 15,000 scale was taken by the Royal Air Force to assist map revision.

*Solomon Islands*

In August 1973, the Royal Air Force took aerial photography on the scale 1 : 60,000 of the Manning Strait area of the Solomon Islands, between Choiseul and Santa Isabel. Large-scale coverage of selected areas was also done from the helicopters of HMS *Hydra*.

Contoured maps on the scale 1 : 50,000 were completed and published of the Russell Islands, Santa Cruz and the Florida Islands. The first sheet of Guadalcanal also was published and the remaining 11 sheets have reached the printing stage.

Considerable effort was again expended in producing maps to illustrate the land resource survey of the whole group. Maps on the scale 1 : 150,000 and 1 : 250,000 were produced of each island to illustrate such subjects as land systems, land-use categories, agricultural opportunity, forest types, physiography, catchment areas and soils. Those maps were augmented by numerous small text maps and figures.

*Thailand*

Maps illustrating the geology and geochemical data for a selected area of Thailand were produced for the Institute of Geological Sciences.

*Tonga*

Work has continued on the new contoured series of Tonga on the scale 1 : 25,000, which is designed to cover

the whole group. The series has a conventional line-map specification for the islands, but the sea areas are depicted by photo-mapping techniques so that as much detail as possible is shown in the areas of off-shore reefs and banks. The sheets covering Niuafo'ou, Vava'u and Tongatapu had been published by the end of the report period and the remaining 18 sheets have reached the printing stage.

Five sheets of Nuku'alofa at 1:2,500 scale were completed and dispatched for reproduction locally.

*Tuvalu*

In July–August 1973 the Royal Air Force took aerial photography of Funafuti on the scales 1:10,000 and 1:40,000, to assist in the remapping of that island in Tuvalu after its devastation by a hurricane in 1972.

A DOS field-party completed the task of establishing the framework and mapping control throughout the former Gilbert and Ellice Islands colony in December 1974. During their last year there, they worked mainly on Funafuti, Vaitupu, Nukulaelae, Niutao, Nukufetau, Nui, Niulakita and Nanumea; and on several of the islands they incorporated the 1965 HIRAN stations into the survey.

A photo map of Vaitupu at 1:10,000 scale was published, and work was begun on photo maps at 1:12,500 scale of Nukulaelae and Niulakita, Niutao and Nanumea, and Nui and Nanumanga. The main settlement of Fongafale on Funafuti was mapped at 1:2,500 scale.

*Yemen*

Eight new map-sheets at 1:250,000 scale, covering the entire area of Yemen, were produced by DMS using the Royal Air Force photography taken at the beginning of 1973.

From November 1973 to July 1975, a DOS field-party worked as part of a multidiscipline British team investigating potential development areas in the Wadi Rima and on the Montane Plains. They established planimetric and height control for project mapping, and built and observed a network of levelled bench-marks. In July 1975, Yemen and the United Kingdom signed a Memorandum of Understanding for a joint survey and mapping project to provide regular contoured mapping on the scale 1:50,000 of the south-western quadrant of the country; this quadrant includes the populated areas round Sana'a, Hudaydah (Hodeida) and Ta'izz. The DOS field-party was increased in size to undertake this work, which was in progress at the end of the period. Five Doppler satellite fixes were observed to provide an accurate origin for the survey. Place-names were collected in the field with the aid of a tape-recorder; they were then written in Arabic and Roman script and then sent back to the United Kingdom for official transliteration.

SATELLITE GEODESY

Military surveyors from the United Kingdom were very active during the report period, working world-wide fixing control positions using the Doppler-based Navy Navigation Satellite System. The sites occupied in Asia and the Far East since the previous report are as follows: (*a*) in 1973, Hong Kong, Singapore, Sharjah and Gan; (*b*) in 1975, Amirante Islands; and (*c*) in 1976, Oman.

One of the Doppler sections reoccupied the Singapore station for a short while in 1976, to provide tracking data for scientific satellites.

DOS used Doppler satellite fixes for the first time to provide an accurate origin for one of its major topographic survey schemes (see preceding section on Yemen).

HYDROGRAPHIC SURVEYING AND CHARTING

*Hydrographic surveying*

Since 1973, only one Royal Navy surveying ship, HMS *Hydra*, has been stationed in Asian, far eastern and western Pacific waters. The surveys undertaken are detailed in annex II.

Most of the work has been concentrated in the vicinity of the island groups in the Indian Ocean and the south-western Pacific which have traditionally relied upon the United Kingdom to meet their hydrographic surveying and charting requirements, namely, Seychelles, Fiji, the Solomon Islands and the New Hebrides. Surveying has been concentrated on the principal ports and their approaches, passages of importance for international shipping, and off-shore banks and reported shoals. In addition, some surveys have been carried out in Maldives and in the Persian Gulf, the latter area being of critical importance to deep-draught oil-tankers.

HMS *Hydra* spent the second half of 1973 in the Solomon Islands conducting surveys along the northern coasts of Choiseul and Santa Isabel islands and of Manning Strait, which divides them and leads to Wagina Island, where workable bauxite deposits exist. Much of this area was previously unsurveyed; and although many new dangers were found, several new routes suited for deep-draught vessels were established. The Government of the Solomon Islands made two Marine Department launches available in order to assist these surveys.

Following a refit in Singapore, HMS *Hydra* spent a brief period in early 1974 surveying in the islands of Maldives. That work included an aerial photographic triangulation of the north Malé atoll and a boat survey of the approaches to Malé. The remainder of 1974 and the first few months of 1975 were spent working the Fiji group, except for a short period of surveying in the New Hebrides. The work in Fiji included surveying the inshore and Bligh Water routes eastward of Lautoka, the major sugar-exporting port of Fiji. Later in 1975, HMS *Hydra* visited Seychelles to conduct hydrographic surveys and provide support for a United Kingdom Army geoceiver team.

During the first four months of 1976, HMS *Hydra* completed a survey of important deep-water routes in the southern Persian Gulf. That work also provided an opportunity to demonstrate modern hydrographic surveying techniques to the Iranian authorities. In May,

HMS *Hydra* left the Persian Gulf for passage back to the United Kingdom. For the first time in many years, there are no Royal Navy surveying ships in the waters of Asia, the Far East and the western Pacific. Given the current economic situation, it is uncertain when it will be possible for the Royal Navy to carry out further hydrographic surveys in the area.

*Nautical charting*

In addition to the normal continuing maintenance of Admiralty chart coverage of Asia and the Far East, a beginning has been made on the replacement of these charts by new ones redrawn in a modern format and using metric units. This is a long-term programme and most of the effort has so far been concentrated on the chart coverage of the Persian Gulf, Malacca Strait and approaches to Singapore.

AERONAUTICAL CHARTS

The work done on aeronautical charts is described below:

(*a*) *Scale 1 : 1,000,000.* The United Kingdom has continued to support the United States of America in the production of the Operational Navigation Chart (ONC) series; during the report period, it produced 17 sheets mainly of islands and island groups in the Pacific and Indian Oceans;

(*b*) *Scale 1 : 500,000.* The United Kingdom has continued to support the United States in the production of the Tactical Pilotage Chart (TPC) series and produced 18 sheets during the period under review;

(*c*) *Scale 1 : 250,000.* The United Kingdom produced or revised some 50 sheets during the period. Those sheets covered Malaysia (25), Indonesia (8), Oman (6), United Arab Emirates (3), Aldabra Island (2), Pacific islands (1), Cyprus (1) and Qatar (1).

THEMATIC (TOPICAL) MAPS

The Directorate of Overseas Surveys prepared and published a number of thematic maps from specialist material gathered and collated by various organizations. It prepared geological maps for the Geological Survey Department of the New Hebrides and for that of Hong Kong, and it published others to illustrate work undertaken by the United Kingdom Institute of Geological Sciences. A large number of maps at various scales were prepared for the United Kingdom Land Resources Division as part of reports on investigations and studies of land use, resource inventories, agricultural potential etc., usually undertaken as part of a technical co-operation or United Nations project. Major projects of that nature were undertaken for Fiji, for Sabah and for the Solomon Islands. Details of thematic mapping are given above in the first section and in annex I.

## ANNEX I

**Table 28. Summary of maps of Asia and the far east published by the United Kingdom directorate of overseas surveys, June 1973-August 1976**

| *Country or area* | *Scale* | *Types of map* | *Number of sheets* |
|---|---|---|---|
| *Brunei*[a] | | | |
| — | 1:12 500 | Contoured | 3 |
| — | 1:50 000 | Contoured | 3 |
| — | 1:100 000 | Contoured | 2 |
| *Burma* | | | |
| Southern Shan States | 1:63 360 | Geological | 1 |
| *Cyprus* | | | |
| Southern part of the island | 1:5 000 | Contoured | 33 |
| *Fiji* | | | |
| Viti Levu | 1:250 000 | Revised edition | 1 |
| Viti Levu and Vanua Levu | 1:50 000<br>1:125 000 | Land capability, land use, land tenure etc. | 12 |
| *Hong Kong* | | | |
| Entire territory | 1:50 000 | Geological | 2 |
| *Malaysia* | | | |
| Sarawak | 1:50 000 | Contoured | 31 |
| Sabah | 1:50 000 | Contoured | 26 |
| Sabah[b] | 1:250 000 | Soil associations | 10 |
| *New Hebrides* | | | |
| Entire group | 1:1 000 000 | Hill-shaded | 1 |
| Entire group | 1:1 000 000 | Geological | 1 |
| Central Islands, Efaté, Torres, Erromango | 1:100 000 | Geological | 4 |
| *Solomon Islands* | | | |
| Russell Islands, Santa Cruz, Florida Islands, Guadalcanal | 1:50 000 | Contoured | 10 |
| Landforms, land use, forest types, agricultural opportunity, soil associations etc[c] | 1:500 000<br>1:250 000<br>1:150 000 | | 29 |

Table 28 (*cont.*)

| *Country or area* | *Scale* | *Types of map* | *Number of sheets* |
|---|---|---|---|
| *Thailand* | | | |
| — | 1:125 000 | Geochemical and geological | 6 |
| — | 1:250 000 | Text maps | 3 |
| *Tonga* | | | |
| Niuafo'ou | 1:25 000 | Contoured | 1 |
| Vava'u group | 1:25 000 | Contoured | 2 |
| Tongatapu group | 1:25 000 | Contoured | 5 |
| *Tuvalu* | | | |
| Vaitupu | 1:10 000 | Photo map | 1 |

[a] Printing only arranged
[b] Plus many small text maps.
[c] Plus many text maps and diagrams.

**Table 29. Hydrographic surveys by the Royal Navy survey ship HMS *Hydra* in Asian and Far Eastern waters, June 1973-August 1976**

| *Area* | *Scale* | *Year* |
|---|---|---|
| *Persian Gulf* | | |
| Jazireh-ye Lavan | 1:25 000 | 1976 |
| Jazireh-ye Farur to Jazireh-ye Tanb-e Borzorg | 1:50 000 | 1976 |
| *Indian Ocean* | | |
| Maldives: North Malé atoll | 1:75 000 | 1974 |
| Seychelles: | | |
| Fortune Bank, Le Constant Bank | 1:250 000 | 1975 |
| Coëtivy Island | 1:25 000 | 1975 |
| African Island | 1:25 000 | 1975 |
| D'Arros and St. Joseph Islands | 1 25 000 | 1975 |
| Amirante Islands | 1:250 000 | 1975 |
| Mahé, eastern approaches | 1:50 000 | 1975 |
| Approaches to Port Victoria | 1:12 500 | 1975 |
| *South-western Pacific* | | |
| Solomon Islands: | | |
| Indispensable Reefs | 1:250 000 | 1973 |
| Southern approaches to Wagina Island | 1:12 500 | 1973 |
| New Georgia Sound (eastern portion) | 1:100 000 | 1973 |
| Manning Strait | 1:50 000 | 1973 |
| Northern coasts of Choiseul and Santa Isabel Islands | 1:100 000 | 1973 |
| Fiji Islands: | | |
| Vatia to Ve Ndrala | 1:25 000 | 1974 |
| Mba Passage to Malaka Passage | 1:50 000 | 1974 |
| Vatututotolu to Yasawa Island | 1:100 000 | 1974 |
| Yandue Passage | 1:12 500 | 1974 |
| Yandue Island to Rukuruku Bay | 1:25 000 | 1975 |
| Rukuruku Bay to Yangganga | 1:25 000 | 1975 |
| Lekumbi Point to Nambouwalu | 1:25 000 | 1975 |
| Bligh Water, south-eastern part | 1:100 000 | 1975 |
| New Hebrides: | | |
| Epi Island, Metfoiu to Tongoa | 1:75 000 | 1974 |
| Emae Island to Makapae Bay | 1:12 500 | 1974 |
| Malekoula Island | 1:50 000 | 1974 |
| Malekoula Island, south-western bay | 1:30 000 | 1974 |

## ANNEX II

### Technical papers on surveying, mapping and charting presented to United Nations conferences and seminars by the United Kingdom of Great Britain and Northern Ireland, 1966–1976

CONVENTIONAL AND SATELLITE GEODESY

Third United Nations Regional Cartographic Conference for Africa, Addis Ababa, Ethiopia, 30 October–10 November 1971:

Procedures used by the Directorate of Overseas Surveys in establishing framework and mapping control in Africa. By J. W. Wright. (E/CN.14/CART/289)

The use of artificial satellites for position fixing. By J. R. Rawlance. (E/CN.14/CART/290)

LARGE-SCALE AND MEDIUM-SCALE MAPPING, INCLUDING TOPOGRAPHIC MAPPING AND PHOTOGRAMMETRY

Sixth United Nations Regional Cartographic Conference for Asia and the Far East, 24 October–7 November 1970, Tehran, Iran:

AIM in production. By H. H. Brazier and D. Read. (E/CONF. 57/L.9) Reproduced in v. 2, Technical papers. p. 195–196. Sales no.: E.72.I.20.

United Nations Seminar on Photogrammetric Techniques, Zurich, Switzerland, 15 March–4 April 1971:

Aerotriangulation by independent models: the photogrammetric procedure. By D. L. Fereday. (Paper 5.1) Reproduced as "Aerotriangulation by independent models (AIM)", in World cartography, 12:72–76, 1972. Sales no.: E.72.I.9.

Aerotriangulation by independent models: computation and programming techniques. By L. M. Windsor. (Paper 5.1.1)

Third United Nations Regional Cartographic Conference for Africa, Addis Ababa, Ethiopia, 30 October–10 November 1971:

The Ethiopia-Great Britain mapping project. By R. J. Hordley. (E/CN.14/CART/288)

Map production methods at the Directorate of Overseas Surveys. By W. D. Rushworth. (E/CN.14/CART/291)

Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973:

Depiction of multilevel complex structures on Ordnance Survey large-scale plans. By W. C. Loveless and C. S. J. Rouse. (E/CONF.62/L.34) Reproduced in v. 2, Technical papers, p. 313–319. Sales no.: E.74.I.25.

First United Nations Regional Cartographic Conference for the Americas, Panama City, Panama, 8–19 March 1976:

An economical approach to large-scale mapping at the Directorate of Overseas Surveys. By D. L. Fereday. (E/CONF.67/L.17) Reproduced in v. 2, Technical papers. p. 159–161. Sales no.: E/F/S.79.I.14.

PREPARATION AND REPRODUCTION OF MAPS, INCLUDING MAP COMPILATION, GEOGRAPHICAL NAMES, AUTOMATION

United Nations Conference on the Standardization of Geographical Names, Geneva, 4–22 September 1967:

Decisions relating to multilingual areas. (E/CONF.53/L.55) Reproduced in v. 2, Proceedings of the Conference and technical papers. p. 90–91. Sales no.: E.69.I.20.

Names on Ordnance Survey maps and plans. (E/CONF.53/L.58) Reproduced as "Paper presented by the United Kingdom", in v. 2, Proceedings of the Conference and technical papers. p. 60–63.

Report submitted by Governments on standardization of geographical names. (E/CONF.53/L.71) Reproduced as annex to "Paper presented by the United Kingdom", in v. 2, Proceedings of the Conference and technical papers. p. 63.

The Roman alphabet rule. (E/CONF.53/L.57) Reproduced in v. 2, Proceedings of the Conference and technical papers. p. 81.

Sixth United Nations Regional Cartographic Conference for Asia and the Far East, 24 October–7 November 1970, Tehran, Iran:

Experimental photomapping at the Directorate of Overseas Surveys. By A. G. Dalgleish and A. B. Whitelegg. (E/CONF.57/L.10) Reproduced in v. 2, Technical papers. p. 196–200. Sales no.: E.72.I.20.

Third United Nations Regional Cartographic Conference for Africa, Addis Ababa, Ethiopia, 30 October–10 November 1971:

Digital mapping in the Ordnance Survey. By J. S. Coulson. (E/CN.14/CART/292)

Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973:

Some photographic aids to map production. By A. C. Marles. (E/CONF.62/L.33) Reproduced in v. 2, Technical papers. p. 256–258. Sales no.: E.72.I.75.

Photomapping at the Directorate of Overseas Surveys. By A. G. Dalgleish and A. B. Whitelegg. (E/CONF.62/L.70) Reproduced in v. 2, Technical papers. p. 263–264.

First United Nations Regional Cartographic Conference for the Americas, Panama City, Panama, 8–19 March 1976:

Recent developments and photomapping at the Directorate of Overseas Surveys (DOS). By F. G. Couzens (E/CONF.67/L.19 and E/CONF.67/L.19/Add.1) Reproduced in v. 2, Technical papers. p. 144–145. Sales no.: E/F/S.79.I.14.

Some uses of a digital topographic data base. By R. G. Atkey and R. J. Gibson. (E/CONF.67/L.20 and E/CONF.67/L.20/Add.1) Reproduced in v. 2, Technical papers. p. 234–239.

### Cadastral surveying and mapping, including urban mapping

Economic Commission for Africa Seminar on Cadastre, Addis Ababa, Ethiopia, 25 November–9 December 1970:

Objects and purposes of land registration. By S. R. Simpson. (E/CN.14/CART/252)

The role of registration of title in the evolution of customary tenures and its effect on societies in Africa. By J. C. D. Lawrance. (E/CN.14/CART/253)

Methods of survey suitable for registration. By D. E. Warren. (E/CN.14/CART/259)

The role of registration of titles in fragmentation and multiple ownership of land. By J. C. D. Lawrance. (E/CN.14/CART/261)

An outline of a model ordinance for Africa. By S. R. Simpson. (E/CN.14/CART/262)

The role of maps in land registration. By D. E. Warren. (E/CN.14/CART/263)

Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973:

The desk-top programmable calculator and its application within the smaller organization, with particular reference to cadastral requirements. By J. L. Fleure. (E/CONF.62/L.32) Reproduced in v. 2, Technical papers. p. 285–291. Sales no.: E.75.I.25.

United Nations Interregional Seminar on Cadastral Surveying and Urban Mapping, Berlin, Federal Republic of Germany, 24 June–12 July 1974:

Some observations on the introduction of registration of title in developing countries. By J. C. D. Lawrance.

### Hydrographic surveying and charting

Third United Nations Regional Cartographic Conference for Africa, Addis Ababa, Ethiopia, 30 October–10 November 1971:

British hydrographic surveys and charting of the African coast. By T. B. Webb. (E/CN.14/CART/293)

Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973:

The international chart, dwarf or giant? By D. Russom. (E/CONF.62/L.64) Reproduced in v. 2, Technical papers. p. 460–461. Sales no.: E.75.I.25.

The past and continuing role of the surveying service of the Royal Navy in Far Eastern and Asian waters since 1946. By M. J. Baker. (E/CONF.62/L.73) Reproduced in v. 2, Technical papers. p. 462–463.

Autocarta—one consequence of radio navigation. By C. Q. McQ. Weeks. (E/CONF.62/L.74) Reproduced in v. 2, Technical papers. p. 463–472.

First United Nations Regional Cartographic Conference for the Americas, Panama City, Panama, 8–19 March 1976:

The potential for international hydrographic co-operation in Central and South America. By D. H. McPherson and D. W. Haslam. (E/CONF.67/L.21) Reproduced in v. 2, Technical papers. p. 165–170. Sales no.: E/F/S.79.I.14.

## CARTOGRAPHIC ACTIVITIES OF THE UNITED STATES OF AMERICA*

*Presented by the United States of America*

### Geodesy

*Adjustment to new North American horizontal datum*

The new adjustment of the North American horizontal datum has begun, and the adjustment will probably place every country from Greenland (Denmark) to Panama on the same datum.

The bulk of the effort is in converting the historical data into computer-readable form. The National Ocean Survey (NOS) has keypunched all the information necessary for automated publication of its horizontal control (excluding station descriptions) for about 185,000 points, all the published points in its possession. A subset of this data file includes the geodetic position, elevation and approximate accuracy of the control points that are used in preliminary adjustments. The astronomical data file of the National Geodetic Survey (NGS), an office of NOS, includes astronomical latitude, longitude and azimuth. It has been completely keypunched, and an associated absolute-error budget for these parameters is complete. Free and combined adjustments of 80,000 points have been evaluated by making free and combined adjustments of each field project. Additional base lines and azimuths to strengthen the network have been recommended and are being observed.

* The original text of this paper, prepared by the United States Geological Survey, appeared as document E/CONF.68/L.40.

The first version of the management system for processing the adjustment is being debugged. The data-base file is station-oriented, which means that all associated information (observations, descriptions, recovery notes, etc.) is filed with the station name and its position. The data-base management system has been written for an IBM 360-195 and will eventually serve all the needs of NGS.

The method of adjusting data has been selected. NOS will solve for the 400,000 unknowns by partitioning the equations into blocks of approximately 1,000 stations (2,000 unknowns). This approach has been agreed to by Canada and Denmark.

In addition to placing existing classical (triangulation) observational data in computer-readable form, Denmark is charged with extending the geoid from Canada to Greenland. Denmark is also evaluating the HIRAN control which tied Canada to Denmark. Mexico and the Central American countries have their data in computer-readable form and have agreed to join in the adjustment. The North American Datum of 1983 (NAD 1983) will undoubtedly be earth-centred on a new reference ellipsoid which will, it is hoped, be adopted by the Inter American Geodetic Survey (IAGS) in 1979.

### *Geodetic surveys*

NGS is responsible for the geodetic operations of NOS and for co-ordinating federal geodetic activities. Functions include field observations for horizontal and vertical control; astronomical and gravity work and operation of observatories for polar motion; office processing, analysis and computation of results of observations; publication and distribution of data; and special related geodetic activities including world-wide geodetic studies, research in methods and equipment, miscellaneous observations and mathematical solutions.

*Doppler point positioning*

During the report period, the Department of Defense (DOD) continued its efforts in satellite geodesy. Survey teams from the United States Naval Oceanographic Office (NAVOCEANO) and the Defense Mapping Agency (DMA) worked in co-operation with other United States agencies and with the agencies of foreign Governments to establish approximately 500 Doppler-derived positions in 25 countries throughout the world. Those surveys were conducted for strengthening established primary geodetic control; establishing control for mapping, positioning electronic and optical sensing devices; and supporting ice-flow studies in the Arctic and Antarctic. For example, 12 Doppler stations were established in the Philippines by Geoceiver teams composed of NAVOCEANO and Philippine surveyors working under a joint agreement to develop an improved national geodetic network. Other stations were similarly established by DMA in New Zealand, Melanesia and Singapore.

In support of the readjustment of the North American horizontal datum, Doppler satellite observations have continued in the United States under a DMA and NGS co-operative agreement. Doppler satellite positions were established at 57 stations, including nine in Alaska and four on off-shore oil platforms in the Gulf of Mexico. Another eight stations were established jointly with Canada, including seven along the western part of the United States-Canada border and one at Whitehorse, Yukon Territory. In Alaska, seven stations established by the Bureau of Land Management (BLM) were reduced under a BLM-NGS co-operative agreement. A station was established with observation support by DMA near Kulasuk, Greenland, in a co-operative agreement with Denmark.

*Doppler beacon programme*

Observations have been continued on the Doppler beacon programme. These low-altitude satellites have been observed to obtain a dense pattern of data to support atmospheric model studies which, in turn, support scientific space operations. Data acquired from these satellites are used with data acquired from Navy Navigation Satellites (NAVSAT) to refine the gravity model of the earth.

*Geodetic Earth Orbiting Satellite (GEOS-3)*

The National Aeronautics and Space Administration (NASA) launched the Geodetic Earth Orbiting Satellite (GEOS-3) on 9 April 1975, for experiments in applying geodetic satellite techniques to geosciences. The primary experiment is radar altimetry designed to measure the geoid in ocean areas between latitudes 65° North and South to an absolute accuracy of 1 m. In addition, the altimeter can determine ocean-wave heights. Also on board the satellite are several tracking-system components, including a laser retroreflector, two C-band radar transponders, an S-band range and range-rate transponder with upward- and downward-looking antennae and a dual-frequency Doppler beacon. An experimental $CO_2$ laser cube is also on board.

The GEOS-3 space craft has no provisions for storing data. Consequently, telemetry stations are needed to receive the altimetry signals when the system is operational. DMA is supporting this project by collecting telemetry data at locations not covered by NASA tracking stations. For example, a DMA manned telemetry station was deployed at Perth, Australia, during July and August 1975, and collected data from 100 satellite passes. Since GEOS-3 has upward-looking antennae the ATS-6 geosynchronous satellite was used experimentally to collect satellite tracking data and telemetry. DMA is processing these data and Doppler tracking data collected by the Tracking Network (TRANET) system to determine precisely the orbit of GEOS-3.

The Geodetic Research and Development Laboratory of NOS/NGS is conducting a series of investigations, sponsored in part by NASA, to analyse altimeter data for improving expression of the global gravitational field and the local field in the United States continental-shelf regions. DMA is establishing a gridded data-bank of the altimetry observations for the project. Altimetry plays a key role in providing measurements in ocean areas, which are generally devoid of observational data of acceptable quality. The NOS/NGS laboratory is also analysing the

GEOS-3 orbit to improve determinations of the amplitude of ocean-tide components.

*Global positioning system*

The success of the TRANSIT satellite navigation system has led the United States to consider a successor with greater capabilities and wider applications. The new system, now under development, is called the NAVSTAR Global Positioning System (GPS). TRANSIT was designed for intermittent position fixes in a horizontal plane; GPS is designed for continuous position read-out in three dimensions, useful for aircraft navigation and for shipboard navigation in confined areas, such as harbours.

GPS will consist of 24 satellites in three orbital planes at about 20,000-km altitude. The navigator will always view four satellites at a time, so by measuring the range to each satellite simultaneously, he can solve for his position and time. At first, six satellites will be launched in orbits that will place them over the south-western part of the United States at the same time, simulating the final constellation over an unknown area of interest. Thus, the system can be tested with a minimum of satellites. Additional satellites will be launched until the full constellation is in orbit in 1984.

*World Geodetic System 1972*

An improved World Geodetic System (WGS 72), published in January 1974, is the culmination of 15 years of data collection by the scientific community of the United States. The data include conventional geodetic control, surface gravity and astronomical-geodetic measurements, and results of BC-4 Passive Geodetic Earth Orbiting Satellite (PAGEOS), Sequential Collection of Ranges (SECOR), Baker-Nunn and Doppler satellite tracking programmes.

The parameters for WGS 72 describe the gravity field of the earth as well as a new geocentric spheroid and shifts from local data throughout the world to the WGS datum. The method of solution for deriving WGS 72 parameters was characterized by setting in format a large-scale matrix by combining the normal matrices of each of the major data input sets. A unique scaling and weighting procedure for the final matrix was developed to best contain all input.

Geodetic positions produced by DMA Doppler point-positioning techniques are referred to WGS 72. The datum transformations are continuously updated for areas where new Doppler-derived positions are established.

*National Ocean Survey world geodetic solution*

A geodetic system that incorporates the same type of data as WGS 72 in lesser amounts was published by NOS in National Oceanic and Atmospheric Administration (NOAA) technical report NOS 62. This publication makes available the parameters of a global gravitational field in the form of spherical harmonic coefficients to the fifteenth degree and order.

*Special surveys*

Special projects were undertaken at the request of the Jet Propulsion Laboratory, California Institute of Technology, at several locations involved in the Astronomic Radio Interferometry programme and for the University of Hawaii to locate several antennae and other structures at the Haleakala Observatory of Maui.

In the Kwajalein atoll, 310 km of precise Geodimeter traverse measurements were made from Bilby towers to connect Kwajalein and nine outlying islands; 18 first-order astronomical positions were observed.

In north-western Iran, DMA advisors helped surveyors from the National Geographic Organization to establish a basic Tellurometer traverse and the photo-mapping control for producing new large-scale maps of the 44,000-km$^2$ area.

*Geodetic information*

The NGS networks currently comprise 600,000 points. A recent agreement between NOAA and the United States Geological Survey (USGS) will add an additional 400,000 points to the NGS files, and the number of control stations for which NGS is responsible will continue to grow as the National Geodetic Data Bank is developed and state and local agencies transmit their data for inclusion.

The Inertial Positioning System (IPS) is an all-weather, self-contained surveying instrument designed to provide the user with latitude, longtitude, elevation and azimuth in relation to an established survey control network. The system is an adaptation of an operational aircraft inertial-navigation system which can be mounted in a land vehicle or a helicopter. IPS requires periodic zero-velocity updates to obtain real-time control of system errors.

During 1974 and 1975, IPS was tested extensively. The data from the tests show that the circular probable error of the horizontal position is under 2 m, the root-mean-square (rms) error in the elevation less than 1 m, and the azimuth rms 20 arc sec.

The United States Army Engineer Topographic Laboratories (USAETL) are conducting tests to extend IPS capabilities to meet the requirements for a Rapid Geodetic Survey System (RGSS). These tests show that RGSS can determine the change in gravity anomaly to an accuracy of better than 2 milligals rms and the relative deflection of the vertical to better than 1.5 arc sec.

BLM and USGS have been testing the Litton Auto-Surveyor, a commercial version of the Inertial Positioning System. The Auto-Surveyor consists of an inertial-measuring unit, a digital-processing unit, a control and display unit, a power-supply unit and a cassette recorder. With a battery and electrical cables, the system weighs 150 kg and fills the passenger space behind the pilot and operator of an FH-1100 helicopter or fits into a survey van for highway use.

The innovation that makes an inertial navigation system perform so accurately is the development of the zero-velocity update procedure. The vehicle is periodically brought to a standstill, and the system automatically levels the platform to the local gravity vector and analyses the residual velocity values to obtain correction terms. As the traverse continues, with periodic zero-velocity updates, the computer accumulates information

about and compensates for systematic observational errors and the systematic changes in the gravity field. Less accurate results are obtained when the line has abrupt changes in direction, such as a right-angle turn.

To streamline ground verification of map-worthy features, a windowed van was custom-fitted to provide a comfortable and well-equipped mobile work-station. The vehicle is a 3/4-ton upgraded Chevrolet van with a wide sliding door on the side and double doors at the rear. Sitting about 0.5 m higher than the average car, the van affords a better view of the terrain. The basic work-station is a cut-down drafting-table with a built-in light-box and drawers for supplies, photographs, maps and field-sheets. The desk chair is mounted on rails, with a variable-position locking device. Special brackets inside and outside the van conveniently store stadia rods, plane-tables and tools. First field trials of the custom van won immediate approval, largely because on-the-spot scribing is particularly helpful in revision surveys and in annotating orthophoto bases.

### Geomagnetics

The NAVOCEANO project MAGNET, a continuing world-wide airborne magnetic survey, gathered 200,000 km of magnetic data in the Sea of Japan, the north-western Pacific area, the Korean Straits and the East China Sea.

DMA makes aeronautical charts for the entire world and Flight Information Publications (FLIPs) for much of the world. These products are also made available to commercial and federal agencies as well as to other countries and to private persons, who can purchase them from NOS. NOS produces and distributes aeronautical charts and flight information for the United States, including Alaska and Hawaii, as well as charts for long-range flights over the Pacific and Atlantic Oceans. United States aeronautical charts and flight information are also made available to many countries and organizations through exchange agreements.

Flight information for Asia and the Far East is provided by the Pacific, Australasia and Antarctica (PAA) series of FLIPs. The PAA FLIP contains the textual and graphic information needed for a flight and to land under varying conditions. Emphasis is on the information needed for instrument flight.

### Aeronautical charting status

The Tactical Pilotage Chart (TPC) series at 1 : 500,000 scale covers the United States, Europe, the eastern portion of Asia, Japan, Indonesia, and the Philippines. These charts do not cover eastern New Guinea, Australia, New Zealand, South America and the islands of the Pacific. This chart series is designed primarily for low-altitude, high-speed radar and visual air navigation. Other uses include mission planning and analysis, briefings and preparation of visual cockpit displays. Charts are produced and maintained by the joint efforts of agencies of the United Kingdom of Great Britain and Northern Ireland and of the United States of America.

The Operational Navigation Chart (ONC) series at 1 : 1,000,000 scale now covers all land areas of the world excluding Antarctica and a few isolated islands. This series is designed for *en route* navigation by dead reckoning, visual pilotage, and celestial, radar and other electronic techniques. Other uses include mission planning and briefings. Charts are produced and maintained by the joint efforts of DMA-NOS/United States, DMS/Australia, DLS/New Zealand, DMC/Canada, and DMS/United Kingdom. ONC charts are available in the large format except for certain mid-ocean island areas which retain the smaller size World Aeronautical Chart (WAC) format.

The Jet Navigation Chart (JNC) series at 1 : 2,000,000 scale, together with the older JN series, cover a major portion of the world, excluding South America, Antarctica and some ocean areas which are yet to be completed. This chart series is designed for high-altitude, long-range radar, celestial and visual navigation. Other uses include planning and briefings.

The Global Navigation and Planning Chart (GNC) series at 1 : 5,000,000 scale covers the world. This series of charts is designed for extended long-range, high-speed, high-altitude, aerospace navigation with secondary considerations of mission planning and general briefings. All 26 charts of this series have been published and are maintained by DMA.

The Global Loran Navigation Chart (GLC) series at 1 : 5,000,000 scale covers a major portion of the northern hemisphere, including the Atlantic and Pacific Ocean areas. This series of charts contains Loran-A and Consol/Consolan information overprints for use in high-speed extended long-range aircraft navigational requirements over large expanses of water.

The Global Loran Navigation Chart (GLCC) series at 1 : 5,00,000 scale has the same coverage as the GLC charts described above and, in addition, has land charts covering Europe and North Africa. This series of charts contains Loran-C information overprints for use in extended long-range aircraft navigational requirements.

### Hydrography and Oceanography

#### *Bathymetric plotting sheets*

In accordance with an agreement made at the Eighth International Hydrographic Conference, Monaco, May 1962, most maritime countries are producing bathymetric plotting sheets. The sheets are forwarded to the International Hydrographic Bureau (IHB) headquarters in Monaco for compilation of the General Bathymetric Charts of the Oceans. The United States commitment, being fulfilled by NOS and DMA, includes the eastern half of the North Pacific Ocean, part of the Arctic and the western half of the Atlantic Ocean. The United States has completed 54 bathymetric plotting sheets, and they are available for sale to the public.

#### *Hydrographic charts*

Since January 1971, DMA has published 342 new nautical charts or new editions of nautical charts in the

Indian Ocean and the Pacific Ocean (excluding North and South America, Hawaii and the coast of Africa). New chart coverage is described by the following categories: (*a*) small-scale general ocean and sailing charts—smaller than 1 : 600,000 scale; (*b*) medium-scale coastal charts—from 1 : 75,000 to 1 : 600,000 scale; and (*c*) large-scale harbour approach and port coverage—larger than 1 : 75,000 scale.

Among the new nautical charts or new editions of nautical charts produced for the Pacific and Indian Oceans are:

(*a*) Small-scale charts for the eastern coast of Asia, Japanese islands, Republic of Korea, Malay Peninsula, Australia, Pacific islands, New Zealand, Indian Ocean, Persian Gulf and Gulf of Oman;

(*b*) Medium-scale charts in the Sea of Japan, South China Sea, Pakistan, Malay Peninsula, Australia, New Zealand, Pacific islands, Philippine Islands, Republic of Korea and the Union of Soviet Socialist Republics;

(*c*) Numerous ports and harbours, including Ras al Tannurah, Persian Gulf, Kuwait, India, Singapore, Bombay, and ports in Australia and New Zealand, Pacific islands, Philippine Islands, Hong Kong, Republic of Korea, Japan, Cebu and the Singapore Strait.

*Nautical publications*

In addition to nautical chart coverage, DMA produces and maintains many special-purpose charts, weekly Notices to Mariners, pilot charts, light lists, radio aids, sailing directions; and the tables for the Loran-A, Loran-C and Omega navigation systems. Among the products in these categories are the World Port Index, the Sailing Directions Planning Guide for the North Pacific Ocean, Sailing Directions (*en route*) for the western coasts of Mexico and Central America, British Columbia, the eastern coast of the USSR, Japan and the coasts of the Republic of Korea and China. The Notices to Mariners were also redesigned in 1975 to assist the mariner in maintaining up-to-date charts and publications.

As the Omega system develops and new stations are established, such as Omega Japan in 1975 and Omega Liberia and Argentina in early 1976, Omega tables are compiled for the new coverage areas. Areas of primary concern are the Indian and Pacific Oceans, where heretofore electronic navigation systems provided only limited coverage. New lattice tables are being printed to aid the mariner in determining his positions while using the new stations resulting from the expansion of the Loran-C navigation system in the north-western Pacific.

*International exchange of charts*

To provide global chart coverage to mariners, the United States has entered into bilateral agreements with 27 countries whereby each may issue for sale to the general public modified facsimile reproductions of the other's nautical charts. As of April 1976, agreements were in effect with, for example, Australia, Indonesia, Japan, the Philippines and the Republic of Korea. These agreements are in accordance with resolutions of IHB.

*Hydrographic surveys*

Hydrographic survey ships directed by NAVOCEANO have logged about 192,000 km of data since the previous report. The primary Pacific effort has been conducted in the Philippine Islands and the Bashi Channel. If the Philippine surveys are completed this year as anticipated, operations will continue in other south-eastern Asian areas. The survey in progress in the Republic of Korea three years ago has been replaced by a joint Republic of Korea-United States programme for harbour and estuarine surveys. The major responsibility for this programme, including the boats, is carried by the Republic of Korea, with limited technical assistance by the United States.

*Photogrammetric activities*

*Shoreline mapping*

NOS has continued publication of the shoreline maps which began in 1834. Special emphasis has been placed on a series of orthophoto base shoreline maps on the scale 1 : 10,000. A pilot project undertaken in co-operation with the state of Florida has demonstrated the feasibility of using tide-co-ordinated infra-red photography to map high- and low-water lines.

*Photo-bathymetry*

Several photo-bathymetric projects were completed during the year. This new method has permitted hazardous underwater areas to be surveyed remotely and economically. Progress is being made to process the analogue, stereo-optically viewed depths by analytical techniques. Computer programmes are currently being perfected to process digital data obtained by a Wild B8 stereoplotter.

*Photo-geodesy*

A numerical-photogrammetric technique to establish geodetic co-ordinates of ground points, within a 50 × 50-km area, is being perfected. The procedure being tested involves photographing ground points from overlapping orthogonal flight lines. A Wild RC10 aerial camera equipped with a réseau lens was used to provide test photography of the first-order Casa Grande Aerial Camera Test Range. Preliminary analysis of data indicates that the 3-cm error budget will be maintained.

*Tides and currents*

NOS has continued to publish tide and current prediction tables, as well as current charts for selected areas of United States coastal waters.

The tide and tidal current survey of Cook Inlet, Alaska, was completed in 1975. Surveys in Puget Sound, Washington; and in coastal areas of the East and Gulf coasts have been continued.

In 1976, these surveys continued; and a comprehensive tide and current survey of Prince William Sound, Alaska, was initiated.

*Nautical charting*

NOS conducts hydrographic surveys and field investigations to provide the basic data for nautical chart

construction; and compiles, reproduces and distributes nautical charts and related products of United States coastal waters and the Great Lakes.

*Nautical charts*

Nautical charts are constructed primarily to serve the needs of mariners and show the nature and form of the coast; the depths of the water and character of the sea-bottom near it; the locations of reefs, shoals and other dangers to navigation; the rise and fall of the tides; the locations of artificial aids to navigation; the direction and strength of sea currents; and the behaviour of the earth's magnetism in areas which must be navigated.

*Sailing charts*

Sailing charts are published at scales smaller than 1 : 600,000 and are used for planning and fixing a ship's position as it approaches the coast from the open ocean, or for sailing between distant coastwise ports. The shoreline and topography are generalized and only off-shore soundings, the principal navigational aids, outer buoys and landmarks visible at considerable distances are shown.

*General charts*

General charts are nautical charts of the coast on scales ranging from 1 : 150,000 to 1 : 600,000. They are designed for coastal navigation on courses well off shore but while a vessel's position can be fixed by landmarks, lights, buoys and characteristic soundings.

*Coastal charts*

Coastal charts are nautical charts on scales from 1 : 50,000 to 1 : 150,000. They are intended for close coastal navigation inside outlying reefs and shoals, for use in entering bays and harbours of considerable size and for navigating the larger inland waterways.

*Harbour charts*

Harbour charts are nautical charts on scales of 1 : 50,000 and larger; the scale depends upon the size and importance of the harbour and the number and kinds of dangers existing. These charts are intended for navigation in harbours and smaller waterways, and for anchorage.

*Small-craft nautical charts*

Small-craft nautical charts are on scales ranging from 1 : 10,000 to 1 : 80,000, and are designed for easy reference and plotting in the limited space available aboard small craft. They emphasize details of interest to small-craft operators, including large-scale inserts of small boat harbours; tide, current and weather data; whistle signals, marina facilities, anchorages, courses and distances.

In preparing these primary products and services for navigational users, certain spin-offs are of value to other government agencies and to the public. Although generally not used for navigation, the by-products provide essential information for planning and designing off-shore engineering projects and for off-shore resource exploration and development.

*Geophysical maps*

NOS no longer produces bathymetric maps on the scale 1 : 1,000,000 for deep ocean areas, but the original maps are still being issued.

*International charts*

In the past year, NOS has issued four international nautical charts at 1 : 3,500,000 scale; in accordance with the same IHB specifications. These charts are:

(*a*) INT 500—North-eastern Pacific Ocean, Dixon Entrance to Unimak Pass;

(*b*) INT 501—North-eastern Pacific Ocean, Mexican-United States border to Dixon Entrance;

(*c*) INT 513—Bering Sea (southern part);

(*d*) INT 514—Bering Sea (northern part).

*Coast pilots*

These charts are published in nine volumes and cover the coasts of the United States together with Puerto Rico and the Virgin Islands. Each volume furnishes information required by the navigator that cannot be shown conveniently on the nautical chart, such as detailed data relating to the coastline, port information, sailing directions for coasting and entering harbours and general information on weather conditions and radio service. The coast pilot is kept current through Notices to Mariners, annual supplements and new editions.

*Chart production activities*

Of the 972 NOS charts on issue, 670 were revised as new editions during fiscal year 1976.

A marine traffic-separation scheme in Prince William Sound, Alaska, established by the United States Coast Guard, was published for the first time on NOS chart 16700. Similar chart applications were done for the Strait of Juan de Fuca, Strait of Georgia and Haro Strait. These were established jointly by the United States Coast Guard and Canadian authorities, and were published for the first time on NOS charts 18400, 18421 and 18465.

New editions of Nautical Chart Catalog 1 (Atlantic and Gulf Coasts), Catalog 2 (Pacific Coast) and Catalog 4 (Great Lakes and adjacent waterways) were issued.

*Computer-assisted nautical charting*

To develop fully the shipboard data-acquisition system, and to design and implement a computer-assisted system for the total process of nautical charting, the Marine Data Systems Project (MDSP) was established in 1970. As a detailed plan was being formulated, the Hydroplot and Hydrolog systems were further improved, the automated system at the Atlantic Marine Center was upgraded and a completely new system was installed at the Pacific Marine Center.

A five-table integrated digitizing system was placed in operation at Rockville, Maryland, for systematic conversion of graphic chart data to digital format. Other chart data were converted at the NOAA National Climate Center in Asheville, North Carolina. These digital data plus the inflow of digital data from automated survey vessels became the base for a comprehensive nautical-chart data bank.

Two large flat-bed plotters were installed at Rockville for data check plotting, graphics programme testing and automated plotting and scribing in support of manual

cartographic operations. During 1973 and 1974, three nautical charts were scribed on the plotters from digital data for direct chart reproduction. This step provided visual evidence of the feasibility and practicability of automated plotting.

During this same period, specifications were prepared for a data storage, retrieval and updating system that would enable the nautical chart cartographer to make full use of data from the bank. This system is also designed to facilitate metrication and development of new chart formats. Procurement of the hardware and software is now in progress, with installation and operation expected within three years.

In 1975, a laser-raster production plotter was installed for making chart reproduction negatives directly from the digital data bank. The negatives are then used to prepare the chart printing-plates. The nautical chart automation project is scheduled for completion by 1980. The five-table digitizing system and the laser-raster plotter are the first units of their kind in operation for chart production.

## Topographic mapping

### *Military topographic maps*

During the report period, DMA programmes for Asia and the Pacific included new areas of large- and medium-scale mapping coupled with revision and reformatting of published maps. The programmes are established through co-operative mapping agreements with various countries. Progress will be reported by representatives of the countries concerned. The maps are important in development of physical, economic and social resources of the participating country.

Comprehensive planning for the Lower Mekong Basin is being carried out by the United Nations Mekong Co-ordinating Committee. In connexion with this project, DMA produced 144 monochrome topographic maps on the scale 1 : 20,000 of the potential Stung Treng reservoir and dam site located along the Mekong River in north-eastern Democratic Kampuchea.

### *National Mapping Program of the United States*

The National Mapping Program (NMP), administered by USGS, provides for gathering, processing and distributing the basic cartotographic data of the United States in a variety of forms, including several series of multipurpose line maps. The data are essentially the same as have been gathered for the well-known national topographic map series although they will now be made available in additional forms more suited to specific needs and for use in computers.

Basic map information is gathered and processed in 11 categories: (1) reference systems; (2) hypsography; (3) hydrography; (4) surface cover; (5) non-vegetative features; (6) boundaries; (7) transportation systems; (8) cultural features, such as buildings, airports and dams; (9) geodetic control and other survey information; (10) geographical names; and (11) orthophotographic imagery. USGS processes the raw data (aerial photographs, field data etc.) to the point of direct usability; the actual content and form of data in these categories will be based on the needs of users.

The National Cartographic Information Center (NCIC) was established to collect, process and distribute information on cartographic data—maps, charts, aerial photographs and space imagery, geodetic control and digital data—to any user. The ultimate objective of NCIC is to become the primary service centre for all surveying, mapping and charting data and products.

General-purpose topographic map coverage on the scales 1 : 24,000, 1 : 62,500, 1 : 63,360 (Alaska) and 1 : 20,000 (Puerto Rico) is now available for about 93 per cent of the total area of the 50 states, Puerto Rico, United States Virgin Islands, Guam and American Samoa. As maps become out of date, revision is necessary to show changes in terrain and man-made features. Currently, more than 900 topographic maps at 1 : 24,000 scale are revised each year, mostly for the expanding metropolitan areas. More than half of the maps in the revision programme are updated by a photo-revision, a low-cost rapid production method that relies primarily on photo-interpretation without a field-check.

The conterminous states and Hawaii are completely covered by 473 topographic maps at 1 : 250,000 scale; they are revised on an average eight-year cycle. The topographic contours of the maps of this series for the 48 states were digitized and are now available from NCIC in the form of magnetic tapes. Topographic-bathymetric editions of the maps of United States coastal zones at 1 : 250,000 scale are being produced in co-operation with NOS. The series at 1 : 250,000 scale is used by USGS as base copy for preparing the state base map series, the International Map of the World on the Millionth Scale (IMW) series; and special maps, such as the land-use/land-cover series currently in production.

Of the 54 IMW at 1 : 1,000,000 scale required to cover the conterminous United States and Hawaii, 30 have been published. Each year several new maps and revisions are prepared as part of the international programme to attain world-wide coverage under uniform specifications.

In addition to the variety of conventional line maps, USGS has introduced a new series of photo-image maps which can be produced quickly, economically and accurately. The standard product is the 1 : 24,000-scale orthophotoquad which consists of either an orthophoto or a mosaic of orthophotos in 7½-minute quadrangle format with very little cartographic treatment (UTM grid and a few feature labels). There is an increasing demand for the orthophotoquad, either as an interim map for unmapped areas or as a companion product to a published line map. Production now stands at almost 4,000 orthophotoquads per annum. Orthophotoquads are in great demand for use as base maps by state planners for land-use information; site selection for industries, utilities and public transportation; tax assessment; management of natural resources; flood hazard, pollution, agricultural and coastal wetlands studies; revision of other maps; and production of special-purpose maps.

A coloured and cartographically enhanced version of

the orthophotoquad is called an orthophoto map, and many have been produced for certain areas of the United States where the conventional line maps cannot adequately portray such difficult terrain as swamps and deserts. The orthophoto map takes approximately the same production effort as the line map, but the coloured photo-imagery accentuates such detail as salt-water encroachment, marshland limits, fault lines and the physical character of prominent geological features. About 300 orthophoto maps are currently in production.

Cartographic products will be tailored to the user's needs and, if possible, time schedule. An equally important objective, however, is to promote simplicity, clarity and economy in design, presentation and reproduction of future products. The plan is to produce maps in both analogue and digital form. The analogue version will include not only the conventional printed map but separations by map feature or colour, permitting flexibility in choice of format and colour rendition when the same base is used for different purposes. The ultimate in flexibility, however, will lie within the digital realm, where all map parameters, with few exceptions, will be variable.

In the face of rising costs, USGS is approaching the economics problem in two ways—improving current operations and systematically redesigning the entire effort—as described below:

(*a*) A new trial design for the standard topographic map incorporates a metric format, simplified symbology, feature-separation flexibility and economy in printing;

(*b*) Maps have been reproduced by process printing on scale-stable transparent plastic. Such colour printings are particularly well suited for thematic overlays registered to topographic bases;

(*c*) To maximize and optimize use of the new USGS five-colour press, experiments are under way in combining colors for printing six-colour interim-revision maps in a single press run;

(*d*) The core of all future cartographic production will be a massive digital file of base data, the Digital Cartographic Data Base (DCDB). Users will be able interactively to extract data from the file and produce the desired graphic, whether an image on a television screen or hard copy produced by a plotter. The map of the future, in some applications, may not even be displayed at all but may serve as a computer model for network analyses or areal correlations. The structure for DCDB has been proposed and made widely available for comment. Meanwhile, cartographic data are being reformatted for future digital storage;

(*e*) Place-names and point symbols on the map of the future will be automatically generated, interactively edited for overprinting and automatically positioned;

(*f*) Maps showing areas of critical ranges of slope are particularly useful to land planners. USGS research in analogue approaches to slope mapping has resulted in the development of photo-mechanical techniques and equipment for semi-automatically deriving slope zones on the basis of distances between adjacent contour lines. By various techniques, the contour lines are widened predetermined amounts so that when they touch each other, specific slope zones are indicated. Then, in a series of line-weight reduction and masking steps, the zones are recorded permanently on film for reproduction. Experimental slope maps have been prepared at several scales, in both colour and black and white, or simply as overlays.

## Photogrammetry

### *Film diapositives*

Film diapositives have been found an acceptable substitute for glass diapositive plates in plotting systems for both aerotriangulation and map compilation. The major objection to film diapositives was a slight loss of image quality, but cost saving has a counterbalancing effect, to say nothing of the trend by manufacturers to phase out glass-base photographic materials.

### *Systems for producing orthophotographs*

Orthophoto products have gained popularity and importance in the National Mapping Program of USGS, and new instrumentation is being developed to meet the increased demand.

The Digital Profile Recording and Output System was developed to provide digital terrain profiles and control off-line production of orthophotos, contours and slope maps. The system electronics are sufficiently flexible to accommodate several types of profiling instruments and exposing units. The first production unit comprises a Zeiss C-5 Stereoplanigraph equipped with two-axis servomotors and three-axis encoders; two consoles with magnetic-tape transports that control scanning, recording and playback of the digital profile data; and a GZ-1 orthoprojector equipped with three-axis servomotors and encoders. The GZ-1 can be operated at 10 speeds up to 2.5 cm per second with good resolution; one double model (for a complete 7½-minute orthophotoquad) can be exposed in 1 hour on the average.

Other production units will contain profiling subunits adapted to such stereoplotters as the Kelsh, ER-55 and Kern PG 2; and exposing subunits adapted to such instruments as the Orthophot, PP08 and Orthophotoscope.

### *Optical calibration laboratory*

On 1 April 1973, the calibration services (with associated equipment) for aerial cameras and lenses provided by the National Bureau of Standards (NBS) were transferred to USGS at McLean, Virginia. All equipment was subsequently moved to the USGS National Center at Reston, Virginia, to form one of the most complete optical calibration laboratories in the United States. During the transition period, a number of modifications were made in all calibration instruments. The four main arrays of the camera calibrator now have complete angular coverage from 0° to 54.4° off axis. The visual optical bench is now equipped with a 30-cm aperture, 3-m focal-length parabolic mirror that provides a collimated

beam for measuring lenses up to 180-cm focal length at full aperture. Several special camera mounts have been designed and are currently in service to assure greater accuracy and stability in positioning and holding cameras during tests.

*Model orientation with pocket calculators*

Pocket-size programmable calculators are being applied to model orientation with optical-train stereoplotters. For the relative orientation of models during semi-analytical aerotriangulation with a Wild A7 or Kern PG 2, the analytical procedure requires only one or two iterations in comparison with the two-six normally required. The technique is particularly helpful for setting up stereo models of rugged terrain or large tilts. With camera orientation data from fully analytical aerotriangulation, the calculator is programmed to compute the stereoplotter settings for relative and absolute orientations. The resulting stereo models are correctly scaled, nearly clear of parallax and nearly level.

*Correcting radial lens distortion*

A new method of correcting for radial lens distortion was devised, in which corrections are applied according to the grid location of a point rather than the radial distance from the point of auto-collimation. This method provides corrections for asymmetrical and irregular distortions and for non-flatness of the magazine platen.

The data for the corrections are obtained by measuring collimator images on a series of film exposures made with the camera on the calibrator at various orientations. The distortions, or differences between measured and true (calibrated) positions of the collimator images, are converted to contour form. Then, a distortion grid is derived from the mathematical model, typically a 5-mm grid for a 23-cm$^2$ format. The $x$, $y$ correction for a given point is determined by interpolating between the nearest grid coordinates.

*Panel photography by helicopter*

A Hasselblad 70-mm camera installed in the chin of each USGS helicopter is being used to obtain improved panel photographs. Since panelling rarely can be timed for the panels to show on the mapping photographs used for aerotriangulation, each panel must be photographed from a small aircraft so that the surrounding ground features can be related to those on the mapping photographs. The helicopter installation was designed to obtain a vertical photograph having a relatively large format and a scale that can be matched with that of the mapping photographs. The pilot makes his run over the panel in a cardinal direction if possible and usually from 600 to 900 m above terrain. Two frames are exposed for each panel to yield a stereo-pair. In the field, a system of leap-frogging the panelled points allows the pilot to fly without passengers on a single trip over any given panel and thus makes it easy to climb to the required altitude. The saving is in taking panel photographs while the surveying crew is on the spot, particularly when it is necessary to take up the panel materials afterwards, as in wilderness and other controlled areas. The helicopter system is producing photographs that make identification and correlation of panelled points easier and cheaper than in the past.

*Panelling LANDSAT imagery by mirror flash*

An experiment was undertaken to determine the usefulness of marking geodetic control stations on LANDSAT imagery of Antarctica. A simple mirror is used to reflect the sun's rays and to direct them into the orbital path of LANDSAT so that a flash is recorded on the satellite imagery. The mirror base is fitted with horizontal and vertical motion for precise adjustment of azimuth and inclination. Similar experiments in the United States have been successful. If flash-marking is found effective with the snowy background, the technique will be of significant value in establishing and maintaining a geodetic control net for the Antarctic continent and could be applied in other areas where establishing control is a serious problem.

*Digitization*

Through digital techniques, it is conceivable that, with a minimum effort, map-makers will be able to respond to users' needs in a matter of hours or days rather than years. The goal is to produce maps digitally at any scale and in a variety of formats. To do so, cartographic data must be converted to numerical data in machine-readable form. A single topographic quadrangle map contains more than 100 million discrete bits of information, so that building a digital map data bank is formidably complex. Also, the data bank must be designed to connect with other geographically related information and management systems.

With the assistance of the Rome Air Development Center (RADC), USGS conducted a pilot project to discover problems in digitization—both in deriving digital map data from the stereo model and in generating graphics from the data. As AS-11B-1 analytical plotter was used to extract digital planimetric and terrain data from the source material for the Estrella SW, Arizona, quadrangle. An interactive system allowed automatic plotting from magnetic tape with the Cartographic Digitizing Plotter, fast manual editing with disc storage and automatic tape correcting. Additional smoothing of the data will be done automatically with the RADC batch processing system. When data editing is completed, the updated tape will be used to drive a first-order plotter and produce the finish-quality colour-separation negatives.

## Image technology

*Advanced image-correlation system*

USGS acquired the first production model of the Gestalt Photomapper II (GPM-2). The GPM-2 automatically corrects for distortion in aerial imagery and concurrently produces orthophotographs and the corresponding terrain data in contour and digital (magnetic-tape) form. The entire process is executed under computer control, with the operator intervening occasionally to assist in correlating the images. Production time is related to various characteristics of the aerial photo-

graphs and of the terrain pictured; in the first two months of operation, production time of 1-7 hours was required to process the overlap area of a stereographic pair of photographs.

Success in applying colour to LANDSAT multispectral imagery shifted attention back to the earliest method of obtaining colour pictures from black-and-white photographic records. That method is to obtain spectrally filtered records on black-and-white film and apply suitable coloured inks on a printing press. In this way, USGS is experimentally adding colour to orthophotoquads. Feature contrast and high resolution are obtained by taking simultaneous panchromatic and black-and-white infra-red aerial pictures. The colour contrasts formed in lithoprinting help the user interpret the unfamiliar aerial view. This technique was used to prepare several colour renditions of an orthophotoquad for the United States Customs Service. Naïve users tend to reject the conventional coloured infra-red presentation, in which healthy green vegetation appears as bright red, and call for a more "natural" colour. But there is no natural colour for infra-red waves; and as any jet passenger can testify, the surface of the earth becomes a dull monotone at usual cruising heights. These so-called "normal" colour films have no advantage over black-and-white films for aerial photography from heights of 3,000 m and up.

### *Digital processing of imagery*

The USGS Center of Astrogeology at Flagstaff, Arizona, has been developing techniques for digitally correlating imagery and elevation data to form a specifically altered image. A stereographic pair of LANDSAT images was produced by digitally applying relief displacement to an image; when the altered and unaltered images are viewed together, the observer sees a stereo image. Another application is generating shaded-relief renditions of maps. The digital terrain data are converted to values of slope, which are used to compute the brightness levels (based on the desired sun angle and direction) that control production of the shaded image. Computer-generated shaded-relief maps were prepared on scales ranging from 1 : 24,000 to 1 : 250,000.

## CARTOGRAPHY

### *Circum-Pacific map project*

A series of maps depicting the geography, geology, tectonics, and energy and mineral resources of the Pacific Basin and bordering lands is being prepared for the Circum-Pacific Council for Energy and Mineral Resources. The maps are being compiled on bases plotted from World Data Bank tapes of the Cartographic Automatic Mapping programme, and data from new bathymetric surveys. Five separate quadrant maps cover the Pacific region and Antarctica at 1 : 10,000,000 scale on the Lambert azimuthal equal area projection with centre points for each quadrant. A sixth map covering the Pacific region at 1 : 20,000,000 scale will show the relationships of energy and mineral resources to geological, tectonic and geophysical features of the whole basin. The project is a co-operative international effort by individuals, commercial firms, private and public institutions, and agencies of the various countries bordering on the Pacific.

### *Geographical names*

The United States of America has continued its programme of maintenance and updating of files of official standard geographical names for each country or area of the world and for undersea features, and the use of these names on maps, charts and other publications. A new committee of the United States Board on Geographic Names (BGN), the Advisory Committee on Extraterrestrial Names, has been formed to work in close co-operation with the International Astronomical Union.

The names, other than for the United States, its territories and dependencies, are made available in official BGN gazetteers which are researched and distributed by DMA. Among the gazetteers of countries in Asia and the Pacific Ocean published between late 1972 and December 1975 are those for: Hong Kong and Macao (1972), 3,000 entries; the Lao People's Democratic Republic (1973), 21,000 entries; Solomon Islands, Gilbert Islands and Tuvalu (1974), 12,450 entries; Fiji, Tonga and Nauru (1974) 14,275 entries; New Caledonia and Wallis and Futuna (1974), 5,950 entries; and New Hebrides (1974), 4,500 entries.

Revised BGN gazetteers have been published for Haiti (1973), 13,000 entries; and the Libyan Arab Jamahiriya (1973), 37,000 entries. Other new publications not previously reported in progress reports are: Algeria (1972), 45,000 entries; Dominican Republic (1972), 28,400 entries; Zambia (1972), 38,000 entries; Southern Rhodesia (1973), 22,000 entries; French Guiana (1974), 3,200 entries; and Surinam (1974), 3,500 entries.

The United States continues to participate in international standardization activities. The sixth session of the United Nations Group of Experts on Geographical Names was held in New York in 1975.

### *Automated cartography*

Preliminary feasibility studies with digitizers that scan with a photo-diode linear array (push-broom) show promise for highly automated cartographic applications. As the push-broom scans the line copy, the intersections (line positions) are recorded. The advantages of this type of device over the line-following device are (*a*) from three to four times faster digitization of a quadrangle; (*b*) virtually automatic operation (a line-follower requires an attendant to ensure continuous operation); (*c*) batch-process computer editing rather than interactive manual editing; and (*d*) draft-quality copy input rather than finish-quality input.

The progress of the United States in automated cartography is presented in a paper entitled, "Instrumentation and techniques for modern cartography".[1]

[1] This paper is presented under agenda item 7 (*b*).

# MAPPING THE UNITED STATES OF AMERICA*

*Paper presented by the United States of America*


## SUMMARY

The United States of America did not begin a systematic mapping programme until 1886, with the publication of the topographic map of the Wingate, New Mexico, 1° quadrangle at 1:250,000 scale. Since that time, mapping practices have changed and improved greatly. Attention is currently being turned to converting maps to the metric system and producing basic map material in digital form.

Current issues, such as energy development *versus* environmental protection, degree and methods of pollution control, land-use planning, conservation and the best use of natural resources, have brought about new and urgent needs for maps. Mapping a country like the United States means collecting and analysing data, and preparing maps and related products that help managers of public enterprises solve their problems. The National Mapping Program has been established to solve those problems.


## BACKGROUND INFORMATION

The most noteworthy surveyor in the colonial era of United States history was George Washington, who later became a military leader and the first President of the country. Since his time, 200 years ago, the mapping of the United States has advanced from the early boundary and charting efforts needed by a young evolving nation to modern technologies that make possible topographic mapping at various scales in formats needed to meet the ever-changing requirements of the present.

Instruments and techniques have progressed from the crude devices of two centuries ago. A wide selection of surveying tools, including electronic distance-measuring instruments and automated digitizing photogrammetric mapping instruments, is currently available. The United States Geological Survey (USGS) has established the National Mapping Program to identify and meet current and future mapping needs quickly and economically.

## PLANNING MAP COVERAGE

Completion of national topographic map coverage at 1:24,000 scale has been a prime objective for two decades, but changes in recent years have brought new considerations and new requirements for the mapping programme. These requirements will be met by the National Mapping Program, which provides for acquisition of the following 11 base categories of map data: (1) reference systems; (2) hypsography; (3) hydrology; (4) surface cover; (5) non-vegetative features; (6) boundaries; (7) transportation systems; (8) cultural features, such as buildings, airports and dams; (9) geodetic control and other survey information; (10) geographical names; and (11) orthophotographic imagery. The actual extent and form of the data provided in these categories will be based on the needs of users and will be provided at different levels of detail and scale.

The Geological Survey will process and reduce these data for direct use by the public. Elements will include topographic mapping, aerial imagery, special-interest mapping, metrication, research and development, digital cartography and cartographic information.

### *Topographic mapping*

Traditional multipurpose line maps remain important and include standard quadrangle and small-scale maps. USGS objectives are to complete nation-wide coverage at 1:24,000 scale and to maintain the series by periodic revisions. The 15-minute series at 1:62,500 scale may eventually be phased out, but the series at 1:63,360 scale will remain standard for Alaska except where maps of selected areas at 1:25,000 scale are needed.

Published topographic maps at 1:24,000 scale are currently available for about 67 per cent of the area of the conterminous states and Hawaii, and future mapping on this scale will concentrate on the energy-producing areas and the coastal zone.

During the past two years, some mapping funds have been reprogrammed to a new intermediate-scale series to provide support for both new and established federal programmes. The reprogramming will result in a somewhat lower production of 7½-minute quadrangle maps. At the current rate, it is estimated that complete 7½-minute coverage for the conterminous states and Hawaii will be available about 1986. USGS will continue to concentrate on the standard mapping programme to the extent possible, while remaining flexible enough to accommodate requirements for other products.

Revision of the maps on the scale 1:24,000 will increase as national coverage nears completion, with a high level of photo-revision. To avoid unnecessary revision, new photographs are compared with published maps to determine whether revision is needed. The goal is to inspect about 5,000 quadrangles annually. Urban and coastal areas, transportation corridors and other areas where cultural change is rapid or national interest is high will be inspected and revised every five years. Other areas will be revised as needed.

Small-scale mapping includes the topographic series at 1:250,000 scale, state base map series, national park series, International Map of the World on the Millionth Scale (IMW) series and national base map series. They are

* The original text of this paper, prepared by Robert H. Lyddan, Chief, Topographic Division, United States Geological Survey, appeared as document E/CONF.68/L.41.

being evaluated for content, format and utility to determine how much money should be spent on them.

Over the past decades, many cities have engaged commercial mapping firms to prepare large-scale maps of their areas. The need for such maps continues to grow; and some degree of guidance on scale, nature and quality is needed. An urban mapping study begun in 1973 was intended to determine what type of maps are most helpful to the cities of the United States. Specifications were prepared by USGS, and the experimental products were prepared by private contractors. The basic product is an orthophotographic base map at 1 : 2,400 scale (1 inch to 200 feet) which can be enlarged satisfactorily to 1 inch to 50 feet or reduced to 1 inch to 800 feet, thus serving a wide range of local users. Interviews with users have been completed for three of the four pilot projects, and guidelines for large-scale mapping are now in final draft.

The new intermediate-scale mapping programme began in 1970 and has expanded rapidly in the past two fiscal years to meet urgent mapping requirements for energy development, environmental protection, conservation and natural resources development. The programme provides base mapping data (topographic, planimetric or special-purpose) on the scales 1 : 50,000 and 1 : 100,000, and allows great flexibility in map production by generating multiple products at different scales and in different formats, and by providing plate separation according to features. The map content is derived from the data base categories of the National Mapping Program and can be selected by the user to meet specific requirements.

From 1974 to 1977, approximately 1.5 million square miles of intermediate-scale coverage will be completed throughout the United States. Most of the coverage will consist of either planimetric or topographic maps in county or quadrangle (30 × 60 minutes) format at 1 : 50,000 or 1 : 100,000 scale. Current emphasis is on preparing planimetric maps to meet immediate needs; however, there are plans to add terrain data and publish topographic maps at 1 : 100,000 scale (in quadrangle format with metric contours) as soon as practicable.

Coastal mapping is important at all levels of government in the United States because of an increased awareness of environmental degradation caused by economic development in the coastal zones. Maps are fundamental means of portraying the interrelationship of land conditions and uses that must be understood in environmental decision making. Accordingly, USGS is currently reviewing coastal-zone mapping activities in an effort to complete mapping of the coastal areas at 1 : 24,000 scale and to revise published maps on a five-year cycle. Arrangements have been made for the National Ocean Survey (NOS) of the National Oceanic and Atmospheric Administration (NOAA), to provide bathymetric data which will be added to maps in the coastal areas and thus make them topographic/bathymetric maps.

The draft of a "Coastal mapping handbook" compiled jointly with NOAA was sent to 200 federal and state agencies for review and comment. The handbook, which will be published in 1977, includes guidelines for mapping, sources of technical assistance and data, and examples of maps and related products. Planners and managers of coastal programmes can use this new reference to formulate mapping requirements, select suitable map and chart formats and communicate with the map-makers.

*Aerial imagery*

The aerial photograph has been for many decades a fundamental source of map information. Today it can be used directly or it can be processed into an orthophotoquad or orthophoto map. The orthophotoquad consists of an orthophoto or a mosaic of orthophotos at 1 : 24,000 scale in 7½-minute quadrangle format with very few cartographic additions, and it can be used as an interim map for an otherwise unmapped area or as an updating companion to a published line map. Orthophotoquads are meeting many needs where conventional line maps are not yet available because they are available or scheduled for virtually all areas of the conterminous (48) states not mapped at 1 : 24,000 scale.

Orthophotoquads are being used for a variety of purposes, as base maps for portraying land-use information; for selecting sites and routes for industries, utilities and public transportation; for tax assessment; for natural resources management; for studies of flood hazards, pollution, agriculture and coastal wetlands; for map revision and for producing special-purpose maps.

The objectives are to have orthophotoquads available by 1978 for all areas not already mapped at 1 : 24,000 scale and eventually to have nation-wide coverage with orthophotographic imagery.

An orthophoto map is a complete map with an orthoimage base that is supplemented by various techniques of colour separation, symbol overprinting and other cartographic interpretation. These maps are produced mainly for problem areas, such as swamps and deserts, which are commonly portrayed by stylized patterns that contain no specific information, whereas photo-imagery contains full detail but must be interpreted by the map-reader.

*Special-interest mapping*

Photo-mechanical techniques for producing slope maps were first tried in the early 1970s and later developed to provide limited capacity for producing slope maps to satisfy specific user needs. To date, about 500 slope maps have been prepared. It must be recognized, however, that slope as required for environmental studies and planning is a fine-grain characteristic of the terrain best portrayed at large scales.

In 1975, USGS published a map of the United States showing all 50 states in their correct geographical position and relationship, on the scales 1 : 6,000,000 and 1 : 10,000,000. This is a planimetric map; a topographic version is also being considered.

USGS is investigating the distribution of maps in folded form, which may provide a product more easily displayed on sales counters and more easily carried and used by travellers and outdoor enthusiasts. Experiments

are being conducted with both paper and plastic map-jackets. A questionnaire is included with each folded map to obtain user opinions.

A second edition of the National Atlas of the United States is likely for the mid-1980s, and a committee has been appointed to plan its production. Communications are being maintained with geographers and demographers who contributed to the original edition so that they can help in improving the new edition.

*Metrication*

The Congress of the United States passed a bill encouraging exclusive use of the metric system, the Metric Conversion Act of 1975, signed by the President in December 1975. Unfortunately, no time-table for conversion was specified in the Act. In anticipation of metrication, USGS distributed a questionnaire to 150 state and federal agencies, educators and private mapping firms. The answers to the primary questions are as follows: a 2:1 preference for 1:25,000 over 1:20,000 scale for the 7½-minute quadrangle maps; a 4:1 preference for a contour-interval sequence of 1,2,5,10, 20,50,100 over other alternatives; and a 4:3 preference for completing the 7½-minute coverage within individual states before changing to the metric system. After evaluating these responses, USGS has decided to proceed as fast as is practical towards producing new metric maps. How and when to convert the 40,000 published maps is another major problem and relates to the problem of mapping to the new geodetic datum, which will be established in the early 1980s.

*Research and development*

Increased research and development in mapping is an integral part of the National Mapping Program. One of the recent developments is the use of non-graphic data, such as digital tapes, as a cartographic product; another is automation.

Automation is a primary objective of current research. As many mapping phases as possible will be automated so that eventually only a few of the critical phases will be done manually. Automatic data-processing is already an integral part of the mapping system—automatic data acquisition, analytical aerotriangulation, computation and adjustment of geodetic control data and automatic plotting.

Currently, a major effort is directed towards digitization. New automated systems being adopted for map compilation will also provide digital cartographic data; manual digitizers are being used to digitize published map material. Automated orthophoto-mapping systems are the most promising. Output from these systems consists of orthophotos, contour-line plots and digital terrain models.

USGS is pursuing an active equipment and product modernization plan that includes: analytical stereoplotters; a Gestalt Photo Mapper II; manual line-following digitizers; high-speed drafting systems; and automated typesetting equipment—a digital profile-recording and output system, colour image maps and the aerial profiling of terrain system.

*Digital cartography*

New technology makes it possible to store and process various kinds of data in digital form. Spatially relatable data will be either based on or in harmony with standard topographic maps. Therefore, basic map material should be available in digital as well as graphic form. USGS is working on the development of systems for putting standard map material in digital form at the time of original compilation (for future mapping) or after compilation (for maps already published).

Acquiring digital data is a relatively new effort. In the past, digitized data have not been considered cost effective in producing standard maps because the type of equipment needed for production is expensive. Now, however, development has provided more efficient instruments; and some users currently require digital cartographic data for direct use. Many agencies are using computers in planning and management and therefore need data in computer-compatible form.

Progress is slow; more research is needed to define techniques and procedures for converting graphic data to digital form and to define storage and retrieval methods. These problems are currently under study. USGS is planning to supply data in digital form for reasonably sized areas within 30 days of request. The data will be supplied on magnetic tapes suited for image and line outputs and computational and statistical analyses.

*Cartographic information*

The National Cartographic Information Center (NCIC), established in 1974, provides an information service which makes United States cartographic data easily accessible to the public as well as to government agencies. Currently, more than 30 federal agencies collect and prepare cartographic data—maps and charts, aerial photographs, geodetic control data and map data in digital form. Amassed data include more than 1.5 million maps and charts, 25 million aerial and space photographs and 1.5 million geodetic control points.

NCIC is developing a comprehensive system to make the data readily available to users by consolidating information on data collected and distributed by co-operating federal sources. The most recent techniques of microphotography and computer technology are used to reduce the vast amount of data to a manageable form. To help eliminate duplication, NCIC also provides information on some planned projects for data collection.

NCIC does not intend to obtain, store and distribute all cartographic data itself. Collecting and organizing descriptive information about the data, telling users where the data are located and helping prepare orders will be its main functions. Established government and private data centres will continue to hold and distribute cartographic data. Some of these centres will also provide local users with direct access to NCIC information through their public service facilities.

Many government and private organizations are co-operating with USGS in organizing a network of NCIC facilities to provide a more efficient system of data distribution. Several federal agencies have already signed agreements with USGS, and several others are working on agreements. In addition, the State of Texas will establish a pilot cartographic information centre linked with NCIC. It may serve as a model for similar NCIC outlets to be established in other states.

The following table summarizes the status of mapping in the United States of America.

**Table 30. Standard topographic map series of the United States of America**

| *Scale* | *Format* | *Dimensions (latitude x longitude, in degrees or minutes)* | *Published coverage as of 30 June 1976 (percentage)* | *Remarks* |
|---|---|---|---|---|
| 1 : 24 000 | Quadrangle | 7.5′ x 7.5′ | 67 | Excluding Alaska |
| 1 : 50 000 | County | Various | — | New series |
| 1 : 62 500 | Quadrangle | 15′ x 15′ | 22 | |
| 1 : 63 360 | Quadrangle | 15′ x various | 84 | Alaska only |
| 1 : 100 000 | Quadrangle | 30′ x 1° | — | New series |
| 1 : 100 000 | County | Various | — | New series |
| 1 : 250 000 | Quadrangle | 1° x 2° | 100 | |
| 1 : 1 000 000 | Quadrangle | 4° x 6° | 98 | International Map of the World |

# AGENDA ITEM 7

## Review of the latest techniques and recent developments related to various areas of cartography

### (a) *Conventional and satellite geodesy*

### DOPPLER SATELLITE SURVEYS IN AUSTRALIA*

*Paper presented by Australia*

In 1966, the Australian geodetic survey had reached the stage at which a national adjustment was undertaken and the resultant co-ordinates on the Australian geodetic datum were adopted by the National Mapping Council for topographic mapping purposes. Those co-ordinates have since been widely adopted for many other purposes and have been accorded legal status under various federal and state Acts of Parliament.

The survey was based almost entirely on electronically measured distances and included a considerable number of Laplace azimuths; but in order that an early survey framework might be available for practical use, the 1966 adjustment ignored the geoid-spheroid separation and used trigonometrically determined elevations for reduction to sea level.

By 1971, an Australian levelling survey and a very dense astrogeodetic survey had been completed; and these surveys, in conjunction with a nation-wide gravimetric survey, provided the basic data from which geoid-spheroid contours were determined.

During the period 1975–1976, Doppler satellite observations were made at 96 major junction points of the original survey for the purpose of testing the accuracy of that survey and of providing a ready means for the conversion of future Doppler satellite observations into co-ordinates of the Australian geodetic datum.

The positions derived from the observations have been calculated in terms of precise ephemeris data supplied to the Royal Australian Army Survey Corps by the Defense Mapping Agency of the United States of America.

The observations were carried out by personnel of the Division of National Mapping, the Royal Australian Survey Corps; and the staff of the Surveyors General of Western Australia, South Australia, Queensland and Tasmania. The over-all organization of the operation and the comparison of data were undertaken by the Division of National Mapping.

Of the 96 stations, 84 were observed with JMR-1 Doppler survey sets, 7 with Geoceivers and 5 with the Marconi CMA-722B system. The Division owns three JMR-1 sets and had a Marconi CMA-722B system on hire for four months during 1975. The Royal Australian Survey Corps owns five Geoceivers.

Specifications for Doppler observations in this survey stipulated that 45 passes of precise ephemeris satellites above 15° were to be obtained.

To date, Doppler point positions at 54 junction points have been computed and a best fit has been obtained between Doppler derived co-ordinates on the NWL-9D datum and those on the Australian geodetic datum. The following transformation parameters have been adopted at this point of time to transform NWL-9D co-ordinates to the Australian geodetic datum:

(a) *Rotation*: NWL 9D East longitude increased by 0.″5;

(b) *Scale*: NWL 9D reduced by 1 ppm;

(c) *Translations*: $\Delta X = +119$ m;
$\Delta Y = +\ 50$ m;
$\Delta Z = -150$ m.

The difference between the latitudes and longitudes derived from NWL 9D co-ordinates and those of the Australian geodetic datum, together with respective differences in geoid-spheroid separations, are illustrated in figure 55 and are listed in table 31.

The average differences without regard to sign are as follows:

$$\Delta\phi = 0.''05 \text{ (1.5 m)}$$
$$\Delta\lambda = 0.''06 \text{ (1.5 m)}$$
$$\Delta(N+H) = 1.3 \text{ m}$$

Currently (October 1976), the Division of National Mapping is conducting two short-arc experiments involving four JMR-1 sets. One experiment simulates the establishment of a national geodetic control system with Doppler stations 300–400 km apart. The other experiment simulates the provision of mapping control in a 1:250,000 map area (1.5° in longitude by 1° in latitude).

During the experiments the performance of the 5MHZ oscillators of the sets is being checked against a portable rubidium clock. The aim is to introduce the derived

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.28.

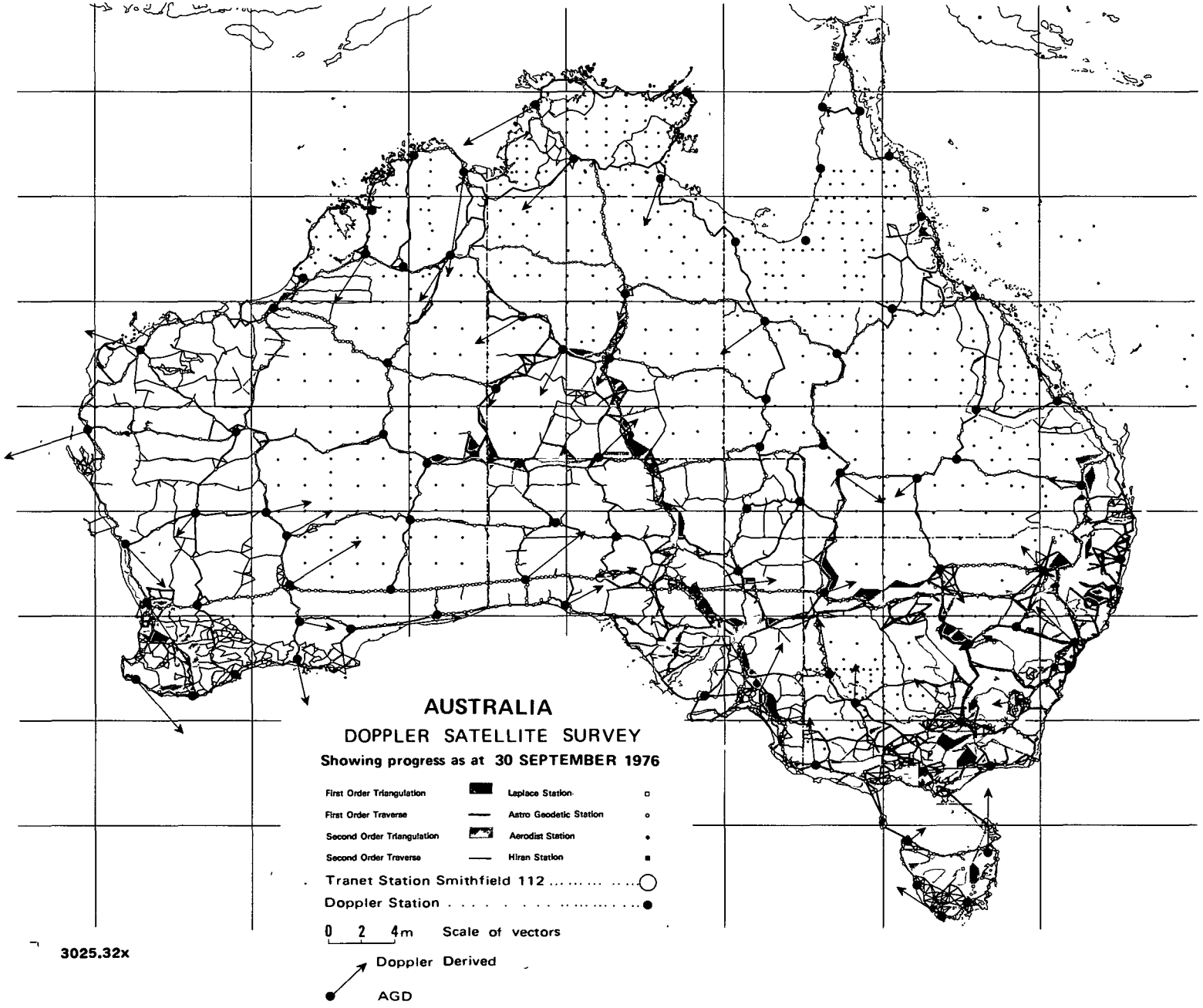



*Figure 55. Australia: Doppler satellite survey as at 30 September 1976*

frequencies of the oscillators in the reduction of the Doppler data.

Arrangements have also been made to get radiosonde data of the atmosphere at four localities surrounding the area in which the experiments are being conducted.

The data set obtained from these experiments will be used to develop computer programmes for routine reductions of short arc surveys.

**Table 31. Australia: difference between latitudes and longitudes derived from NWL 9D and from the Australian geodetic datum, and respective differences in geoid-spheroid separations**

| *Station co-ordinates* | | | | | *Australian geodetic datum— Converted NWL 9D datum* | | |
|---|---|---|---|---|---|---|---|
| *South latitude* | | *East longitude* | | $N+H$ | | | |
| *Degrees* | *Minutes* | *Degrees* | *Minutes* | *(metres)* | $\Delta\phi''$ | $\Delta\lambda''$ | $\Delta(N+H)$m |
| 20 | 21 | 139 | 12 | 525 | −0.06 | +0.09 | +0.56 |
| 28 | 02 | 120 | 32 | 571 | +0.02 | +0.08 | +0.54 |
| 43 | 25 | 146 | 10 | 31 | +0.05 | +0.09 | +2.27 |
| 37 | 51 | 144 | 58 | 42 | +0.01 | +0.05 | −0.20 |
| 18 | 26 | 127 | 25 | 466 | −0.07 | +0.06 | +0.03 |
| 33 | 06 | 147 | 18 | 245 | +0.01 | −0.03 | −3.80 |
| 30 | 50 | 121 | 06 | 567 | +0.09 | −0.15 | −0.07 |
| 40 | 52 | 144 | 42 | 188 | +0.02 | −0.02 | +3.26 |
| 21 | 47 | 131 | 52 | 623 | −0.08 | +0.04 | +1.70 |
| 25 | 07 | 113 | 44 | 32 | −0.06 | +0.16 | +2.88 |
| 31 | 50 | 115 | 58 | 43 | −0.13 | −0.10 | −2.64 |
| 40 | 45 | 147 | 58 | 68 | +0.08 | +0.04 | −1.05 |
| 34 | 15 | 115 | 01 | 64 | −0.11 | −0.10 | −1.54 |
| 30 | 19 | 149 | 34 | 222 | +0.04 | +0.03 | −1.79 |
| 31 | 35 | 117 | 51 | 346 | −0.05 | −0.09 | −0.18 |
| 29 | 59 | 146 | 34 | 173 | −0.06 | −0.03 | −1.41 |
| 37 | 28 | 141 | 55 | 484 | +0.08 | +0.02 | −0.88 |
| 12 | 27 | 130 | 49 | 30 | −0.08 | +0.12 | −0.23 |
| 31 | 06 | 141 | 44 | 294 | −0.02 | −0.06 | −0.17 |
| 28 | 49 | 121 | 18 | 470 | +0.05 | −0.09 | +1.00 |
| 26 | 38 | 145 | 08 | 339 | −0.03 | +0.03 | +0.02 |
| 38 | 14 | 146 | 56 | 235 | +0.02 | +0.08 | +0.76 |
| 26 | 32 | 142 | 23 | 210 | −0.05 | −0.08 | +0.44 |
| 25 | 57 | 133 | 13 | 571 | +0.06 | −0.06 | +1.05 |
| 35 | 15 | 142 | 54 | 108 | +0.07 | 0.00 | +1.80 |
| 33 | 06 | 138 | 35 | 760 | +0.03 | −0.03 | −1.22 |
| 23 | 56 | 151 | 14 | 236 | +0.06 | +0.04 | −2.76 |
| 32 | 27 | 123 | 48 | 179 | +0.02 | −0.19 | +1.99 |
| 31 | 34 | 132 | 05 | 89 | +0.05 | −0.06 | −3.98 |
| 30 | 38 | 130 | 21 | 128 | +0.09 | −0.11 | +0.03 |
| 34 | 12 | 142 | 01 | 78 | +0.10 | +0.02 | +0.72 |
| 14 | 26 | 132 | 20 | 183 | −0.09 | +0.09 | +0.03 |
| 21 | 44 | 115 | 41 | 127 | +0.03 | +0.11 | +1.14 |
| 15 | 36 | 128 | 17 | 64 | −0.17 | +0.05 | −3.85 |
| 20 | 30 | 130 | 14 | 401 | −0.05 | +0.08 | +1.53 |
| 18 | 09 | 124 | 18 | 107 | −0.08 | +0.06 | +1.06 |
| 14 | 51 | 135 | 04 | 107 | −0.10 | +0.02 | +2.59 |
| 32 | 41 | 151 | 47 | 189 | +0.05 | +0.09 | −2.15 |
| 19 | 37 | 134 | 11 | 339 | −0.04 | +0.01 | +1.01 |
| 34 | 41 | 138 | 39 | 42 | +0.09 | −0.06 | +0.01 |
| 22 | 11 | 133 | 39 | 689 | −0.04 | +0.02 | −0.36 |
| 29 | 14 | 115 | 12 | 220 | −0.08 | −0.07 | −0.05 |
| 35 | 19 | 149 | 00 | 789 | 0.00 | +0.03 | +2.31 |
| 36 | 05 | 147 | 06 | 662 | +0.07 | +0.08 | +0.58 |
| 23 | 09 | 128 | 54 | 553 | −0.02 | +0.01 | +3.02 |
| 35 | 05 | 117 | 37 | 291 | +0.02 | −0.04 | +0.76 |
| 19 | 16 | 146 | 43 | 20 | +0.01 | +0.01 | −0.09 |
| 28 | 02 | 117 | 49 | 558 | −0.04 | +0.03 | −2.42 |
| 30 | 32 | 133 | 10 | 241 | +0.01 | −0.07 | −0.43 |
| 33 | 53 | 121 | 53 | 103 | −0.09 | +0.02 | +1.46 |
| 32 | 16 | 121 | 47 | 498 | −0.01 | 0.00 | +0.20 |
| 31 | 24 | 136 | 53 | 147 | +0.04 | −0.15 | −0.67 |
| 32 | 59 | 135 | 33 | 267 | +0.04 | +0.01 | −3.52 |
| 27 | 03 | 151 | 44 | 761 | +0.01 | +0.06 | +0.52 |
| Average of 54 stations without regard to sign | | | | | 0.05 | 0.06 | 1.31 |

# COMPARISON OF THE AUSTRALIAN GEODETIC SURVEY OF 1966 AND NAVSAT GEODETIC OBSERVATIONS*

*Paper presented by Australia*

This paper briefly reviews the development of the Australian geodetic survey under the general guidance of the National Mapping Council; and the results thereof are compared with recent geodetic Doppler (Navy Navigation Satellites: NAVSAT) observations and conversion factors deduced for the direct transformation of such satellite position determinations into the co-ordinates of the Australian geodetic datum of 1966.

The Australian geodetic survey, after a somewhat chequered start, really got under way in the early 1950s. The organizational impetus for this onward drive came from the National Mapping Council and all member organizations represented thereon participated operationally to varying degrees. Its Chairman was responsible to the Council for the co-ordination of planning and the general direction of the survey.

Great technical impetus came from the early introduction of electronic distance-measuring (EDM) equipment and its utilization, primarily in traverse form. At first, triangulation base lines were measured with early Geodimeter equipment, but the bulk of the traversing was done with Tellurometers and a considerable number of Laplace observations were included.

In 1965, the Council decided to adopt a best mean fit between the survey and astronomical positional co-ordinates to determine a central origin (the Johnston Geodetic Station). At the same time, the Council agreed upon an Australian reference spheroid based on the figure recommended at that time by the International Astronomical Union ($a = 6{,}378{,}160$ m; $f = 1/298.25$). Initial computations were then undertaken to determine the desired latitude and longitude values for the Johnston Station and to arrive at trigonometrical heights for all stations of the network.

In 1966, an adjustment was made of the whole survey using a variation of the co-ordinates technique developed within the Division of National Mapping. At that time, there was not a sufficient number of Laplace observations, nor the over-all levelling survey, necessary for computation of geoid elevations. Distances used in the 1966 adjustment were therefore reduced to sea level simply on the basis of trigonometrical heights.

The Director of National Mapping, in his capacity of Chairman of the National Mapping Council, published the parameters of the Australian geodetic datum in the *Commonwealth Government Gazette*, No. 84 of 6 October 1966; and those parameters have since been included in various Legislative Acts of the Commonwealth Government and state governments (primarily legislation relating to off-shore minerals).

In 1967, an estimate was made of the accuracy of the geodetic survey as it then stood. That estimate was based on loop closures of varying length and the conclusion reached was that there appeared to be a 90 per cent probability of errors in length and in azimuth (with respect to the adopted origin) not exceeding 7.5 parts in $10^6$ on short lines and 1.5 parts in $10^6$ across the whole continent.

During the period 1967–1972, two precision traverses were surveyed and adjusted to provide chord distances between three BC4 satellite camera stations of the United States of America. One was from east to west, generally along the 31° South parallel and one went northwards from the east-west base line and extended along the eastern coastal mountain ranges to Thursday Island. These base lines followed existing traverses, distances were for the most part measured by MRA4 Tellurometer, and Laplace observations were made at every station. In subsequent years, continuous lines of astronomical observations were observed along selected traverse lines, appropriately spaced throughout the whole survey.

By 1971, a national levelling survey had been completed and adjusted, thereby providing an Australian height datum that could be adopted by the National Mapping Council. During the course of this levelling survey, numerous connexions were made to trigonometrically heighted geodetic stations and the heights of these stations have since been adjusted to the Australian height datum. This is a continuing practice and one important result of this activity is that the trigonometrical height that had been specified as the elevation of the Johnston Station with respect to the Australian spheroid was higher than the Australian height datum elevation. As a result, the specific $N$ value of the geoid became $+4.9$ m at this point.

From the available astrogeodetic deflections and an extensive network of gravity observations that had been observed over the whole continent by the Commonwealth Bureau of Mineral Resources and by some state Mines Departments, it was possible, in 1971, to prepare a geoid contour map for the whole of Australia. For what appeared to be very good reasons at the time, these contours were based on a geoid elevation of $N = -6$m at Johnston, the objective then being to even out the effect of omitting corrections for the geoid undulations in the 1966 adjustment.

Since 1966, a number of more accurate surveys and resurveys have been undertaken, by various authorities, many of them with laser Geodimeters and other modern EDM equipment. In 1973 and again in 1974, the Division of National Mapping readjusted the Australian geodetic survey, incorporating all available data and applying new elevation corrections based on geoidal height variations from the spheroid. These adjustments were for technical

* The original text of this paper appeared as document E/CONF.68/L.93.

purposes only and are known as geodetic models of Australia (GMA 73 and GMA 74). The main difference between these two adjustments was that GMA 73 was computed on the basis of a geoidal elevation at the Johnston Station of −6 m. GMA 74 used an $N$ value of +4.9 m for this station.

The geodetic models indicated that there had been systematic but not major distortions in the 1966 adjustment. Standard error elipses produced in the course of the GMA adjustments were reasonably circular in shape with average radii of ± 1 m in the interior of the country and of about ± 2 m at coastal positions that are remote from the central origin.

The development by United States authorities of the Doppler Navy Navigation Satellite (NAVSAT) system, and their provision of precise post processed ephemeris data in respect of specific sets of observations, has made possible a complete check of the Australian geodetic survey in the course of which accurate positional fixes have been obtained during the past few years at 96 junction points plus several additional stations.

Specifications for this survey called for 45 passes above 15° and from those passes well-balanced sets were computed. One sigma internal consistencies obtained were about ±0.3 m for elevation and latitude and about ±0.5 m for longitude. Where repetitive observations have been made, the co-ordinate spread was usually within a range of 1.5m; but in two instances, although latitude and elevation remained within these limits, the longitudes differed by 3–4 m.

The satellite and the ground survey co-ordinates were then compared for the purposes of providing a check on the accuracy of the 1966 Australian geodetic survey and in order to provide a means of readily converting satellite observations into co-ordinates in terms of the Australian geodetic datum.

In this operation, the satellite observations are computed in terms of the NWL 9D reference ellipsoid ($a$ = 6,378,145 m; $f$ = 1/298.25) with the derived Cartesian co-ordinates reduced by 1 ppm (15); and as GMA 74 had been computed on an ellipsoid that is reasonably close to this result, and incorporates geoid heights, it was considered that Cartesian co-ordinates derived from GMA 74 could be directly compared with the co-ordinates derived from satellites.

From that comparison, it was found that the centre and the orientation of the Australian portion of the NWL 9D system could be brought into very close agreement with GMA 74 by rotating the NWL 9D longitude so as to increase East longitudes by 0.5″ and by applying the following shifts to the co-ordinates derived from satellites:

$\Delta X + 120$ m  $\Delta Y + 50$ m  $\Delta Z - 151$ m

The best indicator of the fitting together of these two systems is probably given by height comparisons at the 55 geodetic satellite stations that had been directly levelled in terms of the Australian height datum. The absolute average of the differences was −0.1 m with an average spread of ±1 m and maxima of +2.4 m and −3.0 m.

From these results, it would appear that the Australian height datum elevation of any station at which converted, precise Doppler satellite observations are available can be derived with an average accuracy of ±1 m by suitably applying a correction from the available geoid contour map related to a datum value of +4.9 m at the Johnston origin.

A form of scale check was obtained by comparing very long base-line interferometry (VLBI) determined spin axes at Woomera and Tidbinbilla with those derived from Doppler satellite observations. The differences were, respectively, +0.3 and −0.1 parts in $10^6$.

As a further check on orientation, latitude and longitude comparisons were made between GMA 74 and the corresponding satellite values, with the following results:

| | *Mean* | *Average spread* | *Maxima* |
|---|---|---|---|
| Latitude | 0.00″ | ±0.04″ | +0.11″ −0.17″ |
| Longitude | +0.01″ | ±0.07″ | +0.017″ −0.19″ |

It was then decided to undertake a variation of co-ordinates adjustment holding the Johnston Geodetic Station and the South Pole fixed and incorporating the converted satellite latitudes and longitudes in the form of bearings and distances from that pole. Those dimensions were so weighted that the maximum variation of their positional co-ordinates was unlikely to exceed ±2m; and, in practice, the average value came out at ±0.6 m.

The resultant co-ordinates when directly compared with Australian height datum co-ordinates gave:

| | *Mean* | *Average spread* | *Maxima* |
|---|---|---|---|
| Latitude | +0.04″ | ±0.03″ | +0.11″ −0.12″ |
| Longitude | −0.05″ | ±0.06″ | +0.19″ −0.23″ |

Contour plots were attempted in order to show the differences between the satellite and the 1966 Australian geodetic datum latitudes and longitudes over the whole country. As both sets of co-ordinates are derived from reasonably homogeneous surveys, it was expected that the contour plots would be reasonably smooth. That expectation was proved correct for the latitudes, but it was impossible to fit smooth contours to all of the longitude values.

It would appear most practical to prepare contour plots of small surrounding areas when requiring corrections for conversion of latitudes and longitudes of specific precise Doppler fixes on to the Australian geodetic datum.

# GEODESY BY DOPPLER SATELLITE*

*Paper presented by France*

A fundamental function of geodesy is to provide a net based on selected points on the ground, the co-ordinates of which will be used in preparing cartographic documents and establishing data banks.

This net must have the following essential characteristics:

(*a*) It must be uniform for a given territory; ultimately, the trend is towards a unified world-wide system;

(*b*) It must be as homogenous as possible; that is, it must be able to provide the user at any point with a satisfactory scale and satisfactory orientation;

(*c*) It must be based on fixed markers (limits) on the ground which are easily usable.

Conventional geodesy, limited in range to the lines of sight between points on the ground, meets the three criteria described above to varying degrees:

(*a*) It is difficult to unify a conventional net for a given country, because measurements are taken over a period of time;

(*b*) In general, it produces excellent homogeneity;

(*c*) It is easy to set up markers in some climatic conditions, but more uncertain in others. The subsequent use and preservation of such markers is not always easy (particularly in the case of points on wooded peaks or in tropical or equatorial climates).

The introduction into geodesy of targets that change altitude (aircraft, satellites) has increased the range of each operation, making possible the direct establishment of wide-loop nets.

With the use of optical methods (photographing an object against a stellar background, range measurements by laser), it is possible to achieve uniformity over large ranges, but only for a small number of points.

Electromagnetic methods (range, radial velocities) are bound to develop significantly in the future because they permit accurate and rapid operations which are not dependent upon meteorological or topographic conditions and which can be generalized over vast expanses.

This paper discusses in particular the Doppler systems on board TRANSIT satellites as they have developed over the past 15 years, and their potential for obtaining geodetic nets which offer welcome assurances of stability, homogeneity and ease of use.

## Principle of Doppler systems

The system of navigation by TRANSIT satellite was developed in 1961 by the United States Navy. It consists essentially of the elements described below.

Satellites (TRANSIT) operate in polar orbit at an average altitude of 1,100 km (period of 108 minutes) and at varied longitudes. Each satellite broadcasts two simultaneous frequencies in phase (400 MHz, 150 MHz), the regularity of which is ensured by a quartz oscillator carried on board. Currently, six usable satellites are in orbit.

Receivers on the ground, which record the broadcasts from the satellites, compute their orbits on a round-the-clock basis and inject in each satellite at 12-hour intervals predicted positions (accurate to about 20 m) which are valid for the following 12-hour period. The sites of the ground receivers were fixed within the geocentric system, so that all the satellites—and the resulting co-ordinates on the ground—are within the same reference system.

From the TRANSIT satellites, steady frequency transmitters broadcast at 2-minute intervals messages giving their predicted co-ordinates; isolated receivers are then capable of determining their own position on the earth according to the following principle:

(*a*) A Doppler receiver comprises a steady oscillator capable of producing a 400-MHz frequency close to that of the satellite. The combination of the frequency ($N$) received from the satellite with that of the receiver ($R$) creates pulsations, frequency ($R - N$), which are a direct function of the relative radial speed of the satellite in relation to the ground station;

(*b*) The variation in the frequency of the pulsations as the satellite passes overhead, combined with the data provided by the messages broadcast every 2 minutes, makes it possible to calculate the position of the ground station.

This capability was at first reserved by the United States for American military stations—especially in order to position ships at sea—with an accuracy of approximately 50 m.

The use of Doppler systems in geodesy developed simultaneously elsewhere, notably in France, where the DIAPASON (DIA) and DIADEME (DIC, DID, 1967) satellites carried stable frequency transmitters capable of being utilized with appropriate receivers. That capability, at first reserved for fixed stations (laboratories), has since 1970 been extended to mobile stations, as much lighter receiving instruments have been produced.

Reception at a given point from a number of passes by TRANSIT satellites makes it possible to achieve, in a few days, an absolute accuracy of about 3–5 m in positioning the point.

The basic observation at a receiving station consists of counting the pulsations $C$ during a time interval $(t_1 - t_2)$ between the satellite's frequency $f_E$, transmitted with a propagation time of $T$, and the receiver's own frequency $f_R$:

* The original text of this paper, prepared by C. Boucher, Institut géographique national, France, appeared as document E/CONF.68/L.7.

$$C = f_R(t_2 - t_1) - f_E[(t_2 - T_2) - (t_1 - T_1)]$$

$$C = \Delta f(t_2 - t_1) + \frac{f_E}{c}(D_2 - D_1)$$

where $c$ is the speed of light, and $D_1$ and $D_2$ are the optical distances of the station from the satellite at times $t_1$ and $t_2$.

Meteorological corrections make it possible to replace the optical distances with, geometrical distances.

A relationship emerges between the result of the counting $C$, the difference $(D_2 - D_1)$ and the difference in frequencies $\Delta f$ between receiver and transmitter. When that difference is known, the relationship yields as the position of the station a hyperboloid, the foci of which are the two successive positions of the satellite at times $t_1$ and $t_2$.

The counting time $(t_2 - t_1)$, which at first was about 2 minutes, has been reduced to a few seconds with the instruments recently introduced, making it possible to take up to 200 independent measurements on each pass; thus, the position of the station is arrived at by the intersection of 200 hyperboloids.

The variable $(\Delta f)$ can remain a free parameter; the method can then be assimilated to the procedure for resection by triangulation ($\Delta f$ being analogous to the constant of orientation of the round of horizontal angles).

An important innovation was the introduction of simultaneous monitoring of the same orbit with two receivers: translocation (United States of America and Canada); after a few days, relative accuracy between the two ground stations reaches the high standard of 1–2 m, irrespective of distance (up to 1,000 km).

Lastly, more accurate mathematical processing, by collocation, introduces additional parameters, particularly to describe the trajectory arcs above mobile observation stations (short-arc method). With this method, it is possible to bring the relative accuracy down to less than 1 m.

## Instrumentation at the Institut géographique national: methods of computation

The Institut géographique national (IGN) has six receivers of the same kind (JMR), with counting intervals of 4.6 seconds, which are activated by satellite signals (and thus are practically synchronous from station). The equipment is particularly easy to transport (15 kg) and is compact in form.

The basic recordings (time-countings) are made on tape cassettes which are subsequently:

(*a*) Processed directly by mini-computer (PDP 8, Wang, Hewlett-Packard 2000) to determine the position of the station from the recordings made at that station alone (approximately 100 in five days) (programme SP3); or

(*b*) Transcribed on IBM tapes and computed at IGN (by IBM 370) in a processing line which includes: (i) analysis of the message; refinement of the trajectory; (ii) point-by-point computation; (iii) computation of all points by the short-arc method.

The expected accuracy for the relative co-ordinates of stations is approximately 1 m.

## Practical advantages of the Doppler system

Doppler geodesy is particularly effective for obtaining a geodetic net in a territory lacking equipment, as it meets the three criteria described earlier.

First, the reference system is automatically the NWL system, which is world wide.

Secondly, because the basic measurement is so sensitive, the relative accuracy of two neighbouring points positioned simultaneously, and *a fortiori* that of a network, can be high. It is reasonable to expect that advances in methods of instrumentation and computation will make possible accuracies of 1 m. The procedures for observation and computation employed at IGN are directed especially to preserving this relative accuracy.

In case of repeat observations or of establishing links with existing co-ordinates (determined by Doppler or by conventional geodesy), this relative accuracy can be protected by repositioning at the outset two or three points of the network which is already known.

Thirdly, the choice of control points can be made on the basis of a wide range of options: ease of maintenance (markers); ease of identification in aerial photographs; ease of use in conventional triangulation.

Lastly, the speed with which a basic network can be established over a vast area (it is theoretically possible with the use of six receivers to determine one new point per day) enables one rapidly to obtain fixed co-ordinates, which are particularly valuable for subsequent use for cartography and data banks.

## Conclusion

The Doppler system of geodesy is a kind of three-dimensional resection method for a basic geodetic network in space (the set of TRANSIT orbits).

Stress should be placed on how this method links up with plans for the near future (the GEOLE project of the Centre national d'études spatiales), under which ground co-ordinates will be determined by the combination (range plus Doppler) from an orbital space network consisting of the trajectories of one satellite (or more than one), which will itself be tracked by a system of fixed beacons on the ground, or in the more distant future (after declassification) by the United States NAVSTAR system.

The Applied Physics Laboratory of Johns Hopkins University (United States of America) is currently working on refinements to the TRANSIT system, which will undoubtedly improve its performance; the only question is by how much.

# ADJUSTMENT OF THE EUROPEAN TRIANGULATION NETWORK: CURRENT STATE OF COMPUTATION AND FUTURE MONITORING BY SATELLITE TECHNIQUES*

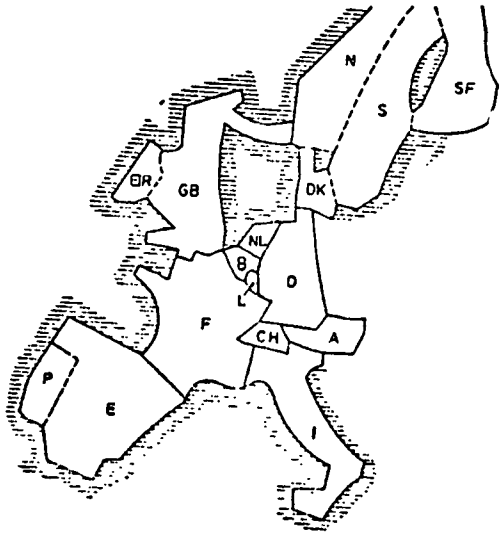
*Paper presented by the Federal Republic of Germany*

The International Association of Geodesy, meeting in Rome in 1954, decided to readjust the European triangulation network (RETRIG). Professor Kneissl, of Munich, was elected President of the Permanent Commission for RETRIG; and after his death in 1973 the position was occupied by Professor Kobold, of Zurich. Division I of the Deutsches Geodätisches Forschungsinstitut (German Geodetic Research Institute; DGFI I) at Munich acts as the secretariat and computational centre for the adjustment of the network. Triangulation network activities in Europe, commencing with the degree measurement conducted in 1864, as well as problems related to the adjustment of RETRIG, have been described in *Geodätische Woche Köln, 1976*[1] and in a publication of the RETRIG Commission.[2] The latter publication also provides background notes and summarizes RETRIG activities since 1954. Periodic reports on the activities of the RETRIG Commission are also published by the Deutsche Geodätische Kommission bei der Bayerischen Akademie der Wissenschaften (German Geodetic Commission of the Bavarian Academy of Sciences) at Munich.

The present paper reflects the state of progress in the adjustment of RETRIG and contains some observations on future comparisons and monitoring techniques by satellite. The use of satellites has brought about a change in the function of a classical triangulation network such as RETRIG in so far as it concerns the geometrical problems of earth measurements. It has become important to create a dense network between satellite stations and their controls. RETRIG is as necessary as ever for the description of plumb-line direction against ellipsoidal verticals and for the establishment of a homogeneous fundamental network as a basis for detailed survey, cartography, traffic, navigation and the determination of boundary lines in the area of the North Sea continental shelf. Last but not least, RETRIG has contributed to the geodetic integration of Europe.

## COMPUTATION PROCEDURES

The total area of RETRIG has been divided into separate "national" blocks, which correspond to the national triangulation networks (see figure 56). Because observed zenith angles were generally not available, a two-dimensional computation had to be chosen by reducing the observations to the international ellipsoid. The observations are: Laplace azimuths; horizontal angles or directions; bases or base-enlarging nets; distances at known scales and distances at unknown scales.




3025.33x

*Figure 56. Federal Republic of Germany: national blocks of European triangulation network*

Following a proposal by H. Wolf, the adjustments are performed by observation equations with co-ordinates as unknowns. The co-ordinates of the European triangulation network of 1950, henceforth referred to as the European Datum 1950 (ED50), which was completed in 1947, are approximate values.[3]

Each country first examines its own observations, forms the observation equations and solves the normal equations for all "inner unknowns". The resulting partially reduced normal equations (buffer matrices) still contain "junction unknowns", which comprise co-ordinate unknowns along boundary lines, satellite stations and unknowns for scale and orientation.[4] The buffer matrices are combined according to the addition theorem for reduced normal equations (F. R. Helmert) and are ultimately solved by the computation centre. Each country obtains the values for its inner unknowns by reverse solution of the total system.

* The original text of this paper, prepared by Ewald Reinhart, Deutsches Geodätisches Forschungsinstitut, appeared as document E/CONF.68/L.20.

[1] H. Wolf, "Das Europäische Dreiecksnetz, Ursprung, Entwicklung und künftige Möglichkeiten", in *Geodätische Worche Köln, 1976* (Stuttgart, Konrad Wittwer-Verlag, 1976).

[2] F. Kobold, "Notice historique et aperçu des traveaux depuis 1954", *RETRIG Commission Publication* (GDK), No. 11 (1975).

[3] C. A. Whitten, "Adjustment of European triangulation", *Bulletin géodésique*, No. 50 (1952).

[4] The buffer matrix for block D (Federal Republic of Germany) is computed by the Deutsches Geodätisches Forschungsinstitut, Division I.

This procedure has many advantages. First, the national authorities need not publish the observation data and the adjusted station co-ordinates, depending upon their policies. Further, data processing, error analysis, error detection and so on are much simpler when the total system is divided into blocks with a limited number of observations and unknowns. This process makes adjustment possible using a computer of limited size.

## Phases of adjustment

The Commission has decided to adjust RETRIG in three consecutive phases. Phase I comprises the geometrical adjustment, using all observed horizontal directions or angles and some non-scaling distances.

In phase II, a rapid computation will be made for practical reasons, introducing, in addition, all measured distances and Laplace azimuths and comparing the results to those obtained from the West European Satellite Triangulation (WEST).

Phase III follows the same procedure as phase II, incorporating all the improvements that can be obtained from a more scientific analysis.

A brief description is given below of these phases and of the traverses and the North Sea ring.

### *Phase I of RETRIG adjustment and traverses*

The geometrical adjustment of RETRIG (phase I) was completed in 1974 and the results are published in a report of the Computing Centre in Munich.[5] The total system of all buffer matrices contains 279 unknowns. When all the blocks are considered, phase I consists of 17,800 observations and 9,500 unknowns. Since orientation and scale are introduced by the fixed ED50 co-ordinates of Munich and Panker, phase I refers to ED50 and the international ellipsoid.

Using terrestrial methods, DGFI I calculated the length of two chords (base lines) within Europe for scaling the satellite triangulation.[6] The two base lines are the north-south base line Tromsø-Hohenspeissenberg-Catania for the world-wide satellite triangulation[7] and this base line and the east-west base line Malvern-Hohenspeissenberg-Graz for WEST.[8]

### *Phase II of RETRIG adjustment and the North Sea ring*

In 1976, the North Sea ring, consisting of the blocks of those countries situated along the coastlines of the North Sea, was computed to test the processing of data and also for other practical reasons.[9] In addition to phase I, distance measurements and Laplace azimuths for scale and orientation were introduced into the adjustment. The results were distributed to the participating countries and will be published in the series of the RETRIG Commission. The computing centre began combining the buffer matrices and solving the total system for phase II at the end of November 1976. In March 1977, during the meeting of the RETRIG Commission at Brussels, the results and the remaining problems will be discussed. Attention has to be drawn to the definition of the final scale and orientation, the standardization of the observation equations and the computation of three-dimensional RETRIG co-ordinates of the satellite stations for comparison with the results of satellite methods.[10]

### *Phase III of RETRIG adjustment, future monitoring by satellite techniques and combined solutions*

Since phase II is to be finished as quickly as possible, not all participating countries were able to process and reduce observation data, desirable as that would have been from a theoretical point of view. A phase III adjustment will therefore be necessary. If the observations are affected only by accidental errors and the data processing is correct from a theoretical point of view, the error propagation is a function ($ln\ i$) for a triangulation network consisting of $i$ triangles. The relative error diminishes by enlarging the number of triangles. Keeping this in mind, it is expected that very small relative mean square errors will be found in RETRIG.

Using two test areas, it has been shown that both the relative scale error and the orientation error diminish with increasing line length and become smaller and steadier beyond a minimum range of 400 km.[11] The average values for the *a posteriori* standard errors for lines of 1,000 (400, 50) km are $\pm 0.3$ (0.4, 0.7) inches and $\pm 0.65$ (1, 2.5) parts per million (ppm) respectively.

In view of the different types of systematic errors in observation or in data processing that are possible, these mean square errors are an over-optimistic estimate of accuracy. It is therefore necessary to compare the terrestrial network with results derived from satellite techniques.

*Future RETRIG adjustment*

For the phase III adjustment, all observed angles or directions, azimuths and distances must be reduced to the same datum, namely, ED50. The net will be oriented to the mean pole of 1903, subject to two conditions: (*a*) that the observed astronomical azimuths refer to this pole; and (*b*) that the longitudes refer to a homogeneous

[5] R. Kube and K. Schädelbach, "Geometrical adjustment of the European triangulation network: report of the RETRIG Computing Centre, Munich," *RETRIG Commission Publication* (GDK), No. 11 (1975).

[6] R. Kube and K. Schädelbach, "Preliminary computation of the European base line Malvern-Graz, adjustment of the satellite base line Tromsø-Catania", *RETRIG Commission Publication* (GDK), No. 10 (1975).

[7] H. Schmid, *Worldwide Geometric Satellite Triangulation* (Rockville, Maryland, Geodetic Research and Development Laboratory, National Ocean Survey, 1973).

[8] Kube and Schädelbach, "Preliminary computation of the European base line Malvern-Graz . . .".

[9] R. Kube, *Report on the Computation of the North Sea Ring* (Munich, RETRIG Computing Centre, 1976).

[10] H. Wolf, "Remaining problems within the future phases of the European triangulation net adjustment", *RETRIG Commission Publication* (GDK), No. 11 (1975).

[11] V. Ashkenazi and P. A. Cross, "Strength of long lines in terrestrial geodetic control networks", *Bulletin géodésique*, No. 50 (1976).

system[12] or the longitude differences are introduced as observations into the adjustment. In a publication of the RETRIG Commission,[13] some essential problems of phase III adjustment are discussed from a more theoretical point of view.

*Future verification and support using satellite techniques*

It is possible to verify and support classical triangulation networks such as RETRIG using satellite methods which are not affected by several error sources inherent in classical terrestrial methods. In planning this type of verification, one must make a distinction between existing results and results that will be available in the near future or from planned experiments.

*Results from satellite techniques available in the near future*

The final adjustment of WEST will be completed in January 1977 by a special research group in the field of satellite geodesy at Munich (SFB 78).

The expected mean square error of the station co-ordinates is ±5 m on average.[14] Taking only accidental errors into consideration, this corresponds to values of ±7 (19, 140) ppm for scale and ±1.4 (3.5, 28) inches for orientation. Therefore, it appears possible to verify RETRIG by WEST; but as a rule, one would not expect it to be improved by WEST.

Several geocentric dynamic solutions are available where consistent coefficients of the potential and geocentric co-ordinates of several stations are determined simultaneously. These earth models are determined by the Goddard Space Flight Center, the Groupe de recherches de géodésie spatiale, the Smithsonian Astrophysical Observatory and SFB 78. Only a few stations in Europe belong to these solutions. For example, six stations belonging to the GRIM 2 solution[15] are located within the area covered by RETRIG. The mean square errors vary between ±5 and ±10 m, on average. Therefore, a combined solution should be calculated with WEST or WEST should be translated on to the geocentric system.

Using stellar triangulation with both satellites and balloon-borne light signals a verification and support of RETRIG is possible. In Finland, the orientation of chords with lengths of about 200 km has been determined with an accuracy of 0.5 inches.[16] Stellar triangulation is also applied in the Intercosmos Programme[17] and DGFI I, in co-operation with the University of Graz, is planning to undertake a balloon triangulation in 1977 in order to obtain the orientation of two chords between the Federal Republic of Germany and Austria. In addition, the orientation of chords forming the Hohenspeissenberg-Tromsø-Keflavik triangle was computed at the end of 1976, using stellar triangulation with satellites. The accuracy of the Hohenspeissenberg-Tromsø chord (2,458 km) may be estimated to 0.3 inches.[18]

The Second European Doppler Campaign (EDOC II) is planned for 1977.[19] The best results for the accuracy of station co-ordinates derived from satellite Doppler methods using precise ephemerides are quoted as having "a repeatability of 70 centimetres in each co-ordinate which is consistent with the agreement with terrestrial measurements of inter-station distances".[20] Considering only accidental errors, a probable accuracy of ±1 m would correspond to values of ±1.4 (3.5, 28) ppm for scale and ±0.3 (0.7, 6) inches for orientation.

Considering the satellite results that will be available in the near future in the area covered by RETRIG, the following solutions appear to be feasible:

(*a*) Verification and improvement of orientation by stellar triangulation results;

(*b*) Verification of orientation and scale using the transformed or combined WEST solution. Geocentric positioning of RETRIG by three translations;

(*c*) Verification and comparison of orientation and scale using the EDOC II Doppler solution and geocentric positioning. As there is a bias of several metres in the orientation of the polar axis with respect to reference systems for star catalogues, the orientation of RETRIG should also be verified according to solution (*b*).

*Planned satellite experiments and RETRIG*

A significant improvement in the accuracy of results achieved by satellite methods will be possible in the future.[21] An accuracy of a few centimetres is expected when neo-dymium-YAG lasers replace rubidium lasers. Tracking spherical satellites, such as STARLETTE and LAGEOS, make this order of accuracy possible. In order to make full use of such precision, directions to the satellite should be determined by cameras illuminating the satellite by a rubidium laser. With a few lasers and cameras at selected stations, their relative positions can

[12] R. Sigl, "Zum Aufbau eines einheitlichen Systems astronomisch beobachteter Längen", *Vermessung, Photogrammetrie, Kulturtechnik*, Fachblatt III, IV (1975).

[13] H. Wolf, "Remaining problems within the future phases of the European triangulation net adjustment".

[14] W. Ehrnsperger, "Geometric adjustment of Western European satellite triangulation (solution 1975)", report to the sixteenth General Assembly of the International Union of Geodesy and Geophysics, Grenoble, 1975.

[15] G. Balmino, C. Reigber and B. Moynot, *The GRIM 2 Earth Gravity Model*, GDK publication A, 86 (1976).

[16] J. Kakkuri, "The use of balloons for geodetic research", report to Committee on Space Research, Philadelphia, Pennsylvania, June 1976.

[17] A. M. Losinsky, A. G. Massevitch and S. P. Oraevskaya, "First experiments in balloon geodesy under the Intercosmos Programme", report to Committee on Space Research, Philadelphia, Pennsylvania, June 1976.

[18] K. Kaniuth and R. Zernecke, "Bestimmung der Azimute im Dreieck Tromsø-Keflavik-Hohenspeissenberg aus Richtungsmessungen nach Satelliten" (in preparation).

[19] V. Ashkenazi, H. Seeger and P. Wilson, "A joint proposal for a Second European Doppler Campaign", report to the Trentième journée luxembourgeoise de géodynamique, Walferdange, September 1976.

[20] R. J. Anderle, "Error model for geodetic positions derived from Doppler satellite observations", *Bulletin géodésique*, No. 50 (1975).

[21] M. Schneider, "Satellitengeodäsie", *Sterne und Weltraum*, vol 11 (1975).

be determined with a high degree of accuracy (e.g., the San Andreas Fault Experiment (SAFE). The accuracy of microwave systems is also expected to improve. The NAVSTAR navigation system, with 24 satellites, will later replace the Doppler method of the Navy Navigational Satellite System (NNSS). Results from new satellite-borne measuring techniques, such as altimetry, satellite-to-satellite tracking methods, drag-free-systems and gradiometry, will also affect the terrestrial networks. First, the reduction to the reference datum will be more correct because of greater familiarity with the geoid. Secondly, the station co-ordinates, determined simultaneously with the coefficients of the potential, will be more accurate.

As a result of the improvements in accuracy, more and more geodynamic questions will have to be taken into consideration, such as how this development will influence RETRIG. It should be noted that RETRIG in its present form cannot answer these questions, except perhaps in a few restricted areas, since RETRIG observation times are distributed over many years and it is hardly possible to define a mean era.

Future techniques can help to verify and improve RETRIG with respect to the reduction of observations, positioning and, in particular, scale. To use integrated terrestrial and satellite methods as suggested by Rinner[22] and to obtain complete and accurate information about the size and variation of geometric, dynamic and gravimetric parameters of the earth or any part of it, new terrestrial observations would have to be carried out.

[22] K. Rinner, "Integrierte Satellitenmessungen für Geodätische Kontrollmessungen", University of Graz, 1976.

### Conclusion and notes on the establishment of new networks

The Permanent Commission for the Readjustment of the European Triangulation Network completed the geometrical adjustment (phase I) in 1974. The phase II adjustment, including distances and Laplace azimuths, will be finished in March 1977. Several refinements from the theoretical point of view plus verification and support using satellite techniques will lead into phase III. Improvements using future results of satellite geodesy have been described.

The establishment of a geodetic network in any country is of fundamental importance for mapping, land development, the exploitation of natural resources, construction etc. The question is how terrestrial and satellite methods can be combined to establish a fundamental network wherever it is needed. There is no doubt that the framework should be established by the NNSS Doppler method. If precise ephemerides are available, an accuracy of range of 1–2 m for the station co-ordinates is possible; greater accuracy could be expected from the NAVSTAR system. Orientation with respect to the fundamental catalogue of stars should be verified and improved using stellar triangulation, especially in countries where weather conditions are good. As a first step, this framework could be filled using terrestrial electronic distance measurements if the elevation of the stations is known and/or by photogrammetry if the degree of accuracy is sufficient. From a scientific point of view and for increased accuracy, Laplace azimuths at several stations, angles or directions and plumb-line deflections should be determined. Zenith angles would make a three-dimensional computation possible.

## PROPOSED SATELLITE OBSERVATIONS WITHIN EUROPE*

*Paper presented by the Federal Republic of Germany*

Within the Federal Republic of Germany, station co-ordinates will be derived during 1977 by translocation and/or by the short-arc method. Transformation of the first-order triangulation network three-dimensional co-ordinates for all portions of this network will be available for special purposes. The method chosen may be of interest with respect to the discussion at this conference. The Second European Doppler Campaign (EDOC II) is supported by the Council of Europe.

Doppler instruments from many European countries will be used in this campaign, and together with some instruments on loan it will be possible simultaneously to observe during one month at more than 30 stations of the unified European triangulation network (RETRIG). Attention is drawn to this method as it is possible thereby to determine three-dimensional co-ordinates of stations with the best possible accuracy without using the precise ephemerides. It is intended to finalize the computations during 1978 and to combine the results with RETRIG.

* The original text of this paper, prepared by E. Reinhart, Director, Deutsches Geodätisches Forschunginstitut (German Geodetic Research Institute), Munich, at the request of the Chairman of Committee I, appeared as document E/CONF.68/L.120.

# CURRENT GEODETIC ACTIVITIES IN INDONESIA*

*Paper presented by Indonesia*

## CURRENT SITUATION OF THE INDONESIAN GEODETIC DATUM

Over the past 100 years, extensive geodetic surveys have been carried out in Indonesia. A network of primary triangulation covers Jawa, Sumatera, Nusa Tenggara and parts of Sulawesi and of Kalimantan. Since these networks are tied to independent datums, it follows that mapping control is divided into several datums. This division is due to the fact that triangulation systems in the past could not tie the widely separated islands into a single system; it is merely the optical observation techniques that limit this effort.

The Genuk datum for surveys and mapping of Jawa, having its datum point at station P.520, Gunung Genuk in Central Jawa, is still used even though this datum has never been defined clearly; the parameters for the computational surface are those of Bessel 1841. The geodetic network on this datum has been extended to Sumatera and to Nusa Tenggara. However, the over-all adjustment of this network has not yet been completed. A number of Laplace stations have been observed in the last few years in Nusa Tenggara and Sumatera to strengthen the network when over-all adjustment will take place in the future. In the meantime, the regionally piecemeal adjustment of this network has already served its purpose for topographic mapping at 1 : 50,000, covering Jawa, Bali and some part or urban areas in Sumatera in the years between the First and Second World Wars.

Different datums with undefined orientation with respect to the physical surface of the earth have been used for mapping purposes in the Riau-Bangka archipelago, Kalimantan Barat, Kalimantan Timur, Sulawesi etc., respectively.

Since the commencement of the first five-year development plan in 1969, a plan has been worked out to utilize satellite observation techniques, either optical or Doppler method of observations, to unify the separated system into a single network, which will be designated the Indonesian Unified Geodetic System (IUGS).

It was not until 1974 that the first Doppler observations took place in Sumatera, connecting six major Laplace stations stretching from Banda Aceh in the north to Gunung Dempo in the south and connecting at the same time the separated Riau-Bangka geodetic system with that of Sumatera. Concurrently, two positions in the Malaysian territory—Western Hill (Pulau Pinang) and Pulau Pisang—were included in the observations. Pulau Pisang is a common datum point mutually agreed upon by Malaysia and Indonesia, pursuant to articles of agreement between both countries relating to the delimitation of the continental-shelf boundaries and the delimitation of the territorial seas of the two countries in the Strait of Malacca (see figure 57).

The adjustment of the Aerodist survey in the Strait of Malacca, which connects the coast of Sumatera with that of Malaysia, will unify the Sumatera geodetic system with that of Malaysia for surveys and mapping in the Strait of Malacca. The above-mentioned activities have been conducted in a co-operative undertaking between Indonesia and Australia with the full support of Malaysia. The objectives of this operation are:

(*a*) To place all surveys and co-ordinates on a single, uniform datum;

(*b*) To establish control for an extensive mapping programme throughout the whole of Indonesia;

(*c*) To provide a system of control stations along the Strait of Malacca for the purpose of hydrographic operations at a later date.

The connexion of the individual datums and the readjustment of all data into a single datum provide a convenient opportunity to select and define a reference spheroid which would provide a good over-all fit throughout the islands and also to conform to some widely accepted international standard.

It was proposed that the definition of the datum be made by Doppler satellite position-fixing methods. Since the datum for Doppler satellite-positioning utilizing the Navy Navigation Satellite System (NNSS) is an earth-centred datum known as the NWL-9D datum, translation formula should be provided for transforming co-ordinates on this datum to any adopted relative geodetic datum on which the mapping is based. The decision to select a relative datum is made in view of the fact that the development method of reduction of control network observations is the common practice in Indonesia and, secondly, due to the unavailability of a good geoidal map.

For the reference spheroid, Indonesia has selected the parameters of the Geodetic Reference System of 1967 spheroid, known as GRS-67, adopted by the International Union of Geodesy and Geophysics at its General Assembly in Moscow in 1971, that is, the equatorial radius of 6,378,160 m with a flattening of 1/298, 247. Hence, for the new mapping in Indonesia the Bessel spheroid of 1841 will no longer be used.

For the datum point, the Doppler station selected is at a place eccentric to Padang base point A (1884 base). The orientation of the axes of the spheroid were defined as being parallel to those of the NWL-9D datum, and hence, parallel to the pole of Conventional International Origin (CIO pole).

Geodetic and Cartesian co-ordinates of the datum

* The original text of this paper, prepared by Professor Jacub Rais, Deputy Chairman, National Co-ordination Agency for Surveys and Mapping (Badan Koordinasi Survey Dan Pemetaan Nasional: BAKOSURTANAL), Indonesia, appeared as document E/CONF.68/L.79.

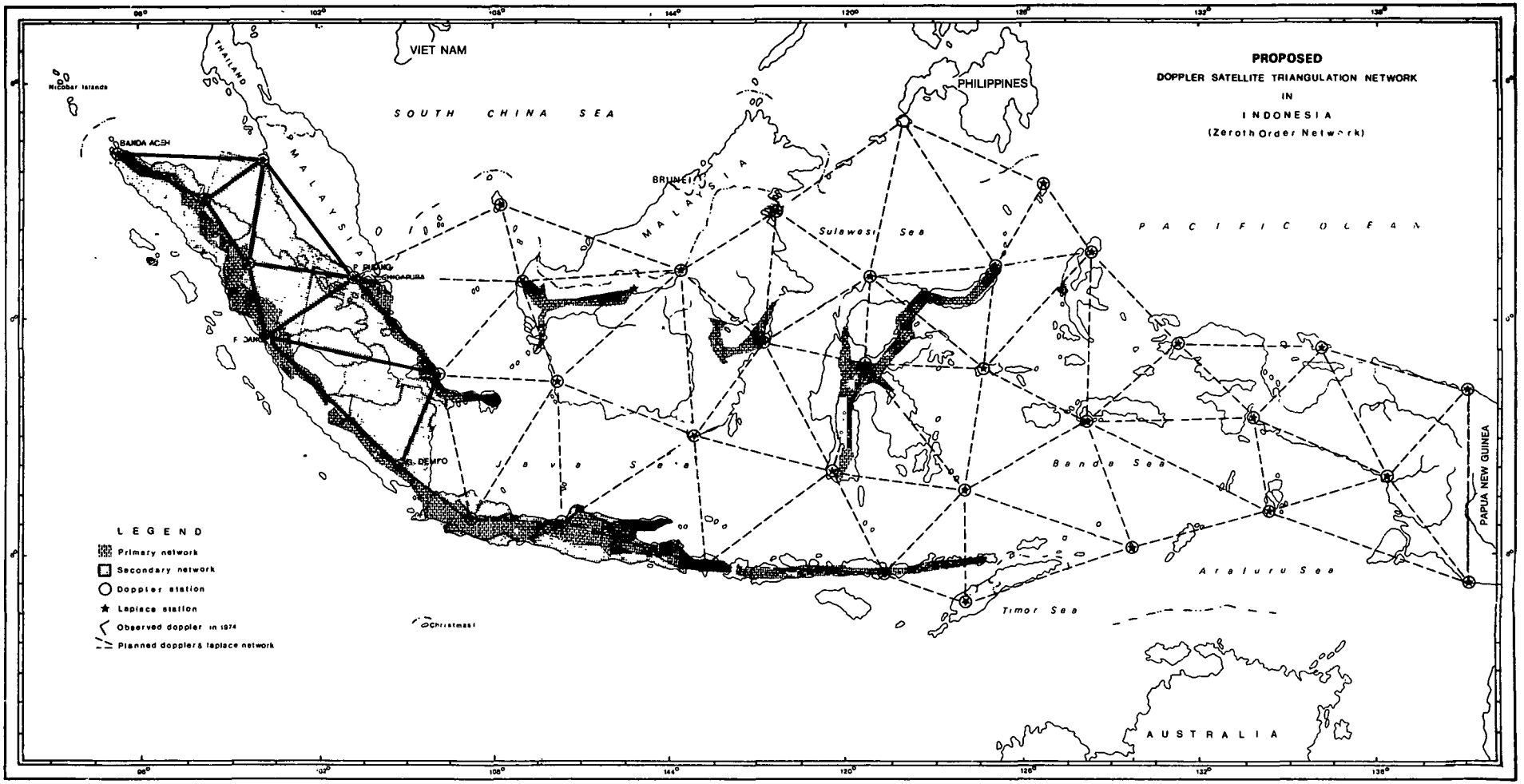



*Figure 57. Indonesia: proposed Doppler satellite triangulation network in Indonesia*

point obtained from Doppler observations on the NWL-9D datum were used to compute the Cartesian co-ordinates with respect to the spheroid having the GRS-67 parameters. The two sets of Cartesian co-ordinates were differenced to give the translation required between the two datums. The geodetic co-ordinates of the datum point of Padang datum are:

Latitude: 00° 56′ 38″.414 South;
Longitude: 100 22 08.804 East;
Height: 3.190 m above the spheroid.

The translation parameters are expressed as the co-ordinates of the origin of Padang datum of having $\Delta X = +2.691\ m$; $\Delta Y = -14.757\ m$; $\Delta Z = +0.224\ m$ in the NWL-9D datum. The two spheroids are thus tangential at the datum point.

It can be seen that this method of definition has considerable advantages. The availability of satellite position-fixing methods at this early stage of the definition of the origin provides a convenient basis for the inclusion of all Doppler satellite co-ordinates into the geodetic system. There is a clearly defined relationship between the Padang datum and a well-defined earth-fixed geocentric system, providing a simple three-parameter transformation between systems. A further advantage is realized by adjusting the existing triangulation to the Doppler stations, now transformed into the new Padang datum.

The disadvantages of such a method of definition arise from the fact that no account was made of the shape of the geoid in the area. Similarly, astronomical azimuths and co-ordinates tend to lose their significance, which, in turn, may effect the ability rigorously to reduce triangulation data to the spheroid for the purpose of future adjustment. The problem of the definition of the geoid with respect to Padang datum has not been fully explored.

In the absence of information on geoidal undulation, an adjustment of the triangulation was made with all observations reduced to the sea level (development method). Before the adjustment was made, the quality of the triangulation was examined by a comparison of the spheroidal distance and azimuth between the stations at Banda Aceh base and Gunung Dempo, for co-ordinates derived by the triangulation and by Doppler observations. The comparisons yielded 1 : 920,000 in distance and 0″.16 in azimuth, indicating that the triangulation was of high quality despite its age.

The adjustment was made using the method of variation of co-ordinates with computers (VARYCORD programme). The accuracies of the results of the adjustment of Sumatera network with respect to the Padang datum were most encouraging:

Maximum length residual, 0.77 m; average, 0.12 m;
Maximum direction residual, 2″.37; average, 0″.39.

The triangulation and traverse chain from the Bangka base to Pulau Pisang has also been adjusted on the Padang datum, holding fixed the terminal Doppler stations, with the following results:

Maximum length residual, 0.58 m; average, 0.23 m;
Maximum direction residual, 170; average, 0″.31.

The network from Jawa running eastwards has not yet been adjusted. The network of West Kalimantan has been adjusted with respect to a local datum at Pontianak (Base A) using the Bessel 1841 spheroid since it was completed before the new decision arrived. Thus far, no connexion exists between the West and East Kalimantan networks. The transformation to the Padang datum will be made if Doppler observations can take place at the datum points of the respective networks.

The mapping of Irian Jaya which is under way will also be referred to the Padang datum for the ease of computations, even though the Padang datum has not yet been decided as the national datum.

A national datum will be defined when the geoid of Indonesia has been studied and a gravity survey for geodetic objectives should be carried out for this purpose. Inclusion of this survey in the national mapping programme is as significant as that of geodetic survey and levelling work. It should be recognized that because of the usefulness of gravity data in geodetic computation, compatability of geodetic and gravimetric reference surfaces should be a major factor in the selection of any datum.

## Current situation of the Indonesian height datum

The island of Jawa is the only place where a high-precision levelling network exists, even though it has never been completed since the beginning was made in 1925. This network covering West and Central Jawa is tied to a sea level datum in Tanjung Periuk which was derived from tide-gauge observations during 1926. No connexion has been made to other tidal observations, so that this network is considered to be temporarily adjusted.

Besides the network mentioned above, there are numerous local level nets, most of them linked to sea level by means of tide-gauge observations. However, there is no uniformity. Some local systems are related to a mean yearly sea level, others to mean high or mean low tides; also, relations to the highest high tide or the lowest low tide do occur. Nearly all original tide-gauges have disappeared and so have the original readings. As a consequence, the relations between the various local systems are not very accurately known. Very often the only link consists of a relatively inexact trigonometrical measurement between triangulation stations.

Within the local systems the accuracy of the observations varies strongly. The other measurements have resulted so far in a number of local systems, badly connected and with insufficient information about the datum on which each separate system has been based. As a consequence, the local level data are practically of no use for the execution of main projects. To obtain homogeneous heights, extensive levelling surveys have to be carried out, at the expense of the project budget. Where a general, accurate height system is available, the extent of these levellings can be greatly reduced.

## A PROGRAMME FOR DEVELOPMENT OF A LEVELLING NETWORK

As several development projects have been prepared and realized in various fields, more extensively in the future, such as drainage and irrigation, urban and town planning, transmigration and rural development, sewerage, highways, harbour extension, dredging at sea for shipping channels etc., a homogeneous height system with a well-defined datum is indispensable so as to obtain knowledge of movements in the earth's crust and of tidal variation at sea, as well as compilation of current and tide-tables and calculation of discharges of rivers. These studies and computations can only be realized if the necessary observations are based on a homogeneous height system materialized in the form of a levelling network covering the entire country.

In order to give an idea of the possible conception of the levelling work for the islands of Jawa and Sumatera, schematic circuits are shown in figures 58 and 59.

The Jawa net is the same as the system originally conceived by the former Dutch Topographic Service, which has partially been measured, but complete relevelling is recommended because a great many of the bench-marks were lost or damaged. The total length of the Jawa net is approximately 4,500 km. Fundamental bench-marks could be placed at the junctions of the level lines and at selected places, such as the larger towns and villages along the routes, at distances of about 25 km. Between these fundamental bench-marks, intermediate bench-marks should be placed at average distances of 1.5 km. Along the coast at distances varying from 200 to 400 km automatic tide-gauges should be installed. Possible sites are roughly suggested on the map.

As for the island of Sumatera, the levelling network is approximately 6,500 km and the loops of the scheme are larger than those for Jawa, but where considered necessary additional connexions can be measured. Unlike the levelling operations in Jawa where first-order accuracy is specified for the main loops, the levelling accuracy for the main loops in Sumatera is considered sufficient if specified to second-order quality. The main aim is to provide in the shortest possible time homogeneous height controls for the whole island of Sumatera to meet the need of various engineering projects.

For the island of Kalimantan and Sulawesi, where no immediate plan for establishing a height control network has been envisioned, it is highly recommended to install automatic tide-gauges along the coast at intervals of 300–400 km and if possible those tide-gauges should be connected by secondary levelling. Laser or radar Airborne Profile Recorder (APR) is probably the solution to provide in a short time a network of height control running through the inland area of the island where levelling with an ordinary level instrument might be a tedious and time-consuming undertaking.

APR also has been used for the first time in Irian Jaya to provide height control in conjunction with the topographic mapping. The installation of a range of tide-gauges has been suggested and a grid of gravity measurements has been proposed for inclusion in the project in order to provide the information about the geoid needed for data reduction.

In order to draw up a well-based proposal for improvement of the current situation, an advanced study will be carried out in close co-operation with various government agencies, concerning the following items:

(*a*) An inventory of agencies and organizations currently active in the field of levelling or frequently making use of levelling results;

(*b*) An inventory of available local data and results of existing level nets as well as an investigation to check their accuracies;

(*c*) Preliminary fixation of the tide-gauge sites and of the nature, scope and accuracy of the measurements to be carried out, taking into consideration the existing schemes as completely as possible;

(*d*) Investigation of the advisability of simultaneous execution of gravity measurements;

(*e*) Advice about instruments to be used;

(*f*) Setting of classifications, standards of accuracy and general specification of height control surveys;

(*g*) Designation of the responsible government agency in charge of the execution and maintenance of the height control networks in Indonesia;

(*h*) Advice regarding the methods of publication of the results for use in the public interest;

(*i*) Approximate estimate of cost and time as well as suggestions for financing the project;

(*j*) Selection of a pilot project and preparation of the execution of the measurements therefor by preparing draft instructions for levelling and computations.

## PROPOSED NATIONAL GRAVITY BASE NETWORK

Gravimetric survey in Indonesia has been carried out extensively by oil firms and by the Directorate of Geology for exploration purposes and for compiling anomaly maps, respectively. A Bouguer anomaly map of Jawa, Madura and Bali was published recently by the Directorate of Geology. However, a national gravity base network with a nationally adopted standard of accuracy as a network of national reference stations has never been established. The individual gravity surveys are either tied to the only known reference station in Indonesia, that is, a station established in the compound of the Directorate of Geology in Bandung, or tied to reference stations outside Indonesia, such as Singapore, Kuching, Port Moresby and Darwin. The gravity reference station at Jakarta, which once was tied to other reference stations around the world by Woollard, could not be recovered for it was not permanently marked.

The relationship of such individual surveys are, however, not known, nor could any gravity station mark be traced on the ground, even though a station description exists in many cases. The recorded information is far from complete and to some extent does not satisfy the geodetic requirements. The format needs to be standardized.

Another problem in obtaining gravity data from oil

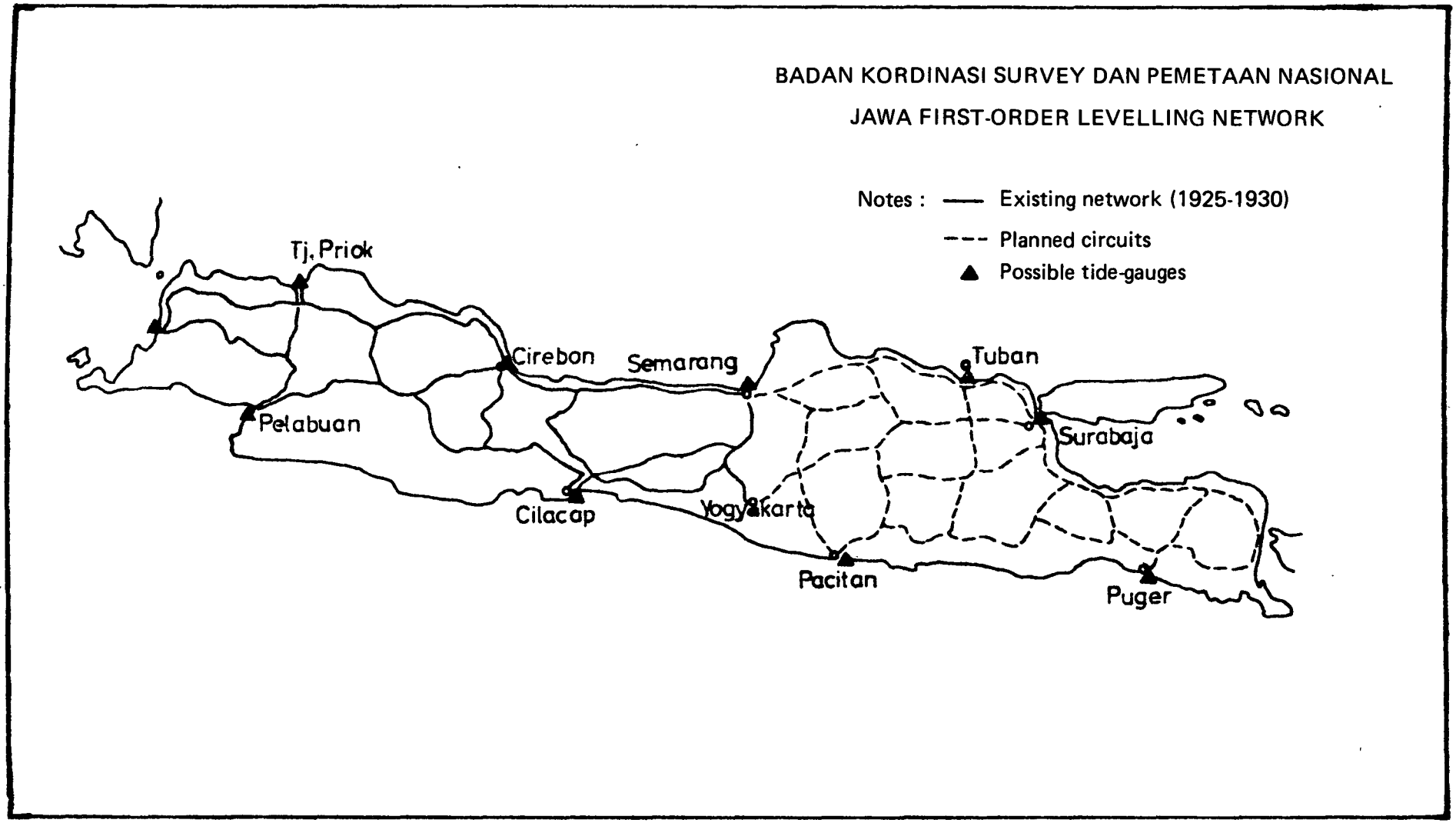



*Figure 58. Indonesia: Jawa first-order levelling network*

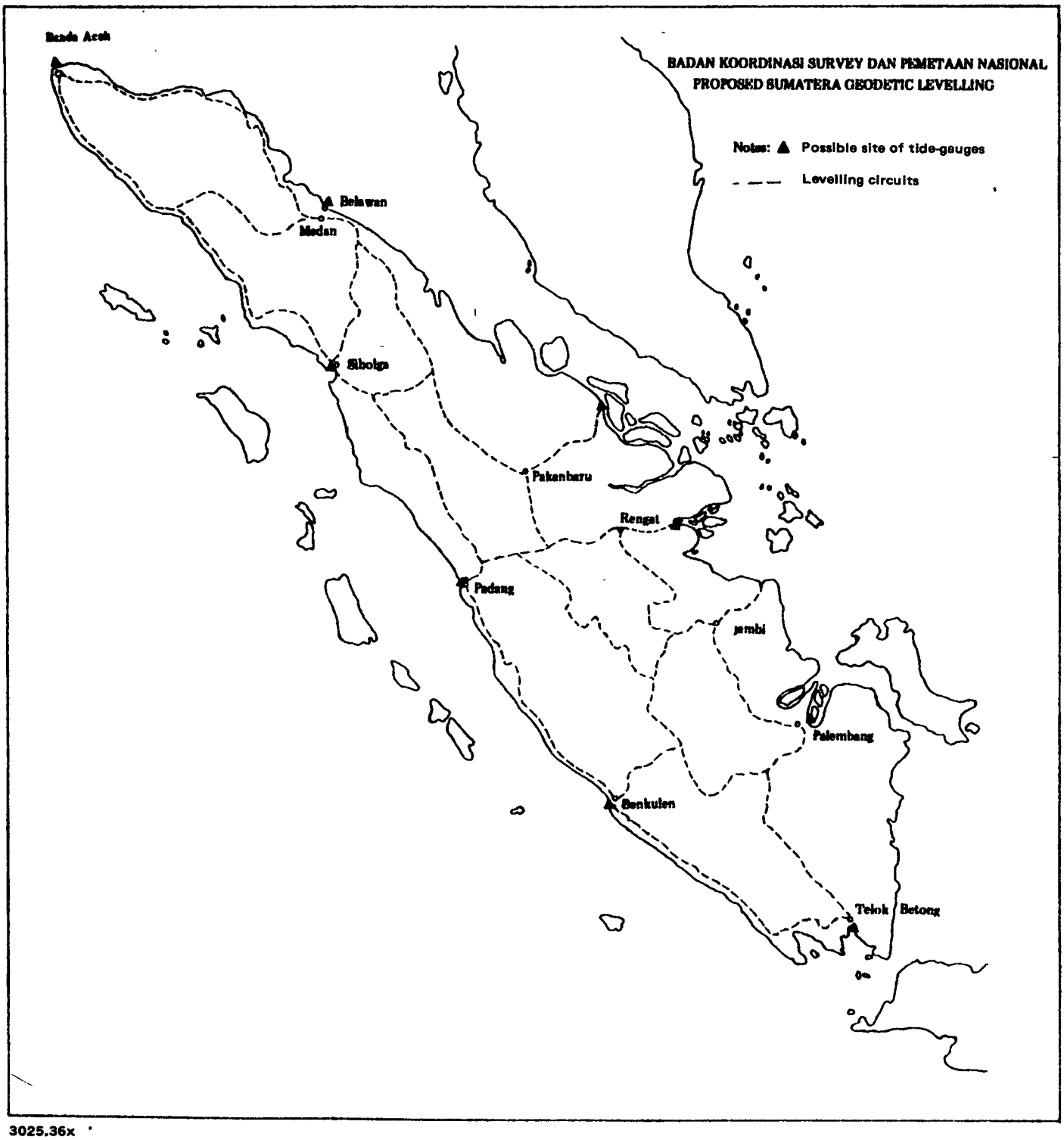



*Figure 59. Indonesia: proposed Sumatera geodetic levelling*

firms is the classified character of these data which are considered by the oil firms as having economic value and relating to the firm's security. It should be understood that gravity data also have scientific and strategic value of national and world-wide scope and it is therefore proper that a government agency should be assigned to manage a national gravity data bank. In this respect, the release and use of gravity data can be made available to any user according to the needs. This national agency should also be responsible for the design and establishment of gravity base stations throughout the country to provide tie stations for convenient use of the users. Considering that gravimetric activities are a part of geodetic concern, it is proper to propose that the national mapping agency—in this case Badan Koordinasi Survey Dan Pemetaan Nasional (BAKOSURTANAL)—be the responsible agency in co-operation with other agencies involved in geophysical activities.

For establishing a national gravity base network, the following efforts have been suggested:

(*a*) Establishment of fundamental absolute gravity stations (zeroth-order gravity network). In addition to Bandung station as the national gravity base station, at least five other stations should be set up occupying the same Doppler stations, namely: Medan; Pontianak; Manado; Biak; and Kupang. At least at two stations, Bandung and Ujung Pandang, earth-tide measurements should be made as a part of a world-wide earth-tide observation programme to provide corrections for absolute gravity measurements and for other corrections needed for precise geodetic and astronomical measurements;

(*b*) Establishment of a first-order gravity network which would have stations with a spacing of 300 km tied to the zeroth-order network. The selection of these stations should be in such a way that at least one station is represented in each of a grid of $5° \times 5°$. It is advisable that Doppler observations should be made at these stations for further analysis by comparing the satellite and terrestrial data;

(*c*) Establishment of a second-order gravity network which would have stations with a spacing of 30–80 km and/or at least in each $1° \times 1°$ grid one station would be observed;

(*d*) Establishment of a national calibration line which would provide a national scale. The greatest variation in gravity on the earth's surface is that related to latitude, so, in practice, a scale is established by determining the acceleration at numerous sites along a north-south line. The National Calibration line should be designed from latitude 10° to latitude 1° South, and in this case should run from Kupang to Biak through the island chain of Maluku.

The zeroth-, first- and second-order networks should be permanently marked on the ground with different types of pillars. All other surveys that originated from the second-order network are considered to be detail surveys. Station spacing in the detail surveys is dictated by local transportation means. In general, bases for detail surveys should ideally be no farther apart than one day's travel.

As far as accuracies are concerned, the following guidelines can be considered:

(*a*) Precision for the zeroth-order network should be better than 0.01 mgal using pendulum equipment or instruments based on free-fall principle;

(*b*) According to the Standards of Precision and Operating Methods for Modern Gravity Surveys applied in the United States of America and in South America, stations of the first-order network should be established to $\pm 0.05$ mgal, with respect to the fundamental stations;

(*c*) The maximum error for the stations of the second-order network is also $\pm 0.05$ mgal.

The expansion of a network from the fundamental station should be accomplished with high accuracy and economy. The modern geodetic gravimeter is ideal for this operation. The standards for such an instrument are: portability (light weight, small size); high range (7,000 mgal); repeatability to $\pm 0.01$ mgal; small, linear drift rate; thermostatted temperature control; low power requirement.

One should keep in mind that in the development of a national gravity network the value of gravity data is their relationship to horizontal and vertical geodetic positioning; therefore, national gravity networks must be developed in conjunction with a horizontal and vertical geodetic system which will eventually be unified.

And the geodetic system is in turn a conceptual framework for the definition of quantities, such as distance and elevation, which forms the base for accurate mapping and charting of the country to produce basic information regarding topography, natural and man-made features to which resources information is related.

## Closing remarks

This paper attempts to express the need for an integrated plan for the development of geodetic networks in Indonesia as these networks are fundamental to resources surveys and mapping.

A national study group should be formed to study meticulously all matters related to the approach as well as to the execution of the envisioned plan, so that economy of the works could be achieved. Once a national fundamental control network has been installed, it is intended to be adequate for generations to come. This is one of the basic endeavours in which the surveying and mapping profession has a most important part to play in exploring and shaping the human environment in order to make the best use of it.

# USE OF SATELLITE DOPPLER SURVEYING FOR MEDIUM-SCALE MAPPING IN INDONESIA*

*Paper presented by Indonesia*

In 1976, a satellite Doppler positioning system was used for establishing controls for a medium-scale (1 : 10,000) photo-mapping project in Indonesia. A tidal marsh area in South Kalimantan and South Sumatera was photo mapped for the purpose of selecting and preparing a preliminary design of a tidal-influenced rice-field project area. Aerial photography had been done on the scale 1 : 20,000 with premarked control points. The area was covered by tidal forest. Therefore, it would be expensive and time-consuming to establish horizontal control with ordinary traversing methods.

The mapping contractor was allowed to introduce the use of a Navy Navigation Satellite System (NNSS) geodetic receiver for establishing the required horizontal controls. Spot heights were measured independently by spirit-levelling.

## POINT POSITIONING

The geodetic receiver instrument used was a Hokushin Magnavox Hx 702A-3. The method of observations was independent point positioning. On average 20 satellite passes were used for co-ordinate computation (see tables 32 and 33) with about 15–30 observations per pass. Computations were based on broadcast ephimerides. The average distance between nearest points was 20 km; most points were located along the perimeter of the block (see figure 60).

For the Banyuasin-South Sumatera area, which is approximately 3,400 km², 13 Doppler stations were established, of which 10 were on the perimeter of the block and one was on a third-order national triangulation station. River boats of 10 dwt were used for transportation, as these boats were the most inexpensive and efficient means for this operation where logistic supply was the most serious problem in swampy area field surveys. The boat was used both as a logistic carrier and as living accommodation for the crew. For the 13 selected stations, 27 continuous field-operation days were needed, including moving from station to station. The average Doppler observation time per station was 34 hours, 37 minutes; and an average of 19.3 satellite passes were observed per station.

The following accuracies were achieved:

(*a*) A root mean square of radial error of 2.85 m, or 0.285 mm on a map at 1 : 10,000 scale;

(*b*) A relative accuracy between two nearest points (BC.7–BC.8–15.3 km) of $M_{\overline{xy}} = 2.65$m or 1 : 5,800;

(*c*) A relative accuracy between two farthest points (B.7–BC.2–81 km) of $M_{\overline{xy}} = 4.68$m or 1:17,307.

This relative accuracy was better than that required for relative distance accuracy on traverses for such projects, which is 1 : 5,000.

Compared with a similar project in West Kalimantan which required three survey teams for four months of traversing and two weeks of computation and adjustment, this Doppler surveying method proves its superiority in cost, time and manpower.

* The original text of this paper, prepared by Leo Nardy, member of the Indonesian Surveyors Association, Jakarta, appeared as document E/CONF.68/L.80.

**Table 32. Indonesia: results of point-positioning Doppler station in the Banyuasin-South Sumatera area**
*(Metres)*

| *Point No* | *Number of satellite 3D passes* | *Latitude (North)* | $M_Y$ | *Longitude (East)* | $M_X$ | *Spheroid height (H)* | $M_H$ |
|---|---|---|---|---|---|---|---|
| T.3448 | 22 | 9 740 182.64 | 0.92 | 435 863.55 | 1.13 | 2.87 | 0.81 |
| BC.1 | 14 | 9 742 844.97 | 3.04 | 449 900.06 | 4.50 | 1.51 | 2.61 |
| BC.2 | 19 | 9 751 792.18 | 2.80 | 481 099.35 | 3.75 | 10.48 | 2.28 |
| BC.3 | 21 | 9 735 766.73 | 2.25 | 470 009.09 | 2.76 | 2.12 | 2.12 |
| BC.4 | 22 | 9 713 921.93 | 1.55 | 470 326.20 | 2.10 | 6.48 | 1.23 |
| BC.5 | 21 | 9 698 037.28 | 1.36 | 447 587.40 | 1.74 | 3.453 | 1.20 |
| BC.6 | 21 | 9 710 350.37 | 1.43 | 428 316.29 | 1.66 | 3.24 | 1.24 |
| BC.7 | 24 | 9 711 623.36 | 0.95 | 410 779.58 | 1.39 | 0.18 | 0.88 |
| BC.8 | 21 | 9 726 434.74 | 1.15 | 406 904.52 | 1.70 | 3.97 | 0.94 |
| BC.9 | 21 | 9 744 193.57 | 1.18 | 425 316.15 | 1.22 | 0.64 | 1.06 |
| BC.10 | 19 | 9 738 146.66 | 0.93 | 448 280.28 | 1.42 | 1.81 | 0.77 |
| BC.11 | 13 | 9 758 876.43 | 1.14 | 444 628.94 | 1.92 | 13.99 | 1.17 |
| BC.12 | 19 | 9 774 218.77 | 1.43 | 464 334.71 | 1.62 | 15.33 | 1.09 |
| | | Root mean square (RMS) | 1.69 | | 2.30 | | |
| | | $RMS_{xy} = 2.85$ metres | | | | | |

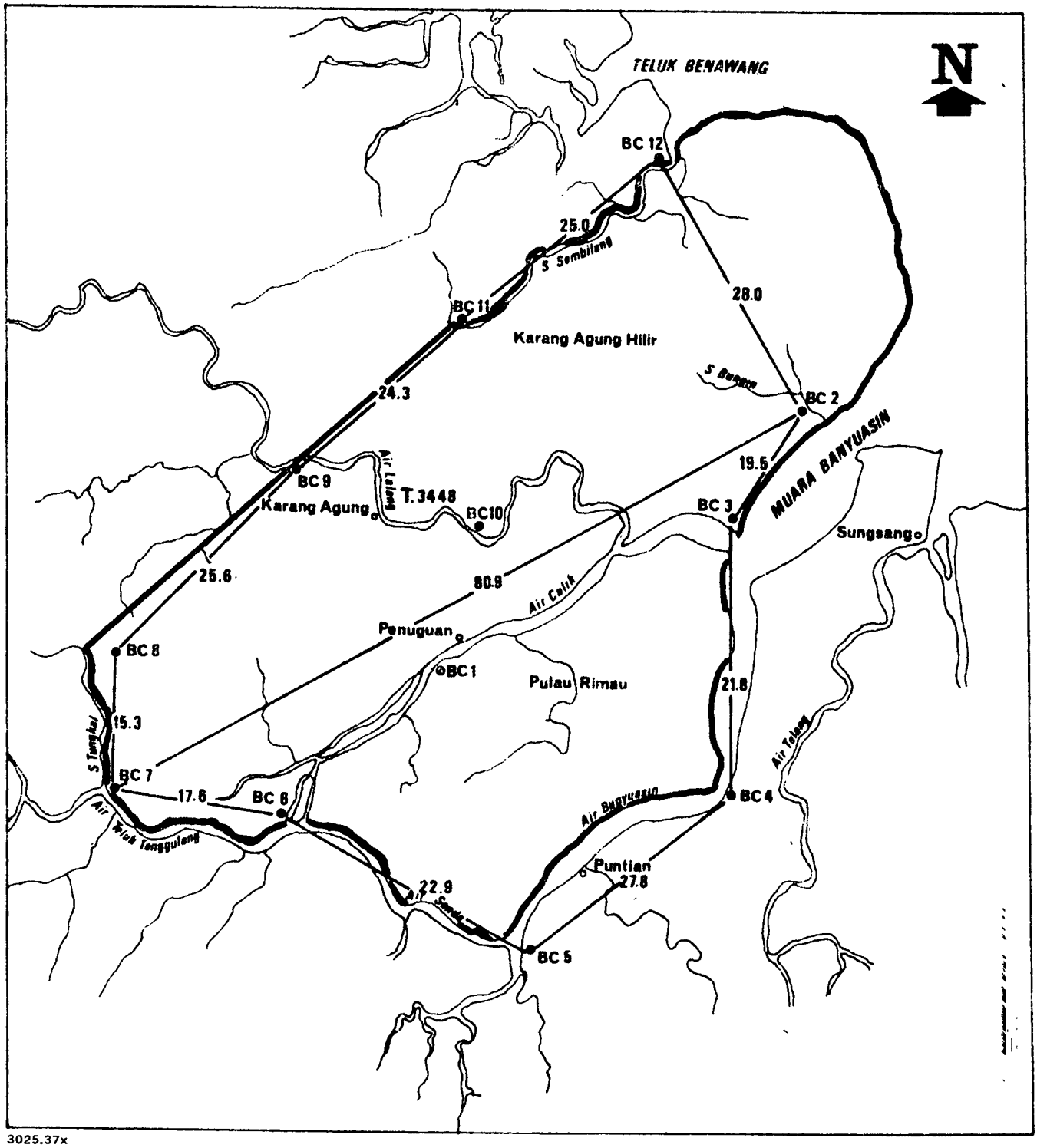



*Figure 60. Indonesia: map of Banyuasin-Calik*

Table 33. Indonesia: time required for Banyuasin-South Sumatera Doppler observations

| Station | Number of satellite 3D passes | Starting-time (hour and minute) | Ending-time (hour and minute) | Total hours of observations (hours and minutes) |
|---|---|---|---|---|
| BC.4 | 22 | 106 (1532) | 108 (0400) | 36.28 |
| BC.5 | 21 | 109 (0414) | 110 (1324) | 33.10 |
| BC.6 | 21 | 111 (0639) | 112 (2310) | 40.31 |
| BC.7 | 24 | 113 (0859) | 114 (2316) | 38.17 |
| BC.8 | 21 | 115 (0711) | 116 (2356) | 40.45 |
| BC.1 | 14 | 117 (1133) | 118 (2324) | 35.51 |
| BC.10 | 19 | 119 (1213) | 120 (2238) | 34.25 |
| T.3448 | 22 | 121 (0751) | 122 (2334) | 39.43 |
| BC.9 | 21 | 123 (0756) | 124 (2328) | 39.32 |
| BC.3 | 21 | 125 (1104) | 126 (2334) | 36.30 |
| BC.2 | 19 | 127 (0819) | 128 (2152) | 37.33 |
| BC.12 | 13 | 129 (1217) | 130 (2344) | 35.27 |
| BC.11 | 13 | 131 (0828) | 132 (1028) | 26.00 |
| | Average 19.3 passes per station | Total | 27 days | Average 34.37 per station |

# JOINT REPORT ON INDONESIAN AND MALAYSIAN ACTIVITIES IN CONNEXION WITH THE SURVEY AND DEMARCATION OF THE BORDER BETWEEN INDONESIA (KALIMANTAN) AND MALAYSIA (SABAH AND SARAWAK)*

*Paper presented by Indonesia and Malaysia*

## Background documents

The documents listed below formed the basis of preliminary discussions between the Government of Malaysia and the Government of Indonesia held at Kuala Lumpur on 6 and 7 December 1972 for the purpose of undertaking a joint demarcation and survey of the international boundary between Indonesia (Kalimantan Timur and Kalimantan Barat) and Malaysia (Sabah and Sarawak):

(*a*) The Boundary Convention signed in London dated 20 June 1891;

(*b*) The Boundary Agreement signed in London dated 28 September 1915;

(*c*) The Boundary Convention signed at The Hague dated 26 March 1928.

## The Memorandum of Understanding of Jakarta, 1973

As a follow-up to the previous discussions, at the second meeting held at Jakarta in November 1973, a Memorandum of Understanding was signed regarding the joint operation of survey and demarcation of the said international boundary. The Memorandum of Understanding outlines the entire set-up of the project involved; the organisation of the Joint Technical Committee, establishment of priority areas, survey procedures, phasing of operations, financial implication, security forces support, logistics and communication, immigration and customs clearance.

## Organizational set-up

At the national level, a National Indonesia-Malaysia Boundary Committee is appointed by each country and a Joint National Boundary Committee meeting is scheduled to be held at least once a year. At this meeting, policies regarding the implementation of the project are

* The original text of this paper appeared as document E/CONF.68/L.61.

discussed and decisions made. Each National Boundary Committee has appointed a technical committee charged with the task of working out jointly the demarcation and survey of the aforesaid international boundary. It was agreed that the Technical Committees of both countries would then operate as the Joint Technical Committee. The Technical Committee is headed *ex officio* by the Director of National Mapping in the case of Malaysia and by the Chairman of the National Co-ordination Board for Surveys and Mapping in the case of Indonesia.

It is also the responsibility of the Joint Technical Committee to evaluate the progress made in the field and find ways and means to speed up the undertaking within the limited resources prevailing in each country and within the shortest possible time.

The survey and demarcation of the boundary are carried out jointly in the field by Malaysian and Indonesian personnel and are supported by the respective security forces. The teams are headed by two Co-Project Directors and two Chiefs of Field Parties from each country, namely, one Co-Project Director for the international boundary between Sabah (Malaysia)-Kalimantan Timur (Indonesia) and one for the international boundary between Sarawak (Malaysia)-Kalimantan Barat (Indonesia).

The duties and responsibilities of the Co-Project Directors are as follows: planning and phasing the operation of the project; formulating rules pertaining to field techniques and procedures; standardizing field-books and booking procedures; selecting the types of field plans used, organizing the security arrangement; holding monthly Co-project Directors' meetings to discuss field problems that arise during the course of the survey and to implement the decisions reached. If there is disagreement, the matter will be taken up at the Joint Technical Committee meeting.

The task of the Chief of Field Parties is to see that the survey operations are carried out smoothly and to implement all decisions made by the Co-Project Directors.

The survey team may consist of about 20 personnel comprising 1 team leader, 1 assistant team leader, 2 observers, 2 bookers and plotters, and 14 labourers.

## Demarcation procedures

As the boundary line runs through a watershed, the reconnaissance party will clear the line on the watershed. Where the ridge is well defined and agreed upon, markers will be planted directly on the agreed spot. At locations where the watershed is not well defined, pegs rather than boundary markers will be planted near the probable locations. The reconnaissance party should number the stations consecutively and should decide where astronomical observations or connexions to existing trigonometrical stations would be made.

A precise traverse is to be carried out along the watershed. Running offsets are taken to clearly defined turnings of the watershed.

In locations where traverses run through an ill-defined watershed, cross-sections are taken at suitable intervals by levelling and then plotted. Land use and vegetation on both sides should be noted in the field-book diagrams.

The exact locations of the salient points of the watershed which have been offsetted should be plotted. The watershed is then interpolated precisely in accordance with accepted procedures. The location of boundary markers should then be selected on the basis of the configuration of the watershed on a fair and equal basis. Suitable boundary markers should then be constructed on the selected locations.

The definition of the watershed is to be related to the definition of riverbasins.

## Survey procedures

For the geodetic connexion, Indonesia has agreed to adopt the Malaysian system of horizontal control, which would ultimately be converted in terms of the common datum, established previously for the survey and mapping of the Strait of Malacca. All main traverses start from and close on to points on the geodetic network. Whenever necessary, the network would be extended to the border for this purpose. In view of the length of the border, which is approximately 1,800 km, it would be desirable to establish Laplace stations at approximately 300-km intervals, at least one at each extremity of the border and one in the middle. Laplace stations are observed with first-order accuracy. Major control points along the border constructed at intervals of approximately 50 km are observed with first-order accuracy, while main control traverses are observed with second-order accuracy.

Distances between stations of the main control traverses which are to be used to control the boundary traverses should be 1–5 km. It was agreed that 10 sets of directions and six sets of reciprocal vertical angles should be observed with the Wild T2 theodolite.

For linear measurement, Tellurometers or equivalent instruments may be used for lines of more than 1 km. For long lines the linear misclosure may not exceed 1 : 15,000 and that for short lines (shorter than 100 m) may not exceed 1 : 8,000.

Azimuth control with a probable error of $\pm$ 10″ may be obtained by sun or star or by connexion to trigonometrical stations at intervals not exceeding 25 stations.

In order to achieve easy comparison of contours and watershed, a common height datum is to be adopted at the starting-point of each area. The common datum is determined by spirit-levelling from the nearest available proved bench-mark or trigonometrical point or by vertical angular observations at the discretion of the team leader.

## Boundary pillars and boundary markers

To differentiate between the existing and new markers, the following terms are used: (*a*) boundary pillars for existing markers; and (*b*) boundary markers for new markers.

For the demarcation of the international boundary, four types of boundary markers are used, which will be specified as type A, type B, type C and type D markers, respectively.

Type A boundary markers will be used for Laplace stations and major control points; this marker has a dimension of 0.50 × 0.50 m at the top and is 1.50 m above the surface, with a weight of about 3,200 kg. Its 1 × 1-m base is emplaced 0.80 m into the ground. Type B boundary marker with a weight of about 640 kg is of a smaller dimension—0.23 × 0.23 m at the top—and is 0.46 m above the surface. Type B markers are to be planted 50 km apart. Type C boundary markers, which weigh about 153 kg, are of much smaller dimension than type B. These type C markers are to be planted approximately 5 km from each other and from type A/B markers, and need not be intervisible. Type D boundary markers are to be planted at closer intervals between type A/B/C boundary markers and these markers must be intervisible. Type D markers are the same as type C markers but without a concrete base; that is, they consist of a prefabricated rectangular concrete pillar 4 × 36 inches with steel bar reinforcing down its length and a splayed brass marker placed centrally at the top.

### Date of commencement of survey and demarcation

As agreed upon by both Governments at the Second Joint National Boundary Committee Meeting in Bali, 3–7 July 1975, all the survey teams were to be assembled at the base camps by 9 September 1975 in order to proceed to their respective localities for the commencement of the demarcation and survey.

### Selected areas

Starting-points for the survey are related to the areas of priority and agreed upon by both Governments, namely:

1. *Sarawak-Kalimantan Barat*:
   Priority Area I: from A, Tanjung Datu, to C, Gunung Pueh (approximately 53 km);
   Priority Area II: from G, Gunung Meranja, to H, Gunung Merachi (approximately 119 km);
2. *Sabah-Kalimantan Timur*:
   Priority Area I: from A, Sungei Sino Solan, to B, Gunung Meliat (approximately 96 km);
   Priority Area II: from B, Gunung Meliat, to C, Gunung Kumaka (approximately 120 km).

### Progress of survey

The data given in table 34 show the progress made since the beginning of the survey on 9 September 1974 (see also figure 61).

**Table 34. Progress of survey and demarcation of the border between Indonesia (Kalimantan) and Malaysia (Sabah and Sarawak)**

| | *Area A-C* | *Area G-H* | *Total* |
|---|---|---|---|
| *Sarawak-Kalimantan Barat* | | | |
| *9 September 1975–31 July 1976* | | | |
| Demarcation survey (kilometres) | 29.3 | 53.5 | 82.8 |
| Number of markers planted | | | |
| Type A | 1 | 1 | 2 |
| Type B | 2 | 4 | 6 |
| Type C | 73 | 125 | 198 |
| Type D | 87 | 189 | 276 |
| Total number of markers | 163 | 319 | 482 |
| | *Area A-B* | *Area B-C* | *Total* |
| *Sabah-Kalimantan Timur* | | | |
| *9 September 1975–15 August 1976* | | | |
| Demarcation survey (kilometres) | 76.3 | — | 76.3 |
| Number of markers planted | | | |
| Type A | 2 | — | 2 |
| Type B | 6 | — | 6 |
| Type C | 148 | — | 148 |
| Type D | 790 | — | 790 |
| Total number of markers | 946 | — | 946 |

### Review of survey procedures

Summing up the achievement made during the past year, one can estimate that with the current survey procedures it will take at least 15 years to complete the demarcation of the international boundary. An idea of utilizing Doppler satellite observation techniques has been brought up at the Joint Technical Committee meeting so as to expedite the survey with a plausible completion within from five to seven years. It is proposed therefore that the main framework of controls, which will concurrently be major boundary markers, be completed

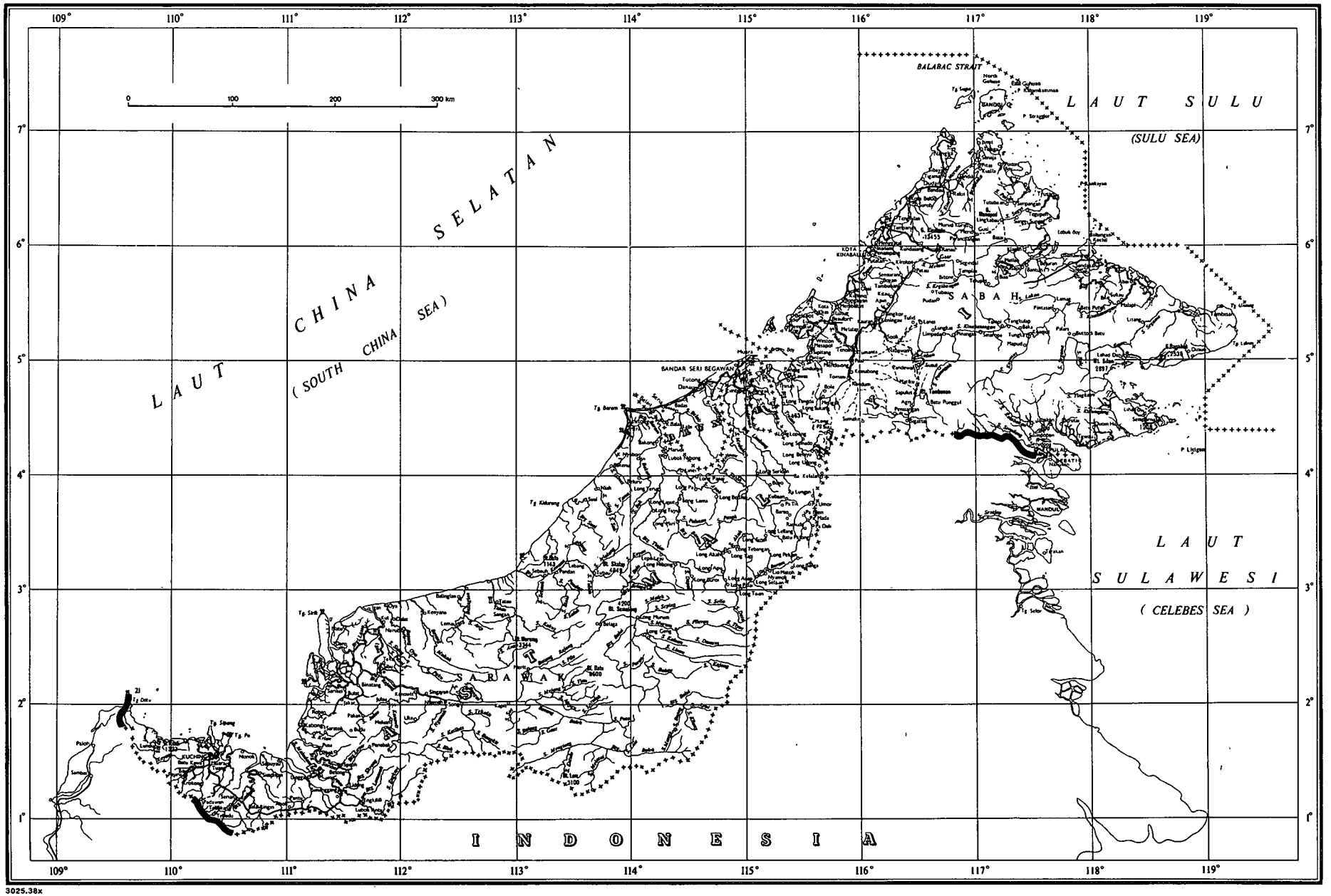



*Figure 61. Indonesia and Malaysia: progress of the survey and demarcation of the Malaysian-Indonesian border*

as early as possible to constitute a framework on which future surveys of demarcation could be based. Assuming that these major boundary markers are emplaced at intervals of some 50 km, there will be about 36 Doppler positions to be established.

A review of demarcation survey is also being made by both parties.

The continuous availability of helicopter support will be of much help in the implementation of the contemplated operation.

### Closing remarks

The meeting of the Joint National Boundary Committee and the Joint Technical Committee as well as the survey operations in the field have proceeded with the complete co-operation of both sides. The determination and professional skill shown by the survey parties of both countries in carrying out the required surveys under extremely difficult conditions of terrain, climate and accessibility are commendable.

## RESEARCH ON ACTIVE FAULTS UNDER THE ALLUVIUM LAYER BY GEODETIC METHODS*

*Paper presented by Japan*

The Geographical Survey Institute (GSI) has been carrying out research in Japan on the method for detecting active faults in the plains and their activity since the fiscal year 1975. The research was sponsored by the Science and Technology Agency and will continue for four years.

### Purpose of the research

A recent earthquake theory indicates that a movement of a fault results in an earthquake. For research on earthquake prediction, it is very meaningful to know about the presence of a fault which moved during and after the Quaternary period. This type of fault is called an active fault. Faults that moved during a geologically recent period are thought to have a greater possibility of moving and shaking (see figure 62) and one can estimate a mean interval of earthquakes due to the fault by knowing their displacement. Thus, research on an active fault is thought to be basic for earthquake prediction and is now strongly promoted.

An active fault in a mountainous area can be easily detected or interpreted from aerial photographs by paying attention to geographical features, especially the discrepancy of ridges or rivers. In the plains, on the contrary, such geographical features are vague so it is almost impossible to determine active faults in those areas by this ordinary method.

From the point of view of protection from earthquake hazards in a city, it is very important to research active faults in the plains where the large cities in Japan are located. For the method to be researched, one can think of the elastic wave by non-explosive means, by relative electric conductivity of the ground and by gravity. The gravity survey method was employed as a field test in the Kanto Plains. The test was to observe whether it is effective to detect active faults in the plains where one knows the location of active faults obtained from other information (see figure 63).

After finding active faults in the plains by this method or by other methods, it is necessary to watch the activity of the faults for earthquake prediction. Therefore, base lines are established crossing the faults and their lengths are measured by a precision distance meter. These lines will be remeasured to detect the activity of the active faults for efficiently observing the precursors of earthquakes.

### Method of research

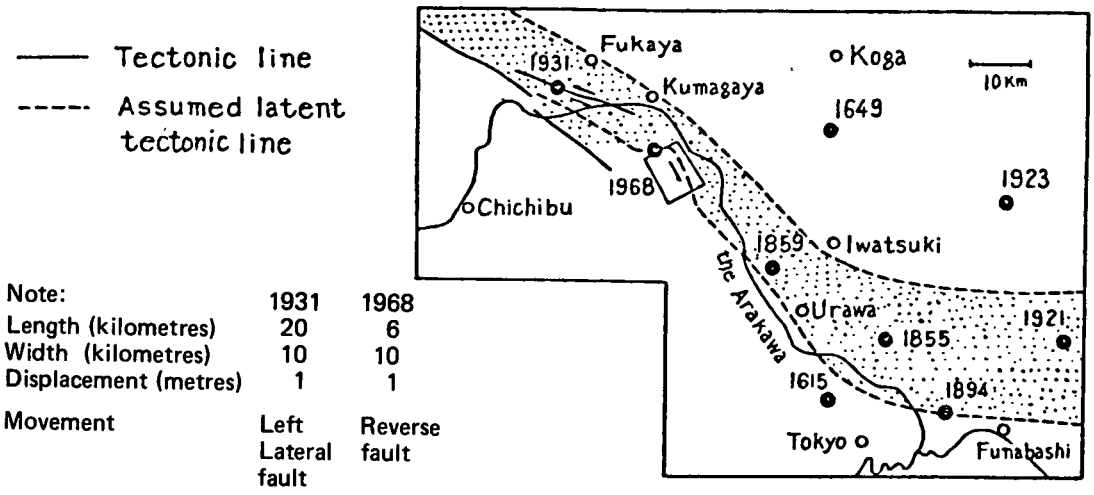
#### *Detection of active faults by gravity survey*

First, one point in 1 km$^2$, the height of which is known or will be known by new levelling, was selected as a gravity station over the area where it was necessary to test in order to detect active faults. The number of gravity stations totalled 570 in 1975, and a part of the Kanto Plains is shown in figure 64. A gravity survey was carried out with a LaCoste and Romberg geodetic gravimeter at the stations. After calculation, a Bouguer anomaly map was drawn. Moreover, another anomaly map called a residual gravity map and using the Seya corrections (normal filter), was drawn to observe the anomaly under the ground and to guess active faults easily.

#### *Measuring the activity of active faults*

In order to measure the activity of active faults, base lines crossing the Tachikawa fault were set and measured, and changes in their length will be detected by re-observation. An ideal figure is a rhombus; however, due to many houses and buildings in the Kanto Plains which obstruct the line of sight, it was possible only to make base lines with a figure as shown in figure 65.

* The original text of this paper, prepared by the Crustal Dynamics Department, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.68/L.73.

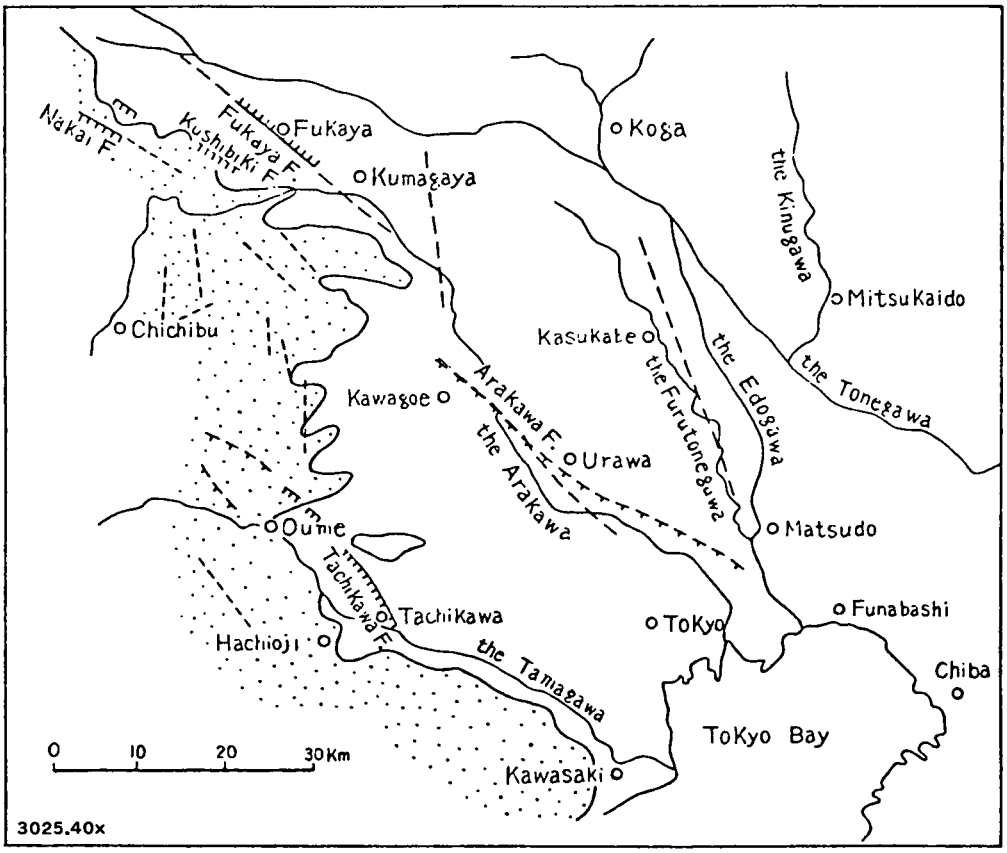



| Note: | 1931 | 1968 |
|---|---|---|
| Length (kilometres) | 20 | 6 |
| Width (kilometres) | 10 | 10 |
| Displacement (metres) | 1 | 1 |
| Movement | Left Lateral fault | Reverse fault |

*Source: Derived from work of Abe.*

3025.39x

*Figure 62. Japan: fault models for Nishi-Saitama (1931) and Saitama-Chubu (1968)*




Mountain
Active fault
Assumed active fault
Lineament
Boundary of declining block

*Source: Derived from work of Kakimi.*

*Figure 63. Japan: faults in the Kanto Plains*

## RESULTS OF RESEARCH

### *Results of the research by gravity survey*

A part of the Arakawa fault which is known from other methods can be read from the Seya map. This fact shows that this method is effective to detect or guess the existence of active faults in the plains.

### *Results of measuring the activity of active faults*

Only the first observations were done at the base lines in 1975, and no information about their activity will be available until the second observations are done. Therefore, the results of the first observation and the observation net is presented in figure 65 and table 35.

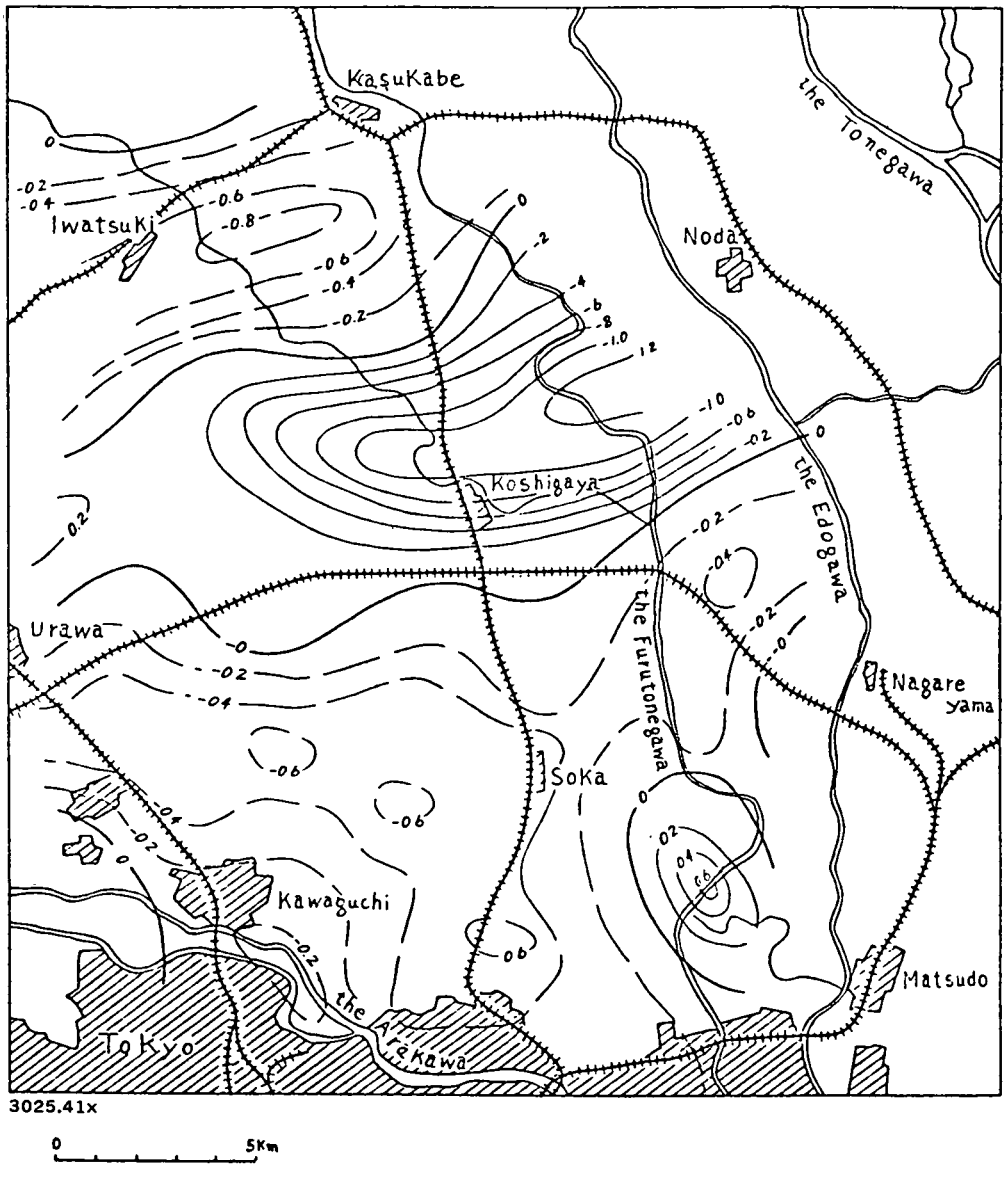



*Figure 64. Japan: Seya anomaly map*

**Table 35. Japan: length of base lines crossing Tachikawa fault**

| Date | Time (hour and minute) | Temperature (degrees Centigrade) | Pressure (millimetres of mercury) | Distance (1) (metres) | Standard deviation (millimetres) | Distance (2) (metres) | Remarks |
|---|---|---|---|---|---|---|---|
| | | | *2(EDM)–3* | | | | |
| 22 March | 1502–1652 | 9.3 | 749.8 | 441.0531 | ±0.4 | 0.0530 | $H$ = 125m |
| 24 March | 1517–1528 | 9.0 | 754.3 | 0.0566 | 0.5 | 0.0566 | $\Delta H$ = −2 |
| 24 March | 1539–1548 | 8.9 | 754.4 | 0.0555 | 0.1 | 0.0555 | $\Delta S$ = 4.0mm |
| 25 March | 1029–1102 | 8.4 | 760.7 | 0.0549 | 0.4 | 0.0549 | |
| | | | Mean | 441.0550 | ±1.5 | 0.0549 ±1.5 | |
| 24 March | 1606–1607 | | MA-100 | 441.0590 | ±0.7 | | |
| | | | *2(EDM)–4* | | | | |
| 22 March | 1432–1526 | 9.8 | 748.3 | 1 985.6594 | ±1.1 | 0.6602 | $H$ = 126m |
| 25 March | 1320–1346 | 10.8 | 758.1 | .6614 | 1.4 | 0.6612 | $\Delta H$ = 36 |
| | | | Mean | 1 985.6604 | | 0.6607 | |
| | | | *2(EDM)–1* | | | | |
| 22 March | 1608–1638 | 8.7 | 749.7 | 1 334.6087 | +0.3 | 0.6087 | $H$ = 126m |
| 25 March | 1432–1446 | 10.1 | 759.5 | 0.6109 | 0.3 | 0.6116 | $\Delta H$ = 7 |
| | | | Mean | 1 334.6098 | | 0.6102 | |
| | | | *4(EDM)–1* | | | | |
| 23 March | 1422–1521 | 13.0 | 745.5 | 1 896.0431 | ±1.3 | 0.0442 | $H$ = 163m |
| 26 March | 1045–1054 | 6.4 | 759.5 | 0.0429 | 0.8 | 0.0432 | $\Delta H$ = −29 |
| | | | Mean | 1 896.0430 | | 0.0437 | |
| | | | *4(EDM)–5* | | | | |
| 23 March | 1648–1738 | 10.3 | 745.5 | 1 973.2542 | ±1.6 | 0.2539 | $H$ = 163m |
| 26 March | 1144–1250 | 7.4 | 757.1 | 0.2546 | 1.1 | 0.2550 | $\Delta H$ = −16 |
| | | | Mean | 1 973.2544 | | 0.2544 | $\Delta S$ = −6.5mm |
| 26 March | 1337–1402 | | MA-100 | 1 973.2479 | ±1.3 | | |

*Notes*:
$H$: height; $\Delta H$. difference in height; $\Delta S$: MA-100–ME-3000;
Distance (1): meteorologically reduced by real data at both stations;
Distance (2): meteorologically reduced by real data at one station and estimated data at another station.

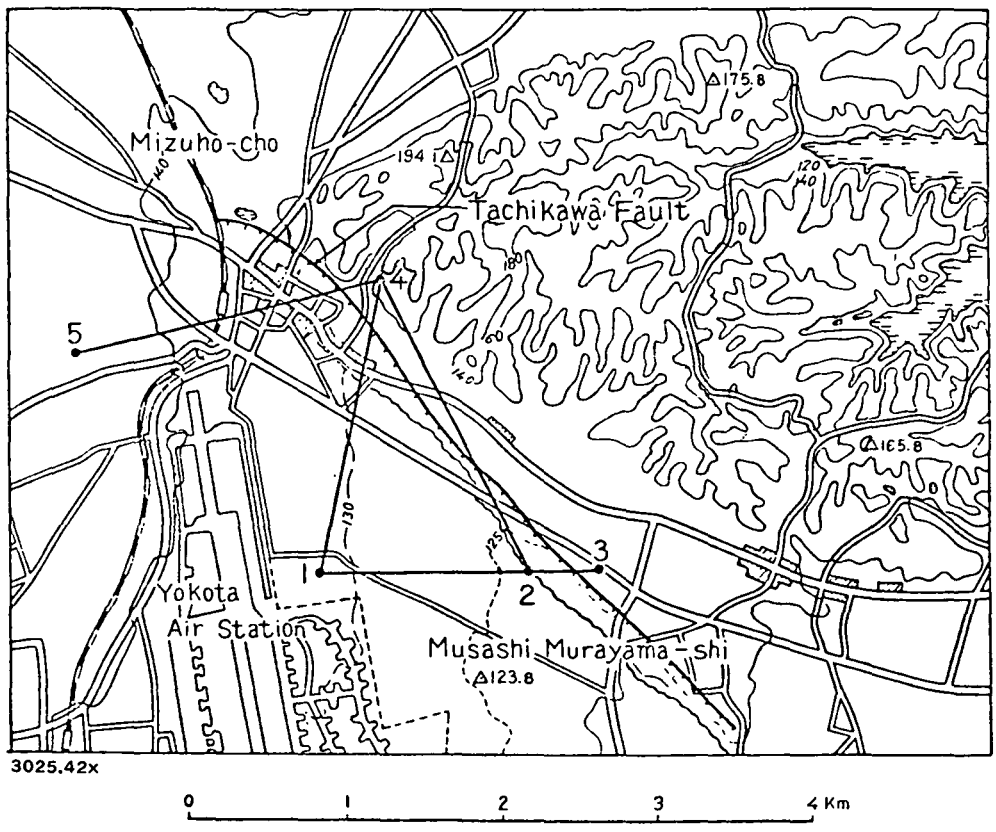



*Figure 65. Japan: observation net crossing Tachikawa fault*

# USE OF HIGH-ALTITUDE PHOTOGRAMMETRY IN DETERMINING THE TRUE FIGURE OF THE EARTH*

*Paper presented by Thailand*

This paper describes an experiment made with respect to using high-altitude aerial or astronautical photographs to determine the true figure of the earth. The research is purely mathematical and attempts to find the means by which all points on the surface of the earth can be fixed by pure rectangular co-ordinates with an assumed origin. If this result can be accomplished it will mean that a true figure of the earth can be obtained. This project involves the accurate analytical determination of the position of the camera at the time the photograph was taken. It is also assumed that in doing so an instrument like a stereocomparator must be used to measure the plane co-ordinates of the points on the photographs taken from the air or from space. In this mathematical experiment, it is assumed also that the refraction of light and interior distortions of all types are not considered. The resolution of the photographs is also excluded. Only perspective conditions of the photographs are taken into account.

The steps of this mathematical experiment are as follows. After the control points on the photographs have been measured accurately, the angles between them at the perspective centre of the photograph or at the focal point are computed for every pair of the points. In this way, three pairs of points can be combined to form a pyramid or three angles between three selected control points can be used for further computation as a pyramid. The formula normally used is the cosine formula. As the focal length of the camera is known it is easy to compute for the angles, and all the data obtained in this way are called the parameters of the interior orientation.

At the beginning of the problem, one must assume that ground control points for the first photograph are referenced to a certain global origin. This origin may be somewhere at the centre of the earth or preferably at a point outside the earth. In the latter case, the earth would be treated as a spatial body, floating in the positive quarter of the rectangular co-ordinates of three dimensions. In this case, the co-ordinates of all points on the earth's surface will have positive signs.

The next step is very important: it is the process of determining analytically and very accurately the length of the sides of the pyramid formed by three control points on the surface of the earth on the first photograph. This step is done by solving the sides of the triangles of the pyramid with a computer. Here, the principle of solving an equation of a second degree is used. The curve is plotted on the graph paper and the approximate position of an unknown ($x$) is determined while the value ($y$) is equal to zero ($o$). By repeating it as many times as wanted, the computation yields the last decimal of a millimetre of the length of the pyramid as required, even a fourth or fifth part of a millimetre. The length of the side of the pyramid assumed may be over 100 km. When this step is done, it means that the first set of parameters have been made known for exterior orientation. For checking of the result it is advisable to compute for one or more sets of the sides of the pyramids. All of the sides of the pyramids obtained for any photographs are nothing but the distances of the focal point of that camera from the control points appearing in that photograph.

After the distances of the control points from the focal point of the camera are known, it is possible to compute analytically the position of the camera in space. The equations of the distances in space are nothing more than the simple analytical distances of the co-ordinates of three dimensions. If only three equations are used, it is possible to eliminate from the three ($X$), ($Y$) and ($Z$) of the second-degree terms. The two remaining equations will give the relationship of the remaining two unknowns linearly. By replacing this linear unknown in the original second-degree equations, it is possible to solve quadratically for the first unknown. Knowing the first, the second and third unknowns can be easily found. If at the beginning of problem solving, more than three equations are used, which can be done because many sets of sides of the pyramids for that photograph have been found, it is possible to solve for the unknowns ($X$), ($Y$) and ($Z$) by pure first-degree elimination. This process when completed is what is generally known as a part of exterior orientation.

Since the sides of the pyramids in the camera, i.e., the distances of the photographs of the control points to the focal point of the camera, are also known within each camera and each photograph, then it is possible analytically to form the equations linearly to solve for the spatial co-ordinates of all photographic control points as they used to appear at the instant of photography. In this manner, it is not necessary to express the position of the camera or the photograph by its tip or tilt or swing. The positions or locations of all photographic points in space, as explained, are essential for further intersection computation for other points on the surface of the earth. When this process is finished, the exterior orientation of the camera is said to be completed.

Since the co-ordinates of the control points are of global status the co-ordinates of the focal point of the camera are also fixed by global origin. In using this analytical method for determination of the true figure of the earth, it is necessary to use photographs with a large percentage of overlap in order to get accurate intersection of the new control points or any required point on the

* The original text of this paper, prepared by Professor Phoon Phon Asanachinta, Department of Geography, Faculty of Social Sciences, Chiang Mai University, Thailand, appeared as document E/CONF.68/L.57.

surface of the earth. The co-ordinates of the required intersected points must be measured and known in their interior orientation with respect to the focal point of their camera and the equation of their spatial lines or slopes can be written, i.e., the equations of a line in space. The equations of the lines from two consecutive photographs of the same points are solved simultaneously for their intersections. These intersections in space are the co-ordinates of the new points on the surface of the earth, and they are referred to global origin.

By triangulation and bridging of the photographs with global origin as suggested above, it will be possible to determine the true figure of the earth without depending upon geographical or astronomical co-ordinates. The latter two, however, may provide the means of checking the result of computation and for general map-making and map-using.

For the purpose of this work, it is suggested that all photographs taken on good film bases and glass plates should be used for this experiment no matter how old such photographs may be, because one is not interested in the changing of the ground features except the true topography which is of interest. The bridging should not be done by photogrammetric plotting machines except when such machines have features similar to the comparator. The photographs used should have large overlapping portions or preferably more than 75 per cent overlap. A large percentage of overlap will ensure accuracy of extension of the strip of the photographs to the next group of control points. The next group of control points are used only for checking of distances and not for co-ordinates. It is only the first set of co-ordinates which is to be the base and is truly for the whole system of the project. Successive sets of higher altitude of photography are suggested, i.e., the lower sets of photography are used for the controls of the higher altitude sets of photography and so on until the space photography can be used to cover a global area and thus can obtain a final figure of the earth.

This method is suggested only because an accurate means of solving simultaneous equations of second degree are made possible. Other factors in physical properties of the camera and the atmosphere and also in the chemical processing of the photographs have yet to be considered. However, it is worth while to be prepared for future developments.

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## GEODETIC INVESTIGATIONS IN GEODYNAMIC TEST AREAS IN THE UNION OF SOVIET SOCIALIST REPUBLICS*

*Paper presented by the Union of Soviet Socialist Republics*

The problem of investigation of recent movements of the earth's crust is of a great importance in the Union of Soviet Socialist Republics. Recent movements are under investigation both in especially built geodynamic test areas and in large regions of the country.

Investigation of recent movements of the earth's crust expands the knowledge about the planet, about its origin and tendencies of development. In addition to their great scientific meaning, such investigations have an important practical aspect. In particular, it is hoped that study of recent movements of the earth's crust will be of use in the search for the forerunners of earthquakes.

In general, earthquake prediction is one of the important tasks of modern times. For the time being, the question has still been partially solved by way of general schemes of the seismic regions on which approximate information about the maximum possible severity of the earthquake is given. This information makes it possible to construct new buildings and industrial enterprises taking into account their seismic stability.

Severe earthquakes not only cause destruction of buildings but are followed by tsunamis, fires and landslides.

A fifth of the world population lives under the threat of earthquakes, and vast territories in the Soviet Union are situated in regions of seismic activity.

Thus far, no reliable methods for earthquake prediction have been found. In spite of the mutual efforts of scientists throughout the world, the problem of earthquake prediction has not been solved. Only in some cases have attempts to determine the forerunners of natural calamities been successful.

In the opinion of many scientists, the basic cause of all severe earthquakes is slow tectonic movements in the interior of the earth which are caused by physical and chemical processes in the core of the earth. These processes cause the slippage of separate sections and strata of the earth's crust covering considerable distances

* The original text of this paper appeared as document E/CONF.68/L.99.

and depths. As a result of this activity in the interior of the earth, deformations are emerging—pressings and stresses or curves of considerable areas of the earth's crust.

The scientists have long conjectured about the connexion between the recent movements of the earth's crust and earthquakes. It has been observed that during the periods preceding seismic activity, the degree of velocity of the vertical movements changes.

In 1967, a scientist in the USSR, Yu. A. Mescherjakow, distinguished three types of recent vertical movements in the seismic areas by connecting them with the periods of preparation of earthquakes and with earthquakes themselves. Subsequently, these three types were detailed by G. L. Lencen, K. Ch. Sholz, Ph. Niomi and Ph. Yochiro.

To study the possible forerunners of earthquakes in the Soviet Union, special (prognosis) geodynamic test areas are set up where a wide range of complex investigations is carried out. In this complex, a great deal of attention is paid both to the geodetic investigations and to the geophysical and geochemical studies etc.

Geodynamic test areas are located in regions of seismic activity of the USSR, in the belts where the concentration of deformation effects of the earth's crust is extremely apparent. One of these belts stretches along the boundary of the Pacific Ocean; the other, through the highest Himalayas, the Pamirs, the Tien Shan, the Kopet Dag and the Caucasus, and the Carpathians. In these areas, research to determine earthquake forerunners is carried out. The same types of investigations are carried out in the rift zone of Lake Baikal, the Crimea and other regions of seismic activity.

Geodetic investigations in general are directed to studying recent vertical and horizontal movements by the method of repeated measurements. Measurements are usually taken by traditional geodetic methods: triangulation, trilateration and their combinations; and high-precision levelling. However, higher precision must be achieved in this type of work than is needed for a regular network. Linear measurements are carried out by means of electronic distance-measuring (EDM) on a special methodology with an error of $\pm(5-7)$ mm; and angular measurements, by theodolite T05 (sometimes OT-02) with the error $\pm 0''5$. Levels Ni-004, NA-1, N-1 and invar rods are applied for high-precision levelling. Allowance for discrepancies of forward and backward runs, as well as the right-hand and left-hand levelling, are rather rigid. Keeping in mind that many geodynamic test areas are located in mountainous regions, precautions should be taken to reduce the influence of the errors yielded by measurements in such conditions: a special technique is applied for temperature measurement during linear measurements; invar rods equipped with thermosensors for measuring the integral temperature of the invar strip are introduced; and thermic coefficients of invar strips are determined on a special thermostat when high-precision levelling is being done.

Further, measures are taken for the more precise calibration of average length of a metre on an invar rod and other measures are taken to reduce measurement errors.

The most intensive geodetic works are carried out in the geodynamic test areas for detecting forerunners in the densely settled and developing regions of middle Asia and Kazakhstan as well as in the districts of the Far East on the boundary of the ocean trench. It is said that in the areas of sinking strata where the chutes are formed, deep-level earthquakes occur and under the influence of friction emerging from the sinking strata, volcanoes arise on the reverse side of the chute.

The geodetic investigation programme in the geodynamic test areas provides for conducting three circles of measurement for the first five years of their existence. On the basis of the previous results, the further investigations (areas of measurements and times of repetition) are made more precise.

One of the main tasks in studying recent movements of the earth's crust in the geodynamic test areas in order to detect the forerunners of earthquakes is to achieve the highest precision of geodetic measurements (there is no limit—the more precise, the better), as well as to increase the repeatability of the measurements, making them permanent in some cases.

Study of the recent movements of the earth's crust is very significant for the construction and exploitation of large storage lakes built in seismic dangerous areas.

Facts about the earthquakes in the districts of such large storage lakes have been already stated; they are called "dam" earthquakes. According to seismologists, they are evidently caused by an accumulation of deformations in the upper bends of the earth's crust which with the extra loading may provoke an earthquake. In this case, between the increasing of the loading and the origin of earthquakes there must exist a correlative relation which depends upon the intensity and direction of the movements of the earth's crust.

The quantitative and qualitative characteristics of both vertical and horizontal movements of the earth's surface could be revealed by geodetic measurements to the full extent.

In the Soviet Union, a decision was taken to set up special geodynamic test areas for studying recent movements of the earth's crust in the regions of hydroelectric stations. The geodetic investigations that are currently being carried out in eight such test areas are described below.

In order to detect vertical movements of the earth's crust on both banks of the storage lake, a first-order levelling network is being run. This network must include lines which lay out of the boundaries of sedimentary surface. At places where it is impossible to put levelling lines along both banks the run is put on one bank; on the other bank, separate runs are put in the places where it is possible. All these runs are connected with the main line by means of "jumping" heights through water obstacles.

For the study of horizontal movements, a number of geodetic quadrangles with the measurement of the length of all four sides and of the diagonals are made and the distances of the diameters between points, fixed on both banks at three different levels, are also measured. On one

of the points of the network an astronomical azimuth is determined; measurements are made for the first time before filling the storage lake, the second time at the moment of filling, then twice a year during the first three years of exploitation and once a year afterwards. Astronomical azimuths are corrected after earthquakes, as are other phenomena which could entail the turning of blocks and slabs.

One more aspect of applying geodesy for the study of recent movements of the earth's crust is connected with the study of the deformations of the earth's surface which are caused by technogical, man-made and exogenous factors. These deformations are caused by the working of natural resources (oil, coal, gas, subsoil waters), the building-up of large constructions (hydrotechnical, underground, industrial etc.), the implementation of the land-reclamation works and so on.

In the Soviet Union, test geodynamic areas are set up for studying the influence on the earth's surface of the pumping-out of oil, gas, water and coal. In the majority of cases, technogical processes are leading to the settling of the earth's surface and geodetic marks; however, in a number of cases horizontal faults take place equally with vertical faults.

The study of the regularity of the deformations of the earth's surface, their qualitative characteristics and the scale of expansion in dependence upon the type of underground workings has a current real significance for industry and agriculture. To give a true idea about the extent of vertical faults of the earth's surface resulting from underground workings, suffice it to say that in a number of mine districts, one can see the settling of the earth surface for 2–3 m and more. It is not only distributed on the districts of coal workings but goes far from their boundaries, because working of the mines and drifts is connected with the intensive pumping-out of water.

For studying the horizontal slips of points of the earth's surface in general polygonometry of the medium precision or triangulation is applied.

The study of the recent movements of the earth's crust in the USSR has become one of the important tasks of geodesy. It is solved in the complex with geological, geophysical, seismic and other investigations.

## TRANSFORMATION OF DOPPLER GEODETIC POINT POSITIONS TO THE LOCAL DATUM IN THE ASIA-PACIFIC AREA*

*Submitted by the United States of America*

The increasing use of portable Doppler receivers to establish geodetic control has focused attention on the methods used to transform the satellite-derived co-ordinates to the local datum. This paper discusses several datum transformation techniques and recommends the "shift of ellipsoid centres" method for general use. Examples and accuracies of datum transformations for several countries of Asia and the Pacific are given. Recommendations are given for the number and distribution of stations that should be established on control points to derive the datum transformation. This requirement will vary in accordance with purpose of the Doppler positioning (strengthening basic network, geophysical survey, mapping control etc.). The determination of mean sea level elevations from satellite-derived ellipsoid heights is also discussed.

The increasing use of portable Doppler receivers to establish geodetic control in unsurveyed areas has developed new interest in datum transformations. This is especially true in the Asia-Pacific area where surveys by Doppler geodetic point positioning are being established to satisfy varying types of requirements. Whether one uses the ephemerides broadcast by the satellites or the precise ephemerides generated by the United States Defense Mapping Agency, the co-ordinates of the Doppler receiver are referenced to an earth-centred co-ordinate system. It is very seldom that there is no need to relate the earth-centred positions to the local datum. If the purpose of the Doppler positioning is strengthening the basic network, extension of the network or establishment of mapping control, the requirement for the datum transformation is obvious. For geophysical exploration, there usually is the requirement to relate the Doppler positions to local mapping or recovered control points. The type and accuracy of the datum transformation are directly related to the accuracy of the control available in the local datum and earth-centred system.

### DOPPLER POINT POSITIONING

Given one of several types of Doppler receivers, a geodetic position is obtained by using tracking data acquired by the receiver and the position (ephemeris) of the satellite. The receiver tracks one or more of six Navy Navigation Satellites (NAVSATs). The satellites are in polar orbit and can be seen at all latitudes. There are two sources of the ephemerides of the NAVSATs. The "broadcast" ephemeris is transmitted by the NAVSAT periodically and can be received by most Doppler receivers. These ephemerides are generated from data acquired from four tracking stations in the United States of America (OPNET), injected into the satellite(s) and

* The original text of this paper, prepared by James W. Walker, Chief, Data Reduction Branch, Defense Mapping Agency Topographic Center, United States of America, appeared as document E/CONF.68/L.45.

updated every 12 hours. The accuracy of a broadcast ephemeris position is 20–30 m. A geodetic position established using the broadcast ephemeris has an accuracy of 5–10 m if an optimum number of passes is used. The precise ephemerides computed at the Defense Mapping Agency Topographic Center (DMATC) is generated from data obtained from a world-wide network of 15 to 20 tracking stations (TRANET). Precise ephemerides are generated for two NAVSATs continuously and for other NAVSATs as required. The accuracy of a precise ephemeris position is 3–5 m. The accuracy of a point position established by using the precise ephemeris is 1 m (one sigma) in each co-ordinate axis. This accuracy is dependent upon acquiring a balanced set of from 35 to 40 usable satellite passes.[1]

Both types of ephemerides are referenced to an earth-centred co-ordinate system. Since December 1975, the broadcast ephemerides have been computed in terms of the World Geodetic System 1972 (WGS 72).[2] The ellipsoid associated with this system has the following dimensions: semi-major axis = 6,378,135 m; flattening = 1/298.26.

The precise ephemeris is computed in the NWL-9D co-ordinate system. The NWL-8E ellipsoid is used with the NWL-9D system. The dimensions of the 8E ellipsoid are: semi-major axis = 6,378,145 m; flattening = 1/298.25.

The relationship between the NWL-9D system and WGS 72 is given below:

$$\begin{aligned} \Delta\phi &= -0''.232 \sin^2\phi \\ \Delta\lambda &= 0''.260 \\ \Delta H\ (m) &= 4.73 - 0.72 \sin^2\phi \end{aligned} \qquad \text{(Formula 1)}$$

where

$\Delta\phi$, $\Delta\lambda$, $\Delta H$ are WGS 72 minus NWL-9D in latitude, longitude and height, respectively.[3]

## Datum transformations

### *Basic formulae*

The complete datum transformation is defined by seven parameters. They are shift of ellipsoid centres (three parameters), scale change (one parameter), and rotation of each co-ordinate axis (three parameters). The basic formula is:

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} + \begin{pmatrix} 0 & -Z' & Y' \\ Z' & 0 & -X' \\ -Y' & X' & 0 \end{pmatrix} \begin{pmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{pmatrix} + (m-1) \begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} + \begin{pmatrix} K_1 \\ K_2 \\ K_3 \end{pmatrix} \qquad \text{(Formula 2)}$$

where

$(x, y, z)$ are geocentric co-ordinates in the local datum.

$(X, Y, Z)$ are geocentric co-ordinates in the earth-centred co-ordinate system (see figure 66).

By definition the $Z$ axis is parallel to the earth's mean rotation axis of epoch; the positive direction is north. The $X$ axis lies in the plane of the equator with positive direction towards the Greenwich meridian. The $Y$ axis is positive 90° east of Greenwich. Geocentric co-ordinates are related to geodetic co-ordinates $(\phi, \lambda, H)$ by the well-known formulae:

$$\begin{aligned} X &= (v + H)\cos\phi\cos\lambda \\ Y &= (v + H)\cos\phi\sin\lambda \\ Z &= [v(1 - e^2) + H]\sin\phi \end{aligned} \qquad \text{(Formula 3)}$$

where

$\phi$, $\lambda$ are geodetic latitude and longitude;

$H$ is height above the ellipsoid;

$(x, y, z)$ have identical definition in the local co-ordinate system:

$$\begin{aligned} X' &= X - \overline{X} & \overline{X} &= \Sigma X/n \\ Y' &= Y - \overline{Y} & \overline{Y} &= \Sigma Y/n \\ Z' &= Z - \overline{Z} & \overline{Z} &= \Sigma Z/n \end{aligned}$$

where

$n$ is the number of points common to both systems;

$\omega_1$, $\omega_2$, $\omega_3$ are small rotations of the $X$, $Y$, and $Z$ axis, respectively;

$m$ is scale change;

$K_1$, $K_2$, $K_3$ are shifts of the $X$, $Y$ and $Z$ axis, respectively.

The solution of the basic equations for the unknown parameters $K_1$, $K_2$, $K_3$, $m$, $\omega_1$, $\omega_2$, and $\omega_3$ is carried out by the method of least squares. Each common point yields three observation equations. Thus, a minimum of three common points is needed for the solution. Several options are available for the number of parameters determined. Usually, three options are considered. Solutions are made for three parameters ($K_1$, $K_2$, $K_3$), four parameters ($K_1$, $K_2$, $K_3$ and $m$), or all seven parameters.

### *Number of parameters*

The number of parameters selected to determine the datum transformation will depend upon the number, accuracy and distribution of common points. Those factors are, of course, dictated by the purpose of the survey. The requirements for Doppler geodetic point

[1] United States of America, Department of Defense, Defense Mapping Agency, *Report of the DoD Geoceiver Test Program*, DMA report 0001 (Washington, D.C., July 1972).

[2] Thomas O. Sepplin, "The Department of Defense World Geodetic System 1972", paper presented to the International Symposium on Problems Related to the Redefinition of the North American Geodetic Networks, Frederickton, New Brunswick, Canada, May 1974.

[3] *Ibid.*

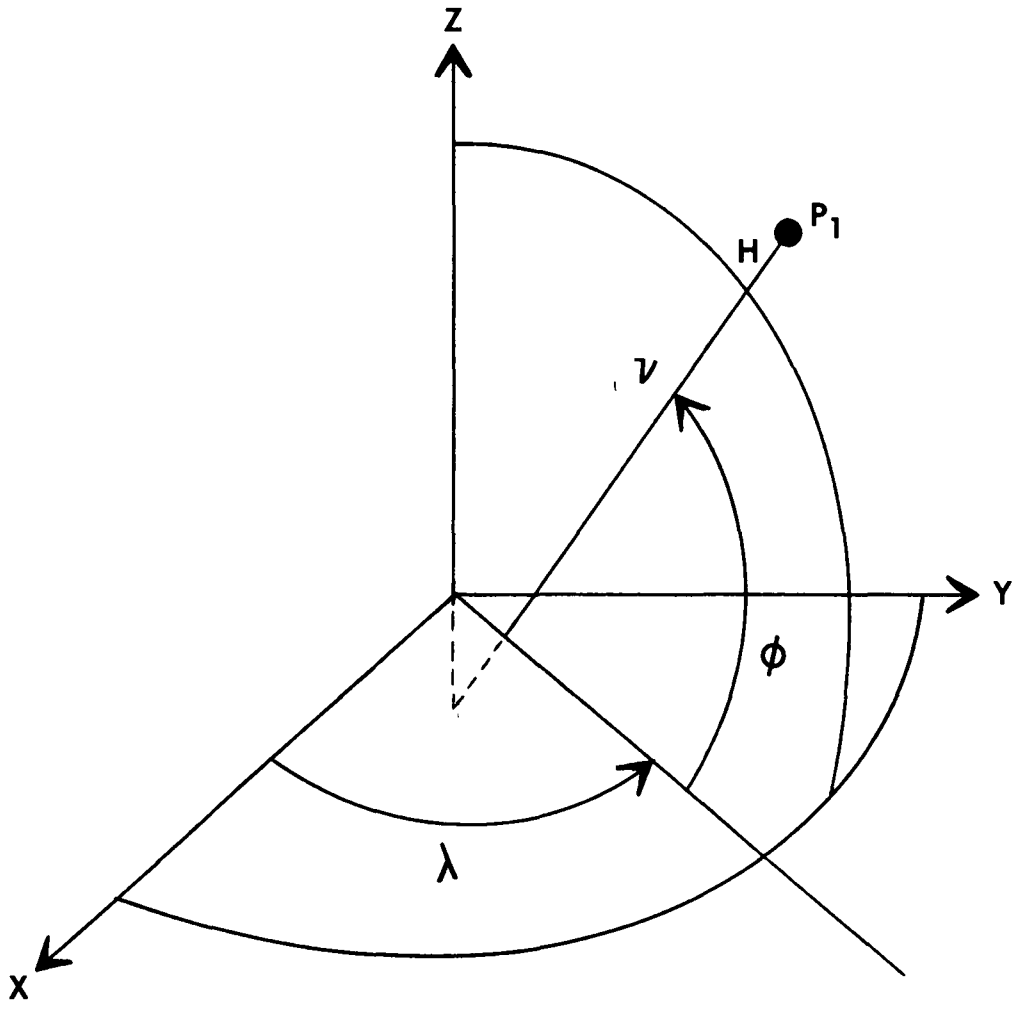



*Figure 66. United States of America: geocentric co-ordinates*

positioning will fall into the following categories: (*a*) strengthening of basic networks; (*b*) extension of basic control; (*c*) establishment of mapping control; (*d*) geophysical exploration; (*e*) special purposes.

It has been found in practice that the determination of scale change and rotations is either not required or cannot be accurately accomplished. The errors in the two systems usually propagate into errors in scale change and rotations that are larger than the parameters themselves. When the requirement for Doppler positions is strengthening the basic networks or extension of basic control, the conversion of earth-centred co-ordinates to the local datum is obtained by the three-parameter solution. The Doppler positions established for these purposes are generally spaced about 250 km apart and are determined from the optimum number of passes (35–40). Earth-centred positions are converted to the local datum and treated as observations (properly weighted) in a readjustment of the basic network. The three-parameter transformation permits retention of the relative accuracy between widely separated positions.

The requirement for establishing mapping control is not as stringent as the requirement for upgrading basic networks. DMATC is collaborating with the Defense Mapping Agency–Inter American Geodetic Survey (DMA–IAGS) project in the establishment of mapping control in South America. Doppler positions for mapping control are established to an accuracy of 3 m in each co-ordinate axis. This result is attained with from 12 to 15 acceptable satellite passes. The datum transformation required to convert the earth-centred positions to the mapping datum are obtained by establishing primary Doppler positions (35–40 passes) on control points. The distribution of points on control will vary with the size and location of the unsurveyed area in relation to the main network. If the mapping control is established in a local area, the transformation should be derived from Doppler positions on control points contiguous to the area. Where the mapping control is distributed over a larger area bordering on the entire basic network of a country, the transformation should be based on a distribution of points in the basic network (see figure 69). The largest

error in the mapping control positions will be in the mean sea level elevations which must be computed from the Doppler-derived ellipsoid heights. The mean sea level elevation is obtained by subtracting the geoid height from the ellipsoid height. The geoid height in the unsurveyed area is obtained from the extrapolated astrogeodetic geoid or from the gravity model used to generate the precision ephemeris. For the former method, the geoid height will be referenced to the local datum and must be subtracted from the ellipsoid height on the local datum. The geoid height that is computed from the gravity model is in the earth-centred system and is subtracted from the earth-centred ellipsoid height.

*Application of three-parameter transformation*

The determination of the shift of ellipsoid centres ($K_1$, $K_2$, $K_3$) will yield the datum transformation satisfying most requirements. The shifts are the arithmetical means of the differences in geocentric co-ordinates:

$$K_1 = \frac{\Sigma(x-X)}{n} \qquad K_2 = \frac{\Sigma(y-Y)}{n} \qquad K_3 = \frac{\Sigma(z-Z)}{n}$$

$K_1$, $K_2$ and $K_3$ are usually designated $\Delta X$, $\Delta Y$ and $\Delta Z$, respectively.

The application of the transformation can be performed directly from the abbreviated version of formula (2), that is:

$$\begin{aligned} x &= X + K_1 \\ y &= Y + K_2 \\ z &= Z + K_3 \end{aligned} \qquad \text{(Formula 2a)}$$

This step requires conversion of geocentric co-ordinates ($x$, $y$, $z$) to geographics by inversion of formula (3). The datum transformation can also be made in terms of geographical co-ordinates by the Standard Molodensky transformation or the Abridged Molodensky transformation.[4] The results of the Standard Molodensky transformation duplicates formula (2a). The Abridged Molodensky transformation is slightly less accurate.

*Thailand*

The primary network of Thailand contains nine Doppler positions that were used in a readjustment of the network (figure 67). Doppler stations were either established directly on primary triangulation stations or the Doppler position was transported to the primary station through a connecting survey. The WGS 72 positions of the Doppler stations were converted to the national datum (Indian) by the three parameter transformations given below:

$$\begin{aligned} K_1 &= -223.49 \text{ m} \\ K_2 &= -837.44 \text{ m} \\ K_3 &= -290.10 \text{ m} \end{aligned}$$

The transformed Indian datum positions yielded the best fit of the Doppler positions to the national datum while retaining the relative accuracy of the Doppler positioning. Thus, the basic network was strengthened without disturbing the existing mapping. The complete seven-parameter solution yielded the same values of $K_1$ given above and the following values for scale change and rotations:

$$\begin{aligned} \text{m} - 1 &= -0.2184.10^{-4} \pm 0.0527.10^{-4} \\ \omega_1 &= 7''.32 \pm 1''.28 \\ \omega_2 &= 12''.34 \pm 1''.23 \\ \omega_3 &= 16''.01 \pm 2''.37 \end{aligned}$$

*Philippines*

A datum transformation based on five Doppler stations in the Philippines provides another example of a network that can be upgraded with Doppler positioning (figure 68). It also shows that transformations to the national datum should be made on a local basis. The complete seven-parameter transformation from WGS 72 to the Luzon datum is:

$$\begin{aligned} K_1 &= 126.21 \text{ m} \pm 12.40 \\ K_2 &= 79.90 \text{ m} \pm 10.42 \\ K_3 &= 62.75 \text{ m} \pm 11.78 \\ \text{m} - 1 &= 0.9279.10^{-5} \pm 3.0759.10^{-5} \\ \omega_1 &= -1.54 \pm 7.67 \\ \omega_2 &= -2.35 \pm 6.92 \\ \omega_3 &= 1.55 \pm 10.28 \end{aligned}$$

The magnitudes of the scale change and rotations are completely masked by the errors in those parameters. Thus, the transformation is not adequate for general use. The large errors in the parameters derive primarily from errors in the Philippine triangulation. Evaluation of the network indicates that its accuracy (90 per cent circular error) is one part in 39,000. Doppler positions established in the Philippines should be converted to the Luzon datum by datum transformations derived from control points in the vicinity of the Doppler stations. Additional Doppler positions are being established in the Philippines. These stations will furnish a basis for strengthening the existing network and establishing basic control in unsurveyed areas.

*Peru*

Peru provides an example of the establishment of mapping control in an unsurveyed area by Doppler point positioning and the attendant datum transformation. The area of Peru where mapping control is being established lies to the east of the surveyed area and is approximately equal in size (figure 69). There are six Doppler positions on control points. Four of the points are in Peru; one is in Bolivia and one in Chile. The six points provide the basis for the datum transformation. The mapping datum is the Provisional South American Datum of 1956 (PSAD 56). A three-parameter transformation was used to convert the Doppler-derived co-ordinates to the mapping datum. The geocentric shifts from the NWL-9D system to PSAD 56 are given below:

$$\begin{aligned} K_1 &= 282.56 \pm 2.96 \\ K_2 &= -105.99 \pm 5.98 \\ K_3 &= 401.47 \pm 5.59 \end{aligned}$$

[4] *Ibid.*

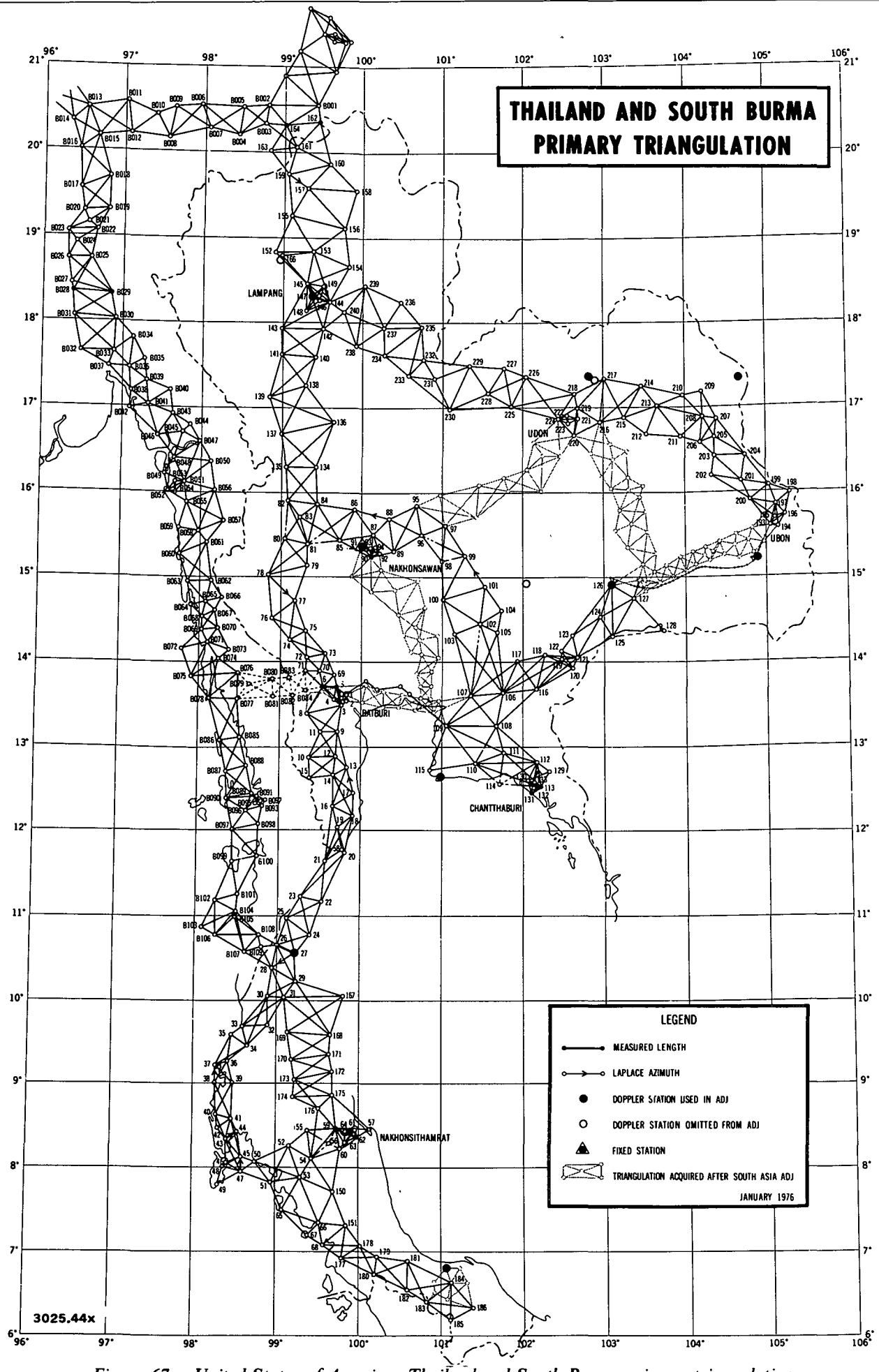



*Figure 67. United States of America: Thailand and South Burma primary triangulation*

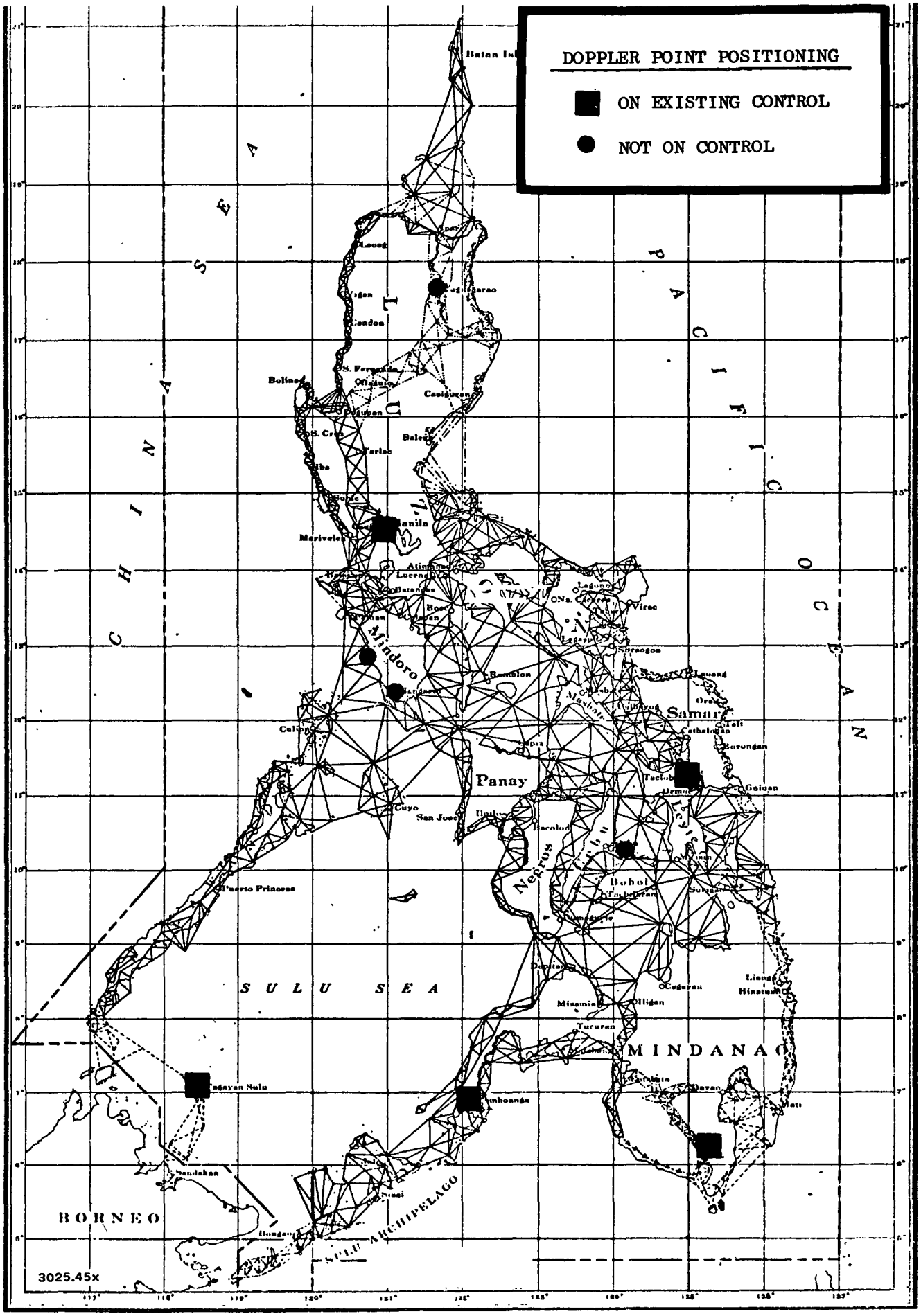
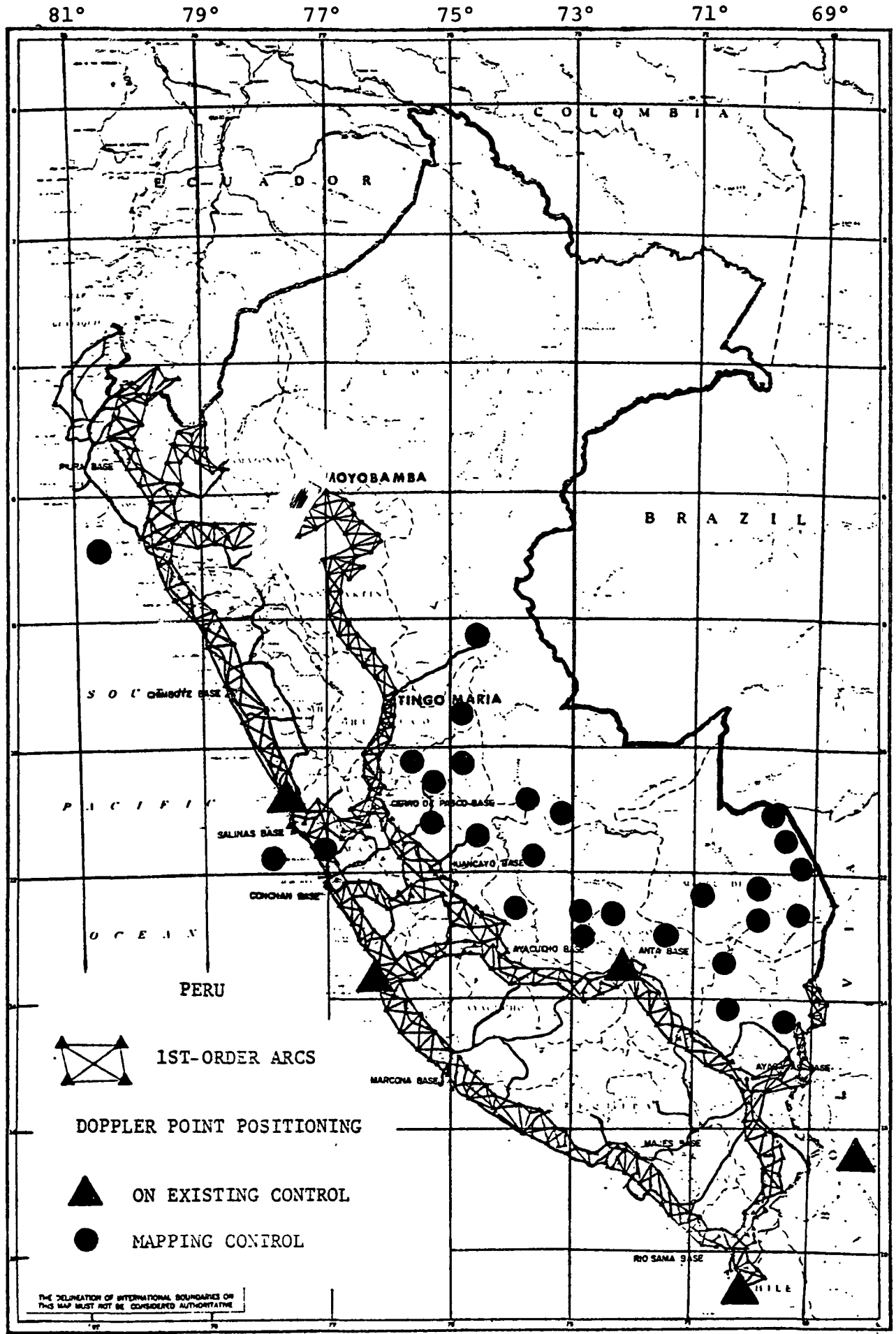



*Figure 68. United States of America: Doppler point positioning*




3025.46x

*Figure 69. United States of America: first-order arcs and Doppler point positioning in Peru*

The three-parameter transformation yields the best average relationship between the earth-centred coordinate system and the mapping datum while retaining the relative accuracy among the Doppler-derived positions.

The mean sea level elevations at the Doppler stations were determined from an extrapolation of the astro-geodetic geoid into the unsurveyed area. The astro-geodetic geoid is referenced to the continental datum, South American Datum of 1969 (SAD 69). The datum transformation given below was used for conversion of the NWL-9D system to SAD 69:

$$K_1 = 83.40 \pm 1.46$$
$$K_2 = 2.60 \pm 1.31$$
$$K_3 = 48.32 \pm 1.48$$

Ellipsoid heights referenced to SAD 69 were converted to mean sea level elevations by subtracting the geoid heights. The smaller parameter errors for the SAD 69 transformation reflect a greater accuracy in that datum than in the PSAD 56 values.


### SUMMARY

The conversion of Doppler-derived positions to the local or national datum is a basic requirement in most Doppler geodetic point positioning. The three-parameter transformation is generally used because it yields an accurate relationship between systems without degrading the relative accuracy amongst Doppler-derived positions. The determination of scale change and orientation is usually not required or not feasible because the numerical values of those parameters are often masked by errors of observation.

Doppler point positioning is established for varying purposes and with varying degrees of accuracy. The number and distribution of points used to derive the attendant datum transformations will depend upon the purpose. The recovery of mean sea level elevations from Doppler-derived positions in unsurveyed areas is a problem related to datum transformations that needs more study.


### ADDITIONAL REFERENCES


Lail, Isaac C. The orientation of three-dimensional triangulation nets and the change of datum. United States Army Map Service, August 1967 (Geodetic memorandum 1608).

Walker, James W. Establishment of mapping control by Doppler satellite point positioning. Paper presented to the American Congress of Surveying and Mapping, Phoenix, Arizona, October 1975.


## DOPPLER SATELLITE POSITIONING: APPLICATION TO GEODETIC CONTROL NETWORKS*

*Paper presented by the United States of America*

The United States of America has in progress a planned network of about 150 stations in the conterminous states whose positions will be determined from statellite Doppler data. These stations are spaced at intervals of 150–300 km and will be used in the new adjustment of the North American Datum to provide additional scale and orientation control. In addition, it is very likely these positions will be used to fit this vast network to a world reference system.

A multiadjustment test of a large network in Mississippi, Louisiana and Alabama has been completed. Five Doppler positions were available for control. This is a report of the results obtained from four adjustments. The first, considered the base adjustment, was carried out in a conventional fashion, holding one point fixed and including all the first- and second-order networks, segments of the high-precision traverse and numerous measured lengths and astronomical azimuths. This computation was then followed by three adjustments of the first-order nets scaled and oriented by the Doppler positions, which were introduced as weighted observations, in various combinations. To compare the results obtained in the adjustments, sufficient relative accuracy estimates were computed between points common to each computation. The conclusions drawn from these accuracy estimates increase the confidence in Doppler positioning which was gained from prior experience and indicate that a network of Doppler positions could be used to control geodetic networks encompassing an entire country.

### BACKGROUND INFORMATION

This very large network in Mississippi, Louisiana and Alabama was selected because the observations for the 32 projects comprising the total network were in machine-readable form (figure 70(*a*)). The mere fact that five Doppler positions were situated at strategic locations was secondary. There are several other areas where five or more Doppler positions are available, but the observational data are not currently in computer-readable form. Actually, one of these areas which is not directly served by the high-precision traverse might be a better test for users of Doppler positions outside the United States, since the comparisons would be made with data scaled and oriented by conventional length measurements and astronomical azimuths. At this time, few countries are employing Doppler positions in the manner described here. In most instances, the procedure is used

* The original text of this paper, prepared by Joseph F. Dracup, National Geodetic Survey, National Ocean Survey, National Oceanic and Atmospheric Administration, United States of America, appeared as document E/CONF.68/L.46.

to control mapping projects and network extensions which do not require precise handling of the Doppler observations. On the other hand, when these data are to be utilized in higher order geodetic surveys, the field operations and data reductions must be carried out in a fashion commensurate with the desired accuracies.

Two previous computations using Doppler positions as control have been processed by the National Geodetic Survey. The first adjustment containing 163 stations in Indiana, Kentucky and West Virginia is discussed by Meade.[1] This network was controlled by lengths and azimuths computed from four Doppler positions and introduced, with weights, as observations. Meade later carried out a similar computation for a network in South Carolina and Georgia; but to date, no report has been prepared. The results were comparable with the first test; and on the basis of these evaluations, considerable confidence was gained that Doppler positions spaced at specific intervals would contribute to strengthening the national network. It is further thought that the large number of new base lines and astronomical azimuths once deemed necessary to upgrade the United States network will be substantially reduced because of the beneficial influence of the Doppler positions.

The only difference, other than the size of the networks, between the previous computations and those under discussion is the use of the Doppler positions as weighted observations, rather than the inclusion in the adjustments of lengths and azimuths derived from the positions. As noted previously, five Doppler positions are available. Four stations (10003, 10022, 10023 and 20016) were positioned by the Department of Defense in 1971 and are discussed in a Defense Mapping Agency report.[2] The fifth station (51009) was observed by the National Geodetic Survey in 1973.

All Doppler positions were converted from the NWL-9D system to the NWL-10F system, as follows:

$$\phi' = \phi$$
$$\lambda' = \lambda + 0''.260 \ (\lambda \text{ east is positive})$$
$$h' = h - 5.27 \text{ m.}$$

where $h$ and $h'$ are heights above a selected common ellipsoid. Meade[3] gives further details in regard to these conversion formulae.

The NWL-10F co-ordinates for the five stations were transformed to the MR-72 datum through a mean datum shift, as computed by Vincenty.[4] This shift is based on differences in co-ordinates between those computed on the NWL-10F system and the MR-72 datum at 36 sites on the high-precision traverse. The MR-72 datum is based on adjustments of the high-precision traverse holding the NAD 1927 position for station MEADES RANCH fixed.

A slightly different shift was used to transform the co-ordinates used in computations discussed previously. The revised shift is:

| *Mean (metres)* | $\hat{\delta}(m)$ |
|---|---|
| $\Delta X = +\ 19.60$ | $\pm 0.22$ |
| $\Delta Y = -155.02$ | $\pm 0.18$ |
| $\Delta Z = -175.12$ | $\pm 0.18$ |

The "Doppler" stations or those points to which the Doppler determinations were transferred are shown by triangles on figure 70(*b*). To further identify these points, the following information is provided:

| *Station* | *Location* | *Transferred from* | *Doppler No.* |
|---|---|---|---|
| KNOB 1914 | North | | 10 022 |
| WINN 1929 | West | GREENVILLE AFB 1957 | 10 003 |
| LITTLE 1934 | South | Point near LITTLE RM A | 20 016 |
| KELLEY 1971 | East | Point near KELLEY 1971 | 51 009 |
| WEBSTER 1939 | Centre | WEBSTER 1939 RM 1 | 10 023 |

Distances between the five "Doppler" stations.

| *From* | *To* | *Distance (kilometres)* |
|---|---|---|
| Centre | North | 160 |
| Centre | West | 181 |
| Centre | South | 266 |
| Centre | East | 253 |

## Discussion of adjustments

Four adjustments involving 32 projects were processed. These projects had been placed in a machine-readable format during the course of the evaluations and adjustments of the individual projects which were made, as part of the data-gathering and examination phase for the new adjustment of the North American Datum. Since the new adjustment concept is to adjust all points, which can be classified to a recognized standard, in a weighted simultaneous computation, the projects contained a vast amount of observational data which would not contribute or would contribute little to the investigation being planned. Accordingly, only the high-precision traverse data and the observations for the principal first- and second-order stations were extracted from the source tapes. Although the term "second order" implies work of a secondary or subsidiary nature, this is not the case for the area networks accomplished by the National Geodetic Survey. Today, with few exceptions, all surveys are established to first-order standards; but in the past, numerous area nets were surveyed to slightly modified first-order specifications and for simplicity were classified as second order. Many of these networks are equal or better in quality than the bounding first-order arcs and are usually stronger geometrically.

The adjustments have been labelled A, B, C and D; a brief discussion of each is given below.

### *Adjustment A*

Adjustment A includes the high-precision traverse

[1] B. K. Meade, "Doppler data *versus* results from high precision traverse", *Canadian Surveyor*, vol. 28, No. 5 (December 1975).

[2] United States of America, Department of Defense, Defense Mapping Agency, *Report of the DOD Geoceiver Test Program*, DMA report 0001 (Washington, D.C., July 1972).

[3] Meade, *loc. cit.*

[4] T. Vincenty, "Experiments with adjustments of geodetic networks and related subjects", 1975 (unpublished).

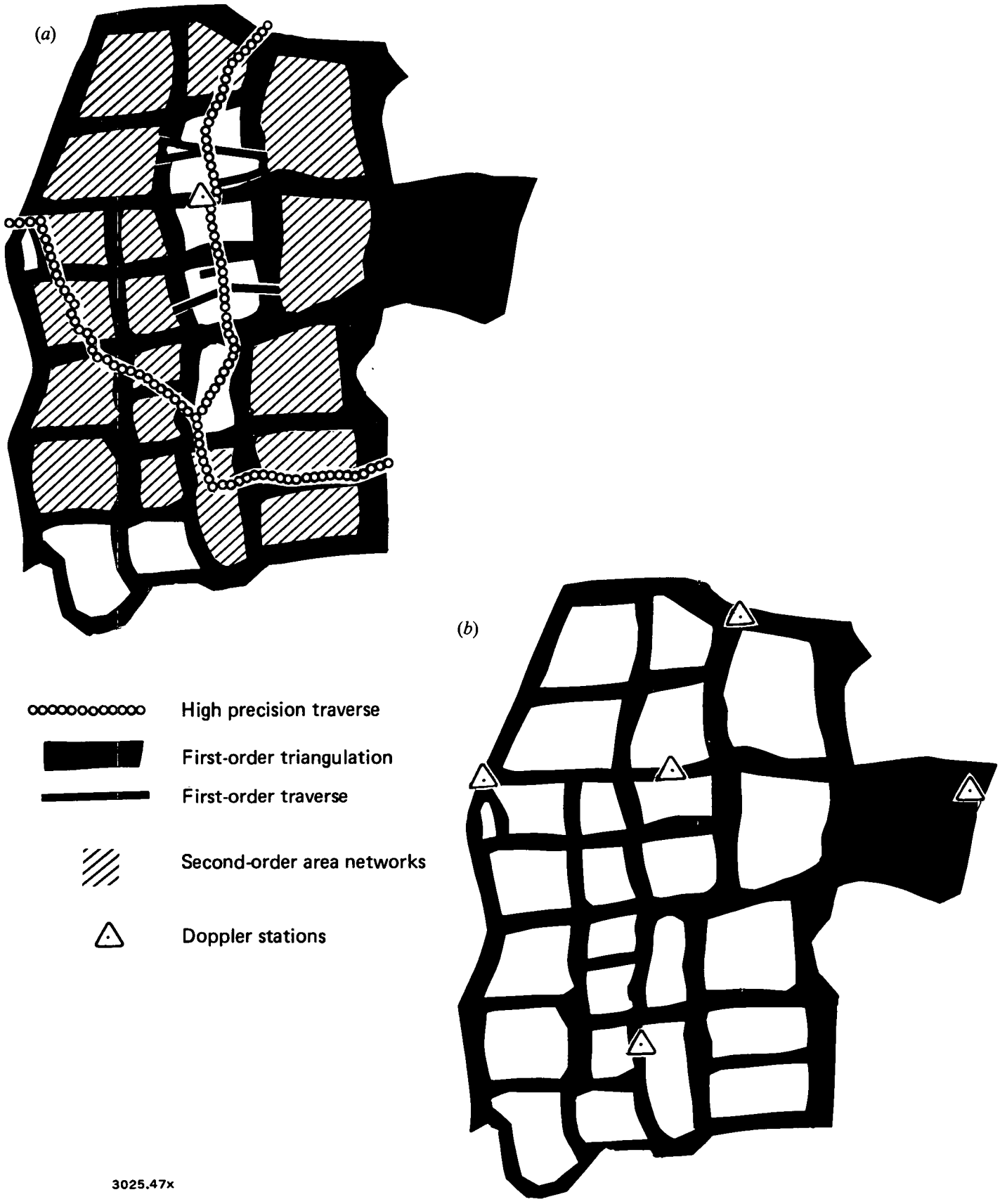



*Figure 70. United States of America: multiadjustment test of a large network in Mississippi, Louisiana and Alabama*

from the east to the centre of the net and then north to the upper boundary and diagonally to the western edge; and first- and second-order arcs and area nets (figure 70 (*a*)). For comparison purposes with the three other computations, relative accuracy estimates were computed over lines common to all computations for which measured lengths and astronomical azimuths were available and with a few exceptions between the boundary arcs, from north to south and from east to west, passing approximately through the middle of the areas.

The network contains 1,566 stations and 7,826 degrees of freedom; and it was scaled and oriented by 16 taped base lines, 285 lengths measured with Geodimeters and 106 astronomical azimuths in addition to 88 short taped traverse connexions. The observational data were reduced to the Clarke spheroid of 1866 for all adjustments. See table 36 for additional statistics.

*Adjustments B, C and D*

Adjustments B, C and D contain only the first-order surveys (figure 70 (*b*)). For adjustment B, all five "Doppler" stations were used as weighted observations. Doppler positions for the north and south stations, KNOB 1914 (10022) and LITTLE 1934 (20016), were used to control adjustment C. The final adjustment (D) was scaled and oriented *via* the centre and west stations, WEBSTER 1939 (10023) and WINN (1929). All nets consisted of 854 stations. Adjustment B contained 3,690 degrees of freedom and adjustments C and D 3,684 degrees of freedom. (See table 36 for other statistics.) Note that the variance for adjustment B is only slightly smaller than the variances for adjustments C and D, which are identical. Furthermore, the average and maximum residuals for the B, C and D adjustments are identical.

**Table 36. United States of America: observational data for multiadjustment test of geodetic network**

| | Class | Adjustment A[a] | B | C | D |
|---|---|---|---|---|---|
| Average residual | 1 | 0.″382 (8 479) | 0.″383 (6 725) | 0.″383 (6 725) | 0.″383 (6 725) |
| | 2 | 0.427 (5 519) | 0.454 ( 570) | 0.454 ( 570) | 0.454 ( 570) |
| | 3 | 0.446 ( 42) | 0.522 ( 2) | 0.524 ( 2) | 0.524 ( 2) |
| Maximum residual | 1 | 2.628 | 3.149 | 3.149 | 3.149 |
| | 2 | 5.110 | 2.267 | 2.267 | 2.267 |
| | 3 | 4.122 | 0.708 | 0.713 | 0.713 |
| Azimuths: | | | | | |
| Average | A | 0.803 ( 102) | | | |
| Maximum | A | 3.297 | | | |
| Average | B | 1.283 ( 4) | | | |
| Maximum | B | 2.819 | | | |
| Lengths (millimetres): | | | | | |
| Average | T | 5 ( 16) | No corrections were received on the short taped lengths connecting various stations in adjustments A, B, C and D. These lengths are not included in the number shown for adjustment A. | | |
| Maximum | T | 18 | | | |
| Average | G | 7 ( 285) | | | |
| Maximum | G | 36 | | | |
| Variance | | 1.240 | 1.369 | 1.371 | 1.371 |

*Note*: Figures in parentheses indicate number of observations for each accuracy class.
[a] Residuals for high-precision traverse observations included in class 1, A and G tabulations.

*Weights*

The weights used in all adjustments were determined from the following variances or standard errors:

(1) Directions $= \sigma^2 = \sigma_D^2 + 2(0.001/\mathrm{L}\cdot\mathrm{Sin}1'')^2$ where "L" = length and the following values for $\sigma_D$:

| | $\sigma_D$ |
|---|---|
| High-precision traverse | 0.″5 |
| First-order | 0.6 |
| Second-order | 0.7 |
| Third-order | 1.2 |
| Other | 3.0 |

(2) A: azimuths $\sigma_A^2 = (0.45)^2 + (0.80)^2 + (\mathrm{Tan}\,\phi/0.80)^2 + (0.40\cdot\mathrm{Sin}\,\phi)^2$;
B: azimuths $\sigma_A^2 = (2.00)^2$;
A: azimuths are those observed on two nights which meet first-order specifications;
B: azimuths are those observed on a single night or introduced into the network by means of horizontal observations to azimuth marks.

(3) Lengths $= \sigma^2 = \sigma_{L_1}^2 + (\mathrm{L}\cdot\sigma_{L_2})^2 + (0.00005\cdot\Delta\mathrm{H}/3)^2$, where for the classes of length measurements used in adjustment A;

| | $\sigma_{L_1}$ | $\sigma_{L_2}$ |
|---|---|---|
| Taped | 10 mm | 0.5 ppm |
| Geodimeter | 15 mm | 1.0 ppm |

$\Delta H$ is the difference of elevation in metres between the stations and is neglected when the elevations are determined by spirit-levelling.

(4) Doppler positions $\sigma_\phi = 0.9$ m and $\sigma_\lambda = 1.2$ m.

Although only the first-order nets were used in adjustments B, C, and D, a number of second- and third-order (class 2 and 3 in table 36) observations were included to maintain a cohesive system. In all cases, the class 3 observations involve short lines connecting the original and replacement stations and in adjustment A the close points in the sliver polygons of the high-precision traverse.

Tabulated in table 37 are the position shifts resulting from the adjustment at the "Doppler" stations. Note that there are small corrections to these stations even though only two points are involved. This is due to the influence of short distances connecting various stations and the fact that the positions were not rigorously held fixed. Shifts resulting when the positions were unconstrained are not shown.

Table 38 is a summary of the relative accuracy estimates in the form of standard errors which have been expressed in the case of the lengths in the form of proportional parts. These values were, for the most part, over lines for which measured lengths and astronomical azimuths were available in adjustment A.

**Table 37. United States of America: position shifts resulting from adjustments at "Doppler" stations**

| | | Adjustments | | |
|---|---|---|---|---|
| | | *B* | *C* | *D* |
| North Station | $\Delta\phi$ | − 0.00351 | + 0.00003 | |
| | $\Delta\lambda$ | + 0.02248 | + 0.00001 | |
| West Station | $\Delta\phi$ | − 0.00680 | | − 0.00003 |
| | $\Delta\lambda$ | + 0.00262 | | + 0.00008 |
| South Station | $\Delta\phi$ | + 0.01699 | − 0.00003 | |
| | $\Delta\lambda$ | + 0.00619 | − 0.00001 | |
| East Station | $\Delta\phi$ | − 0.00863 | | |
| | $\Delta\lambda$ | − 0.03129 | | |
| Center Station | $\Delta\phi$ | + 0.00150 | | + 0.00003 |
| | $\Delta\lambda$ | − 0.00001 | | − 0.00008 |

**Table 38. United States of America: summary of relative accuracy estimates in multiadjustment test**

| | Adjustments | | | |
|---|---|---|---|---|
| | *A* | *B* | *C* | *D* |
| Lengths: | | | | |
| Average proportional part 1 | 650,000 | 178,000 | 156,000 | 90,000 |
| Least proportional part 1 | 141,000 | 87,000[a] | 85,000[a] | 68,000[a] |
| Number less than 1:300,000 | 12 | | | |
| Number less than 1:100,000 | | 5 | 6 | |
| Number less than 1:85,000 | | | | 16 |
| Azimuths: | | | | |
| Average $\sigma$ | 0.″456 | 0.″974 | 1.″188 | 1.″959 |
| Maximum $\sigma$ | 0.977 | 1.551 | 1.645 | 2.312 |
| Number greater than 0.″8 (A); 1.″2 (B); 1.″4 (C) and 2.″2 (D) | 5 | 13 | 9 | 4 |
| Sample | 113 | 90 | 90 | 90 |

[a] Involving the same points, one determined through a single closed triangle.

In reviewing the data tabulated in table 38, it was found for adjustments B, C, and D, that the relative proportional part estimates for those lines worse than the standards (1:100,000 for adjustments B and C and 1:85,000 for adjustment D) were located at the extremes from the control points. Many of the lines that fail to meet the standard for adjustment A (1:300,000) are better than 1:200,000. In addition, there are newly observed distances and azimuths in almost every case nearby which were not included in the adjustment.

Table 39 summarizes comparisons between measured distances and astronomical azimuths and the corresponding results obtained in adjustments B, C and D.

As has been the general case, most differences in excess of 2″ were over lines at a considerable distance from the control points.

In the final tabulation (table 40), the average relative accuracy estimates between the arcs are presented. These estimates were determined from north to south and from east to west across the areas and are given in two forms for the lengths, the average and maximum $\sigma$, and similar proportional part quantities. Only the average and maximum $\sigma$ are shown for the azimuths.

## Conclusion

It is readily apparent from a review of the data presented here that geodesists have a powerful and accurate tool in the form of Doppler positions for strengthening existing networks and for establishing the fundamental framework in those areas which are now devoid of control, to which conventional geodetic networks may be fitted. Although the inclusion of Doppler positions cannot eliminate observational problems, there are occasions where it might be possible to uncover poor observations or network geometry not previously suspect. For example, Meade found in the South Carolina—Georgia test, mentioned earlier, at least one astronomical azimuth which appeared to be in error by about 3″. A similar situation apparently exists in this network, as reported in the explanatory note for table 39. The mere fact that an astronomical azimuth receives a small correction in an adjustment, such as the "A" solution, does not, in itself, assure that the observation is entirely satisfactory. Lastly, there are one or two length comparisons to which no acceptable answer for the rather large differences was found.

**Table 39. United States of America: summary of comparisons between measured distances and astronomical azimuths and corresponding results obtained in adjustments A, B and D**

| | *Adjustments* | | |
|---|---|---|---|
| | *B* | *C* | *D* |
| Lengths: | | | |
| Average difference (metres) | 0.100 | 0.125 | 0.116 |
| Maximum difference (metres) | 0.259[a] | 0.350[a] | 0.300[a] |
| Average proportional part[b] 1 | 317 000 | 285 000 | 277 000 |
| Average proportional part[c] 1 | 156 000 | 140 000 | 147 000 |
| Least proportional part 1 | 44 000[d] | 46 000[d] | 42 000[d] |
| Number less than 1 : 100 000 | 14 | 26 | 16 |
| Number less than 1 : 75 000 | 3 | 10 | 9 |
| Sample | 60 | 60 | 60 |
| Azimuths: | | | |
| Average difference (seconds) | 1.30 | 1.38 | 1.48 |
| Maximum difference (seconds) | 4.10[e] | 4.34[e] | 4.61[e] |
| Number greater than 2″ | 4 | 5 | 5 |
| Sample | 22 | 22 | 22 |

*Note*: The same stations were involved in every case where the differences exceeded 2″. In one instance, the correction from adjustment A was −3″30. The differences from adjustments B, C, and D were −3″69, −3″75 and 3″48, respectively.

[a] Between the same two points at the extreme eastern edge of the network. The distances between the stations is 26 718 m.

[b] Average including entire sample.

[c] Average excluding all proportional part differences better than 1 : 500 000.

[d] Between the same two points in a rather geometrically weak base expansion figure.

[e] Between the same two points at the south-western corner of the net.

**Table 40. United States of America: average relative accuracy estimates between arcs**

| | *Adjustments* | | | |
|---|---|---|---|---|
| | *A* | *B* | *C* | *D* |
| Lengths: | | | | |
| Average $\sigma$ (north-south; metres) | 0.08 | 0.27 | 0.30 | 0.62 |
| Maximum $\sigma$ (north-south; metres) | 0.15 | 0.44 | 0.52 | 1.13 |
| Average proportional part 1 | 785 000 | 235 000 | 200 000 | 100 000 |
| Least proportional part 1 | 530 000 | 175 000 | 160 000 | 90 000 |
| Average length | 58.5 | | | |
| Average $\sigma$ (east-west; metres) | 0.09 | 0.29 | 0.34 | 0.66 |
| Maximum $\sigma$ (east-west; metres) | 0.13 | 0.43 | 0.49 | 0.96 |
| Average proportional part 1 | 730 000 | 235 000 | 200 000 | 100 000 |
| Least proportional part 1 | 470 000 | 175 000 | 160 000 | 95 000 |
| Average length | 62.9 | | | |
| Azimuths: | | | | |
| Average $\sigma$ (north-south) | 0″28 | 0.″86 | 1″07 | 1″87 |
| Maximum $\sigma$ (north-south) | 0.42 | 1.15 | 1.30 | 2.06 |
| Average $\sigma$ (east-west) | 0.30 | 0.85 | 1.07 | 1.87 |
| Maximum $\sigma$ (east-west) | 0.44 | 1.14 | 1.20 | 2.03 |

# NAVSTAR GLOBAL POSITIONING SYSTEM*

*Paper presented by the United States of America*

The development of a new satellite navigation system to replace the TRANSIT system in the 1980s will bring a new era to land, sea and air navigation and to geodesy and mapping. While TRANSIT provides navigators intermittent position fixes in a horizontal plane, the NAVSTAR Global Positioning System (GPS) will provide continuous positioning in three dimensions with a potential for significantly improved accuracy. This objective will be achieved when all of the 24 satellites of the system are placed into orbit, expected to be accomplished in 1984.

The new system will also replace the TRANSIT system as the beacon for Doppler geodetic surveying. However, the TRANSIT system will continue in operation until 1994 to provide a 10-year overlap. It is expected that conversion of existing navigation and geodetic tracking equipment to utilize the new system will be developed.

Plans for GPS receiver design include incorporated computer capability to provide real-time three-dimensional position read-out, probably to an accuracy of less than 10 m in earth-centred co-ordinates, which will bring a significant change in the relationship between surveyors and the user community they support. It will become quite important for the surveyor and mapper to provide information to the user to permit him to relate correctly the GPS co-ordinates to maps, charts and other similar reference materials.

* The original text of this paper appeared as document E/CONF.68/L.119.

## (b) *Large-scale and medium-scale mapping (including topographic mapping and photogrammetry)*

# THE MODBLOCK PROGRAMME FOR PHOTOGRAMMETRIC BLOCK ADJUSTMENT*

*Paper presented by Australia*

As is well known, the purpose of aerial triangulation in general, and block adjustment in particular, is to economize on the amount of ground control required in mapping from photogrammetric models.

A single model has seven degrees of freedom (three displacements parallel to the axes, three rotations about the axes and a scale change) and so requires seven constraints to fix it in space so that it can be mapped. These are customarily two pairs of plan co-ordinates ($X$, $Y$) and three height co-ordinates ($Z$). If each model in a block is controlled in this way, mapping of the block is possible.

It is true that such mapping suffers inconveniences from small differences in the co-ordinates of points common to adjacent models, necessitating some manual smoothing during the plotting. One of the advantages of aerial triangulation is that it obviates this need, but this was not its prime purpose, which was to reduce the amount of ground control needed to level and scale the models for plotting.

The principle is that since successive models in a strip overlap have a common aircraft camera station, it is theoretically possible to use the constraints that common points in the overlaps and common camera stations must have the same co-ordinates. This process in effect makes up a strip like one long model with seven constraints only required to fix it in space, although mathematically in a strip of 50 models (say), at seven degrees of freedom per model, 350 equations would still need to be solved. These equations alone would occupy about 60,000 words of computer storage.

In the past, this difficulty was overcome by using a first-order plotter to observe the models. This apparatus effectively joins successive models into one long model, and the number of constraints is slightly increased to allow bending of the model when fitting it to ground control. This is the basis of the popular polynomial method of adjustment, wherein it is assumed that errors have gradually crept in while forming the strip and that it must be systematically unbent when tilting, rotating and scaling it to fit the ground control. Although less rigorous than solving 350 equations simultaneously, it is very effective and does not require a large computer.

First-order plotters are no longer used, however, and models are observed independently, to be subsequently joined up into a strip by computer in a simulation of the first-order plotter observational procedure, prior to adjustment to ground control by the polynomial method.

The whole process is most economical in that the number of co-ordinates to be supplied as ground control is only a fraction of the seven per model necessary for individual model plotting. It is of the order of 14 for a strip, depending upon the form of polynomial adopted. In practice more ground control co-ordinates are used, but by using a method of least-squares adjustment, the number of equations to be solved is not increased. The additional values allow errors to be detected and also improve accuracy.

In blocks of photography, the strips must overlap to ensure complete coverage, and it can be asked if the fact that common points to adjacent strips should receive the same co-ordinates could be used to supply constraints that could permit blocks to be built up with economies in ground control, in the same way as strips are built up from models.

The situation is not exactly parallel as there are no common camera stations in the aircraft between overlapping strips as there are between overlapping models in a strip. Nevertheless, studies have shown that as far as planimetric control points ($X$, $Y$) are concerned, none at all are required in a block except at the edges. There are fewer economies in height ground control ($Z$), but there is more latitude in positioning of control points. Moreover, whereas models must follow one another in a strip, strips in a block do not all have to be parallel and follow one another. There may be cross strips, filler strips and reflys, all of which complicate the problem.

There is no first-order-plotter type of mechanical solution, and nothing really satisfactory apart from the Jerie analogue computer was achieved until electronic computers came into use. The most common method now is the simultaneous polynomial adjustment of all strips of a block, in which the number of equations to be solved is the number of strips times the number of equations to adjust one strip. This number can quickly

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.29.

mount up, but there are iterative processes that permit the solution to be carried out on a medium-sized computer.

In a block adjustment, the disadvantages of the polynomial method of adjustment become apparent. It assumes that the distortion in a strip is regular, which is not really so. This disadvantage is of little import in a single strip where there is insufficient information to discover the true distortions. In a block adjustment, the many common points in the side laps of parallel strips give a great deal of information as to the progress of distortion, which information is not fully utilized in a polynomial adjustment imposing regularity.

The answer is a rigorous adjustment where all models, each with seven degrees of freedom, are adjusted simultaneously; or all photographs, each with six degrees of freedom, are adjusted simultaneously as in a bundle adjustment from comparator observations. This procedure involves the solution of many thousands of equations and would exceed the capacity of even large computers. Thus, a block of 300 independent models requires the solution of 2,100 equations.

Special methods have been devised to bring the labour within the capacity of a modern large computer; even so the programming effort is great. Three successful solutions can be mentioned.

The firm of DBA in the United States of America appears to have an excellent programme. It is understood that this firm carries out adjustments commercially for a fee.

The other two, the Programme Package for Aerial Triangulation with Independent Models (PAT-M43) of Stuttgart University and the Model Block Adjustment (MODBLOCK) programme of the Division of National Mapping are similar in concept, but differ in detail and in the all-important solution of the equations. Both are independent model adjustments. The Stuttgart programme is available commercially.

The MODBLOCK programme was written in Iran 10 years ago by C. W. B. King, who is now with the Division of National Mapping. At that time, it ran on a medium-size computer, an IBM 7040, and utilized five tape drives. It was subsequently expanded and improved to run on the UNIVAC 1108, and the current version runs on the Control Data Corporation (CDC) CYBER 76.

The principle upon which the programme operates is that the seven unknowns of each independently observed model are solved simultaneously for all models of a block in a full least-squares solution. The constraints are that all transformed values of observations of ground control points should as nearly as possible fit their true ground values, and that all transformed values of observed points in a model must as nearly as possible fit their transformed values in every adjacent model (if any) in which they also fall. This means that each model is made to fit all its neighbours at once, irrespective of the way strips have been flown; and it is clearly better than the polynomial method of forming up strips as a first step, without considering overlapping strips, and then holding the model connexions fixed in the subsequent adjustment.

The number of equations to be formed and solved is great, but the process is broken down into stages that do not affect the rigour of the solution.

It will be clear that strips may be at varying scales, may overlap in any fashion and need not necessarily be parallel. In Australia, the mapping photography is flown east-west to cover a map at 1 : 250,000 scale and three north-south tie strips are flown across each map area. The simultaneous adjustment of this pattern of photography permits the amount of height control to be reduced.

The dimensions of the programme are large: there may be up to 90 strips of 50 models each. There may not be more than 1,000 points in any one strip, but longer strips may be treated as two strips. Up to 2,100 control points are permitted. Control points may be genuine usable points or check points, or a mixture with usable plan co-ordinates and a check height co-ordinate. Check points are not used in the adjustment but their residual errors are obtained and printed. Their use provides a convenient means of testing doubtful control values. A control point does not necessarily have to have all three co-ordinates supplied.

Since independent models are usually observed with a mixed base, the programme accepts the first pair of projection centre co-ordinates supplied as applying to all models until there is a change of base, as can occur when a reobserved model is inserted or when more than one plotter has been used for the observations. However, the base can change at every model, as is the case with the Planimats or PG2s as used by the Division; and to facilitate their use the space rod constant can be automatically applied by the programme. Earth curvature corrections may also be applied by the programme.

A feature that makes the programme easy to use is that sorting routines have been incorporated. The user has only to take the two principal points and the two projection centres as the first four points of every model. He does not have to specify that a point is a control point, a check point, a connexion point between models of a strip, a tie point between strips or a single point. The discrimination is done for him automatically. The final transformed co-ordinates are set out model by model for ease of plotting, with all common points correctly meaned over all the models in which they appear. Within each model, points are sorted in order of ascending point name. This is valuable for dense models as in cadastral work.

Subsidiary programmes plot the vectors of residuals at control points and/or check points for visual interpretation of the validity of the adjustment and also plot all transformed co-ordinates on base sheets for mapping.

The Division of National Mapping will be happy to make the MODBLOCK programme available to any prospective user at this meeting who has access to a sufficiently large computer.

## DIGITAL PHOTOGRAMMETRY AND AUTOMATED MAPPING: APPLICATION TO LARGE SCALES*

*Paper presented by France*

The study in progress since March 1974 is designed to perfect a processing line for the digital data provided by photogrammetric plotters. The experiments have been carried out on scales varying between 1 : 5,000 and 1 : 1,000.

### OBJECTIVES

The objectives of the study are:

(*a*) To obtain from the digital data a graphic document of sufficient quality to supersede, with respect both to form and to cost and production time, the "provisional technical documents" issued by the Institut géographique national (IGN);

(*b*) To develop sophisticated symbolization programmes that would permit cartographic documents to be produced in a format as close as possible to the material regularly produced by IGN;

(*c*) To compile in due course a planimetric and altimetric file capable of yielding graphic output within the criteria set by users as concerns the choice of scale, the sheet-line system, the system of plane representation, symbolization, features to be selected and so on.

### SUMMARY DESCRIPTION OF THE PROCESSING LINE

The processing line comprises the following tasks:

(*a*) Plotting on a stereoplotter with magnetic tape-recorder of the *X*, *Y* and *Z* co-ordinates of the stereo model (currently the PRESA RC 411) and of the codes required for identification;

(*b*) Compilation of two-level working indexes on line with the IBM 370/135 central computer (first level, physical description of elements; second level, topometric description of points); display and control by automatic plotting on the Calcomp 718 plotting board;

(*c*) Correction of detected errors: directly on the working indexes (batch processing); "blow by blow" on the Contraves tracer-digitizer or on the Tektronix/PDP 8 interactive display console; by complementary digitizing on the D-MAC digitizer;

(*d*) Processing of the working indexes (corrections, final adjustments, symbolization) on the IBM 370/135 central computer;

(*e*) Graphic output symbolized on the Contraves precision tracer;

(*f*) Filing.

### PROVISIONAL CONCLUSIONS OF THE STUDY

The current line is still only experimental but should become operational before the end of 1976. At first, it should permit 200 sheets (1 : 5,000 or 1 : 2,000 scale) to be produced annually, at an average cost of less than 20 francs per hectare, through the introduction of the following equipment:

(*a*) A photogrammetry shop producing three pairs a day (probably about 10 machines);

(*b*) A medium-capacity central computer (two disc units, four magnetic-tape units, 192,000 central memory);

(*c*) One quick plotting board;

(*d*) One precision tracer;

(*e*) Two correction systems on an interactive console.

The anticipated time for the preparation of a complete sheet might be 5–10 days from the end of the photogrammetry operations.

* The original text of this paper, prepared by Mr. Saumonneau, Institut géographique national, France, appeared as document E/CONF.68/L.8.

## DIGICART: UNIVERSAL SYSTEM OF LARGE-SCALE MAPPING*

*Paper presented by the German Democratic Republic*

The rapid rate of industrial and agricultural development in the German Democratic Republic has led to an ever-growing demand for large-scale mapping. First and foremost, up-to-date large-scale maps are needed with different contents and on various scales for the construction of industrial plants and traffic roads, as well as for housing, building and amelioration. The map-users are also calling more and more frequently for the required data to be provided in a shorter period of time and in digital, automatically processable form.

In view of the current availability of efficient surveying and photogrammetric instruments, as well as automatic data-processing machines, the Geodetic Service of the German Democratic Republic has developed a geodetic-cartographic information-processing system known as Digicart. According to object and scale this system permits:

* The original text of this paper, prepared by H. Göhler, German Democratic Republic, appeared as document E/CONF.68/L.26.

(*a*) The economical manually assisted production of large-scale maps with a sufficient degree of accuracy;

(*b*) The provision of data that can be digitally programmed.

The entire technique has been unified with instruments supplied by VEB Carl Zeiss-Jena. It has thus been possible to create the prerequisites to satisfying the steadily increasing need for large-scale maps and to a large extent to meet the special demands of many different kinds of map-users.

## Data acquisition

The Digicart system is able to process data obtained from aerial photographs, geodetic-numerical surveys, maps or lists of co-ordinates.

Photogrammetric data acquisition is given priority. First a field identification is carried through with the help of enlarged aerial photographs for supporting digital photogrammetric stereoplotting. In addition to inscribing horizontal details, symbols etc., complementary and control measurements are carried out simultaneously. The model co-ordinates are then determined in the stereometrograph (VEB Carl Zeiss-Jena) and transferred to punched tape by means of the Co-ordimeter F.

Geodetic data acquisition is used either for complementing photogrammetric acquisition or as an independent method, e.g., tacheometric survey. The survey of points can be made with the help of intersection, radiation or orthogonal surveys. Thus, the well-known surveying instruments Dahlta 010 A, Theo 020 A, Redta 002 or BRT 006, all made by VEB Carl Zeiss-Jena, can be employed for obtaining input data to the Digicart system. The data are registered into special field notebooks and then transferred to punched tape.

Similarly, any digital data already stored or data obtained from graphic documents by means of *X-Y* digitizers can also be provided for automatic processing. For this purpose the Präzisionskoordinatograph (VEB Carl Zeiss-Jena), coupled with Co-ordimeter F, has also proved successful. All these methods of acquisition can be applied independently of one another or in any combinations.

Besides co-ordinates, data are required which express the relations between points (semantic information) and serve to complete a graphic file of this nature. In the Digicart system these data are represented by operation key numbers. They indicate the arithmetical, graphic and updating functions to be carried out. For separate programming, the co-ordinates are recorded separately from the sequence of operation key numbers. Therefore, each point must be assigned a number as the order date for combining the two parts of the programme. For integrated programming, the operation key numbers are recorded together with co-ordinates, so that such order data are not necessary.

Lastly, control data (redundant observations) and parameters (figures of sheet lines etc.) are to be made available for automatic processing.

## Data processing and output

For numerical transformations and data reductions, a complex programme has been developed in FORTRAN and modified for the BESM6 computer made in the Union of Soviet Socialist Republics. The programme system consists of several segments activated by a supervisory programme according to the programme versions and kind of data offered. Large objects have to be divided into sections. In each section not more than 1,200 ground-plan points can be treated. The following storage capacities are required:

(*a*) Main storage with 40,000 words or more for routine programmes and operating array;

(*b*) External storage with 400,000 or more words for input data and intermediate quantities.

In automatic processing, extensive test routines provide for sufficient error detection. The largest segment of this programme system is the compilation system, which interprets and performs the arithmetical and updating functions. Thus, the inevitable random errors in measuring are eliminated in such a way that they do not have a negative impact on the final results, which would reduce their usefulness; and the demands of rectilinearity, rectangularity and other requirements are met. The programme also provides for a comparison of control elements measured immediately on the ground, with values resulting from the co-ordinates as calculated.

The final results are made available: as digital values on magnetic tape and clear text; and as control data on punched tape for automatic drawing by means of a Cartimat (VEB Carl Zeiss-Jena).

Not only can the content of the internal storage be made completely available but it can in part be selected according to sheet line or scale. Furthermore, a co-ordinate list stored in an external storage is controlled, corrected and supplemented by performing particular editing functions that are also indicated by special operation key numbers. The data of the plotter drive tape are processed in the Cartimat by means of the special computer in on-line mode. The maps are drawn in pencil, ink or ball-point pen on drawing paper or by negative scribing on plastic drawing material or glass, as needed.

For collecting and preserving cartographic products, a complete microfilming system, known as Pentakta, is available. It consists of camera, developer, printer, diazo-copying unit, reader-printer, reader, microfiche storage and organization means, made by VEB Pentagon-Dresden and VEB Carl Zeiss-Jena; Orwo films supplied by VEB Filmfabrik Wolfen are used for that purpose. With this equipment, photographs can be taken of scribing originals, monochrome and multicoloured editions, half-tone documents etc. based on the use of 105 x 148 mm microsheet films. In addition, there are possibilities for duplicating and re-enlarging; which are done with high accuracy and optimum representation of details.

## Advantages and applications

Digicart is a universal information-processing system

for obtaining, processing and providing the data required in large-scale mapping. The advantages lie mainly in: (*a*) the automatic processability of data obtained from various sources; (*b*) the output possibility in automatically processable digital form and in the form of maps.

The system is particularly useful for:

(*a*) Making cadastral maps in connexion with numerical operations, such as calculating areas or setting up land register files and real-estate documentations;

(*b*) Manufacturing all kinds of projection papers (site plans, special plans for the representation of supply lines etc.) on the scales 1 : 5,000 or over in connexion with calculations for digital terrain models;

(*c*) Updating basic Digicart files;

(*d*) Supplementing maps of various kinds.

The broad use of the Digicart system makes it possible to build up a current data base with a great variety of applications, to reduce access time for the data required and to accelerate the entire process of large-scale map-making. The multiple use of such files and the reduced cost of field-work increase efficiency. The Digicart system can also be used for correspondence with data banks and active display technology. A number of reports describing the theoretical basis of Digicart, practical experience of the system and the instruments used in it have appeared in *Vermessungstechnik*, the periodical on geodesy, photogrammetry and cartography published by the German Democratic Republic, and in *Vermessungsinformationen* and other publications by VEB Carl Zeiss-Jena.

## PROGRESS IN AERIAL TRIANGULATION FOR MEDIUM-SCALE AND SMALL-SCALE TOPOGRAPHIC MAPPING*

*Paper presented by the Federal Republic of Germany*

The methods of block adjustment have greatly reduced the requirements for horizontal control by allowing perimeter control for even very large blocks. The effect on reduction of vertical control has not been as marked. However, with the use of airborne auxiliary data, in particular of statoscope data or Airborne Profile Recorder (APR) profiles, block triangulation becomes strikingly independent of vertical control, permitting bridging of very large areas without geodetic control. The simultaneous adjustment of block data and auxiliary data is a most efficient tool for exploiting the high accuracy capability of such systems.

This paper reviews the available test results and presents theoretical accuracy studies. Conclusions are drawn for project planning. Aerial triangulation has become vastly independent of geodetic vertical control, thus greatly relieving the economic and technical problems of topographic mapping.

### Background information

Topographic mapping for national map series on the scales 1 : 250,000 or 1 : 200,000, 1 : 100,000, 1 : 50,000, or up to 1 : 25,000 has long been a standard task in most countries. Although photogrammetric methods, including aerial triangulation techniques, have been available and applied for more than 40 years, progress has often been slow, mainly for two reasons: it was difficult to obtain photographic coverage for large areas, at sufficiently small photographic scales; and it was often difficult, time-consuming and expensive to establish the required geodetic ground control.

The development of super-wide-angle cameras and of high-altitude aircraft has made the aerial photography problems less stringent. Establishing horizontal and vertical geodetic ground control, however, has remained a serious obstacle in many cases, in spite of the application of conventional aerial triangulation techniques. However, recent developments in aerial triangulation have reduced the requirements for ground control to a very great extent.

### Horizontal control

The development of powerful computer programmes for block-adjustment during the past few years has most strikingly reduced the requirements for horizontal control for blocks at any scale, in particular for medium- or small-scale mapping projects.

Theoretical studies have shown, and practical tests have confirmed, that it is sufficient to have horizontal control along the perimeter only of a block: the area inside the block needs no horizontal control. With regard to accuracy,[1] such perimeter-controlled blocks are particularly distinguished by two features:

(*a*) The accuracy after rigorous adjustment is rather uniform and very high in absolute terms; it is almost as good as for fully controlled single models;

(*b*) The remarkably high accuracy is only slightly dependent upon block size. Referring to the same photographic scale, the theoretical accuracy of the largest possible perimeter-controlled blocks deteriorates very

* The original text of this paper, prepared by Professor F. Ackermann, Institute of Photogrammetry, Stuttgart University, Stuttgart, Federal Republic of Germany, appeared as document E/CONF.68/L.90.

[1] For further information, see F. Ackermann, "On the theoretical accuracy of planimetric block triangulation", *Photogrammetria*, vol. XXI (1966), pp. 145–170; and H. Ebner, "The theoretical horizontal accuracy of adjusted blocks up to 10,000 independent models", *Nachrichten aus dem Karten und Vermessungswesen* (Frankfurt am Main), vol. II, No. 27 (1972), pp. 52–61.

little (less than a factor 2) compared with small blocks of some photographs only, although the area covered is very much larger.

There are two essential corollaries. First, it is possible to apply numerical block triangulation for high-precision point determination, which leads to the application of aerial triangulation methods for densification of geodetic networks of second or third order and for point or boundary determination for cadastral purposes. Such large-scale, high-precision photogrammetric point determination by block triangulation has been successfully applied. It is, however, not the subject of this paper and shall not be further dealt with here.

Secondly, for small-scale mapping, very large blocks are feasible, with horizontal perimeter control only. Thus, block triangulation can cover very large areas, without any known geodetic points within the area, and still meet all accuracy requirements of topographic maps on the scales 1 : 100,000, 1 : 50,000 or 1 : 25,000.

On the scale 1 : 50,000, for instance, 0.2 mm in the map correspond to 10 m in the terrain, or to 140$\mu$m in, say, a photographic scale of 1 : 70,000. There is obviously a great accuracy margin which may be utilized for effectively relaxing the perimeter control.

The ratio of perimeter to area becomes steadily smaller the larger the area is. Thus, the larger the block, the fewer control points needed per area. This basic relation explains the trend to use large blocks in small-scale mapping. It is effective when ground control is expensive or time-consuming to obtain. In fact, the determination of horizontal control has often been a most serious, limiting bottleneck. It has been effectively removed or considerably reduced by the possibility of simultaneously adjusting large blocks, which can be considered a major breakthrough in the development and practical application of aerial triangulation.

Of course, there are some practical considerations which limit the workable size of blocks. Blocks of 2,000 photographs have been successfully treated, and block sizes of 1,000 or more photographs have recently become standard for small- and medium-scale mapping in a few countries.[2]

## Vertical control

Contrary to horizontal control, the requirements concerning vertical control have not been substantially improved by the development of block-triangulation methods. The vertical accuracy of adjusted blocks is dominantly determined by bridging distance, i.e., by the distance between chains of vertical control which run across the block. Because of the high vertical accuracy often required for small- or medium-scale mapping (contour intervals of 20 m, 10 m or even 5 m), the allowable bridging distances are in most cases limited to perhaps 10 base lengths or less in respect of distances of 50 km or less in the terrain. Within each chain of control the vertical control points must not exceed distances of two base lengths (equal to width of strips), in order to control the lateral tilt of strips within the block. Thus, the use of large or very large blocks has no particular advantage as concerns the necessary vertical control. In particular, vertical control is required also inside the block area.

It is true that the geodetic determination of vertical control points (for instance, by barometric methods) is less costly and less time-consuming than of horizontal control points. Nevertheless, it is often a critical problem, and any reduction of the requirements would be highly beneficial.

The theoretical possibility of taking photography with a 60 per cent lateral overlap and thus reducing the requirements for vertical control to some extent is not considered in small-scale mapping projects. Also, some caution would be suggested because of the greater sensitivity of such blocks with regard to systematic image errors and model deformation.

## Auxiliary data

It has long been known that some of the auxiliary data for camera orientation stabilize greatly the vertical accuracy of strips and blocks and potentially allow considerable reduction of vertical control requirements.[3]

However, during the past 20 or 30 years, there has been scarce utilization of auxiliary data from horizon cameras, solar periscopes, gyroscopes or even statoscopes. It is practically only the radar or laser Airborne Profile Recorder which has had rather regular application, for the purpose of small-scale mapping. The rather expensive equipment and the required level of electronic maintenance have limited the regular and successful utilization of APR data to a few firms and national mapping organizations. The application has indeed succeeded in considerably reducing the vertical control requirements.

In view of the subsequent part of this paper, it should be pointed out that the APR profiles were usually utilized for adjustment purposes in a two-step procedure. Each APR profile was oriented separately on to vertical control at the beginning and the end by starting and closing over known heights (possibly even outside the block area). Such adjusted APR terrain profiles in respect of selected points of them were subsequently used as vertical control points for conventional strip or block adjustment. This method implies that the remaining errors of the pre-adjusted APR profiles are fully superimposed on the strips of photographs, affecting their height accuracy. Nevertheless, the procedure gave height accuracies in the order of 2–4 m, being sufficient for mapping with contour intervals of 50 m, 20 m or 50 feet.

[2] J. R. R. Gauthier, J. H. O'Donnell and B A. Low, "The planimetric adjustment of very large blocks of models: its application to topographical mapping in Canada"; M. E. H. Young, "1 : 50,000 mapping in Canada" *Bildmessung und Luftbildwesen* (Karlsruhe), No. 41 (1973), pp. 205–212; H. Ebner, "1 : 50,000 mapping in Canada: a comment on the comparison of the computer programs PAT-M43 and SPACE-M", *Bildmessung und Luftbildwesen*, No. 43 (1973), pp. 78–79.

[3] H. G. Jerie, "Theoretical height accuracy of strip and block triangulation with and without use of auxiliary data", *Photogrammetria*, vol. 23 (1968), pp. 19–44.

More recently, laser profile recorders have become available. They are flown separately from the main photographic flight mission, at low-altitude missions. Such profiles across a block can replace height control to some extent. Flown along the photo strips in the areas of lateral overlap of strips they have even been used to avoid aerial triangulation altogether (concerning heights). In all cases, the conventional method has been used, of orienting each profile separately and accepting the result as vertical control for the subsequent strip or block adjustment in respect of the vertical orientation of stereo models.

### Simultaneous block adjustment with auxiliary data

From a theoretical point of view the auxiliary data (statoscope or APR data in particular) have, in the past, not been used most effectively. The two-step solution of adjustment neglects internal relations and sacrifices accuracy to quite some extent. In addition, vital checks on gross errors and possibilities for statistical accuracy evaluation are abandoned.

Such short-comings are remedied by the development of computer programmes for block adjustment which simultaneously treat and adjust the auxiliary data as observations, together with the photogrammetric measurements. Combined adjustment programmes have been worked out, particularly for statoscope and APR data, which are the only auxiliary data which are currently of interest.[4]

This is not the place to explain the methods of joint adjustment. The results have been most remarkable, however, particularly with respect to improved accuracy, the possibilities of internal checks and accuracy assessment, and the flexibility or rather the almost complete independence from terrestrial vertical control. The practical result is a breakthrough concerning the reduction of requirements for vertical control which is even more striking than it was previously for horizontal control. The available test results with statoscope and APR data will be reviewed and some conclusions drawn.

### Accuracy results of controlled tests

Very few controlled test results are available for photogrammetric blocks, simultaneously adjusted with statoscope or APR data. It is well known that such tests are very costly. The available tests show, however, that the vertical accuracy capability of joint adjustments is much higher than hitherto believed.

#### *International Institute for Aerial Surveys and Earth Sciences—Saudi Arabian APR project*

The APR project of the International Institute for Aerial Surveys and Earth Sciences (ITC) and Saudi Arabia concerns a grid of aerial survey strips rather than complete photographic coverage.[5] Flying altitude was 5,400 m and the grid extended over 800,000 km$^2$, with no control inside. Only a few check points were available; they showed an average absolute height accuracy of 1.6 m, after simultaneous adjustment of APR profiles and photogrammetric strips. It indicates and confirms an unexpectedly high vertical accuracy capability of a combined system which is essentially relying on airborne barometric measurements.

#### *"Oberschwaben" test*

The well-known "Oberschwaben" test of the Organisation Européene d'études Photogrammétriques Expérimentales (OEEPE) refers to a test area of 40 × 62.5 km with more than 400 vertical check points. With a photographic scale 1 : 28,000, both with wide-angle and with super-wide-angle photography, the standard block size was eight strips with 25 models each. together with the flight missions, recordings with a statoscope (Zeiss S2) were taken.

The investigations into the accuracy of the statoscope measurements against a linear isobaric correction gave 0.89 m ($h_{abs}$ = 4,990 m) and 0.79 m ($h_{abs}$ = 3,085 m) over distances of 62.5 km. Both values amount to about 0.7 reading units of the instrument.

The results of the combined adjustment of statoscope readings and independent model blocks are summarized in table 41.

**Table 41. Federal Republic of Germany: Oberschwaben test, controlled vertical accuracy after combined adjustment of independent model blocks and statoscope data**

| *Bridging distance* | *Vertical accuracy* $\mu_z$ |
|---|---|
| Wide-angle, $h_{abs}$ = 4990 m | |
| $i$ = 62.5 km = 25 b | $\mu_z$ = 0.84 m = 0.20 per 1000 of height |
| $i$ = 31 km = 12.5 b | $\mu_z$ = 0.67 m = 0.16 per 1000 of height |
| Super-wide-angle, $h_{abs}$ = 3085 m | |
| $i$ = 62.5 km = 25 b | $\mu_z$ = 0.58 cm = 0.24 per 1000 of height |
| $i$ = 31 km = 12.5 b | $\mu_z$ = 0.55 cm = 0.23 per 1000 of height |

The detailed investigations of the adjustments confirmed a very high stability of the isobaric surface. They also confirmed a high accuracy capability of the statoscope measurements (average residual errors after adjustment against linear correction for the isobaric

[4] See, for example, F. Ackermann, H. Ebner and H. Klein, "Combined block adjustment of APR data and independent photogrammetric models", *The Canadian Surveyor*, vol. XXVI (1972), pp. 384–396.

[5] For further details, see J. Kure, "APR experience and application (with special emphasis on the Saudi Arabia project)", *ITC Journal* (1973/74), pp. 618–639.

surface: 0.38 m (weight average), 0.35 m (standard weight average). The limit appears to be determined by the resolution of the instrument rather than by the physical properties of the atmosphere. The complete results have been reported.[6]

*South-western Ontario APR-test*

The APR test in south-western Ontario (Canada) refers to a block of five strips of about 76 models each, on photo scale ≈ 1:33,000, extending 25 × 250 km. The photographic strips were flown with simultaneous APR profiles. In addition, 10 APR cross-profiles were flown from 2,000-m altitude, all closing on lakes. The adjustment and accuracy investigations are described in Klein.[7] Some of them are listed in table 42; they refer to 170 vertical check points.

**Table 42. Federal Republic of Germany: some results of Airborne Profile Recorder test in South-Western Ontario, Canada**

| | *Controlled vertical accuracy* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Full block* | | | *Half-block* | | | |
| *Bridging distance between Airborne Profile Recorder cross-profiles (kilometers)* | *76 b 250* | *38 b 125* | *19 b 60* | *38 b 125* | *19 b 60* | *10 b 30* | *5 b 5* |
| Test 3[a] (metres) | 2.77 | 1.91 | 1.72 | 1.85 | 1.56 | 1.36 | 1.37 |
| Test 8[b] (metres) | 1.86 | 1.69 | 1.63 | 1.67 | 1.61 | 1.54 | 1.55 |
| Test 10[c] (metres) | 1.45 | 2.13 | 1.53 | 2.06 | 1.45 | 1.22 | 1.17 |

[a] Vertical control points at both ends of block; Airborne Profile Recorder (APR) profiles not controlled.

[b] No vertical control points, longitudinal APR profiles closed on lakes (simultaneously) and APR cross-profiles not controlled.

[c] As in[b], cross-profiles closed on lakes and correction for systematic error for APR on lake surfaces.

The Ontario test also demonstrates the high stability of the isobaric surface which allows vertical accuracies of better than 1–2 m for bridging distances of 250 km. The test also confirms the effectiveness of the combined adjustment of photogrammetric blocks with the auxiliary data. The conventional two-step adjustment of all APR profiles (including all APR cross-profiles) would have resulted in a vertical accuracy after block adjustment of only 3.24 m.

ADDITIONAL FEATURES OF THE COMBINED ADJUSTMENT

The test results of combined block adjustments with statoscope or APR data have shown unexpectedly good vertical accuracy. Such results have been confirmed by various practical applications, especially in Canada and Venezuela.[8] Before further elaboration of the accuracy results some other features of the combined adjustment should be mentioned:

(*a*) Statoscope or APR-profile data are treated as observations. They can therefore be given proper weights, according to the physical circumstances;

(*b*) The adjustment yields residual errors (corrections) to the statoscope or APR data. Thus, the accuracy features can be checked and assessed. In particular, the behaviour of the isobaric surface becomes visible, and gross data errors show up;

(*c*) Data blunders can be deleted without adverse effects. Because of the combined adjustment the bridging effect of the block adjustment takes over. It is accurate enough to allow omission of auxiliary data over one or several models. For the same reason, it is sufficient to select only well-identified points from the APR profiles.

(*d*) The adjustment includes free unknown orientation parameters for the isobaric reference surface separately for each statoscope or APR line. It is therefore unnecessary to have vertical control for the independent orientation of each statoscope strip or APR profile, which gives great freedom for project planning. Separate profiles or strips are interconnected through the photogrammetric block by the combined adjustment. Thus, a network of profiles can be used;

(*e*) If necessary, strips or profiles can be interrupted by treating them as separate lines, each with its own set of orientation parameters, which are determined by the ties with the photogrammetric models;

(*f*) Statoscope measurements and APR profiles have essentially the same accuracy features, as much as they depend upon isobaric surfaces. However, APR profiles, especially from separate low-altitude flights, can be carried outside the block area to known heights (e.g., lakes or rivers). Cross-strips with statoscope readings have effects similar to APR cross-profiles;

(*g*) Terrain profiles, not necessarily straight, which are known from other sources of information (e.g.,

[6] F. Ackermann, "Accuracy of statoscope data—results from the OEEPE-test Oberschwaben", in International Society of Photogrammetry, Committee III, *Proceedings of the Symposium 1974* (Munich, Deutsche Geodatische Kommission, B 214, 1975), pp. 280–286.

[7] H. Klein: "Results from the South-western Ontario APR test-block", in International Society of Photogrammetry, Committee III, *Proceedings of the Symposium 1974* (Munich, Deutsche Geodätische Kommission B 214, 1975), pp. 97–103.

[8] W. Faig, "Independent model triangulation with auxiliary vertical control"; and M. M. Allam, C. K. Wong and C. K. Chaly, "Geometrical distribution of vertical control and the simultaneous adjustment of auxiliary data in independent model triangulation", both papers presented at the Thirteenth Congress of the International Society of Photogrammetry, Committee III, Helsinki, Finland, 1976.

regularly sloping rivers) can be properly considered in the adjustment (by treating them as fictitious APR profiles).

## Project planning for topographic blocks

At the Institute of Photogrammetry of Stuttgart University the accuracy properties of blocks with statoscope or APR data are being studied in a thesis by H. Klein. The test results as described above and other experimental data have been statistically analyzed and used as a basis for theoretical studies. The results confirm the expectation that with APR or statoscope flights extremely large areas can be bridged without vertical control. Tables 43 and 44 display briefly some essential results, concerning statoscope flights alone and statoscope flights with additional low-altitude APR cross-profiles. In all cases vertical control is assumed only at both ends of a block. The error assumptions can claim to be realistic ($o_o = 20\,\mu m$ for photogrammetric $z$ measurements).

**Table 43. Federal Republic of Germany: theoretical accuracy of blocks with simultaneous statoscope measurements and combined block adjustment** (*Photographic scale 1 : 50 000; no cross-strips*)

| *Block size, models (square kilometres)* | *10 × 10 45 × 45* | *10 × 20 45 × 90* | *10 × 40 45 × 180* | *10 × 60 45 × 270* | *10 × 80 45 × 360* |
|---|---|---|---|---|---|
| Wide-angle ($h$ = 7 650 m) | | | | | |
| $\sigma z$ mean (metres) | 1.2 | 1.4 | 1.5 | 1.5 | 1.6 |
| $\sigma z$ maximum (metres) | 1.9 | 2.1 | 2.3 | 2.4 | 2.5 |
| Super-wide-angle ($h$ = 4 250 m) | | | | | |
| $\sigma z$ mean (metres) | | 1.4 | 1.5 | 1.6 | 1.6 |
| $\sigma z$ maximum (metres) | | 2.1 | 2.3 | 2.5 | 2.6 |

**Table 44. Federal Republic of Germany: theoretical accuracy of blocks with simultaneous statoscope measurements, additional low-altitude[a] Airborne Profile Recorder cross-profiles without control and combined block adjustment**

| *Airborne Profile Recorder cross-profiles number* / *"Bridging" distance (kilometres)* | *0 360* | *1 180* | *3 90* | *7 45* | *15 22.5* |
|---|---|---|---|---|---|
| $\sigma z$ mean (metres) | 1.6 | 1.3 | 1.2 | 1.1 | 1.1 |
| $\sigma z$ maximum (metres) | 2.5 | 2.2 | 2.0 | 1.7 | 1.6 |

*Note*: Photographic scale 1 : 50 000; wide-angle (h = 7 650 m); block size 10 × 80 models = 45 × 360 km².

[a] Height, 1500 metres.

The results of tables 43 and 44 show that very long distances can be bridged, provided statoscope measurements are taken together with the photographic flights. Additional APR cross-profiles (or statoscope cross-strips) improve the accuracy. Still, very large distances can be allowed. Similar results are obtained when at the beginning or end of a block only few vertical control points (e.g., the four corners only) are given and statoscope cross-strips or APR cross-profiles are used instead.

Contrary to the cases described above, the application of longitudinal low-altitude APR profiles gives comparable results only if they are taken along each lateral overlap of adjacent strips.

As far as project planning for small- or medium-scale mapping projects is concerned, the results can be summarized as follows.

### *Statoscope*

Statoscope measurements, taken together with the aerial survey photographic flight, are highly effective auxiliary data. With vertical control at both ends of a block they allow bridging of areas for up to 200 or 300 km (or more), still giving sufficient accuracy for contour intervals of 10 m or larger. This is not very dependent upon photographic scale and is equally valid for wide-angle and for super-wide-angle photography. If necessary one or two cross-strips (with statoscope) stabilize and control the lateral tilt errors of the longitudinal strips.

Minimum vertical control comprises four control points in the corners of a block. In this case, statoscope cross-strips at both ends of the block are required. With photographic scales between 1 : 20,000 and 1 : 40,000, statoscope controlled blocks are sufficiently accurate for contour intervals of 5 m or 20 ft.

Because of the inexpensive equipment and the simple data handling it is highly recommended to take statoscope measurements at virtually any photo flight for medium- or small-scale topographic mapping purposes.

In view of the inherent accuracy capability of airborne barometric measurements, it is suggested to improve the resolution of statoscopes by at least a factor of 2, as compared with current equipment. At the same time, the measuring range should be increased.

### *Simultaneous APR profiles*

Except for special cases, the conventional way of obtaining APR profiles together with the photographic strips may be abandoned in future. Practically the same results (or better) can be obtained in a much simpler and considerably less expensive way by statoscope alone.

### *Additional low-altitude APR profiles*

Additional low-altitude APR profiles should normally not replace the statoscope measurements referred to above. They can replace, however, additional statoscope cross-strips. Their main application is given when the photo block has no (or nearly no) vertical control, which must be brought in over some possibly long distance, for instance, from the sea.

## Assessment and conclusions

Summarizing the experimental and practical evidence as well as the theoretical investigations, it can be stated that airborne auxiliary data based on barometric measurements are highly effective tools for obtaining vertical accuracy with very little vertical control. The combined adjustment with photogrammetric blocks allows the bridging of almost arbitrarily large areas for the purposes of topographic mapping on scales between 1 : 25,000 and 1 : 100,000, with contour intervals of 10 m or smaller. Application for 5-m contour interval appears feasible.

In particular, the use of the inexpensive statoscope instrument is highly effective and economical, also in view of the related simple handling of data.

The development is considered a breakthrough for small- and medium-scale mapping, as far as the extreme reduction of vertical control requirements is concerned. The reduction is even more striking than that achieved by block-adjustment methods with regard to planimetric control.

The vertical accuracy capability of airborne barometric measurements turned out to be unexpectedly high. Future statoscope equipment should have improved resolution. There is evidence that statoscopes may be economically applied with larger mapping scales, for contour intervals of 5 m, 2.5 m or 2 m. Further research is required into the behaviour of isobaric surfaces, at altitudes above 7 km and below 3 km, and with regard to possible disturbing effects. It is expected, however, that the foregoing conclusions regarding small- and medium-scale mapping will remain valid within a very wide range of application.

## SPECIAL-PURPOSE TOPOGRAPHIC PLANS IN THE UNION OF SOVIET SOCIALIST REPUBLICS*

*Paper presented by the Union of Soviet Socialist Republics*

The constant growth of the national economy gives rise to the necessity of increasing topographic surveys on the scales 1 : 500, 1 : 1,000, 1 : 2,000, 1 : 5,000 and 1 : 10,000, expanding the field of their applications and specializing the topographic plan contents in compliance with the demands of different branches of science and economy.

In order to solve these problems in the most effective way, there is a unified technical approach in the Union of Soviet Socialist Republics to topographic-geodetic works, to the application of aerophotogrammetric methods to large-scale topographic surveys and to the refinement of conventional signs used in topographic plans. Moreover, provision is made for differentiation of conventional signs taking into account their application either to multipurpose topographic plans or to special-purpose topographic plans, according to additional demands of topographic plans. The term "specialized topographic plan" is used for such special-purpose plans to emphasize that those plans which are in conformity with regular topographic plan requirements have an additional special-purpose application to meet the demands of one or several close branches of the national economy. A specialized topographic plan is not only an independent type of production but a base for making thematic plans for different purposes.

Among the branches undertaking numerous engineering works and projects on the basis of topographic plans are those concerned with agriculture, geological prospecting, land reclamation, mineral mining, hydro energy projects, and road-building and settlement construction.

The principal requirements of different branches with respect to topographic plans are summarized below.

For the purpose of land-reclamation works on irrigation projects, depending upon the area and the means of watering, plans on the scales 1 : 10,000 and 1 : 5,000 with contour intervals of 1 m or 0.5 m are required. For drainage projects, it is necessary to have topographic plans at 1 : 10,000 scale with a contour interval of 1 m (when projecting) and at 1 : 5,000 or 1 : 2,000 scale with a contour interval of 0.5 m (when implementing the project). After land reclamation and land replanning have been completed, the landscape is essentially changed, and the topographic plans needed for waterway engineering should be revised.

To meet the demands of land-reclamation works, a number of additional requirements should be observed. The most important requirements are drawing a line zero-peatbed which is necessary for contouring of peatbogs, determining the depths of not only bogs but lakes, marking the places of ground-water discharges (besides springs); and increasing the number of height marks and vegetation symbols. All those requirements are provided by using in topographic plans two new conventional signs and their 10 combinations.

For agricultural purposes, topographic plans are used in the Soviet Union for land planning, soil and rural mapping and land inventories.

The main scale of rural topographic plans is 1 : 10,000; for heavily farmed and densely populated areas; 1 : 5,000 is used for land areas designated for especially valuable crops. But for difficult terrain conditions (for example, on terraced slopes) the scale is 1 : 2,000.

The main criterion of land representation on such topographic plans is to reflect the economic significance of the land by means of a high degree of detail. On the multipurpose topographic plan, land is represented according to characteristic landscape features with an additional generalized specification of land use. For these two types of topographic plans, different specifications for contouring and representation of prominent terrain features are observed. For specialized topographic plans of agricultural purpose, it is required to have 30 additional new signs and their 75 new combinations, in comparison with multipurpose topographic plans. However, there is no need to use about 230 conventional topographic symbols.

The combination of such different conventional signs

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on the same base plan is impossible. However, it is quite feasible to make two parallel plan bases during one technological process, with one plan being used for multipurpose users and the other (specialized) for demands of any branch of economy.

For geological prospecting, topographic plans are used for exploratory works and for preliminary and detailed prospecting. Scale and contour interval requirements are specified by terrain forms and by the deposit group (i.e, by deposit value, structure etc.). The scales established for such a plan are 1 : 10,000, 1 : 5,000 and 1 : 2,000, with contour intervals of 5 m, 2 m and 1 m, respectively.

Topographic plans for geological prospecting are used for two purposes: for the entire complex of geological works, in the form of a regular multipurpose plan with a full amount of details; and for compilation of report maps in the form of a simplified topographic base. On the latter maps, all the points of vertical and horizontal controls are shown by a common sign; the hydrographic network and roads are given without any characteristics; and vegetation—only by forest boundaries and populated areas—is shown only by block contouring. In general, this system makes it unnecessary to use about 180 conventional topographic symbols.

Many years of practice has proved that there is no need for additional specialized contents to represent the geological situation on regular topographic plans.

For mining and the oil and gas industry, topographic plans of the earth's surface with the terrain situation and relief details are used. Plans of the earth's surface are divided into plans for the already developed territories for the mining enterprise at 1 : 5,000 scale with contour intervals of 2 m and 5 m, and plans for future enterprise construction projects at 1 : 2,000 scale with a contour interval of 1 m. These plans should contain regular topographic information and also specialized information, resulting in a differential representation of shaft frames and shaft collars, drifts and diggings, and communications of different types.

About 30 new signs and their five combinations are needed for the above-mentioned topographic plans; but in the case of a densely detailed concentration, it is necessary to make a basic plan and a specialized plan separately.

For the oil and gas industry, topographic plans should contain both topographic and mining geodesy data. When projecting deposit development works, plans at 1 : 10,000 scale with a contour interval of 2 m or 5 m are required over the whole oilfield and gas-field; when projecting main constructions and the location of development wells, topographic plans at 1 : 5,000 scale with contour intervals of 1 m or 2 m are needed; and for mining projects and communication lines, topographic plans at 1 : 2,000 scale with the same contour interval are required. The entire complex of objects additionally characterizing details and density of topographic plans for the oil and gas industry (pipelines and wells for different purposes, pumping and compression stations etc.) made it necessary to introduce 11 new special symbols and their five combinations.

For the purpose of populated settlement area construction, topographic plans are used for planning and building up, with different topographic materials being required for towns and for settlements of a rural type.

For general urban planning, reference topographic plans on the scales 1 : 5,000 and 1 : 10,000 are necessary. They are used for construction site projecting; and for reconstruction of old blocks, building-up of new residential districts etc. Plans on the scale 1 : 2,000 are required for detailed projects for the planning of towns and industrial urban regions, for town communications and for the planting of greenery in the built-up districts of towns. For non-built-up urban areas within the town boundaries, plans at 1 : 5,000 scale are used.

As for planning and building up rural populated areas, it is necessary to have a plan at 1 : 10,000 scale for projecting land use and rural economy; and a reference plan of current land use and a general plan, both on the scale 1 : 5,000.

In contrast to regular topographic plans, on urban and rural plans contours are drawn through buildings and road signs, and underground communications are presented with additional characteristics. In total, there is no need for specialized topographic plans for the purpose of settlement construction.

To provide for hydroenergy works construction in the Soviet Union, topographic plans have been produced at 1 : 10,000 scale with a contour interval of 1 m or 2 m for plains areas, and at 1 : 5,000 scale with a contour interval of 2 m or 5 m for mountainous areas. For construction sites of hydroelectric power-stations, plans at 1 : 2,000 scale with a contour interval of 0.5 m or 1 m are used. For territories that are contiguous to the storage-lake banks, i.e., populated areas and agricultural land, plans on the scales 1 : 5,000–1 : 2,000 with a contour interval of 1 m are required; for dam and locks construction, plans at 1 : 2,000 scale with a contour interval of 0.5 m are needed.

As for the contents of these plans, there has been one addition resulting in the representation of the bottoms of large rivers and reservoirs, with the help of not only depth marks but their absolute marks, as well as by main contours.

Line construction refers to railway and motor-road construction, transmission and communication lines and pipelines. Engineering railway works are provided with regular topographic plans, except for road construction for which some particular additions should be observed. For railway engineering works, topographic plans on the scale 1 : 1,000 are used for plain relief and on the scale 1 : 5,000 for hilly relief; on a land strip with a width of not less than 300 m and plans at 1 : 2,000 scale for mountainous relief; for construction sites, plans at 1 : 2,000 scale with a standard contour interval. Specialized topographic plans of routes should represent more detailed information, in comparison with regular topographic plans, about screens, landslides, karst forms and river floods—that is, everything that should be particularly taken into account in line construction.

For the purpose of motor-road engineering works, topographic plans at 1 : 10,000 scale are required for plane and hilly relief of the land strip with a width of not less than 100 m; and for mountainous relief,—plans at 1 : 5,000 scale, with plans on the scales 1 : 2,000 and 1 : 1,000 for the hardest parts of the route. For all these plans details of density and contour intervals are the same as for regular topographic plans. When projecting large bridge passage locations, plans on the scales 1 : 10,000 and 1 : 5,000 are needed in addition to regular topographic plans: situation plans should also show the characteristics of the river during a flood.

An analysis of the use of topographic information and of current plans for specialized purposes is necessary in the following cases:

(*a*) When the contents requirements of regular and specialized topographic plans differ so greatly that it is impossible to have the detailed density of both plans on the same base the plans should be made separately, but in one technological process: for example, plans for mining and for the oil and gas industry;

(*b*) When the contents requirements of specialized topographic plans predetermine the introduction of new details in addition to the contents of regular topographic plans, it is opportune and expedient to make one plan with combined details; the main example is a topographic plan for land-reclamation purposes;

(*c*) When the contents requirements of regular and specialized topographic plans differ slightly, sometimes the regular plan is more detailed than is demanded for the specialized topographic plan. In such cases only the regular multipurpose topographic plans are produced. Examples are topographic plans for all types of construction and plans for geological prospecting.

## INSTRUMENTATION AND TECHNIQUES FOR MODERN CARTOGRAPHY*

*Paper presented by the United States of America*

### Background information

Increased emphasis on producing cartographic data in a flexible form to meet many user needs has caused cartographers in the larger mapping organizations of the United States of America to develop new instruments and techniques. Virtually every element of map-making is being scrutinized for applications of analogue and digital electronics and associated computer storage and processing: aerial photography from self-controlled inertial platforms; field surveying with gyros, lasers and computers; photogrammetric triangulation and compilation with digital controllers, correlators and minicomputers; map finishing with automated plotting and phototypesetting systems; and map reproduction by laser recorders.

The complex society in which mankind lives today is placing ever-increasing demands on the cartographic community to provide more complete and timely information for use in studying basic human needs—food, shelter, energy, acceptable environment and other national needs. Careful planning is required to meet these needs, and one of the first steps in planning is to acquire reliable cartographic data that can be processed quickly and easily. Modern cartography is striving to provide the data required. In general, modern cartography employs a variety of programmable instruments and associated software plus suitably modified operational techniques. Much of the new technology has resulted from the application of analogue and digital electronics to the various cartographic processes. Some instrumentation and technique developments are in the conceptual stages while others are operational as third-generation systems are being developed. However, to meet future requirements of users of cartographic data, many new projects must be undertaken; therefore, research and development must be considered never-ending.

The trend of development in modern cartography is greatly influenced by restrictions on manpower and money. In particular, the large government mapping agencies in the United States of America, such as the Defense Mapping Agency (DMA) and the United States Geological Survey (USGS), face the dilemma of increasing demands for their products, e.g., digitized data in support of many users' problems, concurrently with administrative demands for reducing manpower and the budget. Consequently, there is an increasing effort to automate the tedious and time-consuming tasks of cartography and to reduce drastically the amount of non-productive data handling by means of machine data exchange and standardization of digital data codes and formats. Most United States government agencies responsible for collecting and producing cartographic data are now developing digital techniques and systems for map and chart, photographic-image and data processing. The range of the state of development and degree of productive use varies widely; but collectively, the mapping organizations in the United States are developing and using: (*a*) photogrammetric and cartogrphic digital collection systems ranging in complexity from hand-operated line-tracing and simple stereo digitizers, through computer-controlled line-followers, to complex raster scanners and automated photogrammetric systems; (*b*) interactive systems in which an operator identifies ambiguous details and corrects errors; (*c*) precision

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automated drafting and type-placement systems; and (*d*) associated software packages.

Density-slicing technology is being explored for semi-automatically extracting map data from imagery. Electronic technology has given the ground surveyor and geodesist instruments that quickly provide precise distances, positions and elevations. In the larger mapping and charting organizations, the core of future map and chart production will be a digital cartographic data base that will enable users interactively to recall and extract data and produce the desired graphics. The capabilities of easy maintenance and changing of digital data will revolutionize and economize the revision of map and chart detail. The ultimate goal is to provide the cartographer with the ability to record huge volumes of map data in digital form suited for easy processing and recall.

The future exploitation of cartographic data will encompass two major forms of use. Conventional graphic maps and charts, supplemented by orthophotographic products, will maintain their important places in civil and military government and industrial use. In addition, the current ground swell of uses for digital data will become a tidal wave. Use of digital data has begun in industrial and civil agencies, but it is already significant in military mapping and charting.

In general, mapping projects comprise the following major steps: (*a*) acquisition of photographs; (*b*) establishment of field control; (*c*) aerotriangulation to extend the control and relate it to the photographs; (*d*) either stereo or cartographic compilation, or both; (*e*) editing; (*f*) colour separation or map finishing; (*g*) printing or reproduction; and (*h*) distribution. Modern cartography is undergoing major changes in several of these elements. For example, stereo and cartographic compilation are transformed into recording digital data. The editing process is becoming an interaction between man and machine. Map finishing becomes automatic with digitally controlled plotting equipment. Some distribution will soon become electronic transmission of digital data.

## Aerial photography

Early photographic missions carried whatever cameras were available for aerial use, either hand-held or fixed somehow to the aircraft. Without attempting to provide a history of development, one can say that cameras have been considerably improved since the days of George W. Goddard and his first photographic missions for the Army Air Corps. The focal lengths and formats were different from those of today. Most of the photographs used by United States mapping and charting agencies are now taken with European cameras of 15-cm focal length and 23-cm square format. To a lesser extent, photographs taken with 8.5-cm lenses are used for compiling 5-ft interval contours in areas of low relief, and photographs taken with 21-cm and 30-cm lenses are used in orthophoto mapping and photo-interpretation. Cameras with lenses of even longer focal lengths are used for reconnaissance. In 1974, USGS began an extensive programme in the 7½-minute series (1 : 24,000 scale) to produce 5,000 orthophotoquads per annum from quadrangle-centred (quadcentred) photographs. The quadcentred photographs (one photograph covers at least an entire quadrangle) are taken with a 15-cm lens at a flight height of 12,000 m or more.

Recent developments have resulted in a proposal for two bore-sighted cameras, focal length 22.5–25 cm, format 23 × 35 cm, and resolving power 80 l/mm AWAR (as compared with 60 l/mm for the current 15-cm lenses). The cameras would be carried by an aeroplane with an inertial guidance system precise enough to provide accurate overlap forward and sideways along parallel flight lines several hundred kilometers long. The inertial platform would measure the altitude of the camera within a few seconds of arc. An on-board digital computer would master-mind the system, collecting and recording data and controlling operations.

## Field surveying

Recently developed navigational systems are now being applied to the task of establishing ground control for mapping. The Position and Azimuth Determining System (PADS) consists of an inertial platform and a velocimeter mounted in a truck or other vehicle. A commercial version, the Auto-Surveyor, was recently introduced by the firm that developed the military version. The Auto-Surveyor is composed of an inertial measuring unit, power supply, digital processing unit, control console, digital display and cassette tape-recorder. For maximum accuracy, the system requires a zero-velocity update in which the vehicle is periodically stopped (zero velocity) and the system automatically levels the platform to local gravity, computes the effect on previous observations and updates the elements needed for computing forward. As a traverse continues with periodic zero-velocity updates, the computer accumulates information about and compensates for gravimetric anomalies. The system works well for straight survey lines but is less accurate when abrupt changes of direction are included. A similar procedure, the hovering update, has been tested in a helicopter at low heights (2–4 m above ground) with good horizontal results. Extensive tests indicate the system has sufficient accuracy (standard deviations of 0.74 m in latitude, 0.71 m in longtitude and 1.00 m in elevation) for mapping operations.

Another inertial system under development could provide vertical ground profiles by measurement from a small aeroplane. The position and elevation would be measured by an advanced inertial system, and the air-to-ground distances would be measured by a laser altimeter. The system is called the Aerial Profiling of Terrain System (APTS) and is being developed under contract. It will comprise the following subsystems:

(*a*) An inertial platform to compute continuously the latitude, longitude and elevation of the aeroplane;

(*b*) A laser monitor to recalibrate periodically by observations on retroreflectors stationed on known ground points;

(*c*) A laser altimeter to measure air-to-ground distance coupled with a closed-circuit television imaging system for tracking the laser beam on the ground;

(*d*) A computer with magnetic-tape recorder to process the measurements, provide in-flight guidance and record the data.

APTS can be a powerful tool for collecting the profile data needed for flood and water-basin studies and for establishing ground control for mapping.

### Photogrammetric operations

Requirements for photogrammetric instrumentation and techniques are determined, to a large extent, by new-mapping programmes. For the most part, photogrammetric data collected in the future will be extracted and recorded in digital form. Several conventional photogrammetric systems are available for collecting digital data manually or automatically, and new systems are being developed to improve significantly the capability in the immediate future.

DMA, in a continuing effort to increase productivity, has integrated photogrammetric equipment at the Aerospace Center at St. Louis, Missouri, by means of pooled minicomputers in a total distributive processing system. The system consists of 13 AS-11B-1 stereoplotters, 15 AS-11A stereoplotters, 6 TA3/P stereocomparators, 2 Advanced Compilation Equipment (ACE) units, 1 ACE editor and 1 ACE post-processor. The pooled complex provides the following advantages:

(*a*) Economy is achieved because the memory and peripherals of the central computer are shared with all satellite control computers, eliminating costly peripherals for each satellite computer;

(*b*) Magnitude and complexity of on-line computation that can be accomplished is significantly increased by the central computer;

(*c*) Programming on the central computer can proceed concurrently with production;

(*d*) The central minicomputers provide computations previously done off line by a separate large computer;

(*e*) A base is established for transmitting large volumes of data to support operations of the ACE/BX systems and for collecting digital data.

Specific instrument advantages are: increase of 9 per cent in AS-11B-1 and AS-11A productivity and of 25 per cent in total man-hour productivity; and increases of 43 per cent in TA3/P stereocomparator instrument-hour productivity and of 14 per cent in man-hour productivity.

As funds become available, USGS is replacing the optical-projection stereoplotters (ER-55 and Kelsh) used in analogue photogrammetric operations with optical-mechanical instruments, such as the Kern PG 2, Wild B8 and Zeiss F-2. The newer plotters provide increased viewing resolution, versatility and measuring accuracy, and can easily be fitted with digitizing accessories readily available from several manufacturers. The approximate inventory of USGS analogue stereoplotting equipping now includes 160 optical-projection plotters and 85 optical-mechanical plotters; 25 units of the latter are equipped with profile, point or continuous-mode digitizing accessories; and six units have digitally controlled plotting-tables.

Precise computer-controlled analytical stereoplotters and stereocomparators are continuously being improved and used more extensively in mapping operations. These instruments make it practical to apply digital controllers and comprehensive software for correcting systematic errors and for data processing. They can also accept a variety of photographic materials as input for preparing new maps and revising old maps. Automatic image correlators for analytical plotters further automate the process of gathering digital terrain profile data and also speed up stereo compilation.

Currently, USGS is using for production two AS-11B analytical stereoplotters modified with state-of-the-art digital computers and associated servo-systems; four model AS-11A-1 plotters (one unit equipped with an improved image correlator system) will be added to the production line within the year. Each of the six analytical plotters will be connected to a control computer, and each control computer will be connected to a central processing unit to form a pooled operation. The central computer will serve for input/output and provide background processing of data common to all systems in the pool, while the control computer will directly control the analytical plotter.

An automated stereocomparator (TA3/P1) is also being added to reduce control-point measuring time, improve accuracy and permit using a variety of source materials. The system comprises a three-stage, large-format stereocomparator connected to an electronic computer and associated input/output equipment. The system provides the capability of measuring point co-ordinates in the stereo mode with only minor refinement required at each point measured. Known correction constants and calibrated réseau and fiducial co-ordinates can be stored in the computer and applied directly to refine measured co-ordinates.

Orthophotographs and the products associated with orthophotography are now widely accepted as useful cartographic tools. In addition, special-purpose maps on orthophoto-image bases are recognized as a resource with a variety of planning uses. Several actions have been taken to increase the production of orthophoto products.

The eight manually operated orthophoto-producing instruments in use by USGS have been improved for more dependable operation. Precision has been improved by increasing the rigidity of the mechanical components, and new optical and exposing system components have been provided.

A system for manual production of digital profile data and subsequent automatic exposure of ortho-negatives has been developed and put in production. With this system, a group of stereoplotters can produce digital terrain profile data on magnetic tape. The aerial photographs are then scanned with a high-resolution ortho-projector (Zeiss GZ-1) automatically controlled by the

magnetic-tape data in a playback system. The profile-generation position of the system provides servo-control of the $x$, $y$ and $z$ (optional) axes. The $x$, $y$ and $z$ data are recorded on magnetic tape in a machine code directly readable by the playback system; four profiling instruments and two orthophoto projectors are currently in operation.

A second-generation automated orthophoto-producing instrument, the Gestalt Photo Mapper 2, is being used by USGS primarily for producing high-quality orthophotographs of areas of complex terrain. The system has the added capability of producing a digital terrain model (750,000 points per stereo model) and a contour plot simultaneously with the orthophoto. The time needed to produce these three products for a single stereo model ranges from 1 to 4 hours, depending upon terrain relief and image quality. The instrument consists of an operator's console, minicomputer, magnetic-tape unit, four travelling stages (two input scanners and two output printers) and associated electronic hardware. The system depends upon sophisticated software.

## Cartographic operations

Major changes are being made in the cartographic and map-finishing production and distribution areas. Thus, instrumentation for these operations has changed radically in the past several years.

### *Data-collection systems*

Many new digital systems for acquiring cartographic data have been developed, ranging from simple digitizing tables and tablets for hand-tracing of line data through raster-scanning systems to sophisticated computer-controlled automatic line-following systems with interactive editing.

Manual data-collection systems are being used throughout the country in research and in production digitizing of control-point positions, public-land survey corners, political boundaries, contours and land-use data. Raster scanning and line-following devices with laser beams are being used to collect cartographic data from new map manuscripts. Laser technology has improved the performance of these devices over those using cathode-ray beams so that data collection is extremely fast and flexible. Associated electronic recording components and applications software have been developed to a semi-operational level; however, further improvements are required before the systems are truly operational and cost effective.

DMA has been digitizing topographic data since 1962. In the first system, contours only were digitized manually by an operator, who traced the contour pattern with the aid of an etched aluminium plate. Computer programmes then transformed the contour information into a grid of elevations spaced 63.5 m apart at ground scale. The elevation grids were used, for example, in studies of radio-wave interference, defilading and simulations for military applications. Complete ditigizing systems were installed in all these DMA production centres in 1974. Single-station digitizing tables were installed in the five USGS mapping centres in 1976. The primary purpose of each digitizing system is to convert hard-copy source material, such as maps and photographs, to digital data. The data can then be stored and processed by a computer to provide cartographic products and digital information.

The DMA digitizing system contains four subsystems: digitizing table; minicomputer display; system control computer; and proofing plotter. The digitizing table is the primary input device. It has a free-moving stylus and can be used either with the reticle on top of the digitizing surface or with a reticle projected from below the surface. The table resolution is 0.01 mm, accurate within 0.05 mm.

The feature is recorded by moving the digitizing stylus along it. The data are stored in the second subsystem, a buffer called the minicomputer display, which has an 8,000-word memory. The minicomputer functions basically as a control computer for the controller system. It also drives a graphic-display cathode-ray tube (CRT) that both provides a "menu" for selecting data headers or labels before digitizing and shows the data as digitized. Errors appearing in the last 13 cm of work can be corrected.

The system control computer indexes the data and stores them in a disc pack. It has a 64,000-word memory, a variety of options such as memory protection, three industry-compatible tape drives, a 250,000-word fixed-head disc, two 10,250,000-word disc packs and a line-printer. As the name implies, this computer controls the function of the entire digitizing system and can handle up to 10 work stations simultaneously with a maximum response time of 5 seconds.

The digitized data can be plotted for verification on the proofing plotter, the fourth subsystem. Overlays of the plot are made and corrections annotated. The plot is then registered to the source from which the digital data were derived, and necessary corrections are digitized.

Two generations of data-collection instruments beyond manual line-tracing and dititizing are passing from final research and development into production. One instrument is an automatic line-follower and the other is similar to manual line-tracing except that optical sensors automatically follow the line and continually record $x$ and $y$ positions as the detail is traversed. In the second instrument, line detail to be digitized is mounted on a rotating drum, under a sensing-head. The drum spins in the $x$ direction, and the sensing-head traverses in the $y$ direction. All detail "hits" as small as 0.025 mm are recorded as individual spots of digital data. Extensive computer reformatting is then necessary to connect all the separate hits into continuous line detail. The major drawback in this type of data collection is the massive amount of computer processing required.

### *Data-editing systems*

To date, engineers and scientists have not been able to develop instruments with enough intelligence to replace

the map editor. Very different editorial processes, involving interactive editing systems, are required for dealing with digitized cartographic data.

Most of the previously described automated systems (for field surveys, photogrammetry and cartography) must be supplemented with digital data-editing of some type. Thus far, few editing systems are available off the shelf. The trend has been to assemble special systems that satisfy specific needs with components obtained from several manufacturers.

DMA is currently conducting operational tests of an editing system that contains; (*a*) a PDP-11/45 computer controller with 64,000 16-bit words of core memory; (*b*) CRT displays, one a small-scale, direct-view, line-drawing storage tube; and the other a large-scale, high-speed, high-capacity, line-drawing refresher display with a position light and function keyboard; (*c*) a digitizing table; and (*d*) editing software routines. USGS is buying a similar editing system, which will be composed of a minicomputer (96,000 16-bit words of memory) and peripheral equipment, two high-resolution digitizing tables, a low-resolution digitizing table, a CRT display and keyboard terminal for system control, and CRTs for displaying both edited and unedited digital data. The system can be expanded to include up to eight input stations. Both systems will be used for editing data produced by most digital data-acquisition systems.

### *Map-finishing systems*

Currently, most map finishing is still done manually. The master manuscripts are either scribed or inked by cartographic draftsmen or photo-etched from hand-drafted copy. However, in the past five years, several numerically driven large-format automated plotting systems have been developed that are precise enough to prepare master map manuscripts. Precise automatic drafting systems are being used to draw or write grids, graticules, place-names and marginal information. Various new laser recording systems in use or under development have the same capability plus the advantage of faster throughput. In all these systems, graphic copy is drafted from digital tape input, producing higher quality line-work than the most experienced and conscientious draftsman.

The names information management and type-setting phases of map finishing are also continuously being automated. The first automated system was installed in DMA in 1968. Its subsystems are; (*a*) a computer director to run the system; (*b*) a cylindrical co-ordinatograph at which the operator assigns a type position; (*c*) a phototype composition station at which the size and type style are assigned; (*d*) an automatic photo-composer on which the actual names are assembled and exposed on a 70-mm film strip; and (*e*) a co-ordinatograph photoplotter on which the final type positive or negative is prepared.

The next generation of names placement is currently in research and development and is expected to become operational this year. The type composition station will be similar to the one now in use although it will contain additional operator aids; however, the exposing system will be a CRT display that will place the type by a series of raster-like line strokes instead of the conventional photo-exposing system now used. A standard names sheet should be exposed in as little as 5 minutes.

## Reproduction

The newspaper industry has been providing the impetus for laser facsimile plate-making systems and the potential for follow-on digital data reproduction systems, but to date map and chart plate-making and reproduction have not been affected. However, large-format impact plate-engraving systems are being considered for making press-plates. These systems produce plates from digital raster data tapes and analogue signals from companion raster scanners. They can produce up to eight levels of gray tone as well as conventional line-work. Strong blue and green lasers will be incorporated in several large-format flat-field recorder systems, which will be used either to produce the plate negative or to photo-expose the press-plate directly. The laser instruments normally reproduce up to 16 levels of gray tone as well as conventional line-work. All these systems produce the plates from digital data tapes. Most of them operate from raster data, but two operate by line drawing, and at least one will operate in either mode.

## Standardization

DMA has an extensive standardization programme under way to provide more effective management and efficient exchange of digital map feature and elevation data between production centres. A standard for digital terrain elevation data was issued in November 1974. Subsequent study has resulted in a proposed standard for all DMA digitized map and chart features. The proposed standard uses a product-independent four-digit "feature" code to define each cartographic feature, a four-digit "attribute" code applied only when needed to describe attributes of the feature, and a four-digit "text" code applied in special situations where the text is lengthy as in nautical charts. A catalogue in preparation lists all DMA cartographic features, feature attributes and feature text together with their standard codes. The catalogue also includes cross-references to current DMA centres, the North Atlantic Treaty Organization (NATO), Australian, Digital Radar Landmass Simulation (DRLMS) and Lineal Input System (LIS) data codes. Cartographic hardware and software are also being standardized for compatibility with the new DMA standard for digital map features.

## Production

The diverse product requirements that must be met by most United States mapping organizations has resulted in a wide variety of digital data products and digital production of conventional graphic products. This diversity can best be illustrated by discussing some specific production programmes.

*Defense Mapping Agency Aerospace Center*

At the Defense Mapping Agency Aerospace Center (DMAAC), the automated cartographic system has as a first priority the production of digital data to support military requirements. The initial aim is to solve the problems inherent in available light-optical and new digital radar land-mass systems. The project is evaluating the improved training effectiveness made possible by a truly high-resolution digital radar land-mass simulation system. DMA is developing a new digital data base to be used by the simulator. The data base will cover an area of 150,000 square nautical miles, with features encoded at various levels of resolution depending upon their relative importance. Concurrently, prototype testing is under way on chart production using the new automated capabilities. As more digital capabilities are developed and become practical, they will be gradually phased into production.

*Defense Mapping Agency Hydrographic Center*

At the Defense Mapping Agency Hydrographic Center (DMAHC), the first step in automated cartography production was the development of the digital data base for use in testing a prototype shipboard radar navigation trainer simulator. The project included digitization of all or portions of 18 source graphics, both nautical harbour charts and 7½-minute topographic maps. A recording interval of 40 micrometres was used to provide a definable ground resolution of 1.5 m at 1 : 25,000 scale. The digital data base of DMAHC is being expanded to provide in-house capability and expertise for digital land-mass simulation requirements, digital terrain and cultural data bases and graphic display of radar simulations. Additional digitizing projects include digital production of bottom contour charts and naval warfare planning base charts.

*Defense Mapping Agency Topographic Center*

At the Defense Mapping Agency Topographic Center (DMATC), the automated system is being used first for the production of topographic maps on the scale 1 : 50,000. Equipment consisting of nine lineal digitizers with supporting computers and automatic plotters can produce 250 map-sheets per annum, working two 8-hour shifts. This represents approximately 10 per cent of the annual DMATC production of 2,500 items which include maps, data bases and planning graphics. Digital production capacity is expected to increase to 20 per cent by 1978.

*Topographic Division of United States Geological Survey*

USGS, through its Topographic Division, recently redirected its mapping programme the better to serve the basic cartographic data needs in the outlying areas of the United States. The national mapping programme emphasizes the activities needed to make basic map data and a family of general-purpose maps available to users more quickly and in more usable forms. Certain categories of map information, such as structures, hypsography, streams, lakes and shorelines, are identified as base map data categories. Data in non-base categories will be gathered and maintained by the responsible organization and made available through the national mapping programme, by agreement.

New automated systems, modified analogue systems and general digital cartographic techniques are being used to meet the objectives of the redirected National Mapping Program. With the digitally oriented instruments currently available for production, USGS plans to produce a number of map products in digital form during this calendar year: (*a*) 2,000 Digital Terrain Models (DTMs) as a by-product from orthophoto production with automated and semi-automated instruments; (*b*) 2,000 DTMs from profiles generated on analogue and analytical stereoplotters equipped with digital recording equipment; (*c*) 50 base-category manuscripts digitized by manual and semi-automatic instrumentation; (*d*) 200 non-base-category manuscripts, about the same as produced in the past calendar year.

As illustrated in the discussion of digital data production in the United States of America, the programme of all organizations currently represents only a small percentage of total production. However, one foresees a steady and substantial trend towards more digital data production and production systems for both short- and long-range time periods.

## (d) *Thematic cartography and national atlases*

# THE CONTINUING REVISION OF THE AUSTRALIAN NATIONAL ATLAS*

*Paper presented by Australia*

The preparation and continuing revision of the Atlas of Australian Resources was described at the Seventh Conference.[1] That paper referred to serial publication by the Australian Government between 1953 and 1960 of what later became known as the first series (that is, the first edition) of the atlas, which comprised 30 large map-sheets each with a supplementary booklet. The paper then discussed the gradual replacement of the first series, beginning in 1963, by a second series of similar sized map-sheets and booklets. Lastly, plans were mentioned for a third series of the atlas, expanded in subject-matter but presented on much smaller sheets on which supplementary text would also appear.

### Completion of the second series

All but one of the remaining 10 topics of the second series of the Atlas of Australian Resources have been published since the Seventh Conference and even the last one, "Natural vegetation", may be published by January 1977. In addition, a revised second edition of "Population distribution and growth" (1964) has been produced and another early topic, "Roads and aerodromes", second edition (1967), is also being revised, to prevent it going out of print.

A full list of second series topics is given in annex I. Brief notes about some recent topics are given below.

### *Climate*

The trio of climatic topics was completed with the publication in 1973 of the "Climate" map-sheet, which like many others in the second series, has its subject-matter split up into various aspects, each dealt with on separate small maps of Australia. The difficult task of providing a synthesis of climate is attempted primarily in relation to rainfall and secondarily to air temperature. Appropriately for Australia, the largest scale map depicts rainfall, though more broadly than on the sheet "Rainfall", second edition, by a classification based on the season of maximum rainfall and the annual amount of median rainfall and by showing actual seasonal and annual amounts received at selected places for the 30 years from November 1940 to October 1970 (graphs). A second map of smaller scale shows selected isotherms of average temperature for January and July, and graphs of average monthly maxima and minima; and a third map shows evaporation. Climatic effects on the growth of pastures and allied crops are dealt with on a number of small maps, using recent Australian research in applied climatology. There are also small maps of heat discomfort and of broad climatic types according to Koppen's well-known classification.

### *Water*

The ground-water (1973) and water use (1974) maps completed the trio of atlas topics on water. The ground-water map depicts resources, so vital to the Australian economy in many areas of sparse and unreliable surface supplies, in terms of the yield and salinity of the principal aquifers. This map, at 1 : 6,000,000 scale, is a slightly reduced version of the summary map produced from a major study of ground water made by federal and state water authorities in the early 1970s.

The water use map is a pioneering attempt to produce in map form an Australia-wide synthesis of water consumption. Because of the complexity of the subject-matter and because nearly all the chief water-supply schemes are in eastern and south-eastern Australia and in the south-west, the layout chosen comprises two sectional maps at 1 : 4,500,000 scale and a map of all Australia at 1 : 12,000,000 scale. The main dams are shown with their catchment areas coloured to show purpose (irrigation, urban supply, hydroelectricity generation) and pie graphs show reservoir capacity, average inflow and net yield. The average amounts used in rural areas of consumption and in larger urban centres are also shown. The map at 1 : 12,000,000 scale, as well as showing information on water conservation and use for areas not covered by the sectional maps, shows by uniform point symbols the areas of pastures and various crops irrigated.

### *Land use*

The seven topics on land use and land industries were completed with the publication of "Land use" (1973), the map-sheet for which consists of a single map on the scale 1 : 6,000,000. Because very little land-use

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.31.

[1] "Some features of the Australian National Atlas of Resources", *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*, vol. II, *Technical papers* (United Nations publication, Sales No. E.74.I.25), pp. 386–390.

mapping had been done in Australia during the previous 10 or 15 years, with several notable local exceptions at small scales, a method of compilation was developed for the agricultural areas which used agricultural statistics for small areas as "control" data. The classification, like that used for the first series map "Dominant land use" (1957), is primarily in terms of activity rather than of land cover. The determination of dominant and co-dominant activities was, however, much more objectively carried out; and the principle was also followed of showing smaller minimum areas for the more intensive types of land use.

*Manufacturing*

With the setting-up by the Australian Bureau of Statistics in the late 1960s of a new basis for the collection of industrial statistics, small-area statistics also became generally available, though restricted in all but the larger centres by the requirements of confidentiality. Hence, instead of a number of small maps showing numerous specific types of manufacturing in very broad and rather vaguely defined quantitative terms, it became possible to specify the amount of manufacturing more precisely. The presentation adopted for "Manufacturing industries", second edition (1974) was a map at 1 : 6,000,000 scale showing, by self-scaled triplets of columns, the number of establishments, number of workers and value added in manufacture both in major centres and in many smaller ones. The type of manufacturing is shown distinctively for each measure in 10 broad classes. In addition, inset maps at 1 : 500,000 scale give an impression of the concentration of manufacturing within the nine major centres of manufacturing by choropleth colours representing a cross-classification of density of factories and factory workers.

*Transport*

Transport also is dealt with in a trio of topics. The last topic—"Railways", second edition (1974)—departed from the single-map approach of its first series counterpart by presenting a much greater range and amount of information in a multimap treatment which includes maps showing detail within the major cities. The main map distinguishes the lines of the railway network by gauge, maximum permissible axle load and rail weight as well as by ownership; two maps (at 1 : 15,000,000 scale) show annual flows of goods and of passengers and information on type of commodity handled at major railway centres; and two smaller maps show servicing facilities etc., and the historical development of the railway systems.

*Government*

The first series sheet, "State and local government areas" (1953) was largely a reference map at 1 : 6,000,000 scale to the local government areas of Australia. This sheet served a valuable purpose because so many maps on other topics were based on statistics totalled for individual local government areas. On the second series sheet "Government" (1975), this aim was achieved in half the space, by having a map of Australia at 1 : 15,000,000 scale with successively "exploded" sectional maps on the scales 1 : 6,000,000 and 1 : 750,000, so that each local government area could be shown and identified. In addition, mean population density is shown for rural local government areas; and total population number is symbolized for urban local government areas.

The other half of the sheet shows by a similar arrangement of maps the electoral areas for the federal House of Representatives at the general elections of 1969, 1972 and 1974. This part of the sheet was also a first attempt to sum up recent national electoral history in map form, subdivided columns in each electoral area showing voting at each election.

*Major urban areas*

After careful thought it was decided that one of the last topics issued in the second series should be a sheet dealing specifically with the 10 cities of 100,000 or more population. In these cities live about 65 per cent of the entire population of Australia. The maps presented, which are on the topographic map scale 1 : 250,000, primarily show urban land use. A fairly unusual feature of these maps is that residential areas are shown subdivided by population density. Some indication of daily movements within the cities is also given, by showing transport routes (passenger railways, goods-only railways and major roads) and transport centres (railway terminals, aerodromes and wharves) in strong colours; in addition, the central business districts and major suburban shopping centres appear prominently. To round off the sheet, a small map of Australia shows the population size of the major urban areas and of the 25 next smaller centres (with populations in 1971 of over 20,000). Airline distances are also shown between the six state capital cities, the figures ranging from 650 to 2,200 km.

*Other aspects of completion of the second series*

Another topic recently published is "Locational index" (1975), the map-sheet of which comprises a planimetric general reference map at 1 : 6,000,000 scale with a content derived from the other 29 sheets. The booklet accompanying the "Locational index" map includes a list of virtually all place-names shown in the second series, with latitude and longtitude; and if the place does not appear on this map, a reference to an atlas sheet on which it may be found. A further feature of the map, for readers desiring finer locational detail than that given in the atlas, is that the International Map of the World on the Millionth Scale (IMW) sheet areas are indicated by boundary, name and sheet reference. Using a key provided in the legend, the sheet reference for individual national topographic maps at 1 : 250,000 scale may also be determined.

At the time of writing (September 1976), the last map-sheet of the second series, "Natural vegetation" (in preparation since 1968), was nearly ready for printing. This sheet will be one of the most outstanding contributions to knowledge provided by the second series of the Atlas of Australian Resources, and its booklet will

likewise be an outstandingly authoritative summary in its field.

Because of the prolonged time of preparation of the second series, it was judged necessary to produce "Population distribution and growth", second edition (1975; based on the 1971 and 1966 censuses) to replace the first edition (1964; based on the 1961 and 1954 censuses). (For the same reasons, a second edition of the second series topic "Electricity" had earlier been made.)

A recent decision has been to revise the second edition of "Roads and aerodromes" (1967) rather than merely to reprint it. Since this sheet was produced, a nationally agreed functional classification of roads has been made. The revised map on the scale 1 : 6,000,000 will show the three highest categories as well as the type of road surface and the mean density of all public roads. Moreover, the aerodromes shown need to be revised because of changes in the types of air services provided, including the growth of light-plane "commuter" services.

### Serial production and revision

Very few organizations are so well placed with staff and funds that they can produce an up-to-date and comprehensive national atlas in a couple of years. Furthermore, their efforts to do so may be frustrated by factors beyond their control, notably by delays in the availability of source data for some maps.

The two outstanding advantages of preparing and publishing a national atlas serially are that a smaller number of people need to be involved full time in its production and the order in which maps are prepared may be adjusted to suit the availability of data.

Probably most users prefer a single bound volume. Serially published atlases normally cost more; some users may not mind this because their purchases will be spread over several years and they may choose to buy only selected maps. Although they may have to wait, at least the maps will be released as soon as they have been prepared—they do not have to wait for completion of the entire atlas.

These are some of the factors taken into account in the decision to produce the first series of the Atlas of Australian Resources serially and to revise it by producing the second series similarly.

For the second series, it appeared desirable to retain the same format so that holders of the atlas could use the same loose-leaf binders and boxes, and merely replace existing maps and commentaries as the new series became available. Thus the selection made 25 years ago of 1 : 6,000,000 as the basic scale has conditioned the format of the atlas ever since.

The loose-leaf binder used for the atlas consists of two very large cloth-covered boards (735 mm deep by 430 mm wide) held together, with the map-sheets, by three Chicago screws. The map-sheets (720 × 750 mm) are prepared for insertion in the binder by folding them down the middle and, on one side of the fold, gluing a linen strip which has one round hole and two slotted holes to take the Chicago screws. The result is a binder (of greatly oversized depth when compared with most other national atlases) which, when opened, displays the map faces flat.

Accompanying the binder is a small box (280 × 195 mm) large enough to hold all 30 commentaries.

The atlas is also issued in "boxed" sets, comprising three boxes, each containing 10 map-sheets folded to commentary size and their commentaries.

Lastly, each map-sheet (with its commentary) may be obtained separately in flat, linen-strip mounted or folded form to suit the needs of the purchaser.

Even though the atlas is published serially (and therefore holders of sets must purchase new maps as they are published if their sets are to be kept up to date), more than half the maps sold have been in sets. Purchasers have also shown a preference for binder sets.

One of the major problems with serial publication is in keeping purchasers informed about what maps are currently available. The longer the total period of publication, the greater the difficulty; and, of course, it is further accentuated by serial revision.

The production unit may also find that some maps produced early in a series require revision before the series is completed. This need may arise from rapid changes in data but also from depletion of stock. Making a new map (or even reprinting an existing one) tends to prolong the production period.

Continuity of the Australian atlas from series to series is indicated by the use of the same titles where appropriate, for example "Rainfall", second edition (1970) replaced "Rainfall" of the first series. However, with changing circumstances including a rapid increase in knowledge in many fields, marked changes have been made in the data shown and in the style of presentation. In some instances these changes have led to modified titles (for example, "Natural vegetation" will shortly replace "Vegetation regions") or to new topics and the omission of some first series topics entirely.

The advantages and disadvantages of serial production and revision were examined closely by the National Atlas Advisory Committee, which was established in 1970. Its findings and their influence on plans for producing a third series of the Atlas of Australian Resources are outlined in the following section.

### The third series: plans and progress

#### *National Atlas Advisory Committee*

The National Atlas Advisory Committee was established "to advise on the continuing revision of the Atlas of Australian Resources with special reference to a third series". Quoting again from its terms of reference, it was asked to advise on such matters as "the range of topics to be covered, degree of detail desirable, frequency of revision, nature of accompanying descriptive material, and appropriate format. These matters were to be considered in relation to its assessment of users' needs and the role the Atlas should fill as the national atlas for Australia."

The nine members of the Committee were chosen to represent a wide variety of interests, ranging from data collection and research to publishing, and included atlas users themselves. In every case, the members had access to a major public or private organization when they needed to supplement their personal knowledge; for example, one member represented the Commonwealth Scientific and Industrial Research Organisation and another the Australian Academy of Science. Members also convened working groups of invited specialists.

The Committee presented its report in December 1973. It endorsed the proposal to publish a third series. It saw such an atlas as an excellent means of presenting in a concise and convenient form a large body of information useful for government and business planning, scientific research and education. In its view the benefits should fully justify the cost and effort involved.

The Committee recommended a continuance of serial publication, but with several important changes. First, the primary sales unit, the topic, should normally comprise several sheets of integrated maps and commentary under the one title.

Secondly, a major change in format was recommended. The sheet size should be about 430 mm deep by 560 mm wide, large enough for a single map of Australia at 1 : 10,000,000 scale, a quarter of Australia at 1 : 5,000,000 scale, or various combinations of several maps at one or more smaller scales.

Thirdly, the total number of topics—about 45—should be produced over not more than 10 years; and, once publication began, released over not more than eight years in small batches twice a year. In making this recommendation the Committee held the view that, quite apart from a longer period of production, eight years was about the maximum period during which the interest of buyers in a serial publication of this type could be sustained.

Before arriving at recommendations about subject-matter, the Committee carried out a number of investigations, including a survey by questionnaire of the views of many users of the atlas and the establishment of six working groups of specialists to assess the desirable composition of particular groups of topics. The proposals from these working groups were then carefully analysed by the full Committee to achieve a balanced selection. The Committee's list of recommended topics is given in annex II.

*Current plans and progress*

Production of the third series has been delayed by various circumstances, including the current general restrictions by the Government on staff numbers and expenditure. The first priority has been to complete the second series and this goal has almost been reached. At the same time, to the extent that staff numbers have permitted, various preliminary tasks associated with the third series have been undertaken.

The National Atlas Advisory Committee made its recommendations about subject-matter in broad terms only. Considerable progress has since been made on the detailed planning of topics. In most cases, this planning has involved further investigation of the desirable contents and of the source material currently available or likely to become available in the near future. Closely associated with these tasks has been the search for subject specialists who will be willing to assist and the formulation of a production programme to suit all concerned.

Another phase of planning is to determine whether the data should be presented in maps, text, tables, figures etc.; and if in maps, the appropriate scales and the types of symbols to be used.

In some cases, planning is relatively simple because material prepared by an appropriate national institution can be readily adapted for the purpose. For example, the Australian Bureau of Mineral Resources, Geology and Geophysics has recently produced for the 1976 International Geological Congress, held in Australia, several maps which with minor modifications will be suited for the atlas.

However, for most topics planning requires a much more complicated phase of preliminary investigation of data likely to be suitable and step-by-step formulation and modification of ideas on the contents and presentation of maps. In addition to discussions between the editor and staff geographers and cartographers, this work usually involves talks with outside experts and extensive literature searches. In some cases, the detailed plans must remain tentative until they can be tested after the data have been collected and analysed.

The timing of production is very important and calls for flexibility to cope with changes in circumstances. For example, the Committee indicated that all topics dependent upon population and housing data should be based on the 1976 census of population and housing. The implication was that these topics should be produced as soon after the census as possible. This census has now been taken and some preliminary results are expected shortly, but most of the processing by the Australian Bureau of Statistics has been deferred as an economy measure. As a result, most of the local area detail and cross-classifications required for mapping are not expected to be available until 1978.

Other phases of preliminary work on which progress is being made are the preparation of base maps and page layouts for single maps, various combinations of maps and text pages. Attention is also being given to the production of standard symbols of various kinds. These include point symbols in several sizes, a three-colour combination chart, a set of colour combination scales using four colours and three screen percentages, some single-colour scales composed of patterns and samples of the printing patterns available. It is envisaged that use of these standard symbols whenever possible will facilitate the planning of map compilations as well as the production of the final maps.

## ANNEX I
### Atlas of Australian Resources—Contents

*First series: 1952–1960*

Physical features
Geology
Mineral deposits
Climatic regions
Temperatures
Rainfall
Drainage systems
Underground water
Conservation of surface water
Soils
Vegetation regions
Dominant land use
Croplands
Agricultural production
Distribution of stock
Forest resources
Mineral industry
Power and fuel
Manufacturing industries
Population density and distribution
Population increase and decrease, 1933–1947
Population increase and decrease, 1947–1954
Immigration

Railways
Roads and aerodromes
Ports and shipping
Educational facilities
Health services
State and local government areas
Major development projects

*Second series: 1962–1976*

Landforms
Geology, second edition
Mineral deposits, second edition
Climate
Temperatures, second edition
Rainfall, second edition
Surface water resources
Ground water
Water use
Soils, second edition
Natural vegetation
Land use
Croplands, second edition
Crop production
Livestock
Sheep and wool
Grasslands
Forest resources, second edition
Fish and fisheries
Mineral industry, second edition
Electricity, first and second edition
Manufacturing industries, second edition
Population distribution and growth, first and second editions
Immigration, second edition
Railways, second edition
Roads and aerodromes, second edition
Government
Major urban areas
Locational index

## ANNEX II
### Atlas of Australian Resources, third series—list of recommended topics

*Structure and surface features*

Geology and structure
Surface rocks and deposits
Landforms
Soils

*Climate*
Precipitation
Radiation and temperatures
Winds and evaporation
Weather and climate

*Water*
Surface water
Ground water
Water use

*Vegetation and wildlife*
Vegetation
Wildlife
National parks and nature conservation
Marine life

*Settlement and population*
Aborigines
European discovery and settlement
Population change and immigration
Work force
Government

*Land industries and fisheries*

Land use
Crops
Grasslands
Livestock
Irrigation
Forestry
Fisheries

*Minerals, energy and manufacturing*
Mineral deposits
Mineral industries
Electricity
Fuel use
Manufacturing industries

*Transport*
Railways
Roads
Ports and shipping
Airways
Tourism

*Major urban areas*
Terrain and climate
Population
Work force
Land use and housing
Transport services

*Australia in the world*

# NATIONAL AND REGIONAL ATLASES*

*Paper presented by Australia*

## Atlas of Australian Resources

Nine new sheets have been added to the second series of the Atlas of Australian Resources, which is now being produced by the Division of National Mapping of the Department of National Resources.[1] Eight of these sheets deal, respectively, with climate, ground water, water use, land use, manufacturing industries, railways, major urban areas and government; the ninth is a locational index for the entire series.

In addition, a completely revised sheet on population distribution and growth has been published and the last sheet of the second series, on natural vegetation (on the map scale 1 : 6,000,000), is in press. Lastly, the sheet on roads and aerodromes is being revised, because stocks are low and so much of its information has changed greatly in the past 10 years.

The completed second series, like the first series (1952–1960) it gradually replaced, consists of 30 large map-sheets, each with a supplementary booklet.

Meanwhile, general plans have been made for production of a third series of the atlas and preparatory work is in progress. The basis of these plans was provided by a widely representative group of outside experts, the National Atlas Advisory Committee, which was established in 1970.

The third series is planned to be significantly expanded in range of subject-matter and markedly reduced in sheet size without loss in map detail, and to present shorter supplementary texts intermingled with the maps. Each topic is planned to consist of several of these smaller sheets, instead of the single large map-sheet with booklet of the first and second series of the atlas; but, as in the past, topics will be published as soon as they are printed. Simple loose-leaf atlas binders are also to be available.

Maps of Australia in the third series will range in scale from 1 : 5,000,000 to 1 : 30,000,000; and a major innovation will be maps of Australian cities of over 100,000 population at 1 : 250,000 and 1 : 500,000 scales, on a variety of topics.

## Resources of New South Wales

Additions during 1973–1976 to the loose-leaf atlas of the resources of New South Wales, composed of map-sheets with supplementary booklets and published by the New South Wales Department of Decentralisation and Development, comprise a sheet and text on landforms. In addition, a sheet on natural vegetation is in preparation and the double-scale wall-map version of it at 1 : 1,500,000 scale is also expected to be published.

## Resources Atlas of Queensland

The Queensland Department of Mapping and Surveying produced the single-volume Resources Atlas of Queensland in 1976, and it is being distributed by the Queensland State Public Relations Bureau, Brisbane. The 24 multicoloured maps listed on the contents page are nearly all single-page maps of Queensland at 1 : 8,000,000 scale. They are spread through 30 chapters together with text, tables, graphs, supplementary smaller maps and both coloured and black-and-white photographs. The atlas also has a gazetteer and text index.

## Atlas of New England

The University of New England at Armidale, New South Wales, is producing the Atlas of New England for publication in two volumes in early 1977. Volume 1 will have 51 pages of maps on the scales 1 : 1,000,000 and 1 : 2,000,000, covering a variety of physical, economic and socio-cultural topics. Volume 2, of over 150 pages, will elaborate on each map in text, statistical tables, diagrams and small maps.

## Burdekin-Townsville region resources series

The Burdekin-Townsville region resources series of seven topics covering part of Queensland was completed with publication of the topics on land use and water resources. Each topic consists of a cover holding one or two folded map-sheets, with maps mainly on the scales 1 : 1,000,000 and 1 : 2,000,000, and an explanatory booklet. The series was produced by what is now the Australian Department of National Resources.

## Urban atlases

Atlases of socio-economic characteristics, based on the 1971 census of population and housing, have been published for three of the 10 major cities of Australia (for the two largest cities, Sydney and Melbourne, and for Adelaide):

(a) *Sydney at the Census, 1971: A Social Atlas.* This atlas, published by the Australian National University in 1974, consists of 50 monocolour, computer-drawn maps, each with a facing page of text, and a loose plastic overlay map showing base map details etc.;

(b) *Melbourne at the Census, 1971: A Social Atlas.* This atlas, which was published at Canberra in 1975 by the former Cities Commission is similar in presentation but with a topographic base printed on each map in a second colour. The computer-drawn maps for this atlas were also prepared at the Australian National University;

(c) *A Socio-Economic Atlas of Adelaide.* This atlas

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.33.

[1] For details, see "The continuing revision of the Australian National Atlas", under agenda item 7 (*d*).

presents 66 monocolour choropleth maps, also derived from computer analysis of the 1971 census, with brief commentaries. It was prepared by two social scientists of Flinders University, Adelaide, and was published by the South Australian Department of Community Welfare in 1975.

## PUBLICATION BY INSTITUT GEOGRAPHIQUE NATIONAL OF THE NEW ATLAS OF RELIEF FORMS*

*Paper presented by France*

The Institut géographique national (IGN) intends to publish in 1977 the new Atlas of Relief Forms, to replace the atlas of the same title published in 1956 under the auspices of a commission headed by M. Cholley and subsequently published in two new editions, which have now been sold out.

At the end of 1954, when the format of the previous atlas was completed, only very incomplete cartographic coverage was available for France and for those countries of Africa for which IGN had cartographic responsibilities.

The progress made in photographic and cartographic coverage of France and of countries in French-speaking Africa between 1954 and 1974; the development of new types of aerial images taken from high-ceiling aircraft, from balloons or from satellites (particularly multispectral images); and the utilization of spectrozonal emulsions (false colour) have made it possible to prepare a completely new work.

Accordingly, the Director of IGN entrusted the preparation of the new work to a commission headed by Professor Dresch, President of the International Geographical Union.

The format of the new work includes 148 pages of extracts from maps and aerial images, to be examined monocularly or anaglyphically, accompanied by commentary. In some cases, an overlay with a geological sketch is superimposed on the extract from the topographic map. In addition, the work contains a preface by Professor Dresch, a glossary of the geological and geomorphological terms used and five pages of introduction to the chapters and subchapters.

The first chapter, entitled "Approach to ground relief", includes examples of aerial images taken at various scales, from three types of new vehicles: high-ceiling aircraft; stratospheric balloons; and satellites. To facilitate the interpretation of the pictures taken from satellites or balloons, it was considered of interest to compare them with the corresponding classical aerial photographs assembled in mosaic form or mounted anaglyphically.

To give a progressive approach to the ground relief, each page shows the picture taken from a balloon, in false-colour emulsion on the scale 1 : 200,000, an anaglyph on the scale 1 : 40,000 taken from the balloon picture and an anaglyph taken on the scale 1 : 25,000 representing a portion of the preceding anaglyph.

A second major chapter of the work, entitled "Structures and reliefs", concerns:

(*a*) The effects of the nature of rocks: schists; soft rocks; granites; sandstones; limestones;

(*b*) The effects of the arrangement of rocks: cuestas; monoclinic reliefs; faults; folded structures;

(*c*) Volcanic reliefs.

The third chapter, "Types of relief as a function of processes", is devoted to the relief of slopes, river-beds, alluvial terraces, catchments, piedmonts, hydrographic networks, glacial reliefs, periglacial reliefs, coastal forms, arid regions and polycyclic regions.

Obviously, an extract from a map or aerial photograph is of interest in a number of ways by reason of the interference of structural, climatic or palaeo-climatic and historical conditions. The documents have been classified according to their major point of interest, but the table of contents includes references pointing out some characteristics considered secondary to the main theme.

The atlas includes a number of imageries from the Earth Resources Technology Satellite (ERTS-1), specifically the comparison between two homologous images, one of which is taken in the near-infra-red range and the other in the orange-red range of the visible spectrum; there are also sets of pictures of equal colour density taken of the same areas but with different emulsions.

Unlike the preceding atlas, the new work contains a number of extracts from foreign maps (Canada, Norway, Sweden, South Africa and United States of America) showing types of relief that do not exist either in France or in French-speaking countries of Africa.

The Institut géographique national does not intend to publish the atlas unless a sufficient number of statements of intention to purchase are received. If enough statements are received, the atlas will be published in French; but English and Spanish translations of the preface, the glossary and the commentaries will be inserted in copies intended for use abroad.

A brochure including specimen plates of the atlas and

* The original text of this paper, presented by R. d'Hollandér, Institut géographique national, France, appeared as document E/CONF.68/L.9.

an intention-to-purchase statement form will be sent on request addressed to: Institut géographique national, 136 bis Rue de Grenelle, 75700 Paris.

It is hoped that it will be possible to publish the atlas and that the scientific, paedagogical and esthetic interest of the documents selected will make it an effective contribution to the teaching of physical geography throughout the world.

## ANNEX

### Contents of Atlas of Relief Forms

1. "APPROACH TO GROUND RELIEF"
   - Imageries taken from a satellite
   - Pictures taken from a stratospheric balloon and from a medium-ceiling aircraft
   - Pictures taken from a high-ceiling aircraft

2. "STRUCTURES AND RELIEFS"

   *Effects of the nature of rocks*
   - Schists
   - Soft rocks
   - Granites
   - Sandstones
   - Limestones

   *Effects of the arrangement of rocks*
   - Cuestas
   - Monoclinic reliefs
   - Faults
   - Folded structures

   *Volcanic reliefs*

3. "TYPES OF RELIEF AS A FUNCTION OF PROCESSES"
   - Relief of slopes
   - River-beds
   - Alluvial terraces
   - Catchments
   - Piedmonts
   - Hydrographic networks
   - Glacial reliefs
   - Periglacial reliefs
   - Coastal forms
   - Arid regions
   - Humid tropical regions
   - Polycyclic reliefs

## SYSTEMS APPROACH TO THEMATIC CARTOGRAPHY*

*Paper presented by the Federal Republic of Germany*

The rapid growth of thematic cartography in the twentieth century has been the major driving force in a systematic analysis of cartography and in the establishment of a rational basis of theoretical cartography that has derived many of its terms and methods from general communication theory and general sign theory. In recent years, general systems theory has been developed as an interdisciplinary method to overcome the analytical approach that typically characterizes the early stages of a scientific discipline. The basic terms of general systems theory are elements, relations, structure, function, complexity, closed and open systems, dynamics and change. The successful application of general systems theory to various sciences suggests that this approach may usefully be applied also to cartography.

Four aspects of the usefulness of systems theory in cartography may be considered. Two aspects concern the map as a system:

(*a*) The map may be regarded as a closed system, with the signatures as elements and their relative extension and variation as relations. The complexity of the system may be evaluated as a measure of the effectiveness of cartographic information;

(*b*) The map may be regarded as an open system in the processes of compilation and generalization, in which the map producers' operations change the whole system. The current efforts of analytical automatic generalization should be extended by the systems theory approach.

The other two aspects relate to the map as part of a system:

(*a*) The map may be regarded as an active element of an open system. The process of cartographic communication is just such an open system. Its main elements are the map-producer, the map and the map-user; its major relations are perception, compilation and production, use and application, control, correction and modification. The main inputs into the system are the variations of the ecological, socio-economic and technological conditions. This system clearly underlines the control function of the map user and the need to vary the

* The original text of this paper, prepared by Elrich Freitag, Department of Geography, Justus-Liebig-University, Giessen, Federal Republic of Germany, appeared as document E/CONF.68/L.21.

content and design of a map according to the various types of map-users;

(*b*) The map may be regarded as a passive element of an open system. The most extended open system is the world system as developed by the Meadows team.[1] In this model, maps are parts of the information flows which permit the existence of mankind's living system. Analysis of the elements of this system is the best way of determining the spatial and substantial content of thematic maps.

The application of systems theory to thematic cartography can thus help to decide rationally on the content of thematic maps, on their design for various map users, on their compilation and generalization, as well as on their most informative graphic composition. Therefore, systems analysis should be further developed as a tool of cartography.

## Background information

For centuries maps mainly portrayed the visible and most conspicuous features of the human domain, the earth's surface. These maps, known as topographic maps, were developed on different scales and in various styles. Sometimes other elements, such as mines, or other events, such as military operations, were plotted or printed on them.

The development of thematic mapping began about 180 years ago. More and more real and ideal features on, below and above the earth's surface were portrayed on maps. The complexity of man's environment was broken up into hundreds of analytical thematic maps, and a great variety of new signatures and methods of presentation were elaborately prepared. Practical knowledge and experience formed the basis of thematic mapping.

The rapid increase in the number of topics of thematic cartography and the apparent breaking-up of cartography into the spatial research fields of the natural and social sciences gave rise to the first attempts to establish a rational basis for thematic cartography and cartography as a whole. But for various reasons, Karl Peucker's proposition of a geometric-optical system of graphic presentation, made in 1907, was not accepted. Fifty years later, after two world wars, after enormous technological progress, after a steady diversification of sciences and after the information revolution, new attempts were made to establish a rational basis for cartography.

Today, a map is defined not only in descriptive terms but functionally, as a means of visual communication on the spatial arrangements of data sets. Various newly developed disciplines have contributed considerably to the theory of cartography. The descriptive or structural definition of maps can be established, analysed and evaluated by the general sign theory (semiotics), while the functional definition of maps and related terms is derived from the general communication theory. In spite of a disposition to complex approaches in sign and communication theory, their terms and methods are used primarily as tools of analysis, description and definition, and the determination of causal or deterministic dependence.

## General systems theory

To overcome the analytical view in living systems and to understand the dynamics of complex organizations, new concepts and new methods were developed. The first outlines of general systems theory were formulated in psychology and biology about 50 years ago. During the Second World War, similar concepts were developed for military operations, for the armaments industry and for other business organizations; cybernetics and operations research are terms of these concepts. Today, systems theory is an interdisciplinary method to study complex objects and the conditions of their existence. It was applied to different types of biological and mechanical systems and to various types of administrative and social organizations as well as to human society.

The general systems theory has established some well-defined basic terms. A system is defined as a set of elements with relations between them. A set means two, or many or infinite—but normally many—elements. Elements can be grouped into various types. They can be single objects or systems. A system can be treated as an element when the system is seen as an entity, without considering the internal system relations, or as a black box, of which only the input and output dimensions are of interest. This assessment enables one to study the thematic map either as an element or as a system. The map can be termed a real or material artificial system or element. The use of these terms suggests the existence of the ideal or of logic and of natural elements as well. Lastly, the elements can be grouped into active and passive elements. Active elements alter their constitution or structure by receiving, processing and transmitting passive elements. The exchange of the passive elements' energy, matter or information is the most important realization of relations between elements. Relations can be seen as real or ideal, as natural or artificial, as active or passive, as linear or interdependent, as deterministic or probabilistic, as time-variant or time-independent.

The elements and their relations determine the character of the system as a whole; thus, the system includes structural and functional components. The number and the properties of the elements establish the variety of the system; the number and intensities of the relations determine the complexity of the system. Systems can be classified according to the dominant types of elements or relations. More important, however, is the distinction between closed and open systems. Closed systems are systems without active connexions to the environment. Open systems require exchange with the environment, which is controlled by specific steering and regulating mechanisms within the system. The exchange is necessary because the system cannot exist without them; it cannot grow without them or it cannot adapt without them. This type of system is also known as the adapting or learning

[1] Donella H. Meadows and others, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York, Universe Books, 1972).

system. It is obvious that in various learning systems the map as a means of information can play an important role.

## Application of general systems theory to thematic cartography

The general systems thecry was developed as an interdisciplinary method. Therefore, the terms and concepts of the general systems theory could be applied to cartography to further extend the rational basis of this discipline. As a first step, it is appropriate to describe a few possibilities which might demonstrate the utility of the new approach to cartography in general and to thematic cartography in particular.

### *Maps as closed systems*

One possibility is to study the map as a closed system. The elements of this system are the various point, line and area signatures of the map. Their relations of visual dominance or suppression are determined by the graphic structure of the signatures. The various manifestations of the form, size, direction, colour, pattern and intensity of one signature directly influence the possible variations of form, size, direction, colour, pattern and intensity of other elements of the system map.

To a certain extent, the location and relative position of the signatures is fixed by the positions of the objects they portray. However, as the map is only a reduced model of reality, the reduction by scale enforces the selective view and portrayal of reality. The various procedures of map compilation and generalization have influenced this portrait of reality. The analysis of the closed-system map has to neglect these influences and has to concentrate on the map as it exists, on the selected signatures and their relations. In this context, one cannot distinguish between topographic maps and thematic maps, as they are formed of the same elements. One can group the maps into other classes, however, based upon the variety and complexity of the system and ranging from simple sketches to very complex multicoloured maps.

Questions of drawing and printing standards and quality can be raised here, and metric and densitometric measures can be used as objective criteria. The mathematical problem of the information contents of maps could be solved with this systems approach. And the questions of the receptive and aesthetic quality of maps might find an objective answer when one can develop acceptable procedures for their evaluation. Lastly, one can compare and assess the graphics of maps which were produced by manual-mechanical or computerized automatic methods. (It should be mentioned that the study of the closed-system map has much in common with the sign theory analysis of maps.)

### *Maps as open systems*

The systems approach to maps becomes more important when one regards maps as open systems. The elements and relations are the same as in the closed system. The elements and their relations change; however, as a result of exchanges with the environment. One can regard the map producer as the environment; new observations, concepts, objects or ideas as input elements; and map production (with the major procedures of map compilation and map generalization) as the transfer processes. If this is done, one will possibly find out how the addition of new signatures influences the other elements of the map or how the simplification and realignment of signatures modifies the whole structure of the map.

For some time, the problems of automatic map generalization were approached and partially solved by analytical methods. It became evident, however, that more problems could be solved by using the systems approach and interactive automatic systems. These problems are the new research fields of cartography. They are part of the study of the creative process of map production that has been formalized to a certain extent, based on individual experience and commonly accepted standards. If, in the future, systems approach can help to describe exactly the map creation process and to assess the measure of interdependence of its various elements, then procedures might be established which would give the maps the accuracy and utility of mathematical equations.

### *Maps as active elements of open systems*

The foregoing discussion has considered the map as a system and the signatures as its elements. But one can also consider the map as an element of another system.

The map is an active element of open-system cartography, for example. "Active" means that it is influenced and changed by other elements, and that it influences and changes other elements of the system. "Open system" means that the system is connected to its environment through the necessary exchange of energy, matter or information.

Cartographers first attempted to set up a "system of cartography" by applying the model of communication theory to cartography. Most models of this type are linear chains with the main links of the real world, the cartographer's selective conception of the world as the message to be transmitted, the map as the coded signal and the percipient's conception as the received message. This simplified model truly reflects the current state of cartography, with its linear flow of information and its causal dependence.

The extended model of communication theory does include, however, a feedback chain of control and regulation that introduces interdependence into the model and, by so doing, transforms it into a system.

The open system of cartography consists of the map-producer, the map and the map-user as the active elements. They change their attitude, appearance and behaviour through the system's internal relations of compilation or encoding, message transmission, decoding and interpretation, error detection and correction, and through the exchange of information with the environment. The study of the interdependence of all three elements is of fundamental importance today. For

too long cartography neglected the map-user, his pretensions and needs, his suggestions, his reading ability and his control function in the map-production process.

In this context, the fact must be stressed that there are many types of map-users. They include human beings of different levels of intelligence and education, as well as machines. They require different types of maps, and the map-producer should consider these requirements.

*Maps as passive elements of open systems*

One can extend the systems approach even further when one considers the function of the map. Then the map can be seen as a passive element and as part of the information flow that is exchanged between the active elements of the system as a prerequisite of its existence. This system is human society.

As a universal system, human society is described in system dynamic terms by meadows.[2] This system, called the "World Model", was developed in co-operation with the Forrester team of the Massachusetts Institute of Technology (United States of America), within the Club of Rome's Project on the Predicament of mankind.

The World Model consists of five basic elements: population; capital; land; non-renewable resources; and pollution. Some of the elements could be subdivided; for example, land could be subdivided into non-arable land, potentially arable land, arable land and urban-industrial land. Capital could be separated into agricultural, industrial and service capital. The population could be divided into age groups based on natural productivity or into groups based on economic employment. All measurable and mappable elements change at measurable rates of increase or decrease. These rates are influenced by a number of variables or elements, which are connected by material or functional, linear and non-linear relations between them as well as between each other. The differentiated World Model 3 contains less than 85 elements, correlated by a multitude of relations.

For the present purpose, the importance of this world system can be summarized under three points:

1. The World Model is a valuable aid in the decision process; it clearly shows how decisions in one sector of society, which are intended to change one element only, do influence other elements and the enitty of the living world;

2. The model clearly indicates the few alternatives open to mankind. It strongly opposes the current unbalanced and exponential growth that is still the goal of most individuals, institutions and countries. It advocates a basic change of values and efforts, which should be directed to reaching a rational and enduring state of equilibrium by planned measures;

3. The model shows that the change of values and behaviour is forced upon mankind by the limitations of land, arable land in particular; by the limitations of non-renewable resources and by the limited ability of the ecology of the environment to absorb pollution. The rational exploitation of these limiting factors is the major task of all regional, national and international planning.

This short presentation of the world system clearly indicates the fundamental contents of thematic maps. Thematic maps should portray the spatial pattern (dispersal or concentration) of the vital limiting elements of the world system, the land, the non-renewable resources of organic or anorganic origin and the ecology of the environment. Thematic maps should also present the variation in space of those elements and variables which are closely correlated to them, such as the extension of urban-industrial land, land yield, food production, natural soil fertility, the use of fertilizer (as part of the agricultural investment), soil and water pollution by fertilizer residues and so on. Lastly, those elements of the world system might be mapped which are essential to the system, although only of marginal importance to the limiting elements.

The presentation of the world system also stressed the essential function of the map. Thematic maps are the most comprehensive means of information on the spatial pattern and changes of all elements of the system, most important among them those which limit its further exponential growth. (It should be mentioned that the newly developed forms of remote-sensing imageries fulfil similar functions in the world model.)

## Conclusion

These few examples of the application of general systems theory to cartography have shown the fundamental implications and usefulness of the new approach.

In theoretical cartography, this approach will be a means of combining the various terms and aspects that were adopted from sign theory and communication theory, which form the foundations of the modern science of cartography.

In practical cartography, this approach will be a means of deciding on the various forms of maps and mapping. The examples were selected to stress this point.

The function of thematic maps in the world system as means of information clearly determines the topics of thematic maps. Countries and regions require similar tools of spatial information. Thus, the contents of world, national or regional atlases, the most comprehensive form of spatial information, can be definitely specified by a world, national or regional systems analysis. In spite of spatial differences, each atlas should contain maps of all essential elements of the world system, if possible in a standardized and comparable form.

The various types of map uses indicate that the limits of standardization in cartography are very important factors. They also suggest that maps should be more definitely designed for specific groups of map-users, as tools of scientific research or as tools of demonstration or persuasion. Most important is the request to design thematic maps for students. Maps are written in the graphic language of signatures; and as the verbal language instruction proceeds from simple to difficult texts, so should the map language instruction. Only when such maps are produced can one expect to educate the general

[2] *Ibid.*

public and the decision-makers to use the maps to their best advantage.

The systems approach also indicates that complex maps are more useful and informative than simple maps. They contain exponential more secondary informations, that is, more indications of the various relations of the elements portrayed. Therefore, the simple thematic map that still prevails in books, atlases and feasibility studies should be replaced or at least be supplemented by complex thematic maps.

Lastly, the systems approach should be applied to the technical process of map production. It would demonstrate how one basic map could be used for various thematic maps and how one basic design could be used for maps for various types of map users. Thus, it could speed up the process and cut the costs of map production.

The systems theoretical approach should be used and developed in all fields of cartography to improve thematic maps as the tools of spatial information throughout the world.

## OFFICIAL MAP SERIES AS A BASE FOR THEMATIC MAPPING*

*Paper presented by the Federal Republic of Germany*

In recent years, there has been an increasing need for single thematic maps and thematic map series, which must primarily be attributed to the development of the over-all structure of the Federal Republic of Germany (population, industry, completion of the traffic system, environmental protection etc.).

For thematic map series, official topographic map series on the scales 1 : 50,000, 1 : 200,000 and 1 : 500,000 are often used as base materials. Due to their historical development and to the population density of the Federal Republic of Germany, these map series show relatively dense information. Therefore, they are in principle well suited for thematic derivations. The base material must, however, be manipulated in nearly all cases; as a rule, the information must be reduced. This reduction is done by means of repro-technical procedures: the single originals, forming in their entirety the set of originals, are copied together in different combinations, eventually by simultaneous screening of single map features. The features used most frequently in one combination are classified as primary map elements, in others as secondary map elements.

In order to demonstrate how many single originals form the sets of one sheet each of the principal map series existing in the Federal Republic of Germany, the sets of originals are indicated below, along with some titles of thematic maps prepared in the past.

The availability and quick provision of relevant map material for thematic derivations also justify the expenditure invested in the preparation of official map series. On the other hand, the requirements affect the design of single map features; in addition, they influence the combination of the sets of originals.

### Task

Because official map series frequently serve as base material for thematic maps, care must be taken with the over-all design and composition of the official series so that the base maps can be used subsequently for all types of thematic maps without entailing great expense.

As topographic maps and general topographic maps on the scales 1 : 50,000, 1 : 100,000, 1 : 200,000, 1 : 500,000, and 1 : 1,000,000 show the terrain, hydrography, traffic network, settlements and place-names, they can be considered thematic maps as they supply already information on the above-mentioned features. The information provided can be either insufficient (e.g., overgeneralized settlements) or there can be too much of it (e.g., detailed representation of settlements at small scales in the form of individual buildings). In most instances, however, additional topics will have to be represented; or the information contained in the topographic maps can in fact be extracted from the topographic map according to the task, but is in the graphic respect not adequately adapted to the topic.

Therefore, it is important to reduce or omit single topics already contained in a topographic maps series, to accentuate others and eventually to add one or several new topics. By doing so, the usually rich and dense content of the topographic maps must be reduced to an amount of information that suffices to understand the topic. In principle, one should keep in mind that a topographic map rich in content and with a dense net of reference points is at all times appreciated as a base for thematic derivations. The density of content of the topographic data facilitates the positioning of the thematic data; the optimal density of a base map depends, however, upon the topic.

### Procedural possibilities

Depending upon the portion of the basic map series used for the new map, there are three possible procedures:

(*a*) The base materials for thematic maps are the unchanged topographic maps, on which the topic is drawn or printed. However, this procedure is only possible with point, hyphen or linear representations, such as locations, places of finding, hiking-trails, traffic routes

* The original text of this paper, prepared by W. Satzinger, Institut für Angewandte Geodäsie, Frankfurt am Main, appeared as document E/CONF.68/L.89.

or supply networks, as the topographic map series of the Federal Republic of Germany show many densely populated regions and only a few "blank areas". An exaggerated superimposition of the map image by thematic representations would only hamper map interpretation;

(*b*) The source material is manipulated by way of reproduction techniques, which can be achieved by a combination different from the standard procedure and by a reduction of the map originals, the result of which is a reduction of colours and map features represented. In addition, subdued colours can be chosen for printing. Single features can, by way of screening, be represented "thinner" or brightened. The names can be thinned out. All these measures are designed to push the base map into the background and emphasize the topic, for example, in the areal representation of nature reserves or catchment areas, geological maps, soil science maps, plant sociological maps, and land-use maps. But maps of physical planning, administrative divisions, settlement, traffic, planning etc. also call for the reduced base map;

(*c*) The base material is used to prepare a new design. This process can be the costliest or the simplest and optimal solution. But in this case also, the responsible map editor will always fall back upon the initial base material that he must generalize and schematize until it corresponds with his ideas and serves the purposes required.

The procedure described under (*b*) is that applied most frequently.

## Sets of map originals used in the Federal Republic of Germany

Of the topographic map on the scale 1 : 50,000 prepared at the State Survey Offices of the Federal Republic of Germany, each sheet (there are altogether about 580 sheets) usually has a set of map originals consisting of seven or eight single originals: four originals for the planimetry, in particular, settlements and roads, hydrography, contours and wood outlines; and three masks for masking water areas, wooded areas and garden areas. The lettering is mostly separated from the planimetry and has an original of its own at an enlarged drawing scale.

The reproducible and revisable set of originals of the general topographic map on the scale 1 : 200,000 consists of 15 single originals:

*Dark brown (two originals)*: planimetry and rock representation; lettering for orohydrographic edition;
*Red*: road-filling;
*Black (three originals)*: margin/railways/lettering; title-lettering and sheet index/title for orohydrographic edition;
*Blue*: hydrography;
*Light blue*: ocean areas (if existing);
*Brown*: contours;
*Green*: wooded areas;
*Dark green*: wood outlines and vegetation;
*Grey-blue, grey-violet and light yellow (three originals)*: hill shading;
*Orange*: frontispiece and sheet index.

The set of originals of one sheet of the map series on the scale 1 : 500,000 consists of the following 28 originals:

*Black (eight originals)*: Planimetry; mask for background removal for planimetry; lettering of place-names; lettering of landscape names; mask for background removal for lettering of place-names and landscape names; topographic single symbols; edge-matching; graticule;
*First brown*: contours;
*Second brown (two originals)*: hypsometric layers 2a and 2b;
*Third brown (three originals)*: hypsometric layers 3a, 3b and 3c;
*Blue (three originals)*: hydrography (lines); water areas; water names;
*Green*: wooded areas;
*Red (five originals)*: road-filling (main roads); minor roads and directional indications; kilometre marking; filling of areas with compact development; boundary bands;
*Yellow (two originals)*: hypsometric layers 1a and 1b;
*Violet*: Universal Transverse Mercator (UTM) grid;
*Grey (two originals)*: hill shading; depressions.

For printing the standard sheets, this set is reduced to 10 originals:

*Black*: planimetry, lettering and graticule;
*First brown*: contours;
*Second brown*: hypsometric layers 2;
*Third brown*: hypsometric layers 3;
*Blue*: hydrography;
*Green*: wooded areas;
*Red*: road filling and filling of areas with compact development;
*Yellow*: hypsometric layers 1;
*Violet*: UTM grid;
*Grey*: hill shading (and eventually depressions).

The set of originals for the International Map of the World on the Millionth Scale (IMW) consists of the following eight single originals:

*Black*: margin, graticule and lettering;
*Red*: road-filling;
*Green*: hypsometric layers, 0–100 m, 100–200 m and depressions;
*Brown-black*: hill shading;
*Yellow*: contours 200–500 m and built-up areas;
*Blue (two originals)*: hydrographic outlines and tidal flats; hydrographic filling and depressions;
*Brown*: contours and sand.

## Possibilities of combination

The extreme subdivision of the sets of originals of the German topographic maps, e.g., the division of the map elements to be represented in black into eight single originals for the map series at 1 : 500,000 scale, was done mainly for the sake of a later possibility of combinations. Furthermore, the single originals can be revised separately by different cartographers. The greater freedom

of combination leads, however, to an increased expenditure in time caused by the sequential copying of the printing-plates for the print order and to the necessity of fitting the contents of the single originals on one another, which requires a certain capacity in the copying department. In addition, a three-hole register punch was constructed which registers the originals of all sizes in such a way that the unavoidable dimensional instabilities of the originals are reduced to a tolerable minimum by means of register studs.

Since the Institut für Angewandte Geodäsie completed the general topographic map on the scale 1 : 200,000 in 1973, numerous single thematic maps and thematic map series have been derived from it. Among those completed are: vegetation maps; road maps and maps dealing with traffic analysis and the road system, the history of roads and car-parks for drivers; maps concerning water-supply, water resources planning, water protection areas, the course of the Roman water-supply line and the catchment basin of the Elbe River; a ring alarm search map; maps of restricted areas, pedological locations, infrastructure, countryside preservation, leisure-time activities, topographic and/or vegetational boundaries, industry structure, sewage planning, air pollution, long-distance gas, gas-supply, locations of nuclear power stations and locations for incinerating plants; and a hydrological atlas and school atlases.

The topic most frequently dealt with is water, a common property of vital importance. First, it is cartographically recorded according to running waters and stagnant waters, ground-water occurrences, sources and water-supply pipes. Then, because of environmental protection and human ecology measures, it is diagnosed and disturbing influences are submitted to a therapy. The effectiveness of the measures taken can be ascertained with the aid of periodically prepared cartographic representations which often give rise to new legislative initiatives.

## Explanation of maps in pocket[1]

Figure 71 is a section of the map series "Arbeitskarte der Öffentlichen Wasserversorgung, Blatt CC 6310 Frankfurt/M.-West" (Map of the public water-supply). Of the base map, only the combinations contours (brown), place-names (dark grey), traffic routes (light blue) and water outlines including water names (blue) are used. The thematic derivation prefers, of course, a linear representation for the supply mains, supplemented by symbols, figures (dark blue) and a screened areal representation (blue) of the locations. The sparsely represented topographic base is sufficiently accurate to position the thematic data. An additional terrain representation in the form of hill shading for a better depiction of the structure of low mountain range landscapes in the Federal Republic of Germany has in this case been dispensed with because the principal topic of the representation was water-pressure lines and because the decision-taking body was of the opinion that spot heights and contours mark the landforms in an adequate manner.

Figure 72 illustrates procedure (*c*), described above, using as base map an existing map at 1 : 1,000,000 scale with limited density of content. The base map contains only the administrative boundaries (brown with screened band), major waters (blue), some place-names and landscape names, the most important traffic routes, outlines of larger towns and graticule lines (grey). The topic is presented in an eye-catching manner, proportional in area, in triangles which are screened in different colours. In addition, the Institut für Angewandte Geodäsie prepared water-protection atlases for several states of the Federal Republic of Germany, on the basis of official map data.

## Primary and secondary map features

Inquiries on base material received in the Institut für Angewandte Geodäsie prove Arnberger's[2] statement which differentiates between primary and secondary elements of the topographic base material on map scales ranging from 1 : 100,000 to 1 : 1,000,000.

Primary elements are considered to be contours, graticule, hydrographic net, settlements, traffic routes and administrative boundaries of higher order. The means for representing the elements required most of all are predominantly lines and points; thus, the base map can be burdened with phenomena requiring an areal representation. As to possible variants in the combination of the originals, the hydrographic net is most needed and therefore is the most important aid in orientation. This does not imply, however, that from this aid an absolute hierarchy of features, represented on a map, can be derived. Depending upon the topic, other features of the base map may shift the priorities. For a map series serving the search of the police, the road junctions and administrative units were the most important, as the police action relies on these data. In this case, the representation of the traffic net had to be graduated according to categories and had to show the most recent relevant data. Already at the designing stage of a topographic map series, great importance must be attached to the primary map features. The more unconscious practice of the cartographer to omit little and to smooth and displace only slightly while generalizing from a larger scale to a smaller scale is justified in this case.

The most frequently required type of the base map for thematic derivations consequently contains the hydrographic net, the contours (or only spot heights or only hill shading), the settlements and the traffic routes. In this connexion, it is recommended to divide the reproduction original "hydrography" into linear hydrography and areal hydrography or to divide the lettering plate and the traffic route plate into different categories of features.

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figures 71 and 72 are in this pocket.

[2] E. Arnberger, *Handbuch der thematischen Kartographie* (Vienna, 1966), pp. 201–218.

### Some peculiarities

The copyright of the Federal Republic of Germany permits the free use of the official map material, the only condition being that the new product is a product of its own, i.e., a product detached as much as possible from the original. Commercial editors of road maps use this possibility to a great extent.

Frequently, the conditions for thematic maps or thematic map series are dependent not only upon the information wanted but upon the format and type of reproduction or upon the financial means available for the project. If they are limited, a monochrome base material is often requested, which is obtained by the sequential copying of the desired map elements, i.e., generally the primary map elements. By doing so, some features or feature groups, for example, the traffic net or even the lettering, can be "brightened" by screening. If the monochrome small-scale map is used as standard for many sheets of a thematic atlas, a careful examination is advisable in order to find out whether this base map is suited for all topics.

In combining several map-sheets to a larger area, the planimetry often must be matched, i.e., joined together along the edges of different sheets. In the meantime, this time-consuming procedure has been dispensed with. Instead of edge-matching, the edges of the sheets are now covered by a strong line.

### Conclusion

An increased demand for thematic mapping is evident. If official map series exist at suitable scales with sufficient density of content and are adequate up to date, the authors of thematic maps will take this material as a basis. The wishes and individual ideas of the authors of thematic maps can best be complied with if the reproducible map originals are prepared in such a manner that there is great flexibility in the combination of the feature groups of a map series. Printed topographic maps serve among others as a working basis for the recording of events. Their additional use as base material for the preparation of thematic maps justifies the expenditure invested in mapping.

## COMPLEX THEMATIC ATLASES AS AIDS TO ECONOMIC PLANNING*

*Paper presented by Hungary*

Spatial characteristics, i.e., the spatial structure, can only be portrayed realistically and suggestively by map representations. Therefore, maps are the indispensable and most natural instruments of planning.

Maps reflecting the current situation and the development leading to the present constitute the starting-point of regional planning. Planning specialists have expressed the unanimous opinion that the demand for cartographic data in regional planning is much greater than the map information requirements of other scientific fields and practical activities. Accordingly, the large quantity of maps required must be placed at the disposal of users by the mapping authorities in the form of a central cartographic data supply, similarly to the statistical information system of the national economy.

To promote comprehensive national planning, the National Atlas of Hungary was published in 1967. The atlas represented the industrial data by settlements; and the data of population, agriculture etc. by secondary administrative units (districts). The average values, projected on the territories of secondary administrative units, often did not express the territorial differences; therefore, planners required an atlas which would be more adjusted to the various territorial differences and would represent the data projected on the smallest administrative units. The six-volume economic planning atlas series of Hungary, published in 1974, contains data (for 1970) by settlements.

### The planning-economic atlases in Hungary

The requirements for complex thematic atlases designed to assist planning are as follows:

(*a*) The data of the maps must refer to the same date or period;

(*b*) The time elapsed between the data survey and the publication of the map must be the shortest period possible;

(*c*) The scale system and the representation forms of the maps must facilitate good legibility and easy comparison; only a few scales and representation methods are advised;

(*d*) The selection of colours for the maps—in spite of the restriction on costs and production period—must facilitate the quick survey of the information and the easy recognition of areal correspondence.

In accordance with the requirements, all the maps of the atlas, excluding the agricultural maps, represent the data of 1970, i.e., the data of the census year. The agricultural maps indicate the averages of the period 1968–1970.

The series of atlases was published in the middle of 1974; thus, the period between the survey of data and the publication could be considerably shortened.

* The original text of this paper, prepared by Professor Sandor Radó and Arpád Papp-Váry, National Office of Lands and Mapping, Budapest, appeared as document E/CONF.68/L.64.

The size of the atlases is uniformly 56 × 39.5 cm; the individual volumes contain 240–280 maps on 81–83 pages. The two-coloured, palely printed working map of the administrative map was placed on five map-sheets at the end of each volume, enabling the user to register the changes or to make synthetic diagrams on the basis of analytical data.

The scale of full-page maps is 1 : 500,000. By halving the scale, they were represented on four maps on the scale 1 : 1,000,000.

The contents of the atlases follow, in the main features, the recommendations of the National Atlases Commission of the International Geographical Union, excluding the chapters on water economics and on the state of housing and public utilities.

Hungary, being a basin girded with the ring of the Carpathians, places special importance on flood and inland-water control, on water storage and on the utilization of artesian and thermal waters hidden in the depth of the earth. Therefore, the hydrogeographical characteristics, the stock of water and the different forms of their utilization, and the flood and inland-water control were processed within the framework of a uniform chapter, rich in contents (ninth map-page).

The atlas contains detailed data, by settlement, on the state of housing and public utilities: the number of rooms per 1,000 persons; the categories of flats according to the number of rooms; the proportion of flats supplied with electricity, water, gas and bathrooms; the length of built-up roads and pavements within the settlements; and the area of well-kept parks within the towns. Separate maps show the building age and height (number of storeys) of living-houses and the proportion of houses built from sun-dried unburnt bricks (clay). The indexes described provide assistance for the drawing-up of settlement network development plans and, on the basis of the plans, for the distribution of the investment of local authorities among the settlements.

The atlas series of Hungary, which is of uniform scale and presentation, was compiled in four years; it shows clearly that cartographers are able to create a cartographic data supply system simultaneously with a statistical data supply. This thematic map system provides a good survey and accelerates the elaboration of territorial information.

## Proposal for regional planning atlas system in Hungary

One quarter of the maps of the economic planning atlas series are on the scale 1 : 500,000; the remainder are on the scale 1 : 1,000,000. As the territory of Hungary can be represented in an atlas form that is easy to handle on the scale 1 : 1,000,000 and as the detailing of data by settlements proved to be sufficient for the preparation of the national plan of country planning, it was decided that in 1980 the contents of the national and regional atlases would be published together in one atlas volume (in a new national atlas) of larger format. In the new atlas, 80 per cent of the maps will represent the entire area of the country; 20 per cent will show the planning economic regions.

For medium-level planning, by secondary administrative units (counties), it is necessary to know the exact territorial situation of production and the infrastructural endowment. Therefore, the planning specialists of secondary administrative units must be provided with a detailed (scales 1 : 100,000, 1 : 200,000) thematic map series in atlas form.

The rapid growth of urban areas made the planning of urban agglomerations a central question of regional planning. However, for the elaboration of detailed planning town atlases one needs a special data survey system (data survey by building sites) and representation (the formation of squares from building sites). Work on their experimental formation is under way.

The solution of cartographic data supply, established considering the demand of planners and proposed by the National Offices of Lands and Mapping, comprises:

(a) *National atlas*: scale 1 : 750,000 with some maps at 1 : 300,000; for the execution of long-range national and regional organization plans, respectively, in a long perspective;

(b) *Area atlases*: scales 1 : 100,000–1 : 200,000; for the completion of long- and medium-range territorial organization plans of the individual areas of priority;

(c) *Thematic town atlases*: scales 1 : 20,000, 1 : 10,000 and 1 : 5,000; for the processing of the territorial organization plans of settlements with a central function.

In accordance with United Nations guidelines, it is suggested that the atlases should be published so as to utilize the data of the census held in Hungary every 10 years. The maximum time for the completion of the atlases may be two years, in order to ensure that they should be at the disposal of those who require them when the plans for the next five-year period of the national economy are being formulated.

As concerns data that are subject to rapid changes in the course of the two five-year plan periods, it is suggested that supplementary maps be published on two or three occasions. The supplementary volumes, which are to be completed in six months, should be published at such a date as will permit their use for the compilation of the next medium-range plan and/or for the evaluation of the preceding plan period. Parallel with the establishment of city (planning) data banks it will be possible to realize for the first time the continuous registration and the recall of data simultaneously on tables and on maps relating to any point of time.

# STATUS OF PHOTOGEOLOGICAL INTERPRETATION IN INDONESIA*

*Paper presented by Indonesia*

Aerial photographs have been widely used in Indonesia since the first pictures were taken in 1935 covering the very remote and rough terrain of Irian Jaya. Those pictures greatly contributed to the investigations of the area. Since then many parts of the country have been covered by aerial photographs, in particular for the purpose of earth resources exploration.

In the period 1945–1948, or shortly after the Second World War, a very large programme was carried out to cover the country with aerial photographs particularly for military purposes. Approximately 30 per cent of the entire territory was covered, including among others, Jawa and Nusa Tenggara, with a coverage of approximately 90–100 per cent. The scale of the photographs is about 1 : 50,000, which is fairly good for systematic and regional geological mapping.

The geological investigation also has benefited from the availability of the aerial photographs. The first and extensive photographic interpretation was done by Simons[1] in Irian Jaya shortly before the Second World War. Several mining firms, such as Billiton Tin Maatchappij, and oil firms used aerial photographs in their explorations. Almost all parts of the Tertiary sedimentary basin of Sumatera and East Kalimantan were covered by the photographs which were taken for the purpose of exploration.

Today, with the rapid development of aerial surveying including remote-sensing techniques and satellite imagery, many parts of the country have been investigated geologically through aerial pictures and imagery both by private firms and by government survey agencies.

## PHOTOGEOLOGICAL INTERPRETATION IN REGIONAL AND SYSTEMATIC GEOLOGICAL MAPPING

The aerial photographs are used in geological mapping, primarily because of the poor quality of available topographic maps. In a humid tropical country such as Indonesia, the vegetation covers and overburden are very thick; therefore, photogeological interpretation is significantly hampered. However, in many parts of the country where sedimentary rocks are found, those photographs contribute a great deal of data concerning both lithology and structure. Excellent lithological and structural investigation results were obtained in the Kendeng and Rembang Zones of East Jawa and Madura Island.

The remarkable role is played by aerial photographs in geological mapping in volcanic terrain. The volcanic products of Tertiary and Quaternary ages, in general, consist of relatively homogeneous compositions, from andesitic to basaltic rocks. The identification of various eruption products therefore is very difficult. Based on topographic and geomorphological expressions, readily observable through the stereoscopic view of aerial photographs, however, the volcanic products can be fairly well distinguished. Crater rims, crater ruins, eruptions stages and relative ages of eruption centres and volcanic products can be easily studied through aerial photographs providing a regional view of the area.

Some 20 sheets of systematic geological mapping on the scale 1 : 250,000 and as many as 20 others at 1 : 100,000 scale have been prepared with the contribution of the photogeological interpretations, which were done before and simultaneously during the field-work. The regional geological map of Sulawesi on the scale 1 : 1,000,000 was prepared largely on the basis of field-work and photogeological interpretation. Many fault structures were detected on aerial photographs; and as the terrain is very remote and densely covered by forest, the field checks were only done in limited parts of the area. The extension and location of the structures were based on data detected on aerial photographs.

The famous strike-slip Palu-Koro fault can be clearly studied on aerial photographs. This island has been particularly covered by aerial photogrphs for the purpose of mineral explorations (P. T. Inco and the Government of Japan) and regional development (Food and Agriculture Organization of the United Nations: FAO).

## PHOTOGEOLOGICAL INTERPRETATION FOR PURPOSE OF EXPLORATION

Exploratory investigation can scarcely be separated from the geological mapping; however, in such work the photo-interpretation places emphasis on exploration purposes, such as structural analysis, geomorphological studies etc. These works were mainly carried out by private and government-owned companies. Extensive structural investigation has been done by oil firms in the eastern portion of Sumatera island by means of aerial photographs. For the iron exploration, the Government of Indonesia, in collaboration with the Union of Soviet Socialist Republics, spent a great deal of money to cover the Meratus area in Kalimantan with aerial photographs; the interpretation was done accordingly.

In Sulawesi, Inco prepared photographic maps covering the eastern arms of the island in their efforts to find nickel deposits in the area. Some faults of a regional nature which are very significant from the new global tectonic point of view were located. Geomorphological analysis was also done by means of aerial photographs.

Oil explorations using aerial photographs were carried out in eastern parts of Kalimantan, Buton Island in

* The original text of this paper, prepared by A. Sudrajat, Geological Survey of Indonesia, appeared as document E/CONF.68/L.81.

[1] A. L. Simons, "Luchtopname on luchtverkenning", *Mijningenieur*, vol. VII, No. 1 (1940), pp. 1–22.

Sulawesi, the Birdhead of Irian Jaya and the southern part of Central Jawa (Banyumas area).

The Geological Survey of Indonesia has been involved in mineral exploration using aerial photographs, such as in West Kalimantan and Sulawesi for base-metal exploration, in the southern part of Sumatera and some parts of Jawa for bentonite and in some other localities.

The fracture pattern observable on aerial photographs in many cases controls the base-metal occurrences. In bentonite explorations, it has been noted that the frequent landslides detectable on the photos might indicate the location of bentonite.

Geothermal energy, which is currently popular due to energy crisis throughout the world, is being explored in Indonesia with the help of aerial photographs to map the volcanic terrain.

### Photogeological interpretation in regional development

The landslide phenomena in the Cianjur area of West Jawa were very clearly detected through aerial photographs. The development of the landslides can be studied by comparing various photographs taken several years apart. Some regional development surveys using aerial photographs to help field observations were done, for example, in West Sumatera, Bali, Sumba and many localities in Jawa.

### Remote-sensing techniques and LANDSAT imagery in geological interpretation

The current development of remote sensing has also influenced photogeological interpretation in Indonesia. In addition to conventional aerial photographs, data were also collected through radar images, multispectral aerial photographs and infra-red photographs. The Geological Survey of Indonesia is involved in a multispectral photographic experiment for geological mapping on Bali Island in collaboration with other government agencies under co-ordination of The Badan Koordinasi Survey dan Pemetaan Nasional (BAKOSURTANAL). Some significant results have been noted to identify several kinds of volcanic products through several bands and their combinations. Side-looking airborne radar images are available in East Sumatera, East Kalimantan and Irian Jaya (made by oil firms); and in North Sulawesi, Flores Island and Central Kalimantan (made by firms and institutions dealing with base-metal exploration). It has proved its merits for mineral exploration particularly to detect geological structures, folding as well as fractures.

LANDSAT imagery is used widely in geological investigations in Indonesia. The research was carried out by Indonesia National Institute of Geology and Mining to apply the imagery in thematic mapping, exploration and structural analysis. The Geological Survey of Indonesia uses the imagery especially for regional geological mapping. An intensive study of LANDSAT imagery including the employment of various enhancement machines and computer print-out analysis of the computer-compatible tape was done in Central Kalimantan in co-operation with Government of Japan. More recently, LANDSAT imagery was interpreted to analyse the nature of the strike-faulting, curvilinears and kinematics of Central Sulawesi from the plate tectonic point of view.[2]

### Training and courses

In the universities, photogeology has been taught since mid-1950. More recently, remote sensing has been included as one of the optional lectures.

At the Geological Survey of Indonesia, several training courses were held to upgrade the staff's abilities in photogeological interpretation and other remote-sensing analysis. These courses were successfully conducted with technical co-operation provided by the United States of America. Currently, 20–30 geologists use aerial photographs to support their work in carrying out the geological mapping and mineral exploration of the Survey.

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[2] A. Sudrajat, *Some Significance of LANDSAT Image Interpretation in Regional Geological Mapping in Indonesia* (Jakarta, Geological Survey of Indonesia, 1976).

# THEMATIC CARTOGRAPHY AT THE GEOLOGICAL SURVEY OF INDONESIA*

*Paper presented by Indonesia*

In the framework of supporting a national report to the Eighth United Nations Regional Cartographic Conference for Asia and the Far East, the cartographic activities carried out at the Geological Survey of Indonesia during the first five-year development plan (1969–1974) and the currently implemented second development plan (1974–1979) are summarized in this report.

Cartographic work is mainly emphasized in supporting the mapping programmes which include geological, hydrogeological, engineering geological and gravity mapping.

Foreign aid in the form of expertise, equipment and on-the-job training of cartographic personnel has been very useful in promoting the quality and progress of the work.

Up to the end of 1976, about 40 geological and related maps were published and several more are in process or at the compilation stage.

## Mapping programme

During the first plan period (1969–1974) and the second plan period to date, systematic and regional mapping was carried out and programmed as follows (see also figures 73–76):

(a) *General geological mapping*. This category of mapping includes:

(i) Mapping at 1 : 100,000 scale for Jawa and Madura, covering 57 sheets each sized 30′ × 30′, of which 11 sheets were published, 1 sheet is in cartographic process and 6 sheets are at the compilation stage;

(ii) Mapping at 1 : 250,000 scale for the area off Jawa, covering about 100 sheets sized 1°30′ × 1°. Eight sheets were published and eight are at the compilation stage;

(iii) Mapping at 1 : 1,000,000 scale, covering 16 sheets of the whole archipelago of the size of 8° × 6°. One sheet was published, one is in cartographic process and one is at the compilation stage;

(b) *Hydrogeological mapping*. The base map is on the scale 1 : 250,000, and the country is divided into hydrogeological basin areas which form the basis of the quadrangle system. Three sheets were published and eight are in cartographic process;

(c) *Engineering geological mapping*. These maps were planned for publication on the scale 1 : 100,000 and are mainly emphasized in urban and environmental geology. One sheet was published and five sheets are in cartographic process and at the compilation stage;

(d) *Bouguer anomaly gravity mapping*. It follows the general geological mapping quadrangle system. Three sheets of Jawa on the scale 1 : 100,000 were published, two are in cartographic process and six are being compiled. One sheet on the scale 1 : 250,000 was published and three sheets are at the compilation stage; and another map at 1 : 1,000,000 scale was published.

## Base maps

One of the problems in realizing the programme of mapping is the lack of up-to-date base maps (topographic maps), especially for islands outside Jawa, such as Kalimantan, Sulawesi and Irian. Most parts of these islands are not covered by reliable topographic control. In preparing base maps for publication, the following sources are used:

(a) *Jawa and Madura at 1 : 100,000 scale*. Mosaic from topographic map series T 725 at 1 : 50,000 scale, prepared by the Defense Mapping Agency Topographic Center (DMATC) of the United States of America; these maps use the Transverse Mercator projection;

(b) *Indonesia at 1 : 250,000 scale*. The DMATC topographic map series T 503, combined with other series of old and recent topographic maps;

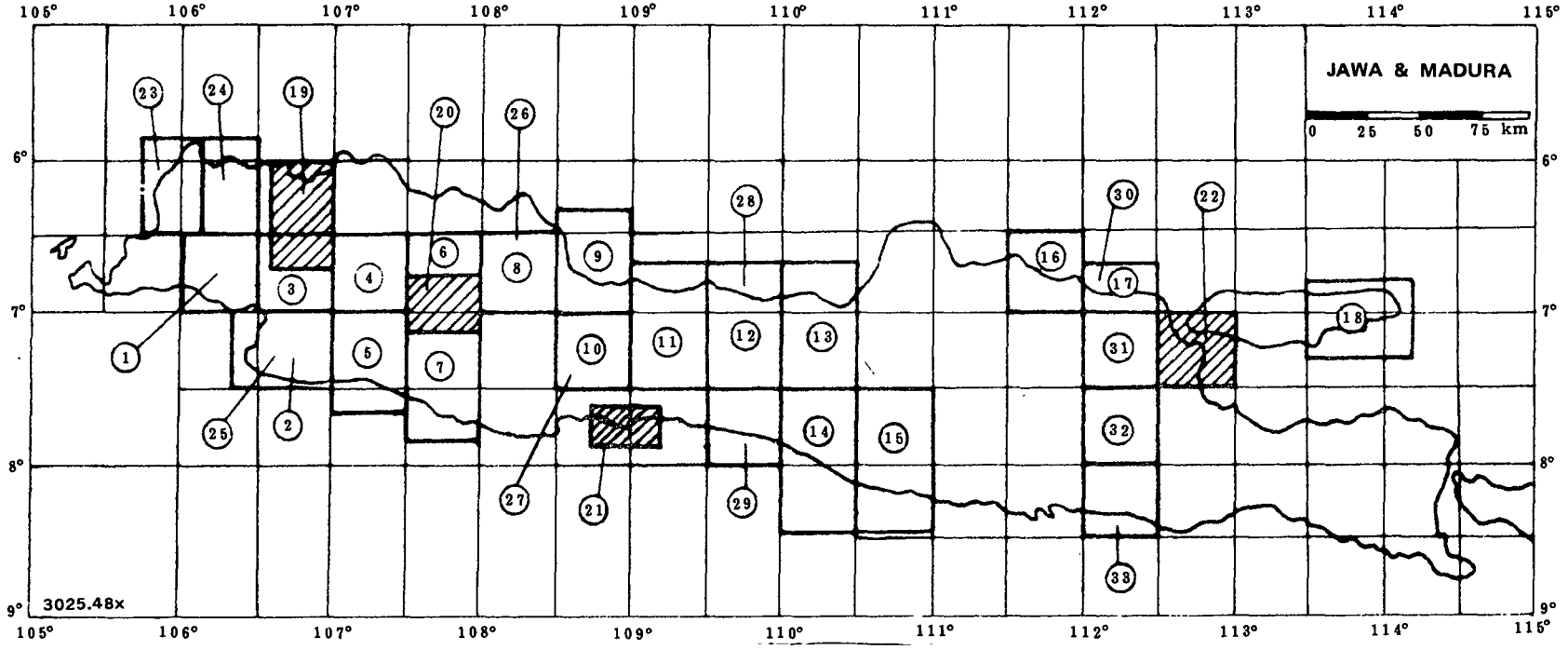
(c) *Maps at 1 : 1,000,000 scale*. Mosaic from the 1301 series of the International Map of the World on the Millionth Scale (IMW) with Lambert Conical conformal projection.

## Map publication

Two types of thematic maps are published by the Geological Survey of Indonesia:

(a) *Multicoloured maps*. These maps are generally used for geological, hydrogeological and engineering geological maps. The standard colours used are those of the "Color-Trol" colour system used by the United States Geological Survey (1970). This system consists of three basic colours and their combination to show geological units. Tints and solid colours obtained by this system produce a number of colour spectra. Three offset-litho plates are required to produce the colour spectra by this system, and three others are used to yield additional colours for geographical features. The "Color-Trol" inks are reduced or lightened versions of the three primary regular printing-inks — yellow, magenta and cyan. They are intentionally lighter than the true primary colours so that the overprinted combinations will not obscure the base map. It is possible to obtain 215 colour spectra by a combination of solid colours and four degrees of tints, which are controlled by film screens with densities of 15, 30, 50 and 70 per cent. For hydrogeological maps, patterns are commonly used in combination with "Color-Trol" colours;

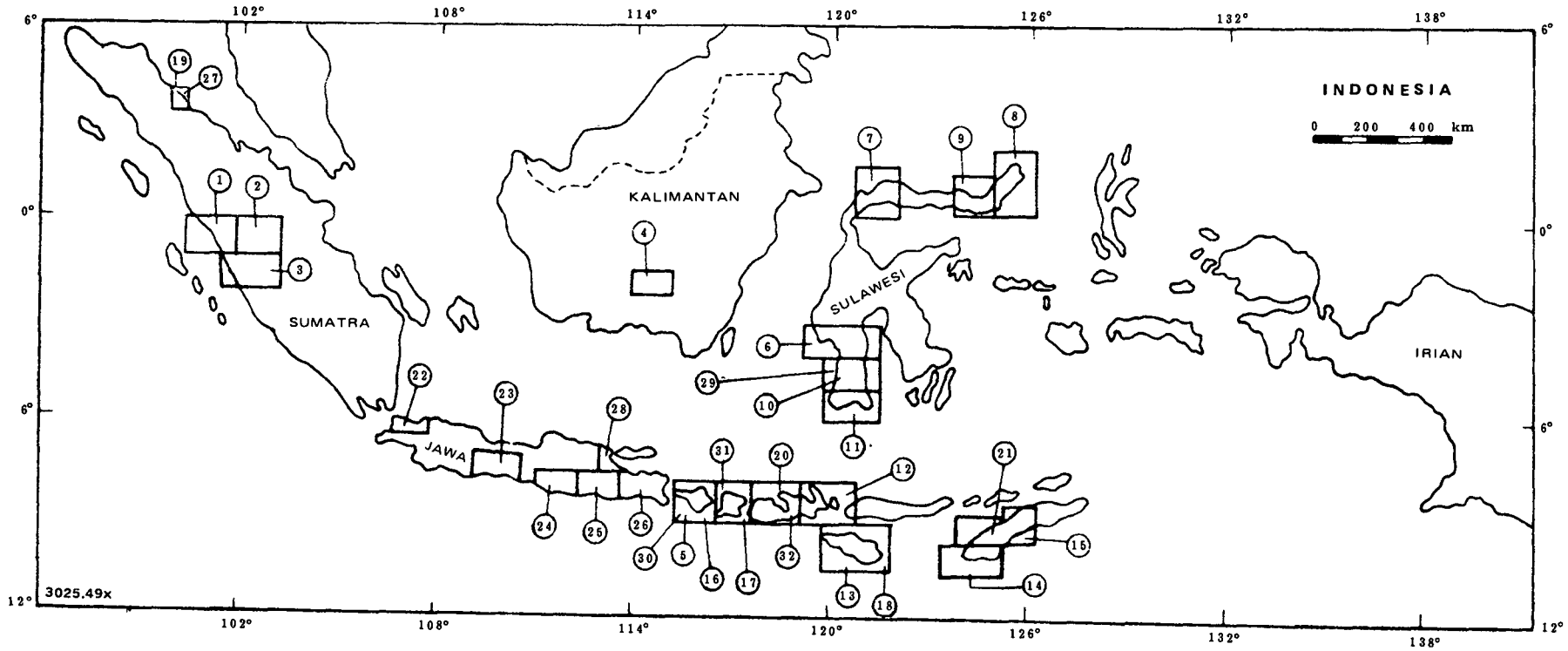
* The original text of this paper, prepared by Rachmat Kusmiadi, Head Publication Section, Geological Survey of Indonesia, appeared as document E/CONF.68/L.82.




*Legend*:

| No. | Map topic | Location | Stage of production | No | Map topic | Location | Stage of production |
|---|---|---|---|---|---|---|---|
| 1 | Geology | Leuwidamar quadrangle | Compilation | 18 | Geology | Sumenep quadrangle | Compilation |
| 2 | Geology | Jampang quadrangle | Published | 19 | Engineering geology | Jakarta-Bogor | Published |
| 3 | Geology | Bogor quadrangle | Published | 20 | Engineering geology | Bandung-Raya | Cartography |
| 4 | Geology | Cianjur quadrangle | Published | 21 | Engineering geology | Cilacap | Compilation |
| 5 | Geology | Sindangbarang quadrangle | Published | 22 | Engineering geology | Surabaya | Cartography |
| 6 | Geology | Bandung quadrangle | Published | 23 | Bouguer anomaly gravity | Serang | Compiled |
| 7 | Geology | Garut quadrangle | Compilation | 24 | Bouguer anomaly gravity | Tangerang | Published |
| 8 | Geology | Arjawinangun quadrangle | Published | 25 | Bouguer anomaly gravity | Jampang | Compiled |
| 9 | Geology | Cirebon quadrangle | Compilation | 26 | Bouguer anomaly gravity | Arjawinangun | Published |
| 10 | Geology | Majenang quadrangle | Published | 27 | Bouguer anomaly gravity | Majenang | Published |
| 11 | Geology | Purwokerto-Tegal quadrangle | Published | 28 | Bouguer anomaly gravity | Banjarnegara-Pekalongan | Cartography |
| 12 | Geology | Banjarnegara-Pekalongan quadrangle | Published | 29 | Bouguer anomaly gravity | Kebumen | Cartography |
| 13 | Geology | Magelang-Semarang | Published | 30 | Bouguer anomaly gravity | Tuban | Compiled |
| 14 | Geology | Yogyakarta quadrangle | Cartography | 31 | Bouguer anomaly gravity | Mojokerto | Compiled |
| 15 | Geology | Surakarta quadrangle | Compilation | 32 | Bouguer anomaly gravity | Kediri | Compiled |
| 16 | Geology | Jatirogo quadrangle | Compilation | 33 | Bouguer anomaly gravity | Blitar | Compiled |
| 17 | Geology | Tuban quadrangle | Published | | | | |

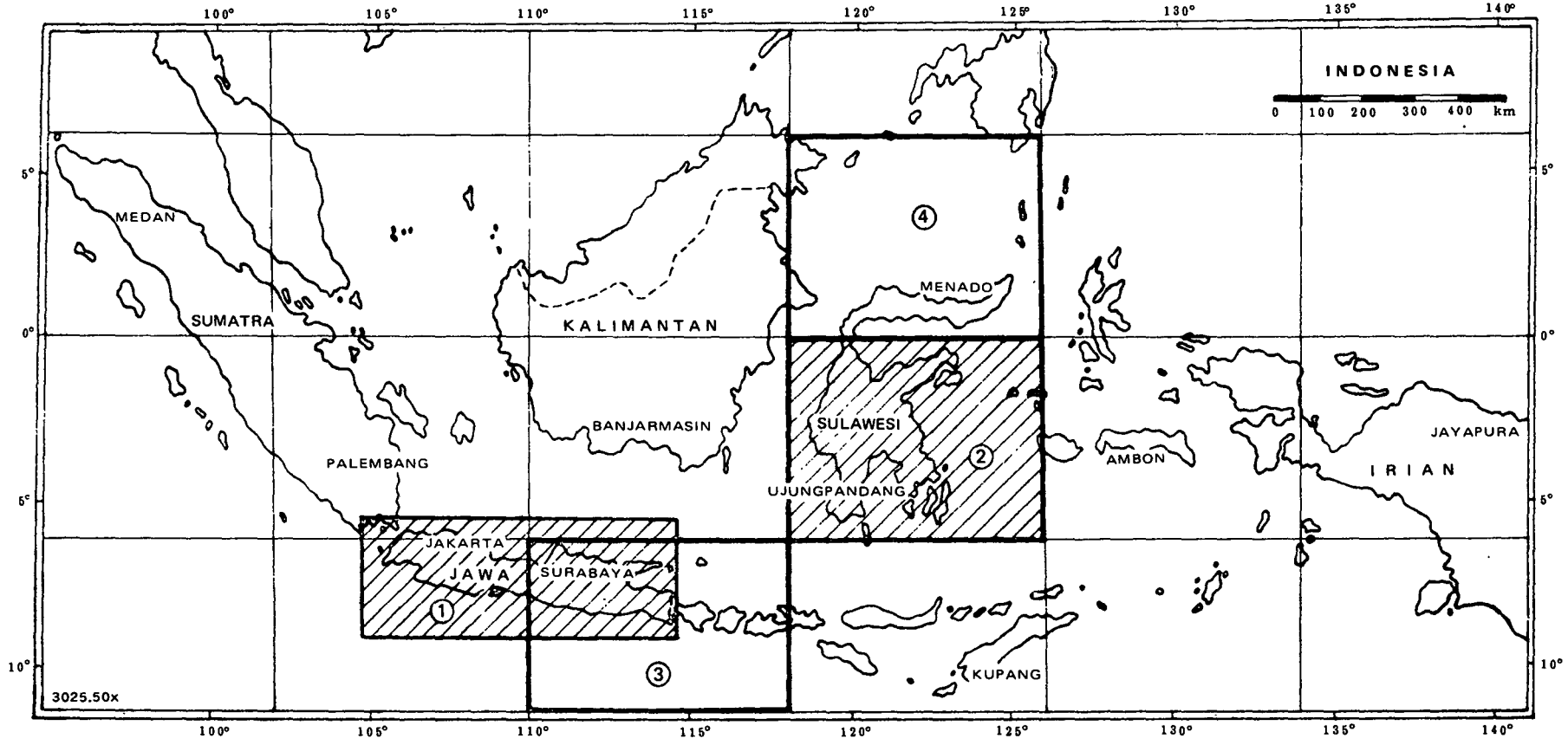
*Figure 73.— Indonesia: status of geological and related mapping of Jawa and Madura at 1 : 100,000 scale, 1976*




*Legend:*

| No | Map topic | Location | Stage of production |
|---|---|---|---|
| 1 | Geology | Padang quadrangle | Published |
| 2 | Geology | Solok quadrangle | Published |
| 3 | Geology | Painan quadrangle | Published |
| 4 | Geology | Tewah quadrangle | Published |
| 5 | Geology | Bali quadrangle | Published |
| 6 | Geology | Majene-Palopo quadrangle | Published |
| 7 | Geology | Tolitoli quadrangle | Published |
| 8 | Geology | Manado quadrangle | Published |
| 9 | Geology | Kotamobagu quadrangle | Compilation |
| 10 | Geology | Danau Tempe quadrangle | Compilation |
| 11 | Geology | Lompobatang quadrangle | Compilation |
| 12 | Geology | P. Komodo quadrangle | Compilation |
| 13 | Geology | Sumba quadrangle | Compilation |
| 14 | Geology | Kupang quadrangle | Compilation |
| 15 | Geology | Atambua quadrangle | Compilation |
| 16 | Hydrogeology | Bali | Published |
| 17 | Hydrogeology | Lombok | Published |
| 18 | Hydrogeology | Sumba | Published |
| 19 | Hydrogeology | Medan | Cartography |
| 20 | Hydrogeology | Sumbawa | Cartography |
| 21 | Hydrogeology | Timor | Cartography |
| 22 | Hydrogeology | Jakarta | Cartography |
| 23 | Hydrogeology | Purwokerto | Cartography |
| 24 | Hydrogeology | Madiun | Cartography |
| 25 | Hydrogeology | Kediri | Cartography |
| 26 | Hydrogeology | Jember | Cartography |
| 27 | Engineering geology | Medan (1 : 100,000) | Cartography |
| 28 | Engineering geology | Surabaya (1 : 100,000) | Cartography |
| 29 | Engineering geology | Ujung Pandang (1 : 100,000) | Cartography |
| 30 | Bouguer anomaly gravity | Bali | Published |
| 31 | Bouguer anomaly gravity | Lombok | Compiled |
| 32 | Bouguer anomaly gravity | Sumbawa | Compiled |

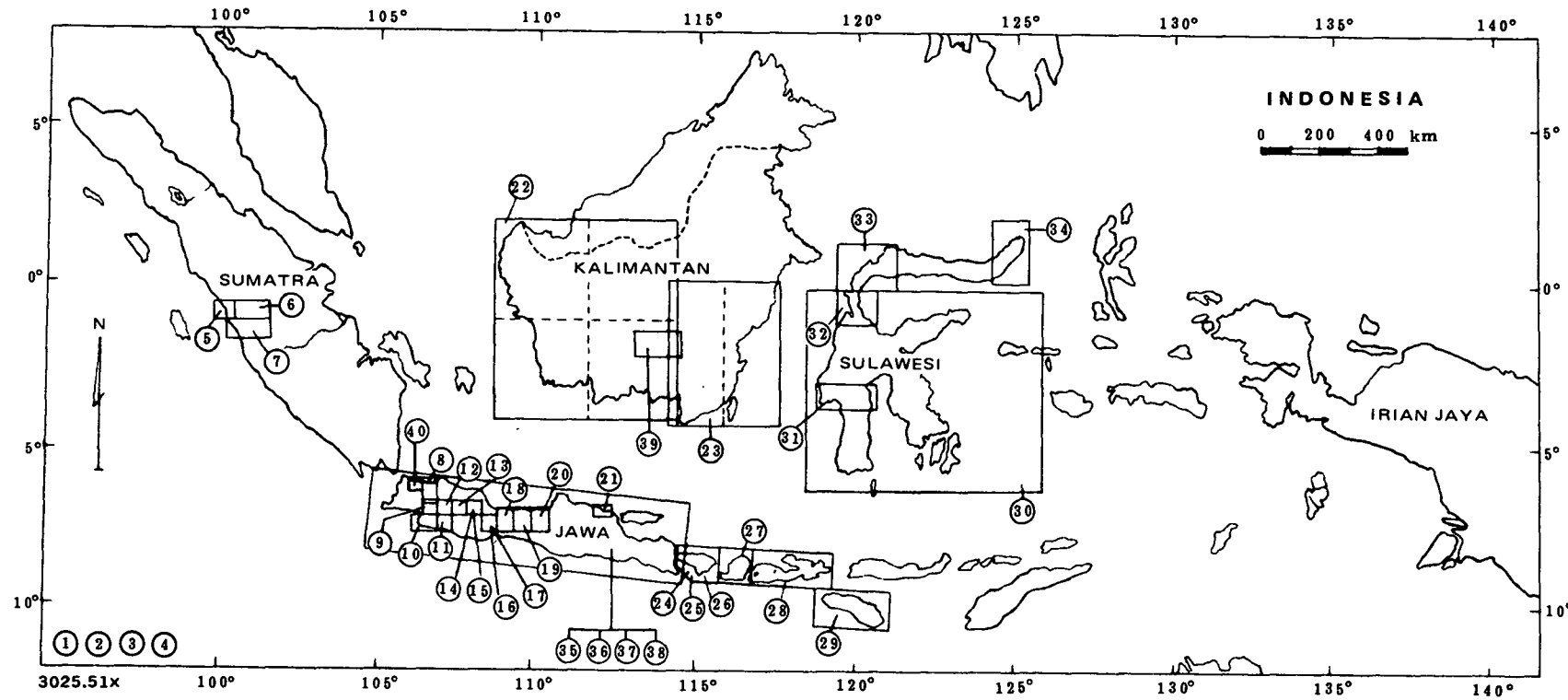
*Figure 74. Indonesia: status of geological and related mapping of Indonesia at 1 : 250,000 scale, 1976*




*Legend:*

1. Bouguer anomaly map, Jawa and Madura; published in 1974
2. Geological map, Indonesia, Ujung Pandang sheet; published in 1975
3. Geological map, Indonesia, Surabaya sheet; cartography stage
4. Geological map, Indonesia, Manado sheet; compilation stage

*Figure 75. Indonesia: status of geological and related mapping of Indonesia at 1 : 1,000,000 scale, 1976*




*Legend:*

| No. | Map topic | Location | Scale |
|---|---|---|---|
| 1 | Bathymetry | Indonesian region | 1:5,000,000 |
| 2 | Sedimentary basins | Indonesian region | 1:5,000,000 |
| 3 | Earthquakes | Indonesian region | 1:5,000,000 |
| 4 | Geology | Indonesia | 1:2,000,000 |
| 5 | Geology | Padang quadrangle, Sumatera | 1:250,000 |
| 6 | Geology | Solok quadrangle, Sumatera | 1:250,000 |
| 7 | Geology | Painan and northern part of Muarasiberut quadrangles | 1:250,000 |
| 8 | Engineering geology | Jakarta-Bogor area | 1:50,000 |
| 9 | Geology | Bogor quadrangle, Jawa | 1:100,000 |
| 10 | Geology | Jampang and Balekam bang quadrangles, Jawa | 1:100,000 |
| 11 | Geology | Sindangbarang and Bandarwaru, Jawa | 1:100,000 |
| 12 | Geology | Tijiandjur quadrangle, Jawa | 1:100,000 |
| 13 | Geology | Bandung quadrangle, Jawa | 1:100,000 |
| 14 | Geology | Ardjawinangun quadrangle, Jawa | 1:100,000 |
| 15 | Bouguer anomaly | Ardjawinangun quadrangle, Jawa | 1:100,000 |
| 16 | Geology | Majenang quadrangle, Jawa | 1:100,000 |
| 17 | Bouguer anomaly | Majenang quadrangle, Jawa | 1:100,000 |
| 18 | Geology | Purwokerto and Tegal quadrangles, Jawa | 1:100,000 |
| 19 | Geology | Banjarnegara and Pekalongan quadrangles, Jawa | 1:100,000 |
| 20 | Geology | Magelang and Semarang quadrangles, Jawa | 1:100,000 |
| 21 | Geology | Tuban quadrangle, Jawa | 1:100,000 |
| 22 | Geology | Kalimantan Barat and Barat Daya | 1:500,000 |
| 23 | Geology | South-east Kalimantan | 1:500,000 |
| 24 | Geology | Bali | 1:250,000 |
| 25 | Reconnaissance hydrogeology | Bali | 1:250,000 |
| 26 | Complete Bouguer gravity | Bali | 1:250,000 |
| 27 | Tentative hydrogeology | Lombok Island | 1:400,000 |
| 28 | Reconnaissance geology | Sumbawa, West Nusa Tenggara | 1:250,000 |
| 29 | Hydrogeology | Isle of Sumba | 1:250,000 |
| 30 | Geology | Indonesia, Ujung Pandang sheet | 1:1,000,000 |
| 31 | Geology | Majene and Western Palopo quadrangles, South Sulawesi | 1:250,000 |
| 32 | Reconnaissance geology | Palu area, Central Sulawesi | 1:250,000 |
| 33 | Geology | Tolitoli quadrangle, North Sulawesi | 1:250,000 |
| 34 | Geology | Manado quadrangle, North Sulawesi | 1:250,000 |
| 35 | Geology | Jawa and Madura | 1:500,000 |
| 36 | Tentative ground water | Jawa and Madura | 1:1,000,000 |
| 37 | Prospective geothermal areas | Jawa and Bali (tentative) | 1:1,000,000 |
| 38 | Bouguer anomaly | Jawa and Madura | 1:1,000,000 |
| 39 | Geology | Tewah quadrangle, Central Kalimantan | 1:250,000 |
| 40 | Bouguer anomaly | Tangerang quadrangle, Jawa | 1:100,000 |

*Figure 76. Indonesia: index showing recently published geological and related maps, as of 1976*

(b) *Single-colour and two-colour maps.* This colour system is applied in Bouguer anomaly gravity maps, reconnaissance geological maps etc. In this case, film screens are used for producing tones of the lines, and patterns are often used to distinguish geological units.

The problems that have to be faced in map publication are as follows:

(*a*) Availability of cartographic and graphic materials, such as plastic-mylar, scribe-coat, peel-coat, film, and paper for printing, in the local market. As concerns paper, the maximum size available is only 65 × 100 cm. Papers of larger size have to be imported, which takes several months of administrative procedures.

(*b*) Printing of multicoloured maps can only be done by a private firm at Jakarta, which is located about 180 km from Bandung. Printers at Bandung are reluctant to print 2,000 sheets per map as planned by the Geological Survey of Indonesia.

(*c*) The procedure of map publication is also hampered by the lack of a full-time map reviewer and editor.

## INTEGRATED MAPPING: THE SCOPE AND RANGE OF MAPS*

*Paper presented by New Zealand*

Reference is made in the New Zealand national report (see agenda item 6) to the various types of mapping coverage in production in New Zealand. The present paper explains how the various map series are related and gives some indication of the advantages of this relationship.

It should be mentioned that, in New Zealand, all land subdivisional records are held by the Department of Lands and Survey so that complete and comprehensive cadastral maps on a nation-wide basis can be generated in a relatively straightforward way. For some years, New Zealand has had national coverage of cadastral maps in some 360 sheets at 1 : 63,360 scale. In early 1976, the final sheet of a topographic series at 1 : 63,360 scale, with identical sheet-lines to this cadastral series, was completed so that the entire country is covered on a map-for-map basis both cadastrally and topographically. The advantage of being able to take two such maps, on some scale, of identical layout and format, of any part of the country need not be emphasized. For any aspect of planning and development, a ready comparison of the land subdivisional situation with the topographic situation has tremendous advantage. Furthermore, the ability to integrate material from each of these series of maps, in whole or in part, to produce a composite picture for some specific purpose with a minimum of labour or photo-mechanical involvement also has great merit.

With the change to metric mensuration for length, height and area for all surveys and land measurements on 1 January 1973, the advantages outlined above were carried forward into a new metric map series which is currently in production. A new metric grid covering the entire country has been used as the basis for subdividing New Zealand into prime rectangles, each 40 km from east to west × 30 km from north to south at 1 : 50,000 scale. The new grid, called the New Zealand Map Grid, and the associated projection have their true origin at latitude 41° South, longitude 173° East. Map grid co-ordinates of this true origin are 6,023,150 m north and 2,510,000 m east. Thus, metric co-ordinates covering the entire country are positive (east and north) and all have seven integral figures.

The prime rectangles of the New Zealand Map Grid and the layout of the new cadastral and topographic map series on the scale 1 : 50,000 are shown in figure 77. It will be seen that the numbering system, devised so that adjoining sheet numbers can be readily identified, employs an alpha-numerical method that quite fortuitously just covers New Zealand from east to west within the 26 letters of the alphabet.

Maps in the cadastral series on the scale 1 : 50,000 are being produced by cutting and assembling photographic reductions of the record maps and then tracing or scribing. Some interim maps are being produced from existing cadastral map coverage at 1,63,360 scale. The programme to provide full national coverage at the new scale is now well advanced. Concurrently, work is proceeding on production of some 10,000 new survey record maps covering New Zealand on the new metric scales 1 : 10,000; 1 : 2,000 and 1 : 1,000, from existing series at imperial scales. The new maps are being produced by preparing photographic scale-change reproductions of the old record maps. These reproductions are then cut and reassembled to the new format, after which line-work is traced to produce the new base map. At this stage, a transparency is made and held for planning purposes. The line-drawing is then lettered by engineering varityper, with some hand and stick-on photo-typeset lettering. The labour content in this redrawing programme has been reduced to as low as 1.5 man-days per sheet, although most sheets take from three to four days to complete. The intention is to hold original drawings in good condition and to operate the record map system, which serves as an index to all survey plans in the plan records system, by reference to a transparency prepared from the original. These transparencies are kept constantly up to date and can be used to make prints as necessary. Updating amendments in black can be readily transferred to the original from time to time, after which a new transparency is produced and the old discarded. Special flat-bed diazo printers are being installed in all

* The original text of this paper, prepared by D. G. Francis, Director (Mapping), Department of Lands and Survey, New Zealand, appeared as document E/CONF.68/L.37.

districts to facilitate the production of transparencies and prints.

These new record maps are to be used as the basis for final cadastral coverage of New Zealand at 1 : 50,000 scale with urban area maps at larger scales. There will be sufficient demand for maps in the 1 : 50,000 series to justify offset-printing. Larger scale cadastral maps of urban areas will be reproduced as plan prints, making more frequent revisions of the original economically viable.

The format and cut-up for the urban area record maps and cadastral maps is based on a breakdown of the prime rectangles at 1 : 50,000 scale with a related numbering system designed to facilitate sheet and scale identification, as illustrated in figure 78.

The New Zealand Map Grid, the related prime rectangle system at 1 : 50,000 scale and its breakdown into numbered sheets on larger scales have been initiated in close liaison with other government departments, local bodies and organizations that use maps and plan record systems, so that a uniform system can emerge.

Plotting of the new metric topographic series is being done photogrammetrically from aerial photography which, in general, is at 1 : 50,000 scale. The plotting scale is 1 : 25,000 with 20-m vertical contour intervals. These completed topographic plots at 1 : 25,000 scale, once field-checked, are available to clients in plan-print form, in advance of the published 1 : 50,000 topographic map. They are produced in four quadrant-sheets each of which is allocated an A, B, C or D suffix to the prime rectangle number (see figure 78).

The production of cadastral and topographic maps is being conducted on a decentralized basis as far as possible. The entire cadastral programme, apart from design, preparation of specifications, materials, lettertype supply and photo-laboratory support, processing, offset-printing, and holding and distribution, is undertaken in the 12 district offices of the department. For topographic maps, the design and preparation of specifications, production programming, aerial triangulation, plotting, photo-typesetting, relief shading, servicing and photo-laboratory processing, offset-printing and distribution are head-office mapping organization functions, while field control, field-checking and preparation of fair-drawings are undertaken in district offices.

Street maps on the scales 1 : 12,500 and 1 : 20,000 of all cities and towns are being converted to the metric grid and metric mensuration as they are revised. There are also tentative plans to produce topographic maps at 1 : 10,000 scale of urban areas, but accent is first being placed on 1 : 50,000 topographic production. This latter work is being programmed to concentrate production in blocks so that each district office can be involved in and benefit from production. The intention is to maintain both imperial maps at 1 : 63,360 scale and metric maps at 1 : 50,000 scale in print until an entire area is covered by the new 1 : 50,000 maps, when the 1 : 63,360 series will become obsolete.

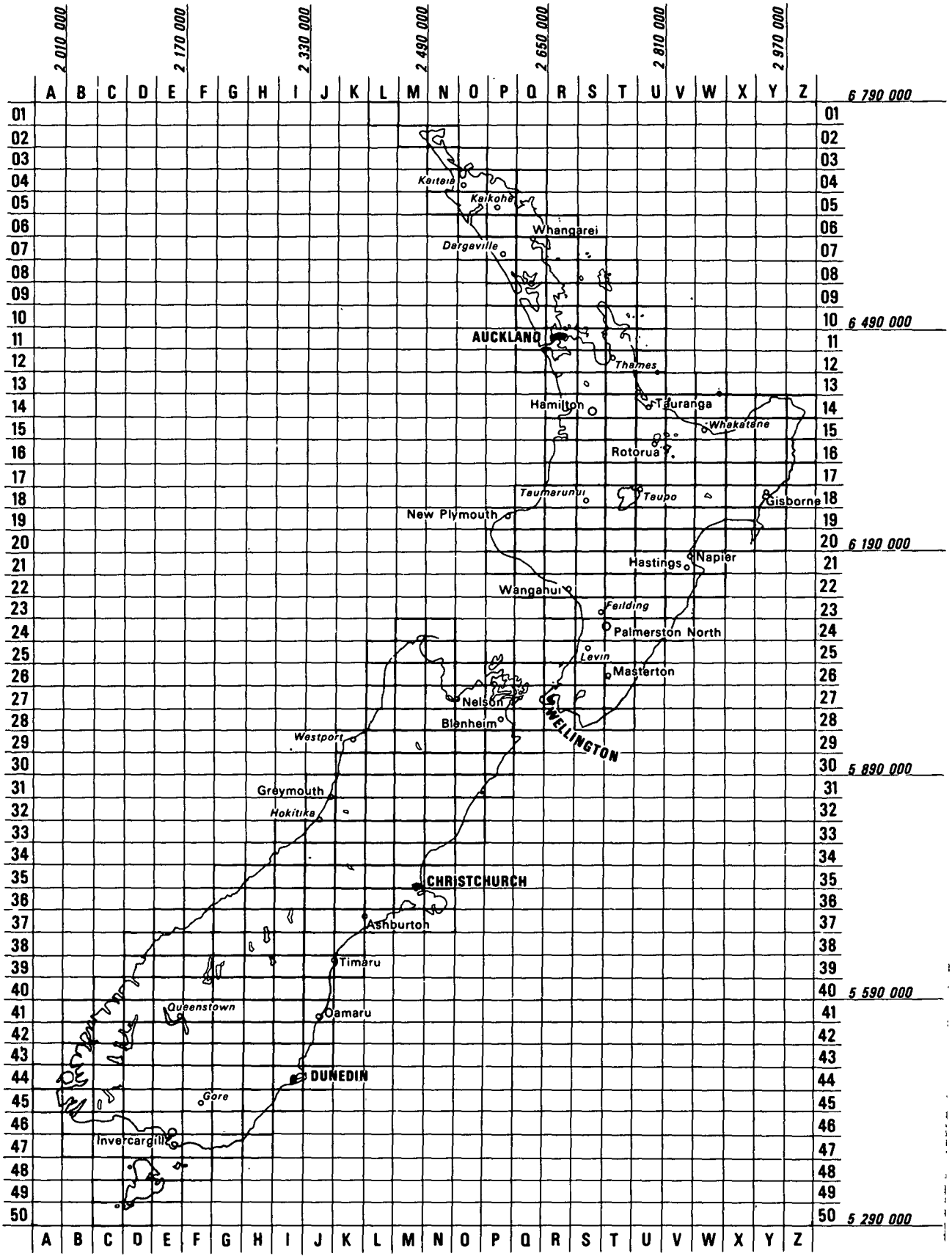
The Department of Lands and Survey has not published topographic or cadastral maps at 1 : 100,000 scale, the nature of the country being such that, for most purposes where maps are needed on scales smaller than 1 : 50,000, maps at 1 : 250,000 scale are adequate. The available national coverage of imperial 1 : 250,000 topographic maps in 26 sheets is currently being replaced by an 18-sheet series which has its quadrangular layout tied to the prime rectangles at 1 : 50,000 scale.

Late in 1976, all four sheets of a new topographic series at 1 : 500,000 scale covering New Zealand were published. Because considerable use will be made of overprinted sheets in this series for aeronautical purposes, all height information remains in feet. Metric coverage at 1 : 1,000,000 scale and a single metric map at 1 : 2,000,000 will also supersede existing maps on those scales. A small metric map of New Zealand at 1 : 4,000,000 scale also was recently published.

Ready availability of well-planned basic cadastral and topographic mapping coverage is invaluable for planning and management. No forward planning can be well founded without a well-based evaluation of resources, which must itself necessarily be based on mapping. In New Zealand, there is a continuing programme of Land Inventory Resource Mapping which in the past has been at 1 : 63,360 scale and is currently being produced at 1 : 100,000 scale. Related are series of soil, geological, land-tenure, land-cover maps with other maps illustrating hydrological and erosion factors. All can be more readily prepared when sound basic mapping coverage, with aerial photography, is available.

For management, derived mapping of many types is essential. The Department of Lands and Survey caters for many of its own land management functions and services other government departments in map production or in staffing their own map production units. The ability to utilize on derived mapping all the compilation and reproduction material and all plant, equipment and expertise necessary for basic mapping is a factor that should not be overlooked in planning for the best economic use of mapping resources and capability. As an indication of the extent of derived mapping, the Department of Lands and Survey in 1975/76 produced 1,062 different maps in this category, of the total output of 1,502 maps published that year.

There is also an increasing demand in New Zealand from sale of maps to the public. In addition to sales over departmental counters, the Department of Lands and Survey has over 550 private map-selling agencies in New Zealand and abroad, which make the department's published maps available to a very wide range of users. Of the total issue of over 567,000 maps from the Map Centre during the 1975/76 financial year, sales through private map-selling agents totalled 152,743 with a further 124,832 sold through departmental outlets. A high proportion of those sales would be for recreational use and for normal reference purposes, but many would have been employed for route-finding and for use in the back country, where use of a map is encouraged for safety in the bush and mountains and as a means of reducing the incidence of search and rescue.




3025.52x

SOURCE: New Zealand Department of Lands and Survey, 1976.
*Notes:* reference by letter and numerals, e.g., R 27; New Zealand Map Grid; metric values in italic numerals; sheet size 40 × 30 kilometres.

*Figure 77. New Zealand: index to sheets of map series at 1 : 50,000 scale*

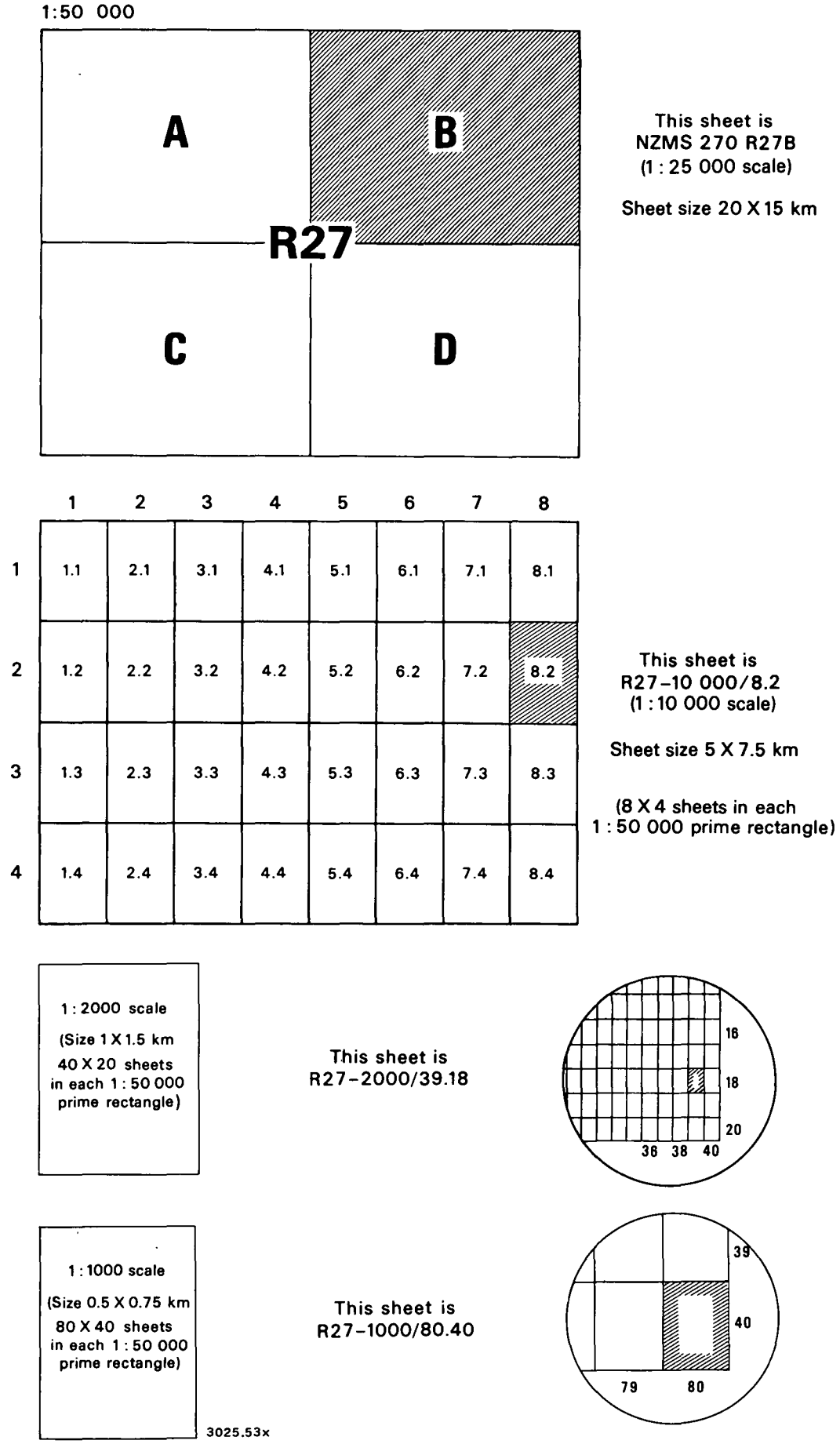



*Figure 78. New Zealand: map-numbering system*

# THE POPULATION DISTRIBUTION MAP OF THE REGIONAL ECONOMIC ATLAS OF ASIA AND THE FAR EAST*

*Paper presented by Thailand*

A map showing the spatial arrangement of the population is a basic map of regional or national planning. It reveals more compellingly than other means the growth of population, the increase of population density, the internal migration pattern, regional concentrations and urbanization processes, and related problems. If it represented the population by dots of equal value and proportional geometric or stereometric signatures, it could serve as a reliable foundation of other maps of population characteristics. Thus, the population distribution map is one of the basic maps of each regional or national atlas that is regarded as a graphic inventory of physical, human and economic resources.

With these considerations in mind, the Seventh United Nations Regional Cartographic Conference for Asia and the Far East unanimously adopted resolution 14, in which it noted the initial work on the Regional Economic Atlas of Asia, undertaken by Thailand; recognized the value of this atlas for social and economic development; and recommended that the international co-operation in the field of atlas production " . . . begin with the compilation of a population distribution map of Asia and the Far East, scale 1 : 5,000,000, to be executed by the Royal Thai Survey Department on the new six-sheet, rectangular format . . ."[1] and that "all nations in the region be invited to submit gratis to the Royal Thai Survey Department without delay appropriate source maps together with the newest and most detailed available population data".[2]

The recommendation to publish a map of the population distribution as the next sheet of the Regional Economic Atlas of Asia was undoubtedly influenced by three facts: the United Nations declaration of 1974 as the World Population Year; the completion of the 1970 round of censuses in most Asian countries; and the publication of population distribution maps of many countries based on the 1960 censuses and the adoption to some extent of the proposals of the International Geographical Union (IGU).

The year 1974 was declared the World Population Year by the United Nations General Assembly to arouse world-wide interest in the rapid increase, the irregular growth rate and distribution of population; the urbanization processes and their problems; and the unbalanced educational, hygienic and nutritional provisions for the world population in connexion with the so-called "world food crisis" and "world energy crisis". Experts and officials discussed the influence of population growth on the long-term economic and social development and the natural resources in several meetings and at the World Population Conference in 1974.[3] A conference background paper pointed out that in many areas the discussions and decisions had to be based on incomplete and unreliable data of population and that in other areas the collected data have not been properly exploited, such as those of the 1960 round of censuses in the region served by the Economic and Social Commission for Asia and the Pacific (ESCAP).[4]

Most countries of the ESCAP region conducted population censuses in 1960 or 1961 to provide comparable population data for a standard period. The successful completion of this round of censuses was supplemented by a new round of censuses in 1970–1973 to obtain more data on the population and on population development. The accumulation of an ever-increasing variety of population data did not lead to better information on population problems, as the classification of the raw data requires much time and the printing of the data for dissemination requires more and more funds. Although the results of the 1960 round of censuses are now available for most countries of the region, the 1970 census results have been published for some countries only.

One of the forms used to condense the data of a population census to quick and reliable information on their spatial distribution, and distribution and correlation is the population map.

With reference to the international co-operation in the preparation and production of the International Map of the World on the Millionth Scale (IMW), the International Geographical Union proposed to produce population distribution maps on the scale 1 : 1,000,000 based on the 1960 censuses. An IGU working commission with W. William-Olsson as chairman worked out and proposed a standard key for the maps which were expected to be compiled as national maps. Lastly, all national maps could be composed to an international world population map. However, not very many countries compiled and printed those population distribution maps, and only few countries adapted the IGU standard key.

To overcome some difficulties of population mapping which were caused by the large scale of the maps, some members of the International Cartographic Association suggested the use of the new world map at 1 : 2,500,000 scale as a base of a world population map. New keys were

* The original text of this paper, prepared by Ulrich Freitag, Royal Thai Survey Department, appeared as document E/CONF.68/L.53.

[1] *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.74.I.7), p. 31.

[2] *Ibid.*, p. 32.

[3] For further information, see *Report of the United Nations World Population Conference, 1974, Bucharest, 19–30 August 1974* (United Nations publication, Sales No. E.75.XIII.3).

[4] Formerly called the Economic Commission for Asia and the Far East (ECAFE).

proposed for such a map, but no map has yet been produced for any Asian country.

Resolution 14 of the Seventh Conference reduced the scale of the regional map even more. The adoption of the scale 1 : 5,000,000 will restrict the accuracy of the map: it will make it useful for regional rather than national planning. On the other hand, this decision appears to put the compilation of a regional population distribution map within achievable bounds of a single mapping institution.

The compilation of a regional population distribution map could be executed without difficulties if all countries of the region would submit national population distribution maps to the Royal Thai Survey Department.

Some countries of the region did produce population distribution maps using the results of the 1960 round of censuses. Examples are the population maps of India at 1 : 1,000,000 scale (in the National Atlas of India), the maps of Indonesia at 1 : 5,000,000 (in the Atlas of Indonesian Resources), the maps of Japan at 1 : 1,000,000, of Northern Borneo at 1 : 750,000 and of the Philippines at 1 : 2,000,000 which were kindly forwarded to the Map Information Centre of the Royal Thai Survey Department. Some countries of the region compiled population density maps only, and other countries did not publish any population map.

As far as the 1970 round of censuses is concerned, only Japan published and forwarded a population distribution map at 1 : 2,500,000 scale as a sheet of the National Atlas of Japan. Hence, map sources could not be used for the compilation of the regional population distribution map around 1970.

Consequently, the Royal Thai Survey Department decided to collect the original census data within the smallest regional units and base the new map entirely on those data. Working schedules were developed that provide for the following combinations of source data:

(*a*) New census data and new population distribution map (e.g., Japan), where both the number and the location of the signatures of the regional map are definitely fixed by excellent new sources;

(*b*) New census data and old population distribution map (e.g., Indonesia), where the number of the signatures is determined by the new census, but where the location of the signatures has to be established by the old map;

(*c*) New census data and no population distribution map (e.g., Burma), where the number of signatures is determined by the new census, but where the location of the signatures has to be established by other means. In general, the Royal Thai Survey Department used two means to locate approximately the population signatures:

(i) A map of the transportation facilities (roads, railways, ports, airports) with the assumption that the population normally tends to accumulate on and along these facilities;

(ii) A map of the forests (mainly based on the World Forest Atlas) with the assumption that in principle the population tends to avoid and live outside the forests;

(*d*) New census data for cities only (e.g., Republic of Korea) which do not allow a complete portrayal of the population distribution, but which should be shown by signatures on the regional map;

(*e*) No new census data (e.g., the Lao People's Democratic Republic) so that the area of those countries has to be left without signatures on the regional map.

These combinations of source materials are indicated in the reliability diagram on sheet IV of the map. The reliability is regarded as very good in case (*a*), good in cases (*b*) and (*d*), and fair in case (*c*). The Royal Thai Survey Department avoided a poor reliability because it did not attempt to fill the blank areas of cases (*d*) and (*c*) by using older or less reliable data.

The Royal Thai Survey Department did not receive any census data from the participants of the United Nations Regional Cartographic Conferences for Asia and the Far East. Therefore, the survey department acknowledges with gratitude the outstanding assistance of the Population Division of the Economic and Social Commission for Asia and the Pacific, Bangkok, which helped the Royal Thai Survey Department in every possible way to obtain the new census data of the countries of the region. Without the support of the Population Division of ESCAP, the population distribution map of the Regional Economic Atlas of Asia could not have been accomplished.

The major sources for the compilation of the population maps are listed in the annex to this paper. In addition to those listed, other geographical and statistical sources were used for many countries.

The Royal Thai Survey Department does hope to obtain the missing data of some of the countries either from the headquarters of ESCAP or from the participants in the Eighth United Nations Regional Cartographic Conference. Then it will fill the hitherto empty areas of the map with the appropriate signatures.

The acquisition of the census data and other relevant data was followed by the development of a signature key. For this purpose, all available population distribution maps were carefully examined to find their common base.

The scales of the population maps, the type and size of the signatures and the units of population figures shown by the signatures differ in accordance with the size and number of population of the countries. In general, however, urban centres are portrayed by graduated geometric signatures and the rural or non-urban population is indicated by dots. One dot, for example, represents 100 persons on the population map of Northern Borneo at 1 : 750,000 scale as well as on the maps at 1 : 1,000,000 scale of the National Atlas of India; it shows 1,000 persons on the map of the Philippines at 1 : 2,000,000 scale, and 10,000 persons on the population map of Indonesia at 1 : 5,000,000 scale. The graphic size of the dots also varies considerably and ranges from the tiny diameter of 0.25 mm on the 1 : 2,500,000 population map of Japan to a diameter of 1.0 mm on the population map of the Philippines.

The various population distribution maps of Japan

vividly illustrate the possibilities and problems of population mapping. Apart from the geometric signatures for the population of the urban centres, the 1950 census map used one dot to show every 500 persons on the scale 1 : 2,000,000, the 1955 census map one dot for every 1,000 persons on the scale 1 : 800,000, the 1960 census map one dot for every 200 persons on the scale 1 : 1,000,000, the 1965 census and the 1970 census map one dot for every 500 persons on the scale 1 : 1,000,000, and the 1970 census map in the National Atlas of Japan at 1:2,500,000 scale one dot for every 1,000 persons outside the densely inhabited districts.

The analysis of these and other sources indicated that first a regional map should portray urban and non-urban population by different signatures. Black dots of 0.5 mm diameter will be used to show the rural population. Squares of different colour (red) were chosen to portray the urban population but were calculated as proportional squares on the same area scale as the dots.

The analysis indicated, secondly, that the small scale of the regional map necessitates a generalization or rather a concentration of a larger number of persons into one signature. The choice was made to summarize 5,000 persons into one dot. As urban centres are considered settlements of at least 50,000 persons, smaller settlements with the status of a town (in an administrative sense) are regarded as rural towns only and will be shown like other rural settlements. All other towns are indicated by graduated squares, the size of which are proportional to the average number of people of the respective class. The following classes of population and their representation by squares were selected:

| *Population group* | *Average population* | *Square-signature size (square millimetres)* | *Side length (millimetres)* |
|---|---|---|---|
| 50 000– 100 000 | 75 000 | 2.94 | 1.7 |
| 100,000– 250,000 | 175 000 | 6.87 | 2.6 |
| 250 000– 500 000 | 375 000 | 14.73 | 3.8 |
| 500 000–1 000 000 | 750 000 | 29.45 | 5.4 |
| 1 000 000–2 500 000 | 1 750 000 | 68.72 | 8.3 |
| Over 2 500 000 | 3 000,000 | 117.81 | 10.8 |

This key was used to compile three test areas of the map in Japan, in the Philippines and in Thailand. The results were found to be acceptable and suitable, and the key was adopted for the regional population distribution map.

The compilation of the population map was executed on the new equivalent four-sheet base map of the Regional Economic Atlas of Asia in accordance with resolution 14 of the Seventh Conference. On a transparent overlay, the square signatures of the urban population were stuck after they were produced in great numbers on sticking-film; this overlay forms the original for the red colour printing-plate. On a second transparent overlay, the dots of the rural population were drawn by a Rotring pen of 0.5 mm diameter. Usually, a first drawing was worked out as a draft to perceive, control and adjust the visual impression of the population distribution; then, a second drawing was completed as original for the production of the black colour printing-plate.

Inset maps on larger scales were compiled for some densely populated areas, for instance, those around Tokyo. For those areas, the map scale was increased to 1 : 1,000,000, while the signature scale remained the same as in the general map. Thus, the signatures can be spread over a larger area to give a detailed and readable correct portrayal of the population around the largest cities of the region.

The completed population distribution map of the Regional Economic Atlas of Asia is an imagery of the concentration and dispersal of the population within the region. It clearly shows the small urbanized, overcrowded areas as well as the extended empty domains of extensive draught, tropical humidity or mountainous frigidity. This map cannot point out the causes of the disproportionate population distribution; but it can help to stipulate discussions about the causes of the current distribution pattern, the tendencies of the regional population movements and the possibilities of influencing population development as an integral part of the social and economic development of the whole region of the Economic and Social Commission for Asia and the Pacific.

## ANNEX

**Sources used for compilation of population distribution map of Regional Economic Atlas of Asia and the Far East**


*Burma*

Demographic report of the Socialist Republic of the Union of Burma, 1901–1973. 2 v. Rangoon, 1975. (Draft)

*China*

Chen, Cheng-siang. Population growth and urbanization in China, 1953–1970. *Geographical review* (New York) 63:55–72, 1973.

Cressey, G. B. Land of the 500 million; a geography of China. New York, McGraw-Hill, 1955.

Hsieh, Chiao-min. Atlas of China. Ed. by Christopher L. Salter. New York, McGraw-Hill, 1973.

Shabad, Theodore. China's changing map; national and regional development, 1949–1971. London, Methuen, 1973.

*India*

India. Ministry of Education. National Atlas Organization. National atlas of India, population 1 : 1,000,000 (coverage not complete). Ed. by S. P. Chatterjee. Calcutta, 1968.

———Registrar-General and Census Commissioner. Census of India 1971. Supplement, provisional population totals (primary census abstract districtwise 1971). New Delhi, 1971 (Paper 1 of 1971).

Singh, R. L., *ed.* India, a regional geography. Varanasi, National Geographical Society of India, 1961.

*Indonesia*

Indonesia. Army Topographical Directorate. Atlas of Indonesian resources; population distribution, 1 : 5,000,000. Jakarta, 1963.

Hasil Sementera. Sensus Penduduk 1971; tabel pendahuluan (Census of Indonesia 1971; advance tables). Jakarta, 1973.

*Japan*

Japan. Geological Survey Institute. National atlas of Japan; population distribution (1970), 1 : 2,500,000. Tokyo, 1972.

———Office of the Prime Minister. Bureau of Statistics. 1970 population census of Japan; densely inhabited districts. Tokyo, 1971 (special volume).

*Malaysia*

Jabatan Perangkaan Malaysis. Banchi pendudok dan perumahan Malaysia 1970; rengkasan kiraan luar (1970 population and housing census of Malaysia; field count summary). Kuala Lumpur, 1971.

Knight, Stanley, *ed.* Secondary school atlas for Malaysia. Singapore, McGraw-Hill Far Eastern Publications, 1970.

*Nepal*

Donner, Wolf. Nepal-Raum, Mensch und Wirtschaft. Wiesbaden, Harrassowitz, 1973.

*Philippines*

Philippines. Department of Commerce and Industry. Bureau of Census and Statistics. Geography Division. Population distribution map of the Philippines; census of 1960, 1 : 2,000,000. Manila.

———Department of Commerce and Industry. Bureau of Census and Statistics. 1970 census of population and housing; population, land density area and percent change in three censal years 1948, 1960 and 1970. Manila, 1972 (Special report 3).

———Department of National Defence. Coast and Geodetic Survey. 1972 national economic atlas. Manila, 1972.

*Sri Lanka*

Sri Lanka (Ceylon). Department of census and Statistics. The Ceylon economic atlas. Colombo, 1969.

———Report on the census 1971 of Sri Lanka (Unpublished).

*Thailand*

Thailand. Office of the Prime Minister. National Statistical Office. 1970 population and housing census; *changwat* series. Bangkok, 1973.

———Royal Thai Survey Department. National resources atlas of Thailand; population distribution 1 : 2,500,000. 4 ed. rev. Bangkok, 1976 (Draft).

*Other countries*

Atlas of south-east Asia. Amsterdam, Djambatan, 1964.

United Nations. Department of Economic and Social Affairs. Statistical Office. Demographic yearbook, 1972, 1973 and 1974. Sales nos. E/F.73.XIII.1, E/F.74.XIII.1, E/F.75.XIII.1.

## DEVELOPMENT, CONTENTS AND DESIGN OF THE REVISED EDITION OF THE NATIONAL RESOURCES ATLAS OF THAILAND*

*Paper presented by Thailand*

The first attempt of systematic thematic mapping of Thailand was made by the Royal Thai Survey Department in 1961. A set of nine topical maps was published on the scale 1 : 1,000,000 on a composition of sheets of the International Map of the World as base map, but the size of the maps proved to be too large.

The scale 1 : 2,500,000 was therefore adopted for a new set of thematic maps of Thailand, which was published by the Royal Thai Survey Department in 1964. Twelve map-sheets contained a great variety of topics ranging from maps of the climatic elements to maps of population density and transportation facilities. This set of maps was presented to the Fourth United Nations Regional Cartographic Conference for Asia and the Far East at Manila in 1964.

The maps of this set were updated and revised by the Royal Thai Survey Department in co-operation with various government departments; they were then published in two volumes in 1966 and 1968, which for the first time appeared under the title "National Resources Atlas of Thailand". By folding the maps on the scale 1 : 2,500,000, the size of the atlas was reduced to 39.5 × 28.2 cm and the addition of 94 text pages was made possible. The handy size of the atlas had the disadvantage of causing difficulties in the use of the maps.

The second edition of the National Resources Atlas of Thailand was published by the Royal Thai Survey Department in 1969. For the first time, the 17 map-sheets were systematically grouped into the three sections: "Physical resources" (with 9 map-sheets and 18 text pages); "Human resources" (with 2 map-sheets and 2 text pages); and "Social and economic infrastructure" (with 6 map-sheets and 16 text pages). The size of the atlas was increased to 54 × 77.5 cm to accommodate one map of Thailand on the scale 1 : 2,500,000 on the unfolded page. The atlas was presented to the Sixth United Nations Regional Cartographic Conference for Asia and the Far East at Tehran in 1970.

The third edition of the National Resources Atlas of Thailand was published by the Royal Thai Survey Department in 1972. It had the same format as the preceding edition, and it contained the same sections. The contents and graphic design of the maps were considerably improved compared with their predecessors. For the first time, all maps of the same scale (1 : 2,500,000) were designed on the same uniform base map, which in turn was derived from the South-East Asia Road Map at 1 : 1,250,000 scale, published in 1962/63 by the Army Map Service of the United States of America. A new map of the geology replaced the older geological reconnaissance map of the 1969 edition, a first hypsometric map was derived from the base map, a land-use map was added and the map of the industries was redesigned. On 19 map-sheets—to which 60 pages with text in Thai and English were added—the atlas presented the following topics:

I. Physical resources
   1. Hypsometry (dates of 1962/63)
   2. Types of climate (1931–1960)
   3. Climatic charts (1931–1960; five maps)

* The original text of this paper, prepared by Ulrich Freitag, Royal Thai Survey Department, appeared as document E/CONF.68/L.54.

4. Geology (1969)
5. General soils (1967)
6. Mineral resources (1971)
7. Types of forests, national parks and wildlife preserved areas (1968)
8. Percentage of land with certificates (1970)
9. Land use (1965)
10. Water resources development (1971)

II. Human resources
11. Density of population per kilometre (1970)
12. Education (1968–1970)

III. Social and economic infrastructure
13. Industries (1963)
14. Fisheries (1967, 1971)
15. Electric generation and transmission systems (1971)
16. Highways, railways and domestic airlines (1971)
17. Inland waterways (1964)
18. Telecommunication (1971)
19. Administrative divisions (1971)

Some of the maps were reduced and redesigned copies of maps of other government resources mapping departments. Examples are the geology map of the Geological Survey Division, Department of Mineral Resources; the soil map of the Soil Survey Division and the land-use map of the Land Classification Division, Department of Land Development; the water resources map (or better, the irrigation map) of the Royal Irrigation Department. Some maps were compiled by the Royal Thai Survey Department from various source maps like the transportation map. Other maps were newly compiled from statistical data and wholly designed by the Geographic Mapping Division of the Survey Department. Examples are the population map (based on the population registration data of 1970), the map of the industries (based on the industry census of 1963) and the map of the fisheries (based on the fishery census of 1967 and fishery records of 1970). Due to the variety of sources, the maps of the atlas were not strongly correlated with one another, but they presented the best available regional data and served their purpose as tools of information on the regional pattern of the resources of Thailand.

During the 10 years of development of thematic mapping, the Royal Thai Survey Department steadily improved the quality of the maps of the National Resources Atlas. The base map was standardized, the geometrical accuracy of the maps was improved, the amount of topical information was increased considerably and the graphic design was amended to meet international cartographic standards. The 10 years of experience and training enabled the Royal Thai Survey Department to design, compile and publish a new set of thematic maps as a revised, fourth edition of the National Resources Atlas of Thailand with the short series title "Atlas of Thailand."

The atlas revision was initiated by resolution 14 of the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, which recommended the "promotion of national atlases by each nation of its own territory, and that each nation render technical assistance, wherever needed, in co-operation with international scientific organizations, such as the International Cartographic Association (ICA), the International Geographical Union (IGU) etc."[1]

In accordance with the advice of the United Nations *Ad Hoc* Group of Experts in Cartography,[2] that a national atlas should be initiated and maintained for planning the use of land and all economic resources and for studying social, political and other human relationships, the Royal Thai Survey Department recognized the need for a national atlas of Thailand. The current political and economic situation of Thailand, however, does not permit this project to be undertaken. Therefore, the Royal Thai Survey Department has confined itself to a major revision of the National Resources Atlas of Thailand, which in its new form could constitute the foundation of a national atlas.

The main features of the revised edition of the National Resources Atlas of Thailand are:

(*a*) The addition of a great number and a wide variety of new topics;

(*b*) The close correlation or comparability of the various maps of the atlas;

(*c*) The versatility of the graphic solutions and the cartographic design;

(*d*) The employment of two standard base maps for the majority of the maps;

(*e*) The extensive application of diagrams and graphs within and beside the maps;

(*f*) The renunciation of explanatory texts;

(*g*) The use of (national) Thai and (international) English names and terms on all maps and graphs;

(*h*) The reduced size of the atlas and its publication as a loose-leaf collection in an atlas box.

The increase of the number of maps and their variety as well as their correlation can be indicated, if not really demonstrated, by the following list of contents of the revised atlas edition.

I. Natural resources
Thailand's environmental location (1 : 50,000,000)
Relief (1 : 2,500,000; 1970)
Surveying and mapping (1 : 4,000,000 ; 1973)
Tectonic structure (1 : 5,000,000; 1975)
Geology (1 : 2,500,000; 1975)
Geological cross-sections
Geomorphology (landforms) (1 : 4,000,000; 1975)
Soils (1 : 2,500,000; 1972)
Land capability (1 : 4,000,000; 1972)
Seasonal storm-tracks (6 maps; 1 : 15,000,000; 1961–1970)

[1] *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.74.I.7), p. 31.

[2] "Report of the *Ad Hoc* Group of Experts on Projections and Planning in Cartography for the Second United Nations Development Decade", *Seventh United Nations Regional Cartographic Conference for Asia and the Far East*, vol. II, *Technical Papers* (United Nations publication, Sales No. E.74.I.25), p. 121.

Mean maximum temperature (3 maps; 1 : 10,000,000; 1951–1970)
Mean minimum temperature (3 maps; 1 : 10,000,000; 1951–1970)
Mean evaporation (3 maps; 1 : 10,000,000; 1951–1970)
Mean relative humidity (3 maps; 1 : 10,000,000; 1951–1970)
Mean annual rainfall (1 : 4,000,000; 1951–1970)
Mean monthly rainfall (12 maps; 1 : 15,000,000; 1951–1970)
Climatic regions (1 : 4,000,000; 1973)
Vegetation (1 : 4,000,000; 1974)
Hydrography (1 : 4,000,000; 1974)
Discharge of major rivers, 1965–1970
Gulf of Thailand: temperature (4 maps; 1 : 15,000,000; 1973)
Salinity (4 maps; 1 : 15,000,000; 1973)
Fish (8 maps; 1 : 15,000,000; 1969)

II. Human resources
Ethnographic-linguistic groups (1 : 5,000,000; 1964)
Population distribution (1 : 2,500,000; 1970)
Population density, 1960 (1 : 5,000,000)
Population variation, 1960–1970 (1 : 5,000,000)
Migration 1965–1970 (1 : 4,000,000)
Educational provision (1 : 4,000,000; 1972)
Medical provision (1 : 4,000,000; 1974)
Economically active population in agriculture and mining (1 : 4,000,000; 1970)
Economically active population in manufacturing industries and construction (1 : 4,000,000; 1970)
Economically active population in commerce, transportation and services (1 : 4,000,000; 1970)

III. Economic resources
Land tenure (1 : 4,000,000; 1973)
Major land uses (1 : 2,500,000; 1973)
Land-use case studies (4 maps; 1 : 15,000; 1972–1974)
Crops: food crops I, II (2 maps; 1 : 5,000,000; 1973)
Irrigation (1 : 2,500,000; 1974)
Crops: oil crops, fibre crops (2 maps; 1 : 5,000,000; 1973)
Livestock (4 maps; 1 : 8,000,000; 1970)
Fisheries (1 : 4,000,000; 1973)
Forestry (1 : 4,000,000; 1973)
Mineral resources (1 : 4,000,000; 1973)
Industry (1 : 4,000,000; 1973)
Industry centre Krung Thep (1 : 100,000; 1975)
Electric energy (1 : 4,000,000; 1975)
Central places (1 : 4,000,000; 1975)
Road and rail traffic (1 : 4,000,000; 1972–1974)
Transportation (1 : 2,500,000; 1974)
Airline centre Krung Thep (1 : 100,000,000 and 1 : 8,000,000; 1974)
External trade, 1963 and 1972 (2 maps; 1 : 100,000,000)
Tourist map of Thailand (1 : 2,500,000; 1973)
Tourist centres: Bangrak District, Krung Thep (1 : 7,500; 1974); Patthaya, Bang Lamung (1 : 15,000; 1974); Khao Yai (1 : 75,000; 1974)
Old administrative divisions (ca. 1 : 5,000,000; 1905)
Administrative divisions (1 : 2,500,000; 1974)
List of administrative divisions (with data on area and population)
Special administrative divisions (1 : 4,000,000; 1975)
Telecommunication (1 : 4,000,000)
Navigation installations (1 : 4,000,000)

Some of the maps are revised and redesigned copies of maps of other resources mapping institutions or persons, as, for instance, the maps of the geology or the climatic regions, and are clearly marked with the name(s) author(s). The majority of the maps, however, were based on numerical data from various institutions and could not be compiled without their close co-operation. The map compilation and map design were carried out entirely by a special working group of the Geographic Mapping Division of the Royal Thai Survey Department.

Due to the diversity of the topics, a great variety of cartographic symbols and methods was employed. Simple choropleth maps were drawn and some were combined with dots or graduated circles. Isorithmic lines were used as contours, isotherms, isohyets, isodistances and others. Many point signatures were utilized to portray qualitative and quantitative data—dots, bars, triangles, squares, circles, diagrams, pictorial symbols etc. Line signatures appear as lines of different shape and colour and as flow lines of varying width; area signatures appear as patterns, screens and colours. Most maps combine several types of signatures to show the connexion and correlation of different elements or aspects of the same topic in order to overcome the isolating character of the map.

Another means to support the synthesizing view of the maps as a portrayal of the diversity of reality is the use of two standard base maps; they facilitate the comparison from map to map. Following the recommendation of the National Atlas Commission of the International Geographical Union, the scales 1 : 2,500,000 and 1 : 4,000,000 were adopted as standard scales of the maps. A new equivalent projection was calculated and plotted. Into the grid lines the elements of the base map were compiled from up-to-date topographic maps. They include coastline and drainage patterns, hypsometric and bathymetric contours, highways and railways, and the boundaries and centres of states, provinces (*changwats*) and counties (*amphoes*). Some of the elements are preserved in all thematic maps; some are deleted in those maps which do not require them as elements of orientation or explanation.

In addition to the two base maps, other map scales and map projections are used wherever it appears necessary. For example, the environmental location of Thailand is visualized on an orthographic hemisphere centred on central Thailand. The connexion of Thailand with the world by trade and airways is shown on two different maps on the same modified cylindrical projection with a precalculated area distortion of the higher latitudes. The

tectonic and ethno-linguistic context of Thailand is portrayed on the equivalent base map of the Regional Economic Atlas of Asia which is currently produced by the Royal Thai Survey Department. The seasonal storm-tracks are displayed on reduced and generalized sections of the same base map.

Although a multitude of cartographic signatures were used to avoid poor analytical maps, diagrams and graphs are extensively employed within and beside the maps to overcome the static character of the map. Diagrams of the monthly variation of the climatic elements are used in a traditional way, while comparable daily and monthly discharge diagrams of the major rivers are new features of the atlas. Development diagrams of various forms are designed for various topics covering time periods of up to 70 years, as in the irrigation map.

Other striking graphic features of this atlas are cross-sections and drawings, which were intentionally introduced to facilitate the map-reading and to extend the statements of the horizontal map into the vertical, third dimension. To this effect, geological cross-sections will accompany the geological map and typical vegetation profiles will go with the vegetation map. Drawings of various kinds of fish and livestock will help the map-user to imagine unfamiliar animals and to transform the dots of the maps into living creatures. The tourist map of Thailand is surrounded by drawings of outstanding cultural tourist attractions which are carefully selected also to illustrate the various art styles of Thailand. They are added to the map to attract the interest of the map-user.

Unlike the earlier editions of the National Resources Atlas of Thailand, the revised edition will not include text pages. A comprehensive, explanatory text or map interpretation with additional information can be an essential aid to secure the correct use and interpretation of the map. Currently, the Royal Thai Survey Department cannot obtain the assistance of all the experts who are in the position to write those map-corresponding substantive texts as the maps have to be published first. The form of the atlas provides enough space for some further expansion so that a future inclusion of text pages or more maps presents no difficulties.

The size of the basic maps of the atlas was determined by the decision on the scales and projections of the base maps. The rectangular frame around the elongated shape of Thailand at 1 : 2,500,000 scale measures 405 × 671 mm; and on the scale 1 : 4,000,000, only 253 × 420 mm. To reduce the size of the atlas to a handy format, the smaller map is placed on a single map page in an upright position while the larger map at 1 : 2,500,000 scale covers a folded double page in a transverse position. Thus, the size of the atlas could be fixed at 370 × 505 mm for the single page and the over-all shape of the atlas and at 505 × 740 mm for the double page. This size not only can accommodate the basic atlas maps but is large enough for the world maps with an equator length of 359 mm as well as the sequences of the climatic and economic maps and a series title on every page.

Lastly, the form of the atlas was determined in correspondence with the models of the national atlases of Sweden and Switzerland. The complete atlas will consist of a solid box with the imprinted atlas title in which the whole set of maps as loose-leaves, additional title and dedication pages, explanation and bibliography or sources pages can be stored. The advantage of the loose-leaf form are that the maps can be reached easily and arranged according to individual requirements, that the required map can be used without the burden of all the other pages and binding, that the maps can be individually replaced by revised editions of the maps, that the map user can add his own pages with notes and sketches and that the publisher also has the chance to add text or map pages to his atlas without the expense of a totally new atlas edition.

The work on the revised edition of the National Resources Atlas of Thailand was begun early in 1974. Thus far, most drafts of the first 60 map pages are completed and are being processed in the map reproduction section of the Geographic Mapping Division of the Royal Thai Survey Department. Several maps of the atlas have been published and may be obtained from the Royal Thai Survey Department.

## CONSIDERATIONS ON THE REGIONAL ECONOMIC ATLAS OF ASIA AND THE FAR EAST*

*Paper presented by Thailand*

To the Third United Nations Regional Cartographic Conference for Asia and the Far East, held at Bangkok in 1961, the Thai delegation presented a proposal and a background paper[1] on the systematic thematic mapping and the compilation of a regional economic atlas of Asia to provide a sound basis for adequate regional planning. The proposal listed the topics that should be included in the atlas:

1. Basic mapping status
2. Climatic maps and diagrams
3. Natural vegetation and forest resources
4. Soils
5. Geology
6. Agriculture
7. Industrial centres

* The original text of this paper, prepared by Ulrich Freitag, Royal Thai Survey Department, appeared as document E/CONF.68/L.55.

[1] "Establishment of a central organization for compiling and printing a regional economic atlas for Asia", *Third United Nations Regional Cartographic Conference for Asia and the Far East, 27 October – 10 November 1961, Bangkok, Thailand*, vol. II, *Technical Papers* (United Nations publication, Sales No. 64.I.17), pp. 292–293.

8. Population
9. Communication
10. Transportation
11. Minerals
12. Water resources
13. Power resources
14. Animal resources
15. Tourist resources

The proposal and its discussion led to the adoption of resolution 12 which reads:

"*The Conference, Recognizing* the increasing need for international cooperation in topical mapping,

"*Noting* that significant progress has already been made by the Economic Commission for Asia and the Far East in the preparation and publication of the regional Geological Map and other related maps,

"*Appreciating* the offer of the Government of Thailand to initiate the compilation and publication of a regional economic atlas,

"*Recommends* to the interested countries that they co-operate with the Government of Thailand by supplying relevant data and information as soon as possible."[2]

During the following years, the Royal Thai Survey Department tried to implement that resolution. The department contacted the various survey departments of the countries of the region to obtain the necessary data for the map compilation. Some countries followed the recommendation of the resolution and supplied relevant data to the Royal Thai Survey Department. However, the correlation of the various data and the establishment of uniform map keys for all areas of the region posed problems which could not be solved for some time without the assistance of a geographical cartographer. Another, and more serious, threat to the atlas project was the long delay in the production of the first atlas map, which was caused mainly by the insufficiency of the data supplied and which in turn resulted in an ever-decreasing interest in the regional economic atlas. In spite of the repeated recommendations of the following United Nations Regional Cartographic Conferences for Asia and the Far East that Thailand be assisted through the free supply of source material so that the project could be completed, the expected international co-operation did not really materialize. For example, a questionnaire of the Royal Thai Survey Department, distributed with the aid of the United Nations[3] in 1971, was answered by only a few countries which cover merely 10 per cent of the area and 10 per cent of the population of all countries of the region served by the Economic and Social Commission for Asia and the Pacific (ESCAP).[4]

In view of the reluctant international assistance, the Royal Thai Survey Department did appreciate the long-lasting, encouraging and helpful co-operation of the survey institutions of Australia, Japan and the Philippines, as well as the technical assistance provided by the Federal Republic of Germany for this project. The Royal Thai Survey Department also acknowledges with gratitude the outstanding help of the various divisions and the personnel of ESCAP headquarters in the acquisition of relevant data for the atlas project.

## Maps produced by Royal Thai Survey Department

With the above-mentioned assistance, but mainly based on its own initiatives and on its own financial, technical and manpower resources, the Royal Thai Survey Department was able to compile and publish some maps of the Regional Economic Atlas of Asia.

The first atlas map was the population density map, published in 1970 and presented to the Sixth United Nations Regional Cartographic Conference for Asia and the Far East, held at Tehran. Plotted on the outline of the ECAFE natural gas and oil map, the map portrays the population density of province-sized regions by colour tints and of urban agglomerations of 500,000 or more population by graduated circles.

The second atlas map was the climatic regions map (Köppen classification), published in 1973 and presented to the Seventh Conference, held in Tokyo. The map shows 19 distinct types of climate according to the classification of W. Köppen by area colours, and it shows the climatic diagrams of over 100 climatic stations for the standard period 1950–1960.

In the course of the atlas compilation, the old base map of the ECAFE natural gas and oil map proved to be inadequate because it was compiled before 1960, that is, before the accurate topographic mapping of large parts of the region. For this and other reasons, the Royal Thai Survey Department compiled a new base map of the region within the graticule of the equivalent conical projection of the International Union of Geodesy and Geophysics (IUGG) 1967 reference spheroid. Conceived as a work-sheet, the new base map contains the 10 grid lines, a detailed drainage network on the land area and the accurate coastline as its major components. In addition, it shows the generalized bathymetric contours, all towns with 250,000 or more population by signatures and names, and the international boundaries as non-authoritative elements. The layout of the six map-sheets of uniform shape and size, as well as a sample sheet, was presented to the Seventh Conference. The Conference unanimously accepted the new map as the base of future maps of the Regional Economic Atlas of Asia, and the Royal Thai Survey Department compiled and published all six sheets of the map in 1974.

The Royal Thai Survey Department is currently working on three maps of the atlas. These maps are all correlated and serve the aim of implementing resolution 14 of the Seventh Conference which recommends that international co-operation in the field of atlas production should begin with the compilation of a population

[2] *Third United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference* (United Nations publication, Sales No. 62.I.14), p. 10.

[3] Assistance was given by the Cartography Section, Centre for Natural Resources, Energy and Transport, Department of Economic and Social Affairs.

[4] Formerly called the Economic Commission for Asia and the Far East (ECAFE).

distribution map of Asia and the Far East.[5] As the required map cannot be produced immediately with the data and maps available, the Royal Thai Survey Department has adopted the following plan to achieve the population distribution map:

(*a*) A map of the transportation network will be compiled to serve as guidance to the placement of the signatures of the population as, in general, a dense road network indicates a concentration of settlements and population. The map will be compiled in co-operation with the sections of the Transportation and Communication Division of ESCAP. Parts of the map or components of the map could be utilized as supplementary elements of the newly designed base map;

(*b*) A map of the forestry resources will be compiled from various topographic and thematic maps, these mainly from the World Forest Atlas. This map can be seen as a special land-use map. It will also serve as a directing device of the signature plotting of the population distribution map as, in general, only a few people base their living on forest products and dwell in forest areas;

(*c*) The map of the administrative and census divisions that has been drafted for the regional population density map of 1970 will be revised and completed. The delineated census units also will be necessary aids in compiling the population map although they will not appear in the final map;

(*d*) On the basis of these maps, the older population distribution maps and the regionally grouped census data, the Royal Thai Survey Department will compile the recommended population distribution map of Asia. A sample sheet of this map will be presented to the Eighth United Nations Regional Cartographic Conference for Asia and the Far East in 1976.

## Development of regional atlas project and future considerations

When one compares the list of maps of the first proposal of a regional economic atlas by the delegation of Thailand in 1961 with the current status of mapping, one can summarize the development of this atlas project and base on it some conclusions and considerations on the future of the atlas.

The map of the basic mapping status of the region should be dropped as an atlas sheet. A small-scale substitute of the map has been published in an article on the status of the mapping of the world.[6]

According to the recommendation of the United Nations Regional Cartographic Conferences and the *Ad Hoc* Group of Experts on Projections and Planning in Cartography, the review will be repeated periodically and printed in the same publication. The periodic publication of up-to-date black-and-white maps is more appropriate to a topic of such rapid change than a single map at 1 : 5,000,000 scale.

The climatic regions map of Asia and the Far East was published by the Royal Thai Survey Department in 1973. The map could be transferred to the new base map and revised, if required. Then, inset maps could be added to show the seasonal variation of air masses, temperature and precipitation.

A map of the forest resources is being compiled by the Survey Department in spite of the poor supply of data from the member countries of the ESCAP region. A map of the natural vegetation at this scale cannot be compiled because of the inadequate informations available. Furthermore, such a map does not appear to be of much relevance to the aim of an economic atlas.

The geological map of Asia and the Far East at 1 : 5,000,000 scale was compiled and published by the Mineral Resources Section of the ECAFE Natural Resources Division as early as 1955. The map was revised and edited jointly by ECAFE and the United Nations Educational, Scientific and Cultural Organization (UNESCO) in a second edition in 1971; this map should be regarded as a sheet of the regional economic atlas as it led to the atlas project and was the model of the first atlas sheets. In addition to the stratigraphic map, the Mineral Resources Section planned to publish a tectonic map of the region, but this map will be compiled and published by the Commission of the International Geological Map of the World.

The population density map of Asia and the Far East, the first map of the atlas, shows the population distribution around the year 1970; it is being prepared by the Royal Thai Survey Department. The Population Division of ESCAP has rendered substantial help with the supply of population data which could not be collected by the Survey Department.

The transportation map showing the road and rail network, the harbours and the airports will be one of the next atlas maps to be published. In co-operation with some sections of the Transport and Communication Division of ESCAP and the Asia Highway Commission, the Royal Thai Survey Department is compiling this map.

The mineral resources are shown on two maps which were produced by the Mineral Resources Section of ESCAP. The "Oil and Natural Gas Map of Asia and the Far East" at 1 : 5,000,000 scale portrays the liquid and gaseous fuel resources of the region in their structural frame; the first edition was printed in 1975. The solid fuel, metallic and non-metallic mineral resources in their stratigraphic formations are displayed on the "Mineral Distribution Map of Asia and the Far East" at 1 : 5,000,000 scale published by ESCAP in 1963; a new edition of this map is being prepared. Both maps could be included as atlas maps.

The power and energy resources were depicted in the Energy Atlas of Asia and the Far East compiled by the ESCAP Section on Electric Power and Energy Resources and published in 1970, which shows various types of

[5] *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.74.I.7), p. 31.

[6] "The status of world topographic mapping", *World Cartography*, vol. XIV (United Nations publication, Sales No. E.76.I.13), pp. 3–70.

energy resources, energy transmission lines and the energy consumption *per capita* at the end of 1968. The atlas consists of country maps of most ESCAP member countries at various scales. The atlas could be improved by using a uniform scale and base for all maps. Then, those maps could also form a sheet of the Regional Economic Atlas of Asia and the Far East.

The topics discussed above are those which have been mapped or are being mapped either in sheets of the proposed atlas or in maps that meet some requirements of this atlas. They cover about 50 per cent of the original plan. Some comments are necessary on the remaining topics.

The soils of the region, as one of the most important natural resources, are mapped in many countries on large-scale maps. A generally accepted soil classification for the entire region has not yet been worked out. Similar to the international key of geological maps, a unified key for soil maps should be adopted by an international forum of soil scientists. Only then can a regional soil map be compiled, based on such a key.

An agricultural map may include several topics, with the most valuable information being supplied by a land-use map. Land-use maps of various small scales are the main contents of the World Atlas of Agriculture, prepared by the International Association of Agricultural Economists and published in 1969 at Novara, Italy. These maps can be regarded as a first preliminary world land-use survey. The development of land-use maps is the aim of the International Geographical Union (IGU) Commission on World Land Use Survey, with H. Boesch as chairman. Again, the compilation of the land-use map of the region should be postponed to avoid unnecessary duplication of work and to await the map key from this international commission of experts. In addition to the land-use map, other maps of smaller scale should be compiled to indicate the major areas and the production of the principal crops, as well as the share of consumption and export and their development. The data for these maps could be obtained from the Food and Agriculture Organization of the United Nations (FAO).

The map of the animal resources or livestock regions is an agricultural map that supplements the land-use map. This map could be printed as an inset map in the land-use map if it shows the livestock regions. A regional map at 1 : 5,000,000 scale is necessary only if it has to show the livestock distribution; then, however, the compilation will encounter the same problems as a population distribution map.

The most problematical maps of the whole set are those of the industrial centres and of communication. The problems do not arise in the cartographic fields of compilation and design, but are due to the difficulties of data collection. Information on the industrial sector in countries with market economies is difficult to obtain and is not always reliable because most industrial firms are reluctant to release data which could help other firms in this highly competitive branch of the economy. In countries with centrally planned economies, the location and production of industrial establishments are regarded as being of military importance and the information on industry is therefore restricted. The strategic importance of the communication network, however, is acknowledged by all countries. The available information is limited and confined to selected public installations. If the countries concerned will ever agree to release information on the spatial distribution of industrial constructions and communication installations, it will certainly be given to international organizations rather than to the mapping department of a potential competitor or political opponent.

The development of water resources, on the other hand, is a public concern, especially the use of international rivers. The Water Resources Section of ESCAP has promoted national consciousness and the international development of surface-water resources with respect to flood control, irrigation and hydroelectric energy in various parts of Asia. A map of the surface-water resources is not currently available, but it could easily be compiled from the data obtainable from the Water Resources Section of ESCAP.

The mapping of the group water resources in connexion with the rock types is a major concern of hydrogeologists. The Mineral Resources Section of the Natural Resources Division of ESCAP has initiated international co-operation to establish a generally acceptable key, for a large-scale synoptical map of the region must be delayed until such a key has been adopted and is widely used by the countries of the region.

Abundant data are available for the compilation of a tourist map. Many private, government and international organizations and institutions publish these data to attract tourists or financial support. Those institutions not only supply the data but are the potential users of a regional tourist map. The early publication of this map would have raised more public interest in the regional economic atlas than any other map.

## Comparative analysis of project

The comparative analysis of the project of a regional economic atlas of Asia and the Far East might be summarized in the following statements and proposals:

(*a*) Since 1961, the United Nations Regional Cartographic Conferences for Asia and the Far East have recommended the international co-operation of its members to produce the Regional Economic Atlas of Asia and the Far East. Some member countries vigorously tried to implement the recommendations by submitting gratis the required source data and source maps to the Map Information Centre of the Royal Thai Survey Department, even though some of the information supplied could not be used for the compilation of a homogeneous regional map. Most countries, however, did not forward the necessary data; and the Conference has neither the authority nor the possibilities to enact its own resolutions. The insufficiency in this specific cartographic field can be explained in part by the composition of the conference participants, who are primarily not interested in thematic mapping.

(*b*) The Royal Thai Survey Department had voluntarily accepted the compilation and publication of the Regional Economic Atlas. It has tried in vain several times to achieve international support and co-operation as requested by the conference resolution. With the assistance of a few member countries, but principally based on its own manpower, resources and funds, the Survey Department published the first atlas sheets, and plotted, compiled and produced a new reliable base map for regional mapping purposes. Currently, it is compiling additional maps of the atlas to the extent possible without international financial assistance;

(*d*) The major difficulties of atlas production arise from the fact that in many cases national thematic maps of the required topic do not exist; in other cases, existing maps cannot be compared due to the differences of the topical classification. The standardization of various keys for a regional map can be accomplished by the map compiler, but it is beyond his task to produce new national thematic maps. Consequently, each country must be encouraged and supported in the production of thematic maps and national atlases of its own territory. Only they can form and should form the proper basis of each regional map;

(*e*) The compilation of a regional atlas should not be solely entrusted to a national mapping institution which has neither the experts of the various fields of thematic mapping nor the position to secure the assistance of all countries concerned nor the funds satisfactorily to produce and distribute the atlas maps. All these problems would not arise if the atlas project were realized by an international organization. Examples of successful international co-operative mapping projects are the geological and bioclimatic maps of Africa and Europe produced by UNESCO and the various geological maps of Asia produced by the Mineral Resources Section of the Natural Resources Division of ESCAP. The United Nations Regional Cartographic Conference for Asia and the Far East should ensure the completion of the atlas project by entrusting it to the Cartography Section of the United Nations (or the ESCAP Natural Resources Division) after the foundations have been laid and the working schedule has been outlined by the Royal Thai Survey Department. The Cartography Section, in co-operation with the experts from ESCAP, UNESCO and FAO, could compile the missing maps; and, what appears to be more important, it could disseminate the maps to the various Governments and departments involved and concerned to ensure that the Regional Economic Atlas of Asia and the Far East shall be utilized according to its objective as a tool of regional planning and of the economic and social development of the region as a whole.

## SOME CHARACTERISTIC FEATURES OF THE COMPILATION OF GEOLOGICAL MAPS IN THE UNION OF SOVIET SOCIALIST REPUBLICS*

*Paper presented by the Union of Soviet Socialist Republics*

Geological cartography represents one of the divisions of general cartography and its task involves compilation of special thematic maps of geological contents. These maps are of great scientific and practical value being the documents reflecting major results of all kind of geological operations and various methods of geological research.

One of the main features of geological maps is the great volume of data shown, exceeding by hundreds the capacity of the corresponding data described in the text. The general principle in compiling geological maps involves the determination of the spatial distribution of sedimentary, intrusive and metamorphic rocks, as well as some other elements of geological structure. The main method of data presentation in maps is the colour showing the distribution of various geological formations. The quality of geological maps is to a major extent, determined by the precision of display of geological margins, the correspondence of the degree of division of geological complexes to the scale of the map and the scientific foundation of the interpretation of geological data shown on the maps.

The principles and methods of geological cartography were elaborated at the end of the nineteenth century by the Russian geologist A. P. Karpinsky, who was active in the project for a general legend for maps, which was adopted by the Second International Geological Congress at Bologna (1881) and was recommended for further application in map compilation. The suggested system of multicoloured indications and letter indexing has preserved in its major features its significance up to the current time. This method is based on the principle of the division of beds comprising the earth's crust into sedimentary and volcanic deposits of certain geological age and the subdivision of magmatic formations according to age and composition. Thus, a definite colour has been assigned to each geological system and its subdivisions differ in shades of the same colour. Magmatic formations are shown by bright colours differing in colour for acid, medium, basic and ultra-basic rocks. The geological age of the rocks is shown by Latin letters.

Over the years following its adoption and especially in the past few decades, due to the successes of geological science, an increase of the detail of maps and the need to

* The original text of this paper appeared as document E/CONF.68/L.96.

reflect provincial peculiarities, this sytem of colours, letters and other indications has been considerably supplemented and to a certain extent changed.

Geological maps are compiled on the basis of topographic maps. These maps, which are accompanied by the publication of thematic maps, thus have became simpler and only involve elements of specific contents. All the necessary elements of the general geographical basis of the map are selected in each concrete case. In the compilation of geological maps, the same scales as those adopted for topographic maps are generally used; yet, depending upon the scale selected, the volume of specific data and the purpose of geological maps may change.

Depending upon the scale, the geological maps are subdivided into large-scale (1 : 10,000–1 : 50,000), medium-scale (1 : 100,000–1 : 200,000), small-scale (1 : 500,000–1 : 1,000,000) and general-purpose maps (1 : 2,500,000 and smaller). Large- and medium-scale maps usually represent original maps since they are compiled according to the results of geological operations; maps on other scales are compound maps derived from the former two types of maps.

In the Union of Soviet Socialist Republics, compound geological maps are, as a rule, published on a definite scale, depending upon the purpose and geological specialization.

Thus, general maps of the USSR on the scale 1 : 10,000,000 are designed to be used as a guide in various branches of national economy and are compiled on the basis of claims of industrial and scientific organisations and schools. All-Union maps on the scales 1 : 5,000,000 and 1 : 2,500,000 represent official editions of ministries and departments. The contents of these maps reflect the level of geological knowledge at the moment of their compilation. Publication of such maps is undertaken every 10–15 years.

Compound maps on the scales 1 : 1,500,000 and 1 : 500,000 are compiled by organizations possessing appropriate data on individual geological regions. Compilation of these maps is undertaken following the acquisition of new data obtained during geological, geophysical and hydrogeological operations, and geological surveys and special studies which significantly affect previous knowledge of the peculiarities of territories. Publication of such maps is usually carried out every 10 years.

Compound and general-purpose maps represent the most important production reflecting in their unified form the newest ideas on geological structure and the prospects for mineral resources of continents, countries and the major regions of the Soviet Union. This category comprises more than 30 types of maps, for example, geological, tectonic, geomorphological, Quaternary, metallogenic, mineral resources, hydrogeological, engineering geology and geophysical.

In the development of geological cartography over the past few years a certain tendency in specialization and compilation of maps of principally new contents has appeared, concerning geological and magmatic formations, structural-formational maps, metamorphic facies, levelling surfaces and weathering crusts, lithological-palaeogeographical and geological-economic features and some others. The elaboration of the principles and methods of compilation of tectonic, metallogenic and predictive metallogenic maps successfully continues. In the past decade, a great number of general-purpose, specialized and general geological maps of individual regions, of the entire territory of the USSR and of the world and continents have been compiled and published.

The other tendency in the development of geological cartography is the grouping of maps of various contents compiled in the same scale and with strict mutual correlation. Currently, a considerable amount of work is being undertaken for compilation of a new series of state geological maps of the USSR on the scale 1 : 1,000,000, and the set of each sheet will include maps of pre-Quaternary formations, Quaternary sediments and magnetic anomalies, a gravimetric map and a map of mineral resources (with elements of forecast). For individual regions, hydrogeological, geomorphological and some other maps are also to be compiled. Sets of the above-mentioned maps are to be accompanied by explanatory notes.

A certain increase in the degree of detail of geological maps is envisaged in connexion with the increase of the degree of geological knowledge and the shifting of regional operations to the scale 1 : 50,000.

Considerable work has been done in the USSR in the field of geology and lithology of the Precambrian. On the basis of analyses of the Precambrian throughout the world and the detailed studies over the old Precambrian massives in the USSR, the general stratigraphic scale of the Precambrian has been worked out; and the Precambrian correlation has been completed and the geological map of the Precambrian over the continents of the world on the scale 1 : 15,000,000 has been compiled. Foundations for the scientific restoration of the original composition of the Precambrian deeply metamorphosed formations have been worked out and comprehensive studies on the problem of restoration of the palaeogeographical environment of the pre-Fhanerozoic epoch are being conducted.

In particular, a paleogeographical map of the eastern part of the Baltic shield for the Jatulian stage of the middle Proterozoic era has been compiled which permitted the definition of areas of distribution of ore-bearing conglomerates of that age, to reveal regions of development of old weathering crusts and to forecast geological prospecting for various mineral resources.

One of the most recent approaches introduced into the practice of regional studies over the territory of the Soviet Union is the geological—morphological analysis of the central type of structures. Methods of this analysis elaborated by Soviet geologists permit the determination of the geochronological structures of any period of emplacement depending upon the stage of their stripping. Therewith are confidently acknowledged both the exposed and hidden central type structures of various fractures. The first map of central type structures

compiled for the USSR on the scale 1 : 10,000,000 and the study of similar objects in Africa made it possible to arrive at a conclusion on the considerable role of these structures in the general process of tectogenesis and on their importance in the distribution of deposits of a number of mineral resources.

In the USSR, extensive operations on regional forecasts on the basis of generalized data and scientific studies are carried out in the field of metallogenic analyses which have been conducted by Soviet geologists over the past 10–15 years. The results of these operations has been summarized in the all-Union and regional metallogenic maps on various scales. The first metallogenic map of the USSR on the scale 1 : 2,500,000 was compiled in 1971. More than 2,000 deposits of 37 types of hard minerals are shown on the map. The advantage of metallogenic maps compiled by the Soviet experts is that not only do these maps register the known discoveries, as is natural for register maps of mineral resources compiled on a geological basis, but they represent the result of analysis and synthesis of all geological data systematized in a certain particular way, to be used for better understanding of mode of formation and regularities of spatial distribution of mineral deposits for their further prospecting. The maps are compiled with due regard for the principles of regional metallogenic analysis elaborated by the well-known Soviet scientists S. S. Smirnov, N. M. Strakhov and Ju. A. Bilibin.

The main idea of these principles is in the complex approach to studies of the history of the formation of mineral deposits in connexion with the processes of sedimentation, hypergenesis, magmatic activity, metamorphism, folding and major deep fractures which took place in the course of the formation of major tectonic units of the earth's crust.

Metallogenic maps are of exclusive practical and scientific significance for the Geological Survey of the USSR. They enable one to see general regularities of distribution of various mineral deposits over large territories. The maps provide scientifically based metallogenic zoning of the country and serve as a base for further, more detailed metallogenic studies. They make it possible to define more accurately the potentials of the already known mining regions and structural-metallogenic zones and to outline new areas for geological survey and prospecting operations over the territory of the country.

The comprehensive information shown in the maps permits a change-over to a specific forecast for each type of mineral, with the utilization of all necessary initial data not only for the tectonic structures of the USSR but for other continents of the world.

A certain degree of success has also been achieved in the Soviet Union in the compilation of original large- and medium-scale maps. The entire territory of the USSR has been completely mapped on the scale 1 : 1,000,000. The geological survey of the country on the scale 1 : 200,000 is almost completed. Currently, the main scale of the Geological Survey is 1 : 50,000 which was the scale of mapping of the most important mining districts of the country. For the higher informational value of this kind of survey its process involved complex geophysical and geochemical studies. Large-scale geological studies were accompanied by abyssal geological mapping and the compilation of supplementary maps of buried surfaces; the folded basement of the platforms; individual marking horizons; etc.

Recently, for the purposes of compiling original geological maps, new data obtained through the application of modern remote-control methods of study—space, airborne, radar, thermal and some others—have been used. The great field of vision of satellite and aerial photographs allows one to obtain qualitatively new information on geological objects and phenomena. Thus, for example, an analysis of satellite imageries of the Caucasus, Urals and some regions of Middle Asia made it possible to reveal certain previously unknown circle, arc and linear tectonic disturbances. New dome structures have been disclosed the drilling of which leads to discovery of oil and gas deposits.

Successes in the field of sea geology, the elaboration of realistic methods of analysis of the history of geological structures and the significant improvement of the technical level of geological operations were prerequisite to producing the original geological maps of the sea territories of the USSR and for the first time, of its continental-shelf zone, which is highly promising for various minerals.

The method of in-layer correlation within the sedimentary sections, elaborated by the Soviet geologists on the example of the Palaeozoic era of the Russian and Siberian platforms, was a prerequisite of the possibility of determining the stable vertical and lateral margins of local stratigraphic subdivisions which considerably increased the degree of reliability of large-scale geological maps.

Extensive work also is done in the USSR in the compilation of large-scale predictive maps. These operations are focussed mainly on the regions of active mining and metallurgical plants as well as in the newly established mining industrial complexes where there is a constant problem of further increasing the revealed resources and making a preliminary quantitative evaluation of potential resources.

Geological maps are used in all branches of national economy connected with natural resources—mining industry, building, agriculture, forestry etc.

Geological cartography in the USSR, considering its practical importance in the national economy, the extension of territories under study, comprehensive methods and organizational unification within the uniform state system, has no equal in other branches engaged in the problems of thematic cartography.

The great volume of operations and broad range of maps under production in the field of geological cartography demand further improvement both of the basic methods of map compilation and publication and of the organization of the operations involved. This need anticipates unification of the basic composing elements on maps, more accurate typological legends for various

kinds of special maps, standardization of symbols on maps of different scales and those entering the sets, limitation of scales of newly made maps, co-ordination of map-compiling and map-production operations and improvement of approval of maps.

All these problems may well be solved only under conditions of centralized and standard processes of compilation, approval and publication of geological maps. The socialist economic system enables the experts to solve the tasks facing geological cartography in the age of scientific—technical revolution in the most successful way.

## UNESCO ACTIVITIES IN THE FIELD OF CARTOGRAPHY*

*Paper presented by the United Nations Educational, Scientific and Cultural Organization*

The activities of the United Nations Educational, Scientific and Cultural Organization (UNESCO) in the field of cartography are concentrated on a number of scientific and applied aspects, mainly with respect to the study and rational utilization of the natural environment and its resources.

UNESCO is not involved in the preparation of topographic and general geographical maps, this work being co-ordinated directly by the Economic and Social Council of the United Nations and the Centre for Natural Resources, Energy and Transport of the Department of Economic and Social Affairs of the United Nations. But with regard to the preparation and publication of scientific (thematic) maps and atlases, the contribution of UNESCO is essential.

For a number of years, UNESCO has been engaged in the preparation of a series of small-scale maps which will give a general picture of the physical and biological environment and its resources on a global scale. This long-term enterprise which is directed to covering the whole world and to including various components of the environment is unique in its scope and value. It is implemented by UNESCO in co-operation with other agencies of the United Nations and with non-governmental international scientific organizations, and is closely linked with the large international research programmes co-ordinated by UNESCO, such as the Programme on Man and the Biosphere, the International Hydrological Decade and the International Geological Correlation Programme.

A number of these maps have already been published, and many more are in preparation.

In the series of geological maps, one of the first maps published was the geological map of Africa on the scale 1 : 5,000,000 (nine sheets) issued in 1964 as a co-publication of UNESCO and the Association of the African Geological Services. It was followed in 1967 by the geological maps of Africa on the scales 1 : 10,000,000 and 1 : 20,000,000, which were to serve as the base maps for different synthesis and thematic maps in the field of geology and connected sciences (soil science, hydrology, geomorphology, Quaternary geology etc.). In 1968, the International Tectonic Map of Africa on the scale of 1 : 5,000,000 was published; in 1969, the mineral map of Africa on the scale 1 : 10,000,000; and in 1972, the first sheet on the International Quaternary Map of North-west Africa on the scale 1 : 2,500,000.

Simultaneously, the preparation of a new edition of the International Geological Map of Europe on the scale 1 : 1,500,000 (49 sheets) was begun in collaboration with the Commission of the Geological Map of Europe of the International Geological Congress and the Geological Survey of the Federal Republic of Germany; 27 sheets of the map have been published since 1964. Since 1967, UNESCO, in collaboration with the International Union for Quaternary Research and the Geological Survey of the Federal Republic of Germany, has prepared and published the International Quaternary Map of Europe on the scale 1 : 2,500,000; 10 of the 15 sheets of the map have already been published. The metallogenic and geomorphological maps of Europe (scale 1 : 2,500,000), as well as hydrological maps of Europe, North Africa and South America, are in preparation.

In 1971, jointly with the then Economic Commission for Asia and the Far East,[1] UNESCO published a geological map on the scale of 1 : 5,000,000. UNESCO also participates in the preparation of tectonic, metamorphic and metallogenic maps of this region. Work has begun on the preparation of the Geological Atlas of the World on the scale 1 : 10,000,000. The atlas will consist of 15 sheets devoted to the continents and five sheets of a smaller scale representing the geological structures of the polar regions and oceans; six sheets of the atlas have been already published.

Under a joint project with the Food and Agriculture Organization of the United Nations (FAO), UNESCO has been publishing since 1971 the Soil Map of the World on the scale 1 : 5,000,000. The map comprises nine continental units making up 18 sheets: North America, Mexico and Central America; South America; Europe; Africa; South Asia; North Asia; South-East Asia; Australia; New Zealand and the Pacific Islands. An ad-

* The original text of this paper appeared as document E/CONF.68/L.105.

[1] Now the Economic and Social Commission for Asia and the Pacific (ESCAP).

ditional sheet is devoted to the general legend. Up to 1977 eight of the continental units and the sheet of the general legend have been published. The last continental unit (Europe) is expected to be published by the end of this year.

The series of maps of vegetation was begun with the publication in 1973 of the vegetation map of the Mediterranean region on the scale 1 : 5,000,000 and preparation of the vegetation map of Africa on the same scale.

In the series of climatic maps, UNESCO jointly published with FAO the bioclimatic map of the Mediterranean zone on the scale 1 : 5,000,000 (1963) and with the World Meteorological Organization (WMO) and Cartographia (Budapest) the Climatic Atlas of Europe (1970). The atlas consists of 27 maps on the scales 1 : 5,000,000 and 1 : 10,000,000 which contain climatological data collected during the period 1931–1960. This is the most complete and precise climatological atlas of Europe which can be used for research and educational purposes in various fields of natural and human sciences where such data can be useful. It was followed in 1975 by the Climatic Atlas of South America (volume I), consisting of 28 map-sheets, all on the scale 1 : 10,000,000 except for two sheets at 1 : 5,000,000 scale.

With regard to oceanographic maps, UNESCO is engaged in the publication of the Atlas of the International Co-operative Investigations of the Tropical Atlantic (ICITA), which will contain maps and vertical sections compiled from the data of international expeditions in the Atlantic Ocean in 1963–1964.

It should be stressed that all the maps published or co-published by UNESCO are the result of international scientific activities involving many individual scientists and research institutions of different countries.

The process of compiling these maps includes the elaboration of common nomenclatures and general legends as well as intercalibration of research methods for comparability of data, which can be achieved only through international scientific collaboration and mutual understanding of different schools. The information which they contain make these maps a very useful tool for general study of natural resources and planification of their utilization and management, as well as for various educational purposes.

Amongst other activities of UNESCO with regard to cartography, one should mention the collaboration with the International Cartographic Association in the development and promotion of modern techniques and methods of compiling maps and national atlases, including the automation of cartographic processes, as well as in cartographic education, mainly for the benefit of developing countries. During the past several years, UNESCO has taken part in the organization of a number of scientific symposia, technical conferenes and expert meetings, and has published some of their reports.

UNESCO also provides assistance to the International Cartographic Association in the preparation of the Multilingual Basic Manual on Cartography for the needs of developing countries.

In relation to its work on integrated studies of natural resources and in different disciplines of environmental sciences, UNESCO has long been deeply involved in activities closely connected with the utilization and development of aerial photography and other remote-sensing techniques. It can be mentioned, for instance, that in 1964, UNESCO organized at Toulouse a conference on "Aerial surveys and integrated studies" to draw the attention of natural resources research workers and planners to remote sensing from aircraft not only as a modern time-saving technique in the field of environmental studies but as a means of ensuring integration of approaches in such studies. Promotion of the utilization and development of remote sensing has been duly reflected in the current UNESCO programmes, both in the field of research and in education.

Aerial photographs and some other types of remote-sensing data are used in a number of field studies, implemented by UNESCO in the frame-work of projects of the United Nations Development Programme (UNDP), as well as under the regular programme of UNESCO, and particularly in some of the projects of the intergovernmental Programme on Man and the Biosphere, the International Hydrological Decade etc. UNESCO sponsors a number of post-graduate courses in the field of integrated study and rational management of the natural environment and its resources where, for instance, at the ITC/UNESCO Centre for Integrated Surveys, at the International Institute for Aerial Survey and Earth Sciences (ITC) at Enschede, Netherlands; and at the University of Sheffield in the United Kingdom, the training and research activities are based on aerial photography and other remote-sensing techniques.

## REALIGNMENT OF PACIFIC FLIGHT INFORMATION PRODUCTS*

*Paper presented by the United States of America*

The Flight Information Publications (FLIPs) produced by the Department of Defense of the United States of America are a group of specialized Instrument Flight Rules (IFR) comprising charts and textual publications designed primarily for use in aircraft cockpits. FLIPs provide up-to-date and accurate flight information characteristics of various national and international air-space systems and are produced for all free-flying areas of the

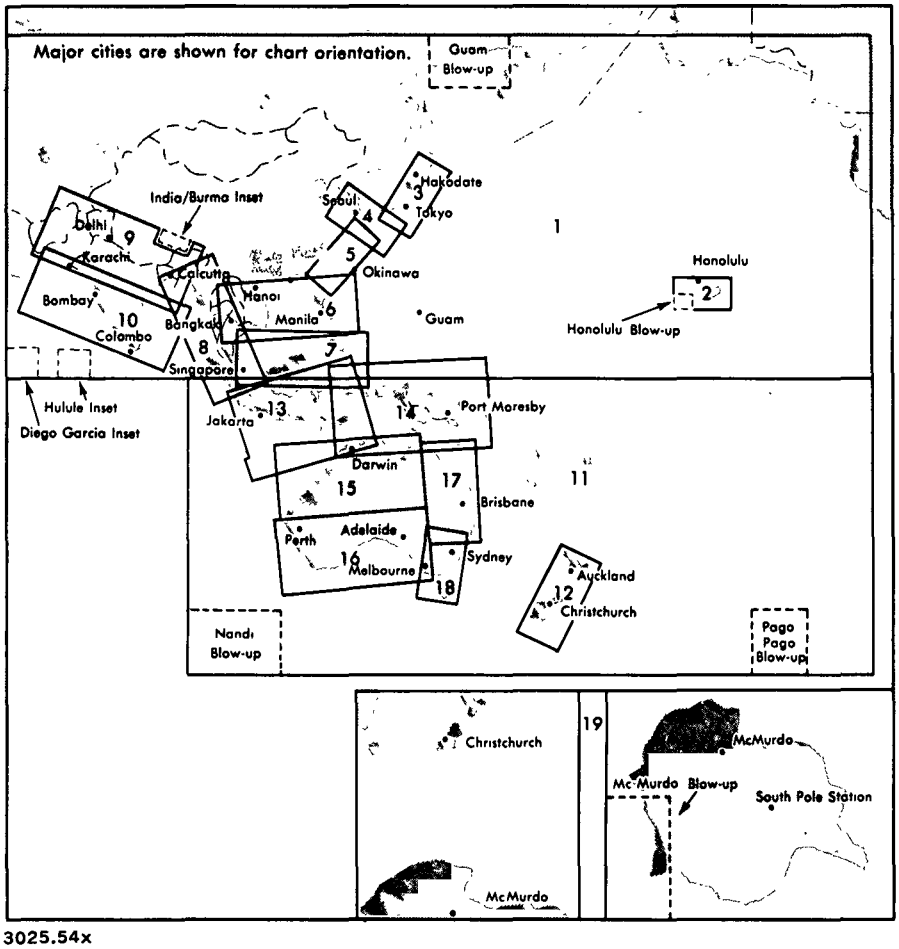
* The original text of this paper, prepared by Robert Stillwell and Lawrence Knopfel, Defense Mapping Agency Aerospace Center, United States of America, appeared as document E/CONF.68/L.44.

world. Although designed primarily to fulfil the flight information operational requirements of official aviation personnel in the United States, the products are also widely used by the public and by civil and military aviation organizations of other countries. This extensive use can be attributed primarily to the fact that the contents of FLIPs conform to International Civil Aviation Organization (ICAO) standards and practices on the publication of aeronautical information. Among the regular users of these products in the Pacific area are the Department of Civil Aviation of Thailand, the Aeronautical Information Centre at Hong Kong, Philippine Airlines, All Nippon Airways, Qantas Airways, the Philippine Air Force, the Royal New Zealand Air Force, the Japan Air Self-defence Force and the Republic of Korea Air Force.

Because of the volume and diversity of data, separate products are arranged and published for each phase of flight: planning; *en route* (in flight); and terminal (approach, landing and take-off). As FLIPs cover all free-flying areas of the world, they are further separated into convenient, homogeneous geographical area product groupings: Pacific, Australasia and Antarctica; United States; Alaska; Canada and North Atlantic; Caribbean and South America; Europe, North Africa and Middle East; Africa.

Supplying accurate and complete flight data in a simplified form to meet a multitude of user requirements is a challenging and formidable task. As the responsible agency, the Defense Mapping Agency Aerospace Center (DMAAC) not only continuously reviews and updates the data provided but examines the format and coverage of its publications to ensure that the data shall be presented in the most economical and effective mode.

This paper describes, from conception to completion, a realignment in the coverage of flight information products for the Pacific area. It outlines changes in the format of the products, the publication schedules and the distribution methods, all of which have resulted in improved service at less cost.




*Note*: The Pacific, Australasia and Antarctica (PAA) Flight Information Publication (FLIP) replaces the Pacific and South Asia (PSA) and the Australia, New Zealand and Antarctica (ANZA) FLIPs.

*Figure 79. United States of America: Pacific, Australasia and Antarctica FLIP* en route *charts*

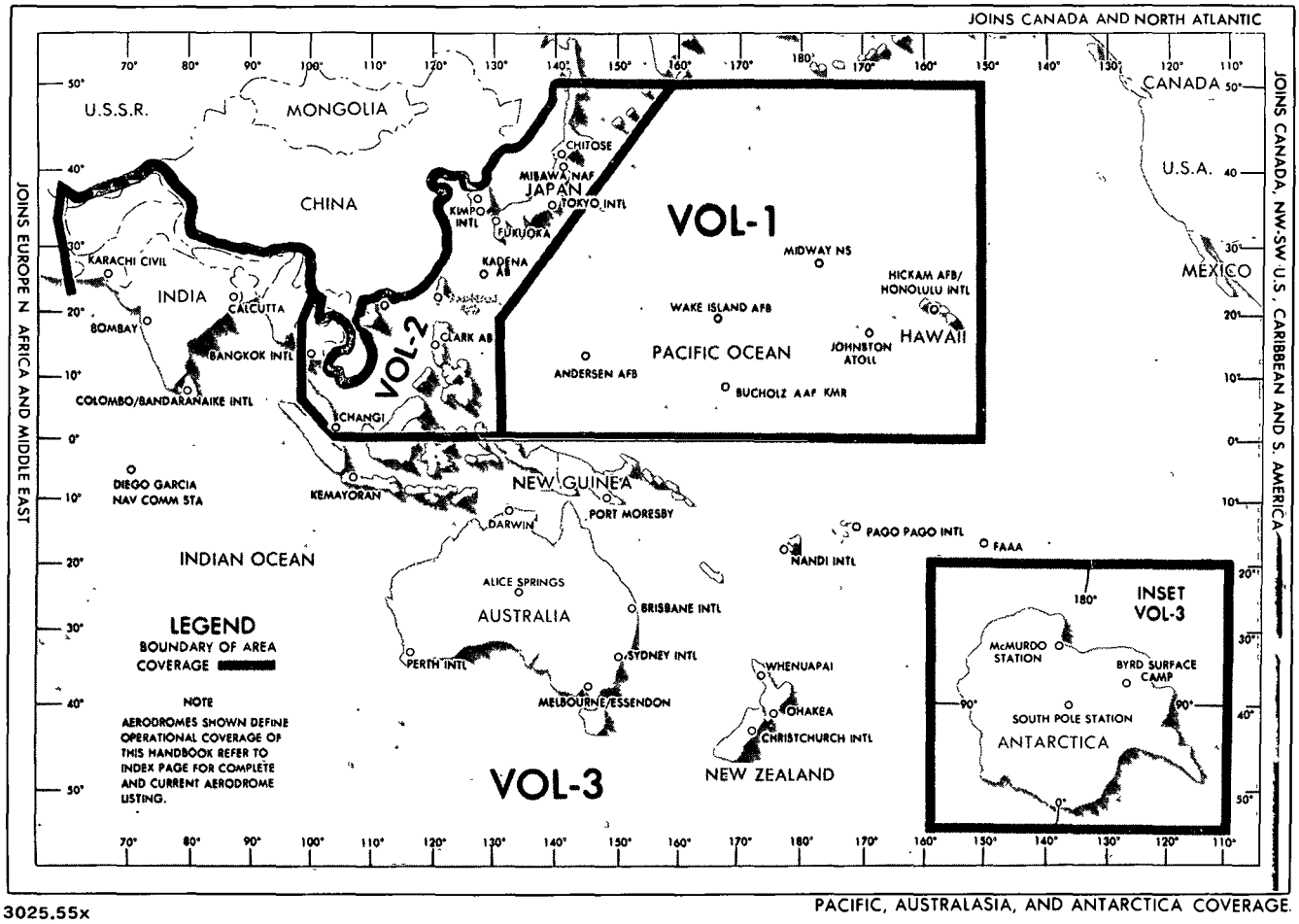
## Changes made in Pacific Flight Information Publications

Two former FLIP packages, the Pacific and South Asia (PSA), and the Australia, New Zealand, Antarctica (ANZA), were recently combined into a single FLIP package and redesignated the Pacific, Australasia and Antarctica (PAA) FLIP.

The former PSA and ANZA *En route* Supplements have been combined into a single PAA *En route* Supplement. The companion *en route* chart coverage remains the same; only the chart numbering scheme has been changed. Figure 79 outlines details of this change. The *en route* FLIPs, except Charts 1 and 2, are now published every 16 weeks (formerly eight weeks) with a corrective Military Aviation Notice (MAN) issued every eight weeks listing intervening changes in aeronautical data. Charts 1 and 2 are continued on an eight-week cycle to meet United States Federal Aviation Administration requirements.

The Instrument Approach Procedures (Terminal Books) have been consolidated into three high/low-altitude combination volumes (see figure 80). These volumes also contain Standard Instrument Departure (SID) procedures, expanded airfield diagrams and Standard Terminal Arrival Route Procedures (STAR). The volumes are now published every 24 weeks (formerly eight weeks). Two MANs are published at eight-week intervals between cycles, with the second MAN containing all changes that have accumulated over the 16-week period. The realignment and cycle change will have no adverse effect on air operational safety.

A new distribution system was also initiated for the PAA FLIPs along with the consolidation of products and changes in publication cycles. Distribution of products had previously been made to users by complete regional "sets", but this distribution is now limited to the specific publications within the sets requested by each using organization. This elimination of distribution by "sets only" permits DMAAC to print and distribute only the number of publications actually needed and reduces costs and production time. Resources saved in this activity can




*Notes*: Instrument Approach Procedures (IAP) include high/low-altitude procedures, Pacific Command standard instrument departures and Honolulu standard terminal arrival routes.

The Pacific, Australasia and Antarctica (PAA) Flight Information Publication (FLIP) replaces the Pacific and South Asia (PSA) and the Australia, New Zealand and Antarctica (ANZA) FLIPs.

*Figure 80. United States of America: Pacific, Australasia and Antarctica FLIP Instrument Approach Procedures*

be diverted to the improvement of other air chart and navigational data products.

Because of the potential for economy, DMAAC is continuing to look for more efficient means of producing and distributing FLIPs. For example, it is considering extending the eastern overlap of PAA *En route* Charts Nos. 1 and 11 to include a larger area, thereby increasing the utility of the charts. The planning data appearing on the western side of the charts may also be eliminated, since the information already appears in the index on the chart panel.

For the accuracy of information in FLIPs, so critical to safe air operations, DMAAC is largely dependent upon updating information furnished by national aviation authorities. This is the everyday "operational" flight data which are subject to frequent and rapid change, and include the operational length and capacity of runways, air-way and air-space changes, changes in electronic aids to navigation and all the other data which are essential to flight operations. DMAAC very much appreciates the assistance of the national agencies in the region for the excellent support they give to the FLIP programme. It is strongly urged that aeronautical data changes issued by the various Governments be synchronized with the new effective dates of DMAAC publications, wherever possible. In this way, the using agencies in the region can obtain maximum operational benefit through a reduction in the changes reported in the Military Aviation Notices.

## THE CIRCUM-PACIFIC MAP PROJECT*

*Paper presented by the United States of America*

A series of maps depicting the geography, geology, tectonics, and energy and mineral resources of the Pacific Basin and of bordering lands is being prepared for the Circum-Pacific Council for Energy and Mineral Resources. The maps are being compiled on bases plotted from World Data Bank tapes of the Cartographic Automatic Mapping programme and from data from new bathymetric surveys. Five separate quadrant maps cover the Pacific region and Antarctica at 1 : 10,000,000 scale on the Lambert azimuthal equal area projection with centre points for each quadrant. A sixth map covering the Pacific region at 1 : 20,000,000 scale will show relationships of energy and mineral resources to the geological, tectonic and geophysical features of the entire basin. The project is a co-operative international effort by individuals, commercial firms, private and public institutions and agencies of the various countries bordering on the Pacific.

The Circum-Pacific map project was initiated in February 1973 during planning for the first Circum-Pacific Conference on Energy and Mineral Resources, held at Honolulu in August 1974 and sponsored by the American Association of Petroleum Geologists, the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas and the Pacific Science Association. The ultimate goal is to advance the exploration and development of the energy and mineral resources of the Pacific region and to ensure their compatibility with the environment. The project objectives are: (*a*) to map the most recent geological, energy and mineral information about resource distribution in the Pacific Basin; (*b*) to illustrate the relationship between known resources and major geological features as a guide to exploration; and (*c*) to focus attention on the geological data of the Pacific Basin and areas where more data are needed.

### Organization

The map project was formed to provide a continuing study of energy and mineral resources in the Pacific region. It is a means for collaboration between geologists, geophysicists and other earth scientists involved in continental and marine studies in governmental, industrial and academic institutions. To encourage the participation of able scientists, the project was organized in five panels. Each panel is responsible for compiling geological, tectonic and resources map data of a segment of the Pacific region.

About 100 geologists and geophysicists on the panels are contributing to the map compilations. Most of them, excluding those on the Antarctic panel, live within their areas of interest. In addition, other contributors are compiling specific segments (e.g., seismic epicentres) for all maps. Advice in related subjects is contributed by more than 25 other consultant specialists. Panel chairmen and other project members have met twice at Menlo Park, California (May 1975 and May 1976) to plan map compilations and contents.

### Maps

Geographical, geological, tectonic, energy and mineral resources maps at 1 : 10,000,000 scale will be prepared for the five areas of the Pacific region shown on the index map (see figure 81). A tectonic-resources map of the entire Pacific Basin at 1 : 20,000,000 scale will also be prepared to synthesize the information on the maps of the five segments.

#### *Geographical maps*

To make the maps most useful for exploration and development, new bathymetric-topographic bases have

* The original text of this paper, prepared by Paul W. Richards and Francis X. Lopez, United States Geological Survey, appeared as document E/CONF.68/L.47.

been compiled on an equal-area projection. These bases are now being used for the geological and other compilations. They are to be published in colour (with tints for topography and bathymetry) as geographical maps; plans to print and distribute them are being prepared.

*Geological maps*

The geological maps will show the geological units needed as background information for energy and minerals maps. They will emphasize the geological and stratigraphic similarities between the continental areas bordering the Pacific and the significant non-conformities that bear on the distribution of energy and mineral resources. Sediment accumulations and exposed bedrock units on the sea-floor will be shown, with emphasis on the correlation of the geology from the continents to the ocean basin. Compilations of the land areas, already well advanced, will follow more or less standard techniques. Compilations of the sea-bed will require considerable experimentation with the interpretation and representation of data from oceanographic research, deep-sea drilling and other programmes. The target date for completion of the geological compilations is the end of 1976.

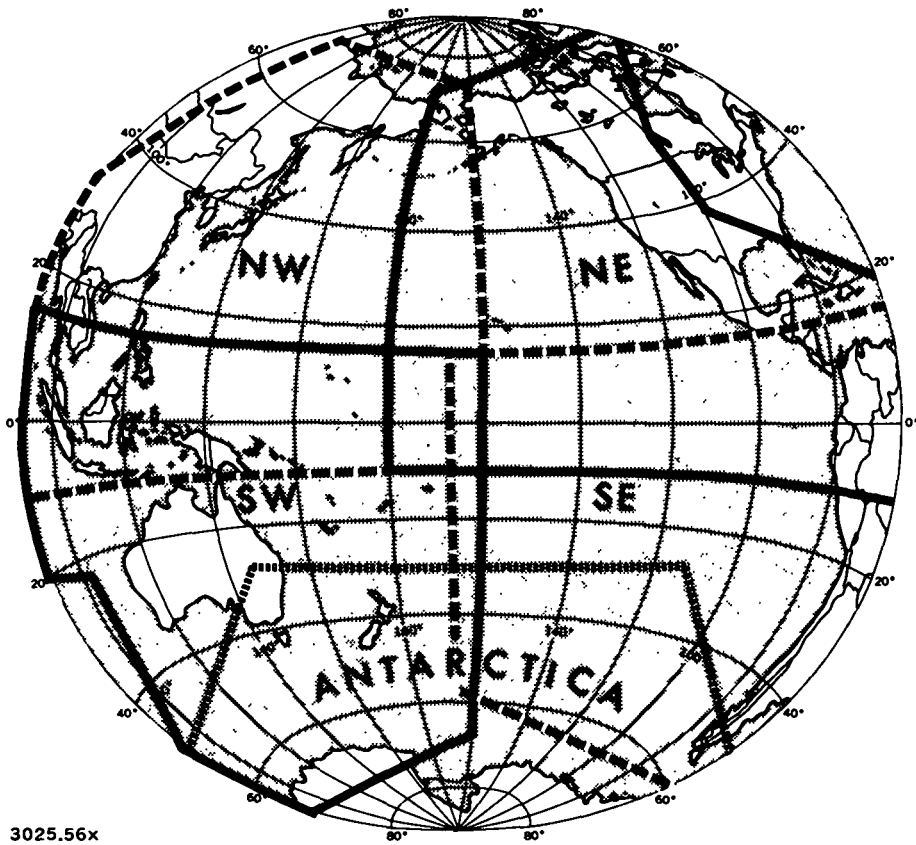



*Figure 81. United States of America: index map of the Pacific Basin showing boundaries (and overlap) of the quadrant maps and the Pacific Ocean boundary of the Antarctica map*

*Tectonic maps*

The tectonic maps, which also provide background data for the energy and minerals maps, will emphasize mappable structural elements of the earth's crust and show such geophysical data as magnetic anomalies, seismic epicentres and heat flow. Because of an abundance of structural and geophysical information, decisions on which data contribute most to the map will be made during the next meeting of the panel chairmen. Of particular concern is the depiction and interpretation of structural features across the continental margins, which are significant in relation to the interaction between the ocean basis and surrounding continents. Currently, seismic epicentres, first-motion solutions and heat-flow values are being compiled for each map. The tectonic maps are scheduled for completion in 1977. Geology and tectonics are to be combined for the Antarctic map.

*Energy maps*

The energy maps will show the distribution of solid, liquid and gaseous deposits that are, or may become, sources of energy; and raw materials and their relationship to geological features. Background information will include geological units, structural features

(faults, anticlinal axes) and isopach lines showing thickness of relatively undeformed sedimentary cover. The distribution of oil, gas, coal, oil-shale, tar-sands, uranium/thorium and thermal fields will be shown by a combination of symbols and colours. Compilation of the energy maps has begun in some quadrants and will be completed in 1978.

*Minerals maps*

The objective of the minerals maps is to show in as much detail as possible the distribution of the principal types of mineral deposits and mineral provinces and their relationship to major geological elements. Mineral localities will show by symbol and colour the mineral or commodity, size of deposit and type of deposit. An important feature of the minerals compilation is use of data cards by compilers for storage in computer data banks. These are being designed to be useful in future studies as well as in the current map compilation. After final review and printing, cards will be sent to compilers. Experimental compilations have been made of minerals maps, which are to be completed in 1978. Minerals and energy maps of Antarctica will be combined.

*Pacific Basin map*

Compilation of the smaller scale (1 : 20,000,000) map of the full Pacific Basin must await compilation of the five area maps. In general, it will be a synthesis of data shown on the other maps to relate geology and geophysics with economic features. It may also lend itself to an interpretation of economic deposits in relation to plate-tectonic postulates and the relation of oceanic and crustal rocks (figure 81).

## Co-ordination with other programmes

The map project is bringing together in its series of maps the most recent available geological and geophysical data on the Pacific region. To do so, close co-ordination is maintained with several programmes, including those of the Commission for the Geological Map of the World, the International Decade of Ocean Exploration, the International Programme for Ocean Drilling, the International Geodynamics Project and the International Geological Correlation Programme. The map project is also co-ordinated with the United Nations Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas, the Economic and Social Commission for Asia and the Pacific, and other regional organizations within the project area.

## Specifications for maps

The following map specifications are tentative, pending a study of experimental compilations that is under way. Three series of maps are planned: a series (two maps) covering the entire Pacific Basin and adjacent land areas on one sheet at 1 : 20,000,000 scale; a series (five maps) covering the four quadrants of the Pacific and adjacent land areas on the scale 1 : 10,000,000; and a series (three maps) covering the Pacific-Antarctic region on the scale 1 : 10,000,000 (see figure 82).

*Pacific Basin maps*

The specifications for the Pacific Basin maps are as follows:

(a) *Parameters*:
- (i) Scale: 1 : 20,000,000;
- (ii) Projection: Lambert azimuthal equal area, centred on 160° West and the equator;
- (iii) Area of coverage: 90° East to 50° West; 67° North to 67° South;

(b) *Base map (printed in black, blue and brown)*:
- (i) Geodetic grid;
- (ii) Country boundaries and names;
- (iii) Major cities by initial letters only;
- (iv) Land-sea boundaries (possibly brown tints over land and blue tints over sea);
- (v) Land drainage;
- (vi) Bathymetry in metres;
- (vii) Names of principal trenches, rises, sea-mounts, and sea-bottom features;

(c) *Tectonic map (overprint in colours on grey base)*:
- (i) Major geological features, tectonic elements and names;
- (ii) Geophysical anomalies on sea-floor to the extent needed for tectonic interpretation;
- (iii) Generalized geologic units and rock ages at surface on land, and oldest sedimentary rock age in sea-bed sequence;
- (iv) Volcanoes, areas of thermal activity and high heat-flow anomalies;
- (v) Seismic epicentres classified in three depth intervals and two levels of magnitude;
- (vi) Sedimentary basin outlines, names and gross thicknesses;
- (vii) Sea-bed drill locations and indexed drill logs.

*Pacific quadrant maps*

The specifications for the Pacific quadrant maps are as follows:

(a) *Parameters*:
- (i) Scale: 1 : 10,000,000;
- (ii) Projection: Lambert azimuthal equal area, centre for each quadrant map near geographical centre of quadrant;
- (iii) Area of coverage and centre point of each map:

| *Centre point* | *Boundaries* | | | |
|---|---|---|---|---|
| | *West* | *East* | *North* | *South* |
| North-west: 35°N, 150°E | 95°E | 160°W | 70°N | 10°S |
| North-east: 35°N, 135°W | 180°W | 75°W | 70°N | 10°S |
| South-west: 40°S, 150°E | 95°E | 160°W | 15°N | 70°S |
| South-east: 40°S, 100°W | 165°W | 35°W | 15°N | 70°S |

- (iv) The quadrant maps will have a 20° overlap East and West north of the equator, 5° East and West south of the equator, and a 25° overlap North and South. Boundaries have been selected

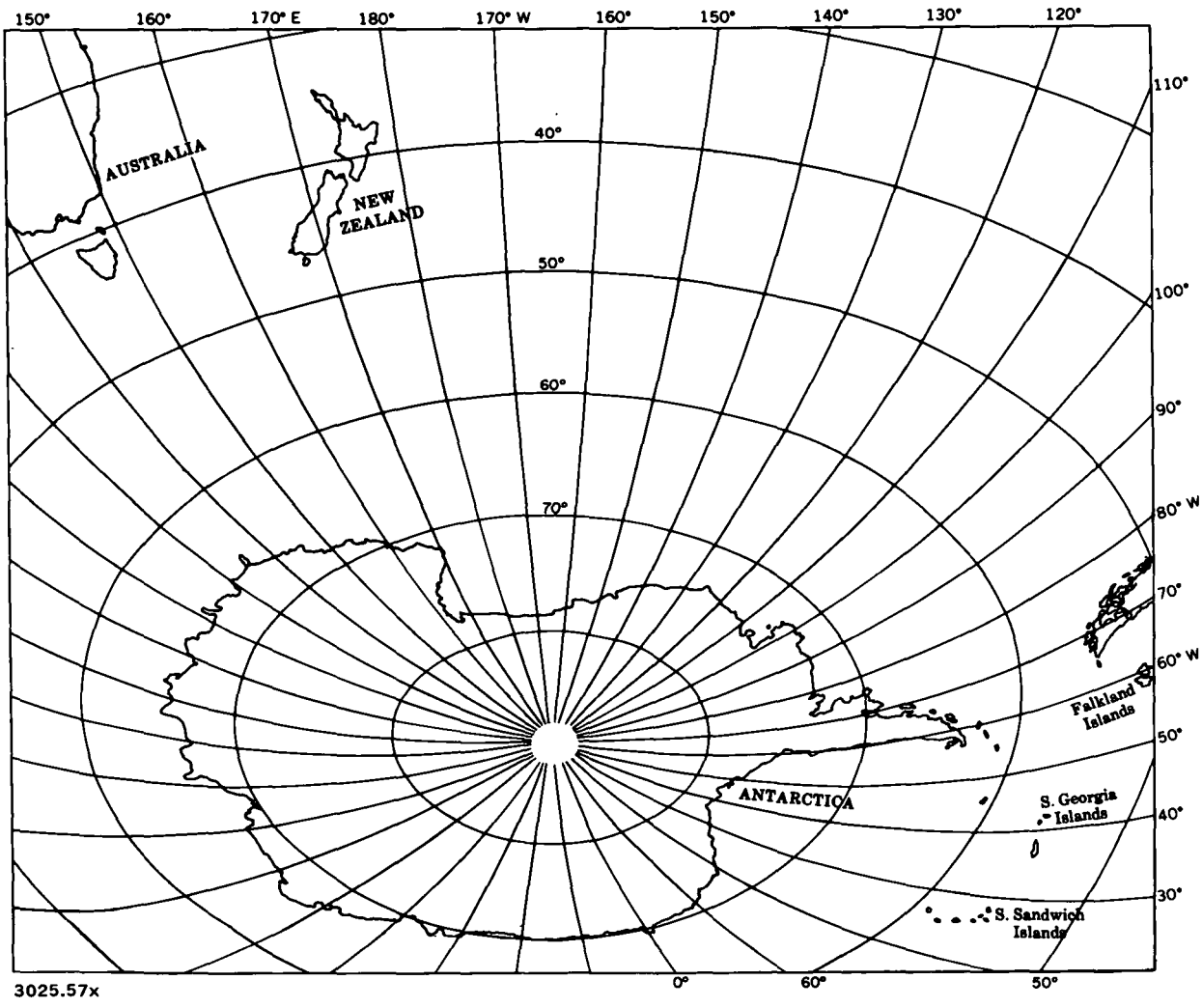



*Figure 82. United States of America: the Antarctic region*

so as to include significant geological geographical and political units and make each map of maximum use without reference to adjoining maps;

(b) *Base maps*: Same contents as for Pacific Basin base map but with topographic contours on land and with more detailed bathymetry and sea-bed features;

(c) *Geological maps (overprint in colours on grey base)*:

(i) Generalized geological units, including Quaternary (systems of series in detail required for mineral resources and energy resources maps—intrusives and volcanics subdivided on basis of composition), structural features to the extent feasible on land and sea-bed, and names;

(ii) Geophysical anomalies on sea-floor to the extent needed for tectonic interpretation but restricted to areas not covered by substantial thicknesses of sediments;

(iii) Sea-bed sediment thickness and characteristics, including shelf carbonates, deltas, slope deposits, slump areas and volcanogenic deposits;

(iv) Ages of oldest rocks in sedimentary sequence of sea-bed where known;

(v) Volcanoes;

(vi) Sea-bed drill-hole locations and indexed drill logs showing age of rocks penetrated;

(d) *Tectonic maps (overprint in colours on grey base)*:

(i) Major faults, fault zones, trenches, basin areas, and other structural elements;

(ii) Generalized geological units classified by age and genesis, not including Quaternary deposits;

(iii) Geochronological determinations;

(iv) Volcanoes, heat-flow anomalies and thermal springs;

(v) Geophysical anomalies on sea-floor to the extent needed for tectonic interpretation;

(vi) Seismic epicentres classified in three depth intervals and two or three levels of magnitude;

(vii) Sea-bed drill-hole locations and indexed drill logs showing age of rocks penetrated;

(e) *Mineral resources maps (overprint in colours on grey base)*:

(i) Major tectonic and metallogenic elements including batholiths and volcanic units;
(ii) Mineral districts or provinces; major deposits where feasible;
(iii) Metallic deposits classified as to mineral content, form of ore body, geological environment and size;
(iv) Major coastal and off-shore placer accumulations;
(v) Distribution of manganese nodules, metal concentrations and metallic content of sediments;

(f) *Energy resources maps (overprint in colours on grey base)*: several maps may be required to show oil and gas, coal, geo-thermal energy and radio-active mineral deposits:

(i) Selected sedimentary basins showing general age and thickness of contained sedimentary rocks (including deep-sea stratified deposits);
(ii) Selected major tectonic elements;
(iii) Generalized geological units;
(iv) Oil and gas fields and petroleum indications—possibly age of reservoir rocks;
(v) Oil-seeps, oil-shale, tar-sands and asphalt deposits;
(vi) Coal-fields classified by rank and quality;
(vii) Volcanoes, areas of thermal activity, heat-flow anomalies and areas of geothermal potential;
(viii) Radio-active mineral deposits.

## THE LAND-USE AND LAND-COVER MAP AND DATA PROGRAMME OF THE UNITED STATES GEOLOGICAL SURVEY*

*Paper presented by the United States of America*

A land-use and land-cover map is a thematic map, such as a soils map, a geological map or a map showing population distribution. The United States Geological Survey has undertaken such mapping to provide timely, accurate and consistent land-use and land-cover data on a nation-wide basis. Remote-sensing technology is providing the primary source of data for such mapping.

Although the land-use and land-cover map is in itself a useful tool in land-use planning, management and regulatory activities, there is also an urgent need for statistical data by counties, states, hydrological units, census county subdivisions and federally owned lands. These statistical data can also be used with soils, hydrological, topographic, geological, demographic, socio-economic and other data sets. Not only must land-use and land-cover data be obtained efficiently over extensive areas, but the capability to manipulate large amounts of such data in a computerized geographically oriented information system is necessary for effective use of such data for regional analysis, comparative studies and decision modelling. More effective ways of presenting land-use and land-cover data in various graphic formats are needed. Timely and inexpensive thematic comparisons and separations can be effective tools for the land-use planner or manager.

### NEED FOR LAND-USE AND LAND-COVER MAPS AND DATA IN THE UNITED STATES OF AMERICA

The United States Geological Survey (USGS) has undertaken a programme to provide land-use and land-cover maps and data for the entire United States of America. This programme begins to satisfy a long-standing need for a consistent level of detail, standardization in categorization and scale of compilation for land-use and land-cover maps and data. No base-line or bench-mark land-use and land-cover maps and data have ever been compiled for the entire United States. Consequently, it has been impossible to make an adequate analysis of land-use patterns, trends and problems among states, drainage areas, counties etc. Initiated in 1975 and scheduled for completion by 1982, with systematic updates to be provided, this programme relates closely to the long-standing service of USGS to federal, state and local governments and the public in general in the collection, analysis and publication of objective information about the national mineral, land and water resources.

This fact-finding mission of the Geological Survey originally described in the enabling legislation of 1879 still is directed to providing basic information and analysis "of the extent, distribution, and origins of the Nation's natural resources"; and the geological, topographic and hydrological processes "that affect the use of the land so that man may intelligently adjust his activities to the constraints imposed by the environment and may wisely manage the Earth's resources".[1]

The new programme is providing, for the first time, national land-use and land-cover information which can be related to information available on the basic USGS topographic maps at comparable scales. Geological, hydrological and soils maps and data can also be related more directly and accurately to the ways the land is being used.

Before undertaking to provide a base-line set of maps and data on land use and land cover, a four-year effort was

* The original text of this paper, prepared by James R. Anderson, Chief Geographer, United States Geological Survey, appeared as document E/CONF.68/L.48.

[1] United States Geological Survey, *Annual Report, Fiscal Year 1975* (Washington, D.C.), p. 31.

made to contact a wide array of current and potential users of such maps and data, beginning with a major forum held at Washington, D.C., in June 1971. Extensive testing of the proposed system which is described in a USGS circular,[2] was carried out through the mapping of approximately 325,000 km² in Arizona, the Central Atlantic area, and in the Ozarks and lower Mississippi Valley. Another systematic review was solicited from federal, state, and local agencies; from university staff; and from researchers in the private sector. After giving careful consideration to the many reviews and comments received, the Geological Survey published a professional paper[3] as a revision of USGS circular 671 (see table 45).

**Table 45. United States of America: land-use and land-classification system for use with remote-sensor data**

| *Level I* | *Level II* |
|---|---|
| 1. Urban or built-up land | 11. Residential |
| | 12. Commercial and services |
| | 13. Industrial |
| | 14. Transportation, communications and utilities |
| | 15. Industrial and commercial complexes |
| | 16. Mixed urban or built-up land |
| | 17. Other urban or built-up land |
| 2. Agricultural | 21. Cropland and pasture |
| | 22. Orchards, groves, vineyards, nurseries and ornamental horticultural areas |
| | 23. Confined feeding operations |
| | 24. Other agricultural land |
| 3. Rangeland | 31. Herbaceous rangeland |
| | 32. Shrub and brush rangeland |
| | 33. Mixed rangeland |
| 4. Forest land | 41. Deciduous forest land |
| | 42. Evergreen forest land |
| | 43. Mixed forest land |
| 5. Water | 51. Streams and canals |
| | 52. Lakes |
| | 53. Reservoirs |
| | 54. Bays and estuaries |
| 6. Wetland | 61. Forested wetland |
| | 62. Non-forested wetland |
| 7. Barren land | 71. Dry salt flats |
| | 72. Beaches |
| | 73. Sandy areas other than beaches |
| | 74. Bare exposed rock |
| | 75. Strip mines, quarries and gravel pits |
| | 76. Transitional areas |
| | 77. Mixed barren land |
| 8. Tundra | 81. Shrub and brush tundra |
| | 82. Herbaceous tundra |
| | 83. Bare-ground tundra |
| | 84. Wet tundra |
| | 85. Mixed tundra |
| 9. Perennial snow or ice | 91. Perennial snow-fields |
| | 92. Glaciers |

*Source*: James R. Anderson and others, *A Land Use and Land Cover Classification System for Use with Remote Sensor Data*, United States Geological Survey professional paper 964 (Washington, D.C., 1976).

At this point in time, approximately 1,820,000 km², or about 20 per cent of the total area of the United States, has been mapped at Level II of the classification system described above. Priority has been given to the mapping of coastal areas, energy production areas, areas of rapid urbanization and areas for which 50–50 cost-sharing arrangements have been made with states and regional commissions (figure 83). Under such arrangements, land-use and land-cover mapping have already been completed for the states of Arkansas, Louisiana, Kansas and Florida, and for the Atlanta area of Georgia. Mapping is under way for West Virginia, Pennsylvania, Alabama, Missouri and North Carolina. Discussions are in progress for mapping in 10 other states.

[2] James R. Anderson, Ernest E. Hardy and John T. Roach, *A Land-Use Classification System for Use with Remote-Sensor Data*, United States Geological Survey circular 671 (Washington, D.C., 1972).

[3] James R. Anderson and others, *A Land Use and Land Cover Classification System for Use with Remote Sensor Data*, United States Geological Survey professional paper 964 (Washington, D.C., 1976).

In the setting of priorities, careful attention is being given to the needs of federal and state agencies for land-use and land-cover maps and data which can be effectively and directly met by carrying out a systematic nation-wide collection of such data on a reasonably standardized basis. Requests from states have generally been associated with the need for land-use and land-cover data over extensive areas to develop and implement plans related to the improvement of water quality, development of transportation systems, recreational development, urban and regional growth etc. Federal incentives to develop and implement planning activities are often present. For example, the implementation of section 208 of the Federal Water Pollution Control Act Amendments of 1972 requires a display of land-use patterns. For implementing section 701 of the Housing Act of 1954, a land-use element is required.

In-depth discussions, pilot studies and research activities with several federal agencies are also being carried out by the Geological Survey in order to aid such agencies in meeting their needs for land-use and land-cover maps and data. Some specific examples are:

(*a*) The United States Soil Conservation Service (SCS) is concerned with the identification, location and use of prime agricultural land. USGS will provide data on land use and land cover which can be interfaced with SCS mapping and data compilation for prime agricultural land;

(*b*) The United States Fish and Wildlife Service needs maps and data on wetlands and other land cover and land use. Using the USGS data base as a starting-point in the inventory of wetlands, data collection can be added and related effectively to the surrounding land cover and land uses to satisfy a requirement of wildlife management and many wildlife studies;

(*c*) In implementing the Forest and Rangeland Renewable Resource Planning Act of 1974 (PL 93–378), the Forest Service can make effective use of USGS mapping and data to select sample areas for the collection of more detailed information on timber volume and production, rangeland use by cattle and wildlife, etc.;

(*d*) The United States Geological Survey and other agencies responsible for the preparation of environmental impact statements frequently need land-use and land-cover maps and data. USGS data are being used in the preparation of the Environmental Impact Statement by USGS for phosphate areas in Idaho.

## Development of the land-use and land-cover mapping programme

The variety of needs for land-use and land-cover maps and data is so great at the current time that it is difficult to cope with the situation satisfactorily with the resources available in the Geological Survey. To meet existing needs that can appropriately be addressed by the Geological Survey under current funding and personnel levels, the following products are being provided:

(*a*) Land-use and land-cover maps for use with the base maps at 1 : 250,000 scale and with the new base maps at 1 : 100,000 scale as they become available;

(*b*) Associated maps showing political units (counties and states), hydrological units (drainage areas), census county subdivisions including census tracts, and areas of federal land ownership;

(*c*) Magnetic tapes containing digital data obtained by digitizing in polygon format the land-use and land-cover maps. Documented software, necessary for the effective use of the digital data, is also being provided;

(*d*) Land-use and land-cover statistics by political units, hydrological units, census county subdivisions and areas of federal land ownership. Such statistics are to be made available mainly by states. However, statistics may also be made available for such areas as coastal areas, Standard Metropolitan Statistical Areas and major river basins.

In close association with the provision of products indicated above, research and development is being carried out in the geography programme on the following topics:

(*a*) Experimentation and demonstration of land-use and land-cover mapping on the scales 1 : 24,000 and 1 : 50,000 to determine: (i) the level of categorization appropriate for such scales; (ii) the type of land-use and land-cover data obtainable from different remote sensors and usable at such scales; (iii) the minimum areal extent of a given category suited for delineation at such scales; and (iv) the relationship between data compiled at such scales with data derived from intermediate-scale mapping (1 : 100,000 and 1 : 250,000);

(*b*) Research to determine the possible uses of LANDSAT data in association with higher resolution source materials for Level II land-use and land-cover mapping requirements in the Geological Survey in order to provide: (i) suitable remote-sensor data for mapping such areas as Alaska, for which other suitable remote-sensor data do not exist over extensive areas; and (ii) a part of the remote-sensor data that will be necessary for a systematic updating of the land-use and land-cover maps of the Geological Survey;

(*c*) Continuing development and refinement of a geographical information system for handling and disseminating land-use and land-cover data that will provide the following results: (i) graphic display of land-use and land-cover data either as a total thematic presentation or by separate or varying combinations of categories such as forested wetlands, residential and industrial; (ii) generation of land-use and land-cover statistics for the standard associated map units being used by the Geological Survey (political units, hydrological units, census county subdivisions and areas of federal land ownership); (iii) opportunity for the users of the digital tapes containing land-use and land-cover data to generate statistics for other areal units such as municipalities; (iv) capability to relate land-use and land-cover data effectively by use of electronic computers with other data sets, such as soils, topographic, hydrological, geological, socio-economic and demographic; and (v)

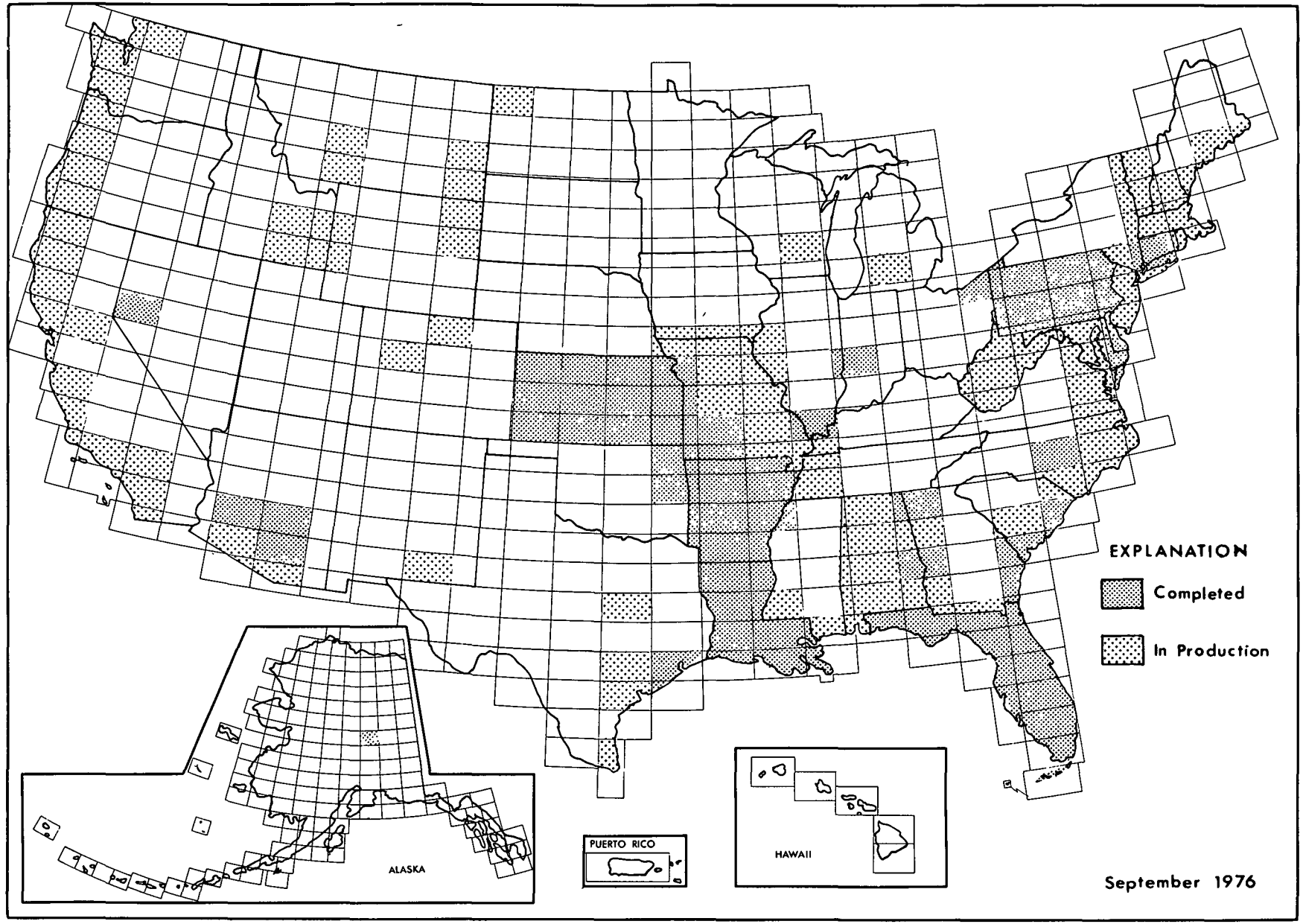



*Figure 83. United States of America: status of land-use and land-cover mapping*

satisfactory colour-separation plates for publishing land-use and land-cover maps either in solid colour or with a combination of line patterns and colour for selected maps;

(*d*) Demonstration analytical and interpretative studies in which land-use and land-cover data are being applied to the solution of "real world" problems. Some examples of studies already completed or currently being carried out in the geography programme are: "Climatology of land-use patterns"; "Modelling the effects of land use on the urban temperature field"; "Streamflow characteristics: improved prediction using land-use data"; "Shore zone land use and land cover"; "The impact of the oil and gas industry on the Louisiana coast"; "Land-use and land-cover analysis for Chattahoochee River quality assessment"; "Land-use impacts of strip mining phosphate in southeastern Idaho"; "Analysis of selected land-use patterns in relation to environmental problems in the Little Rock, Arkansas four-county area."

### Land-use and land-cover mapping in other countries

The Ninth International Conference of Agricultural Economists, held in Finland in 1955, endorsed the need for uniform data on land use and land cover from country to country. A group of Italian scholars headed by Professor Giuseppe Medici, University of Rome; Professor Carlo Vanzetti, University of Padua; and Professor A. Antonietti, University of Bologna, decided to prepare a World Atlas of Agriculture[4] with co-operation and inputs from scholars around the world.

The atlas was prepared under the general guidance of a Committee for the World Atlas of Agriculture under the aegis of the International Association of Agricultural Economists. The atlas consists of a series of land-utilization maps fitted to the plates of the Times Atlas of the World accompanied by monographs prepared for each country, published in four volumes. The map scale is either 1 : 2,500,000 or 1 : 5,000,000.

The preparation of the land-utilization maps, which extended over a period of years, preceded the availability of high-resolution remote-sensor data obtainable from high-altitude platforms and LANDSAT data. Had such data been available, a more timely and consistent approach to land-use and land-cover mapping on an international basis would have been possible. Similarly, much mapping of land use and land cover carried out in western Europe in the 1930s and 1950s was done without major reliance on remote-sensor data. In the land-utilization survey carried out in Great Britain[5] and completed under the general direction of L. Dudley Stamp in the 1930s, field inspection by schoolchildren supervised by their teachers was the corner-stone source of data on the use of the land.

As early as 1962, Canada undertook to map land use and land cover for the settled part of the country, consisting of about 1 million square miles, by using high-resolution remote-sensor data. With co-operation from the provincial governments, the mapping was first completed on the scale 1 : 50,000 and was later generalized to the scale 1 : 250,000 as part of the Canada Land Inventory[6]. At the current time, Mexico is mapping land use and land cover from remote-sensor data for the entire country at 1 : 50,000 scale under a plan to complete the mapping by 1979, which would be within a 10-year period.[7] In Australia, land-use, land-cover and land-tenure maps are currently being prepared on the scale 1 : 1,000,000 with use of LANDSAT data for the mapping of land cover.[8]

### Remote-sensor data requirements

Undertaking to compile land-use and land-cover maps and data for the first time for a large country such as the United States within a short period of time dictates primary reliance on remote-sensor data.

In order to provide thematic maps portraying land use and land cover in a timely, accurate and consistent manner on a nation-wide basis on the scales 1 : 250,000 and 1 : 100,000, the Geological Survey needs remote-sensor data which will provide: (*a*) initial base-line land-use and land-cover maps and data within a reasonable span of time, 5–10 years; (*b*) updating of land-use and land-cover maps and data in a systematic and timely way. Experience to date in the Geological Survey indicates rather clearly that certain requirements must be met if such mapping is to be completed satisfactorily. Among the requirements are the three described below, which are especially important.

#### *High-altitude remote-sensor data*

When a country as large as the United States is to be mapped, it is impractical to use large-scale remote-sensor data except in limited complementary ways, such as to supply data for relatively small areas for which suitable higher altitude sources do not exist. In general, it has been determined that remote-sensor data obtained from altitudes in excess of 12,200 m are desirable. The costs of integrating data at larger scales are excessive if required over extensive areas.

#### *Resolution characteristics sufficient to interpret Level II categories with reasonable accuracy and consistency*

The resolution of remote-sensor data required to obtain Level II categories varies greatly. In general, high-resolution data obtained from high-altitude platforms has proved particularly necessary for consistent interpretation of: (*a*) urban or built-up categories; (*b*)

[4] Istituto Geografico de Agostini, *World Atlas of Agriculture* (Novara, Italy, 1969), vol. I, p. ix.

[5] United Kingdom of Great Britain and Northern Ireland, *Land Utilisation Survey of Britain* [1931–1934] (Nottingham, n.d.), sheet 54, scale 1 : 63.360.

[6] Canada, Department of Forestry, *The Canada Land Inventory* (Ottawa, 1966).

[7] Mexico, *Comisión de estudios del territorio nacional (CETENAL)* (Mexico City, 1976).

[8] Australia, Department of National Resources, *Australia 1 : 100,000 Land-use Series: Notes on Classification Used* (Canberra, 1976).

reservoirs; (*c*) confined feeding operations; (*d*) other agricultural land; and (*e*) transitional areas in an urban setting. LANDSAT data will generally be most suited for use over extensive areas having a predominance of most other Level II categories not mentioned above, provided that the intermixture of such categories is not too great.

*Remote-sensor data with comparable currency*

A synoptic view of land use and land cover would be ideal, but such a perspective is not attainable from a practical standpoint. Data from LANDSAT most nearly approximates synoptic coverage for the United States. However, the requirement for currency does vary markedly from place to place. For areas having a very dynamic land-use situation, such as in the rural-urban fringes of rapidly growing cities, it is desirable to have data just as current as possible. From a practical point of view, the Geological Survey is adhering as closely as possible to the use of remote-sensor data that has been acquired within two years of the time that map compilation begins for dynamic land-use situations. For areas where changes can be reasonably well identified, somewhat older remote-sensor data can be used efficiently in combination with more recent remote-sensor data for areas known to be undergoing rapid change. More detailed field-checking of small areas of rapid change is desirable and possible for such areas.

The land-use and land-cover mapping completed so far by the Geological Survey has been carried out with primary reliance on high-resolution source materials. Much of the area mapped to date has been in those parts of the country having complex land-use and land-cover patterns which require such materials in order to map the Level II categories being used for nation-wide mapping on the scales being used. Some use of LANDSAT data has been made in supplementing other remote-sensor data in the delineation of some Level II categories, such as wetlands, deciduous, evergreen, and mixed forest land; and perennial snow or ice. However, this is the only purpose for which LANDSAT imagery has been used to date in the operational land-use and land-cover mapping programme.

Research is being carried out by researchers in the geography programme of USGS on the use of LANDSAT data in computer-compatible tape format to be used in combination with higher resolution remote-sensor data for areas of limited extent (comprising less than 5 per cent of the area being mapped) for the initial base-line mapping of land use and land cover for extensive sparsely settled areas. At this time, it is not expected that LANDSAT data can be used efficiently for mapping land use and land cover at Level II in urban areas, nor in rural areas having a great mixture of land-use and land-cover patterns, since too much supplemental information is required to obtain Level II data in such areas.

Three possible approaches are being evaluated for producing land-use and land-cover maps from LANDSAT data:

1. Use of film-recorder output from the automated classification of multispectral LANDSAT data registered to base maps of a specified scale to generate land-use and land-cover maps and data;

2. Use of film-recorder output from the automated classification of LANDSAT multispectral scanner data as source material for the manual delineation of land-use and land-cover polygons comparable to those being delineated for Level II categories in the mapping programme of the Geological Survey;

3. Development and use of computer programmes to produce land-use and land-cover polygons directly from the classification tapes derived from LANDSAT multispectral scanner data.

Some areas of the United States for which LANDSAT data might be used in combination with the limited use of higher resolution source materials for land-use and land-cover mapping in the Geological Survey include Alaska, parts of the Great Plains, parts of the intermontane western area and the upper Great Lakes region.

## Updating requirements

Changes in land use and land cover occur at highly variable rates from place to place. Thus, variations in the intervals between updates of land-use and land-cover data should be carefully evaluated in order to provide an appropriate frame of reference for the systematic updating of such data. A methodological framework is needed for updating land-use and land-cover maps that will be timely, relatively inexpensive and appropriate for widely varying needs at national, interstate regional, state, multicounty, county and city levels.

Given the current range in the availability and characteristics of remotely sensed data, the methodological framework for updating land-use and land-cover maps should be designed to make maximum use of such sources of data. It is also extremely important to recognize that remotely sensed data will not provide all of the land-use information that may be wanted by a specific user. Supplemental sources of information are available and should be used when land-use and land-cover data are being collected. Even expensive field-mapping may be necessary for some purposes.

Many differences in need exist among users of land-use and land-cover data for the updating of such data, but the following guidelines should be helpful in providing more timely and useful updating of land-use and land-cover maps at less cost per unit area being mapped:

(*a*) Make as much use as possible of remote-sensor data;

(*b*) Use those kinds of available remote-sensor data appropriate for the particular area being updated;

(*c*) Select minimum mapping units and level of detail in categorizing land use and land cover that can be used at the smallest scale compatible with survey needs in order to minimize time and cost of data collection and updating;

(*d*) Map only those areas which have actually undergone change from one land-use or land-cover type to

another. As a rule, mapping changes in land use and land cover is less costly than complete remapping.

The potential value of LANDSAT data for consistent mapping and measuring of spatial and temporal changes in land use and land cover for a wide range of users has not been fully demonstrated at this time. However, the need for a remote sensor capable of periodically scanning extensive areas for such changes is becoming more obvious as the costs and problems of collecting information about land use and land cover from enumeration, ground surveys and low-altitude high-resolution aerial photography continue to mount. Use of a lower resolution remote sensor to complement the use of high-resolution remote-sensor data for selecting areas where higher resolution remote sensors are most needed for obtaining land-use and land-cover data must now be more carefully evaluated. If such data are to be maintained at a reasonable level of currency in a cost-effective manner, more research is needed to assure that appropriate use shall be made of the wide range of remote sensing technology now available.

### Need for a geographical information system

In its 1976 report on current issues and studies, the National Research Council assesses the utility of remote sensing for economic development. In pointing out some of the successes and limitations of the LANDSAT programme, the report takes note of an important problem pertaining to the use of remote sensing from space, namely, "the difficulty of transforming remote sensing data into information suited to existing decision models, and more generally, of diffusing a new technology among a heterogeneity of potential users".[9] As a matter of fact, this statement should not be limited to remote sensing from space, since to a marked degree this problem has existed in the use of other remote-sensing data.

Particularly crucial in addressing this problem is the need to give careful attention to the organization and presentation of remotely sensed data. In developing the land-use and land-cover map and data programme in the Geological Survey, much thought was given to this matter. Continuing attention to the problem will be required in order to meet effectively the needs of data users. Among the first aspects of the problem that was addressed was the search for common ground in developing a classification system suited for use with remote-sensor data on a nation-wide basis. The considerations addressed in developing a classification system have previously been reported.[10]

In order to organize and present land-use and land-cover maps and data effectively for use in the decision-making and problem solving processes, a geographically oriented information system for handling and disseminating such maps and data is essential if timely and effective use of such maps and data is to become a reality. Development and implementation of a geographically oriented information system is a costly and complex process.

Maps and statistical presentations of land-use and land-cover data are being requested by a wide array of users. Some users want such maps superimposed on a base map in order to locate different use and cover types with respect to such features as roads, water bodies, populated places and topography. Other users view such a map as a means of quantifying the character of land use and land cover for a given areal unit such as a county, along a given line such as a highway, or around a given point such as a shopping centre or a central business district.

Thematic maps of land use and land cover are generally requested by users of such maps in two formats: with land-use and land-cover categories superimposed on a base map; and with no base map. In providing such maps, the Geological Survey is making the thematic maps of land use and land cover available on transparent stable-base film positive or on less expensive semi-stable diazo foil which can be registered to the standard base maps at 1 : 250,000 or 1 : 100,000 scale. If less than the total contents of the base map is desired, some selection of background features can be made by special order. Paper diazo copies of these maps are also available for sale. Release of such maps in these formats provides the most timely and inexpensive approach to placing information in the hands of the user at the scales being used in the nation-wide mapping programme. Publication of colour lithographed maps for selected quadrangles is planned in order to provide a presentation of representative regional patterns of land use and land cover.

Users purchasing land use and land cover from the Geological Survey have the option of using the map either with the standard base map or to overlay maps presenting other data such as soils, demographic or socio-economic data, provided such data are presented on the same base map.

After the land-use and land-cover maps have been digitized and the information stored on magnetic tapes, it is then possible to extract a single land-use and land-cover category or combinations of categories for graphic presentation at different scales. For example, only the residential category can be displayed in an interactive mode or on a graphic print-out. Residential and water categories can be shown in combination. Flexibility in graphic presentation is of considerable assistance in making use of such maps in the decision-making and problem-solving processes. Graphic displays of selected categories of land use and land cover can be made for a given area such as a county, for a given distance around a point, or for a given distance from a stream or a highway, provided areal units such as counties have been digitized and provided that the software for manipulating data in relation to points and lines is available for use with the geographical information system being used.

Statistics can be efficiently produced from land-use and

[9] National Academy of Sciences, *The National Research Council in 1976–Current Issues and Studies* (Washington, D.C., 1976), p. 180.

[10] United States of America, National Aeronautics and Space Administration, *Proceedings of the NASA Earth Resources Survey Symposium*, Houston, Texas, June 1975 (1976), vol. I-C, pp. 1610–1611.

land-cover maps if such maps have been digitized or if the maps were originally in digital format, such as those which can be derived from LANDSAT data. In order to organize and present statistical information on land use and land cover that has been derived from remote-sensor sources, a selection of associated maps must also be placed in digital format.

The Geological Survey has selected four associated maps or overlays for use with the main land-use and land-cover maps being prepared. Since most data available from the United States Bureau of the Census is being presented by counties and by census county subdivisions including census tracts, two associated maps presenting political units and census county subdivisions are being prepared. This makes it possible to relate statistical information on land use and land cover to demographic, socio-economic and housing data published by the Bureau of the Census. A map of hydrological units permits an interface of land-use and land-cover data with hydrological and related data. The fourth map showing federal land ownership by principal administering agencies provides a means of analysing the land-use and land-cover patterns on federally and non-federally owned land.

Statistics on land use and land cover can also be generated from other areal units, such as for municipalities, regional council areas, drainage districts and irrigation districts, by digitizing the boundaries of such areal areas. In general, such areal units compatible for use with land-use and land-cover data can be digitized quite cheaply. However, if a complex data set, such as a soils map, is to be compared with land-use and land-cover data, considerable care must be exercised to provide an effective interface if statistics are to be generated.

## Need for an international interface

For many kinds of mapping there have generally been numerous opportunities to exchange information in international meetings such as the present Conference. However, much of what has been done in the past in the mapping of land use and land cover has been carried out with relatively little discussion among interested and informed persons in different countries of the world. There is a current need for a viable means of exchanging information relating to the use of remote-sensor data in mapping land use and land cover. The degree to which efforts should be made to standardize information contents and methods of presentation is an example of this need for discussions among countries such as is possible at this meeting.

## (e) *Preparation and reproduction of maps (including map compilation, geographical names, automation etc.)*

# COMPUTER MAPPING IN THE DIVISION OF NATIONAL MAPPING*

*Paper presented by Australia*

### AUTOMATIC PRODUCTION OF THEMATIC MAPS

The statistics of the 1971 census have been portrayed for Melbourne and Sydney in two social atlases prepared by the Urban Research Unit of the Australian National University. The maps were prepared as line-printer maps using the Harvard University Symap programme and were photographically reduced. As data, the Division of National Mapping prepared computer files of latitudes and longitudes of the centres of the Collectors' Districts, which are the basic census units. The centres were digitized from the census maps using an inexpensive string digitizer, designed and built at the Australian National University. This instrument is interfaced to a PDP 11/40 minicomputer and if four graticule intersections are first digitized for each map-sheet, all centre points subsequently digitized are immediately converted by programme to geographical co-ordinates. The points were digitized in order of Collectors' District code number, thus ensuring a match with the statistics issued by the Australian Bureau of Statistics.

The maps in the atlases are "proximal" and are in effect filled-in statistical contour layers. The Division of National Mapping is to produce the corresponding maps following the 1976 census and is experimenting with the shading or colouring of Collectors' Districts, or aggregates of them, to produce choropleth maps which will present the statistics in a clearer fashion than the 1971 census line-printer maps.

This procedure entails the more onerous task of digitizing boundary segments rather than just the centres, followed by computer programming to join them into Collectors' Districts or aggregates, such as local government areas. This work will cover the entire continent and is well under way.

Of the two forms of maps, the first consists of computer-controlled shading techniques of different densities, using a scribing head on a flat-bed plotter. The other form entails the use of a computer output microfilm apparatus producing computer-controlled graphic maps on 10-inch film. The computer output microfilm apparatus is to produce miniature colour separations which will be photographically enlarged and subjected to normal photolithographic printing processes.

### AUTOMATIC TYPE-SETTING

The project reported on at the Seventh Conference, for automatic type-setting of names for maps of Papua New Guinea, has been applied by the Division to its Australian maps.

When the first edition of the series of Australia on the scale 1 : 250,000 was finished, all names appearing on the 541 maps were extracted, sorted by computer and published in a gazetteer. It was automatically type-set on a Photon 7000 machine from a magnetic tape of which each record contained the name, its geographical co-ordinates, a feature code describing it, the map-sheet number on which it appears and the state in which it falls. When a name appears on two or more map-sheets, it is repeated in the gazetteer. The master type is being updated as new maps at larger scales—and so with more names—are being produced.

The objective of the automatic type-setting method is to produce sheets of names on film, set in the correct style and point size, of most of the names to appear on any specified map-sheet.

To achieve this goal, the records of the master tape were sorted in order of map-sheets at 1 : 250,000 scale, within these sheets in order of component map-sheets at 1 : 100,000 scale and within them in alphabetical name order. An additional hierarchy number, specifying the order of importance of the features, was added to each record. The allocation of the hierarchies was done by inspection, examining all maps according to a set of rules.

Lastly, a computer programme was written which extracts the names for any specified map-sheet at a specified scale, uses the feature codes and hierarchies to look up the required fonts and point sizes, and produces the type on film using the Photon 7000 machine at the Government Printer.

For the larger scale maps, some of the names of small features will not appear on the master tape, as the gazetteer was made from a smaller scale series, and some additional manual setting will often be necessary.

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.30.

# STANDARD FOR EXCHANGE OF TOPOGRAPHIC DATA ON MAGNETIC TAPE*

*Paper presented by Australia*

This paper consists of a brief description of a standard for exchange of topographic data on magnetic tape adopted for use by federal mapping agencies and recommended by the National Mapping Council as a guideline for all Australian mapping agencies. Copies of the standard (17 pages) will be made available upon request.

## AIM OF THE STANDARD

This standard has been devised for the exchange between survey organizations of digitized topographic data on magnetic tape. The introduction of this standard will reduce costs in two ways: it will permit the digitized data held by mapping organizations to be considered a single entity, thus minimizing duplication of work; and it will minimize the cost of exchanging digitized data between organizations.

It is not foreseen that survey organizations will necessarily store or operate on data in this exchange format. Most organizations will have a working format determined first by the machines they use; and, secondly, on how they wish to manipulate their data; and for storage of large masses of data, some form of compression may be desirable. This standard is for exchanging data, and each organization is likely to need two programmes: one to convert data from its working format into this standard exchange format; and one to convert data received from other organizations in this exchange format into its own preferred working format.

## PRINCIPLES ON WHICH THE STANDARD HAS BEEN DESIGNED

### *Distribution of work between donor and receiver*

Where there is a choice, the donor should be required to do as little work as possible. The recipient is, in some sense, getting something for nothing and should be expected to do the bulk of any work that has to be done.

### *Satisfaction of requests by supersets or subsets*

Information will normally be exchanged as a result of a request from the receiver to the donor. This request may be satisfied by the donor passing the exact set, several subsets or a superset of the information requested, according to the mode of operation of the donor organizations.

### *Data deemed to be error free*

Since the exchange tape will need to be especially prepared by the donor, all errors should be eliminated from it, and the data on the exchange tape should be deemed to be error free. The standard contains no provision for correction codes.

### *Comprehensibility more important than compression*

It is not foreseen that masses of digitized data will be stored in the exchange format. It is more likely to be stored in the working format of the donor organization or in some compressed form. The prime requirement of an exchange tape for the receiver organization is not that the data shall be tightly packed but that they shall be readily comprehensible. For this reason, the opening blocks in the exchange format are 80 bytes long so that they can be readily interpreted, without any programming, on a line-printer.

### *No specially compacted data*

Similarly, the standard makes no provision for the inclusion on exchange tapes of data packed, for example, in STARBURST form or in special grids or arrays. Special attention is, however, given to arrays of spot heights as a means of depicting the topography.

### *Feature codes*

Although feature codes should be allocated on some logical system, they should be capable of great expansion in order to cope with the needs peculiar to individual organizations and with unforeseen demands in the future. The system adopted is based on the specifications for the national topographic map series, and should be suited for any topographic map. Some codes for bathymetric features and some for common hydrographic features have been added (they appear in annex A to the standard).

The coding system is capable of almost indefinite expansion in two ways. First, no less than 10,000 codes are available, of which less than 200 have been allocated to date. Secondly, each feature header contains not only a feature code but a "modifier" of a further four digits. In the case of height features, such as contours (but excluding spot heights), the modifier contains the height of the feature; but the modifier more generally is at the disposal of the donor organization. For example, feature code 1203 defines "Building or shed", and if the modifier which follows it contains four zeros, that is all that it means; but the donor may say that if the modifier contains 0001, the building is a post office; that if the modifier contains 0002, it is a church; and so on. By this means, no less than 10,000 options are available for modiying each of the 10,000 possible feature codes, and expansion is therefore virtually limitless. Each feature header is followed by either a single pair, or a string of pairs, of horizontal co-ordinates, defining the position of the feature.

### *Volume and file headers*

Many items of information that the recipient of a tape needs to know are more or less standard, and it is convenient to have a fixed format to remind the donor what these items are and to ensure that he shall consider

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.32.

whether they are applicable. In addition, in almost every case, the donor will need to explain some peculiarity in his data or to define some feature codes or feature modifiers, and ample space has been provided for this purpose.

Nine blocks of 80 characters called User Volume Labels (UVL 1-9) are available in free format to say what a volume or tape contains (given in the standard, section 5). A further nine blocks called User Header Labels (UHL 1-9) contain, in fixed format, room for information which is foreseen to be necessary for nearly all data; and the donor has the option of up to 26 further blocks of 80 characters, free format (UHL A-Z), for explaining the peculiarities of each individual file to the recipient (in the standard, section 6).

*Dates*

It is desirable to have a standard method of expressing dates. In the system adopted, five digits, "yyddd", give the last two digits of the year and the serial number of the day of the year, which is now given in most desk diaries. For example, 31 December 1974 is coded as 74365.

*Negative numbers*

Owing to the difficulty of reading arithmetical signs in numerical fields, no plus or minus signs are required by the standard. Specific feature codes are allocated to negative heights or depths; and unless otherwise defined by the donor, all latitudes are measured southwards from the equator, and all longitudes are measured eastwards from Greenwich. The standard can, of course, be used for areas north of the equator; the donor simply specifies in a user header label that in this particular file unsigned latitudes are measured northwards from the equator.

*Co-ordinate system*

Although data may be digitized in any system and stored in compressed forms on any arbitrary co-ordinate system convenient to the user, it is convenient to have a standard system of co-ordinates for exchange tapes. Australia is fortunate in having at its disposal two such systems; longitudes and latitudes on the Australian geodetic datum; and eastings and northings on the Australian map grid. The standard requires the donor to convert all co-ordinates into one or the other of these two forms when making the exchange tape.

For topographic mapping, co-ordinates to the nearest metre should always suffice, and it is foreseen that co-ordinates will usually be listed in integral metres on the Australian map grid or in hundred thousandths of a degree (0.00001°) on the Australian geodetic datum. To save space on the tape, provision is made for a constant amount to be subtracted from co-ordinates before they are recorded. For example, near Canberra, 149° might be subtracted from all longitudes and 35° might be subtracted from all latitudes; or 600,000 m might be subtracted from all eastings and 6 million m might be subtracted from all northings. These figures and the number of digits remaining for each co-ordinate—in this case, 5—are specified by the donor in the file header. These constants, once defined, remain constant for the whole file.

No specific provision is made for co-ordinates in units other than integral metres or 0.000001°. However, it is always open to a donor to define in the file header that all co-ordinates in a file are in units, for example, of decimetres or millionths of a degree.

*Heights*

For topographic mapping, heights to be nearest metre will nearly always be adequate; and no mountain attains 10,000 m. Unless otherwise specified in the user header label, heights are therefore given as an unsigned four-digit number with no decimal point, which is the height of the point in metres. The datum will nearly always be the Australian height datum, except in the case of bathymetric or hydrographic work. The datum is specified in the box provided for the purposes in one of the user header labels. The difference between a strange datum and the Australian height datum should be stated by the donor. Special feature codes have been allocated for heights and depths in decimetres; as with co-ordinates, provision is made for a constant to be subtracted from all heights before they are recorded.

*Spot heights*

Individual spot heights can be considered control data; they are then referred to in this standard as "spot elevations" and a special feature code has been allocated in the control data section. But in large arrays, spot heights form a method of depicting the topography as an alternative to contours. In this case, it would be wasteful to repeat the feature code, with the modifier containing the height of the point, for every spot height. Four feature codes have therefore been allocated which, instead of being followed by strings of co-ordinate pairs, are followed by strings of triplets—two horizontal co-ordinates and a height. The number of characters in the height can differ from the number in each co-ordinate and is defined in the file header. The most common code is for positive heights in metres. The other three are for positive heights in decimetres, for negative heights in metres and for negative heights in decimetres. All feature codes apart from these four are followed by strings of co-ordinate pairs.

*Binary code*

As binary codes change from machine to machine and are not readily understood by other machines, they are not suited for use on exchange tapes. The standard adopts the set of 128 binary-coded decimal characters adopted in Australian Standard XI of 1969. ASXI-1969 is identical with the seven-bit set defined in ISO recommendation R646-1967, with the addition of national selections. The set defined by the standard is identical with that specified in the Americal Standard USASX 3.4-1967.

*Tapes*

Although seven-track tape has been much used in the past the advantages of nine-track tape are being increasingly recognized and the standard requires the use of

nine-track tape at the medium density of 32 rows per millimetre—800 bytes per inch.

*Size of file—"page size"*

The standard requires that data shall be exchanged in files that correspond to any one of the standard map-sheets, on any scale, approved by the National Mapping Council, or multiples of such sheets. Calculations revealed that a standard sheet, whether at 1 : 10,000 or at 1 : 100,000 scale, will nearly always fit comfortably inside a single 2,400-foot reel of tape. Owing to the difficulties of uncorrected edge comparisons, the standard does not provide for the exchange of data by photogrammetric models.

## THE CURRENT STATE OF AUTOMATED CARTOGRAPHY IN FINLAND*

*Paper presented by Finland*

Automated cartography was not introduced in Finland until the beginning of 1974, when the National Board of Survey had an opportunity to rent an automatic drafting-machine. The Board had already begun to develop procedures for producing thematic maps so that production in this sector began within the space of a few months. In 1974, the first such maps were exhibited at Madrid. At the beginning of 1975, the Board purchased its own automatic drafting-machine. Bearing in mind the greatest extent to which the machine would be used, primarily in scribing topographic maps, the Board, after some deliberation, chose a Kongsberg DC 300/1216 machine. The device is equipped with a magnetic-tape unit and a tool-holder into which four tangentially controlled scribing tools can be fixed at the same time.

For automatic data-processing, the Board has been able to use a UNIVAC 1108 by means of a remote batch terminal situated in its office. The required programmes for producing thematic and cadastral maps have been installed in this machine. A beginning has also been made on developing a programme for topographic maps for the Board's own NOVA-840 minicomputer. The memory of this minicomputer is 56,000 words at 16 bits and the disc capacities are 500,000 and 28 million bytes. In addition, the equipment includes a card-reader, a line-printer, a magnetic-tape unit and a tape punch. FORTRAN V has been used as the programming language for both computers.

A digitizing d-mac system-2 equipped with a magnetic-tape unit has been available for the collection of graphic data. At the time of writing, installation of Comdig equipment comprising two digitizing tables and a Wild A-8 interface had begun. All three devices produce output simultaneously, using the same magnetic-tape unit.

### Topographic maps

In Finland, topographic maps are made in the Gauss-Krüger projection. The country is divided into four zones of 3° width, whose central meridians are 21°, 24°, 27° and 30° east of Greenwich, respectively. In addition to the zone in question and the geographical co-ordinates, every map has the grid of the 27° zone which is always printed in red or brown on the maps. Using automation, the first stage in the preparation of these maps was to produce this grid; for topographic maps of any scale this can be done by giving the desired sheet number to the programme.

In the preparation of topographic maps, most of the work goes into producing the basic map, which is fair-drafted on the scale 1 : 10,000 and printed at 1 : 20,000 scale. Here, it should be pointed out that there is a shortage of adequately trained draftsmen in Finland, and the signs are that the situation will continue to deteriorate. Thus, automation appears to be the only means of guaranteeing map production in the future. As the Board begins to introduce automation for the drafting of the basic map, it is clear that it will not be possible to achieve a very high degree of automation in the foreseeable future with the resources available. The development of the arrangements to be described later has been influenced by the factors mentioned below.

The Board's future plans include a change-over to an interactive cartographic system within the next few years. According to the most recent available information, buying a ready-made system and making a limited number of changes to it appears to be the right solution. In the current situation it is not worth while for the Board to begin developing its own data base. Similarly, instrument resources during the next few years will be limited to off-line digitizers and the automatic drafting-machine so that real-time data processing will not be possible. This temporary arrangement should, however, mean more flexible editing.

For these reasons, the Board has reached the solution shown in figure 84. With this arrangement the Board is not attempting to achieve complete automation, but only to use automated drafting for perhaps a good half of the basic map.

Digitizing is carried out from the original plot using the "menu" technique. The output tape is processed in the first programme which carries out the transformation of the co-ordinates, indicates possible errors and outputs the files on to a disc. The information for each map-sheet is divided in several files of the "random" type and is recorded in binary form. There is one file for property

* The original text of this paper, prepared by Matti Vahala, Automation Project Leader, National Board of Survey, Finland, appeared as document E/CONF.68/L.113.

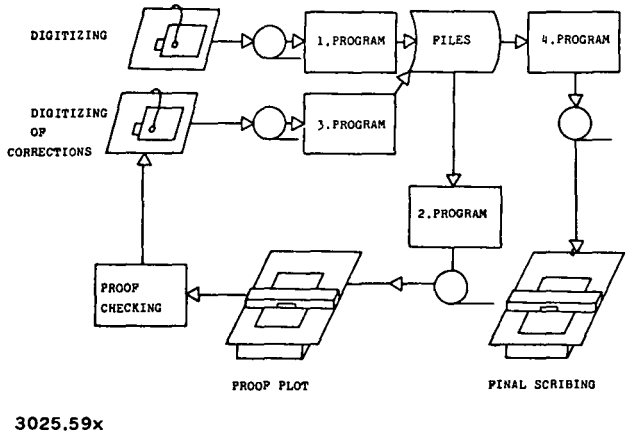



*Figure 84. Finland: partially automated map production system*

boundaries, one for property registration numbers and for other alpha-numerical data; and one file for communications, fields, buildings, symbols etc.

The next stage is to write out the control tape with the second programme in order to direct the automatic drafting-machine. The machine uses ball-pens to prepare a draft. The result is a simplified version of the final draft and contains information for controlling the digitizing directions, the initial and final points of the segments etc. This draft is proof-checked and returned to the digitizing table. Using the "menu" technique instructions, it is possible to delete, supplement, relocate and change the meaning of the points and the segments. Activity is always directed to the object to be recorded by indicating it with the cursor. The files are updated by the third programme. The search for the point to be edited from the files takes place on two levels. The operation code of the "menu" indicates to which file the operation should be directed; searching the files for the point or segment requires use of the co-ordinates. No indexes are attached to the files; the search always begins at the beginning of the file and continues until the required point has been found through its co-ordinates. Despite the simple construction of the files, the automatic data-processing times are not long; in fact, they are shorter than expected. The run times required by this programme are usually shorter than, for example, the time spent producing the control tape necessary for producing the draft.

The final, i.e., the fourth programme, produces the final control tape needed for the fair-drafting. The fair draft is produced by scribing. Here, the correct line types and the calculation of the lengths of the breaks in dash lines are taken into account so that, from the cartographic point of view, the final product is the equivalent of a hand-made draft. The hardware for the automatic drafting-machine comprises, e.g., generating dash lines; this does not adjust the spacing of the dashes between the initial and final points. Likewise, capital letters have been programmed into the control unit of the drafting machine in the same way as numbers, but neither the omission of small letters nor the spaces between different letters conform to accepted norms; their output is achieved by using the host computer to generate the control instructions necessary to draft them. These alpha-numerical signs are needed for the production of the cadastral draft. The production of a names plate by scribing has not been considered.

Currently, drafting of both the cadastral draft and the symbols has reached the production stage. Besides property boundaries, the draft includes the names of villages and property designations. The drafting of buildings, communications and areas of rock will come into production within the next few weeks.

### Cadastral maps

The National Survey Administration carries out tens of thousands of land divisions each year. Maps are made for most of these divisions. Most of the divisions are so small that automated cartography is not of great significance as far as they are concerned. The largest operations, however, may involve considerable mapping work. So far, a software has been developed for drafting the titles, the grid frame-work and the property boundaries from maps of this type. The co-ordinates of the boundaries are obtained from the values calculated after measurements from stereoplotting or ground survey. In addition to these data, the programmes must have information on sheet-lines, how different points are joined together, titles etc.

### Thematic maps

The Board has begun to develop its software by recording the input information according to the so-called "co-ordinate method". Thus, the maps printed out show the areas entirely independently of any administrative division. So far, the Board has not developed a programme by which choropleth maps can be made. The starting-points for the Board's programming have been quite favourable in Finland. In the 1970 population census, for example, the co-ordinates of every dwelling were calculated with a formal accuracy of 10m; in this way, all residents have been allocated co-ordinates. In addition to this information, the co-ordinates of buildings are continuously kept up to date in the population register centre and in the building register. Several municipal authorities have registers concerning their own administrative spheres, where information is also localized by co-ordinates. Programmes are ready for the production of the types of maps described below, using the automatic drafting-machine. The software has no restrictions to the size of the area to be mapped and the output can be done on the wanted projection zone.

#### *Symbol map*

The way the information is classified, how each kind of symbol is selected for each group, the map scale, the location of the area to be mapped etc.—all have to be included in the input information for the programme. Each item is entered on the map at the point indicated by its co-ordinates by means of the appropriate classification symbol.

*Grid map*

In the grid map, the area mapped out is divided with a regular grid. The values for the features to be represented (two at a time can be mapped) are shown in numerical form in each square. Output can also be achieved with a line-printer.

*Grid dot map*

The grid dot map is a variation of the previous type of map. The grid is left out and the numbers are replaced by dots whose areas are proportional to the feature to be depicted inside that particular square. When the area of the dot exceeds that of the square, that section of the grid is itself drawn as a compact square. In addition to the usual information concerning the limits of the map area, the scale etc., the input information for the programme includes a formula from which the radii of the dots can be calculated. Further, under a certain limit smaller dots are omitted, which is significant when using an automatic drafting-machine since with the equipment at the Board's disposal it is not possible to cut dots of less than 0.5 mm diameter properly into the membrane.

Graphic output is obtained by the cut-and-strip method. The dots and squares are removed manually. The information given by the machine is incomplete in those sections of the grid depicted as squares, since all that is known in those cases is that the value of the feature depicted exceeds a certain limit. Such cases are comparatively rare and for this reason such squares are completed manually by sticking the numerical values up into the empty spaces. In addition, the Board has further improved the map—if one or more squares are connected together—by using circumstances whose radius is calculated with the same formula as the smaller ones, although the value of the function is obtained from the combined value of the full area formed by the squares.

*Isoline map*

Isoline maps were reported on at Madrid[1] and are therefore not included here.

[1] Mauno Kajamaa and Matti Vahala, "Developing thematic cartography in Finland", paper presented to the International Cartographic Association Technical Conference, Madrid, 1974.

## ORTHOPHOTOGRAPHY IN COMBINATION WITH AUTOMATIC RESTITUTION: THE FASTEST AND MOST ECONOMICAL METHOD FOR SMALL-SCALE TOPOGRAPHIC MAP PRODUCTION*

*Paper presented by the German Democratic Republic*

Automation offers a variety of possibilities for accelerating and rationalizing working operations. The introduction of the orthophoto technique marked a major break-through towards automation in the restitution of aerial images and terrestrial photographs when compared with stereo mapping. By using the orthophoto technique the restitution of photographs can be accomplished from 2 to 10 times more quickly and more economically than by stereo mapping.

Another means of increasing the speed and economy of image restitution is by using the correlation technique. In this technique, the operator is replaced by an electronic control system, the correlator. The operator merely has to prepare the instrument for restitution, i.e., he has to insert the photographs, orient them, set the gear ratios, insert the photo material for differential rectification and connect the peripheral instruments. The model profiling is then done completely automatically. This method of restitution produces orthophotos, digital profile recordings and graphic drop-line representations.

There are still vast areas of the globe, especially where population density is low and economic development poor, for which topographic maps are inadequate or altogether lacking. As all these regions, including deserts, steppes, jungles and alpine areas, continue to be opened up to traffic and economy, the need to make topographic maps that cover large areas, and to make them as quickly and economically as possible, becomes all the more pressing.

Where scales are small enough—between 1 : 200,000 and 1 : 2,500,000 or smaller—satellite photographs and side-viewing radar photographs have in some cases proved useful as cartographic input material. For larger map scales, 1 : 50,000 or 1 : 100,000, these techniques are hardly applicable. Besides, maps derived from satellite or radar photography cannot seriously be regarded as topographic.

Orthophotography, on the other hand, is a particularly suitable technique for mapping on the scales 1 : 50,000 and 1:100,000. In the past 10 years, it has gained widespread application in topographic mapping. For example, for over five years several Topocart-Orthophot systems have been used to make topographic maps of large areas of Australia on the scale 1 : 100,000. The merit of this equipment lies in the fact that it is particularly well suited to the production of small-scale orthophoto maps since it can process normal, wide-angle and super-wide-angle photography directly to map scale.

In combination with a device for automatic image correlation, this system is now available under the name Topomat. Restitution on Topomat is faster by a factor of 2 or 2.5 than it is on conventional orthophoto instruments (and it is from 5 to 20 times faster than with stereo mapping).

* The original text of this paper, prepared by Klaus Szangolies, German Democratic Republic, appeared as document E/CONF.68/L.25.

Aerial photographs for small-scale orthophoto maps are most successful when taken with super-wide-angle 88-mm (3.5-inch) cameras or wide-angle 152-mm (6-inch) cameras, the former being primarily suited for flat or hilly terrain and the latter for mountainous and alpine regions.

Table 46 shows photographic conditions and data, as well as the evaluation performances of up-to-date photogrammetric equipment for small-scale orthophoto-map production. One Topocart-Orthophot system, for example, would permit the entire 2 million km² of the Amazon basin to be mapped orthophotographically at 1 : 100,000 scale from 1 : 80,000 aerial photographs within 16 years. With eight systems, the map would be completed in two years. It would comprise 800 sheets (see table 46). The same work can be carried out within half the time using the automatic Topomat system.

In a comparison of the speeds of conventional stereoplotting and orthophotography, the latter is from 2 to 10 times faster. A special advantage of the orthophoto map over the symbolized, plotted map, especially in barely accessible regions, is that it contains a wealth of information on forest stands, water, flooded areas, soils, geology etc.

Thus, although the accuracy of the orthophoto map is comparable to that of the symbolized map, the orthophoto is definitely more useful.

For hilly or mountainous ground, there is an advantage in combining orthophotography with relief representation by dropped lines or digital recordings. From such digital or graphic representations of elevation it is possible to derive contour maps which can be printed on top of the planimetric orthophoto map, thus adding to its over-all usefulness.

**Table 46. German Democratic Republic: photographic flight data and efficiency of orthophotography for making orthophoto maps on the scales 1 : 50 000 and 1 : 100 000**

| | *Scale 1 50 000* | | *Scale 1 . 100 000* | |
|---|---|---|---|---|
| | *Plains* | *Mountains* | *Plains* | *Mountains* |
| Camera | MRB 9/2323 (super-wide-angle) | MRB 15/2323 (wide-angle) | MRB 9/2323 | MRB 15/2323 |
| Photo scale | 1:50000 | 1:50000 | 1:80000 | 1:80000 (1:40000) |
| Mean flying altitude above ground (metres) | 4500 | 7500 | 7000 | 12000 (6000) |
| Area covered by each stereo model (square kilometres) | 50 | 50 | 125 | 125 (30) |
| Area covered per map-sheet sized 50 × 50 cm (square kilometres) | 625 | 625 | 2500 | 2500 |
| Compilation on Topocart-Orthophot; | | | | |
| Models per work shift | 2–3 | 2–3 | 3 | 3 (2–3) |
| Square kilometres per work shift | 125 | 125 | 375 | 375 (75) |
| Annual output (200-work-days per annum and two shifts per day) | 50000 km² = 80 map-sheets | 50000 km² = 80 map-sheets | 150000 km² = 60 map-sheets | 150000 km² = 60 map-sheets |
| Compilation on Topomat: | | | | |
| Models per work shift | 4–7 | 4–7 | 5–8 | 5–8 (3–6) |
| Square kilometres per work shift | 280 | 280 | 800 | 800 (140) |
| Annual output (200 work-days per annum and two shifts per day) | 110000 km² = 175 map-sheets | 110000 km² = 175 map-sheets | 320000 km² = 125 map sheets | 320000 km² = 125 map-sheets |

*Note*: Data added in parentheses ( ) require subsequent photographic reduction from orthophoto scale 1 : 50 000 to map scale 1 : 100 000. All other compilations can be made directly to map scale.

# ASSEMBLAGE OF CARTOGRAPHIC FAIR-DRAFTS OF SELECTED ELEMENTS BY MEANS OF DIAZO COPY*

*Paper presented by the Federal Republic of Germany*

In the cartographic reproduction technique, the different fair-drafts which are to be printed in one colour are usually assembled by means of foil copy (potassium dichromat layers). The colour masks, which are introduced into the assemblage copy as screened-up areas, are considered also to be fair-drafts.[1] The known disadvantages of the classical assemblage copy—great expenses in time and bad suitability for standardization—have always been the origin of the search for other techniques of processing and for light-sensitive materials.

Since diazo layers on dimensionally stable carriers exist, diazo-copy methods are becoming increasingly prevalent. The present contribution groups the investigations that were undertaken in order to introduce this method into cartographic reproduction technique. According to these investigations, the preparation of the assemblage copy of screen tints appears to be quite justifiable from the technical and economic points of view.

## Background information

Positive diazo layers have long been used in the cartographic reproduction technique.[2] As opposed to other techniques, these materials for the so-called "heliographic" printing have an advantage in that they are processed in a dry way and immediately give positive reproductions of transparent positive originals.

In the cartographic reproduction technique, heliographic printing has so far been applied only in cases where just a small number of copies of print proofs was needed and where a printed reproduction was not worth while. For this reason, the method is applied chiefly for the large-scale cartography of the surveyor's and land regulation offices, as well as for all agencies and private firms dealing with planning on the basis of large-scale maps. There, the most frequently employed carrier of diazo-copy layers is paper, opaque as well as transparent (master print). Colouring of lettering and drawing can be black, blue, red or sepia brown according to the chosen material.

The diazo papers used can be divided into two main groups according to their chemical structure: "two-component" paper; and "one-component" paper.[3] The two-component paper is developed in a dry way in ammoniacal fumes, as opposed to the one-component paper, which is sprinkled with a developing solution; this is called "half-dry" development. During recent years, a further method for the development of diazo papers has been used—the diazo heat process. In the course of this process, which still needs testing, colouring matters arise under the action of heat.[4] For the reproduction of line-drawings the blueprinting process gives adequate results with all sorts of papers. This process does not apply to the reproduction of screen tints, where some materials turned out to be inappropriate for a sufficient standard of quality.

The development of processes through which diazo layers can be coated on dimensionally stable transparent material has made it possible to use this method to do tasks involving cartographic reproduction technique and achieve the high standards of quality which formerly were reserved for the foil copy. The latter method involves a great expenditure in time and money and, furthermore, is not suited for standardization. To this belongs above all the assemblage of dispersed screen tints with different tonal values on one colour original. In order to get qualitatively good and invariable results during the production of such a colour original, all factors that have an effect on tonal value (exposure, development etc.) were taken into consideration and investigated for the commonly used "dry" diazo materials by means of objective measuring and controlling systems.[5]

## Combination of surface masks with synchrone screening through assemblage copy

The assemblage of different fair-drafts on one carrier by means of the copying technique is called "assemblage" or "combination" copy.[6] It is usually carried out in order to get a fair-draft in which all the elements that are to be printed in one colour are combined. The assemblage copy can be prepared with the help of different light-sensitive layers, which in most cases are coated or are to be coated on a transparent material. The methods thereby applied are distinguished either according to the light-sensitive

* The original text of this paper, prepared by D. Morgenstern, Institut für Kartographie and Topographie der Universität Bonn, appeared as document E/CONF.68/L.91.

[1] D. Morgenstern, "Die photographische Zusammenkopie als Alternative zur Folienkopie", *Kartographische Nachrichten*, No. 4 (1972), pp. 138–143.

[2] W. Neugebauer, "Neuere Entwicklung der Lichtpaustechnik: Fortschrittsberichte auf dem Gebiet des Kartendrucks und der Kartenreproduction", *Vermessungstechnische Rundschau*, No. 9 (1958), pp. 299–308.

[3] F. Endermann, "Lichtempfindliche Schichten ohne Halogensilber", in *Reprographie II* (Darmstadt und Wien, Verlag O. Helwich, 1969).

[4] *Ibid.*

[5] R. Brandt, *Bestimmung der Tonwertübertragungsfunktion vom Rasterpositiv zur Lichtpause, dargestellt an verschiedenen Lichtpausmaterialien*, Unveröffentlichte Diplomarbeit (Bonn, Institut für Kartographie und Topographie der Universität Bonn, 1974).

[6] I. Folkers, "Die Zusammenführung von Elementen einer thematischen Karte durch photographische Kopierverfahren", in *Thematische Kartographie* (Mannheim, Wien and Zurich, Bibliographisches Institut, 1970), pp. 225–249.

layers (positive copying coating, diazo layer, negative or positive reacting photographic layer) or according to the type of the fair-drafts (negative or positive originals).

Three methods are currently used in the cartographic reproduction technique to assemble surface masks with different screen tints on one fair-draft:

(*a*) The positive foil or glass copy with the use of positive colour masks;

(*b*) The negative photographic print with the use of negative colour masks;

(*c*) The positive blueprinting process with the use of negative colour masks.

The method presented under (*c*), which was developed only recently, is discussed below.

*Assemblage copy prepared by blueprinting*

The commercial development of diazo-coated polyester foils has recently resulted in the utilization of blueprinting by some cartographic establishments to make assemblage copies.[7] The great practical advantages of the use of transparent blueprinting material are the relative insensitivity to light which allows processing in subdued daylight and an easily standardized development.

The assemblage copy of screened areas during blueprinting presupposes negative masks, which are projected one after another together with the copying screen in the desired tonal value on the blueprinting layer. In doing so, the coated side of the screen and the diazo layer must be in direct contact. After the projection of all raster tints, an exposure under a positive mask of all the screened-up surfaces must take place. Only after that process does a sole development occur. Figure 85 shows all necessary steps of the process of preparing the assemblage copy of four screened-up areas. A considerable reduction of the amount of work, compared with that required for the conventional foil copy, is obvious.

In order to determine the suitability of blueprinting foils for these tasks of reproduction technique, an investigation was carried out, by means of which the sensitometric properties and the quality of reproduction of different diazo materials were to be determined.[8] In connexion with the present problem, the only investigations of interest are those which apply to diazo layers, the carriers of which are dimensionally stable.

[7] H. Pahl, "Reproduktionstechnische Arbeitsverfahren als Folge veränderter kartographischer Aufgaben in Ballungsräumen", *Kartographische Nachrichten*, No. 1 (1973), pp. 23–29; and H. Schmidt, *Neue Verfahren zur Herstellung vielfarbiger Karten* (Vermessungsamt Hamburg, 1972).

[8] R. Brandt, *op. cit.*

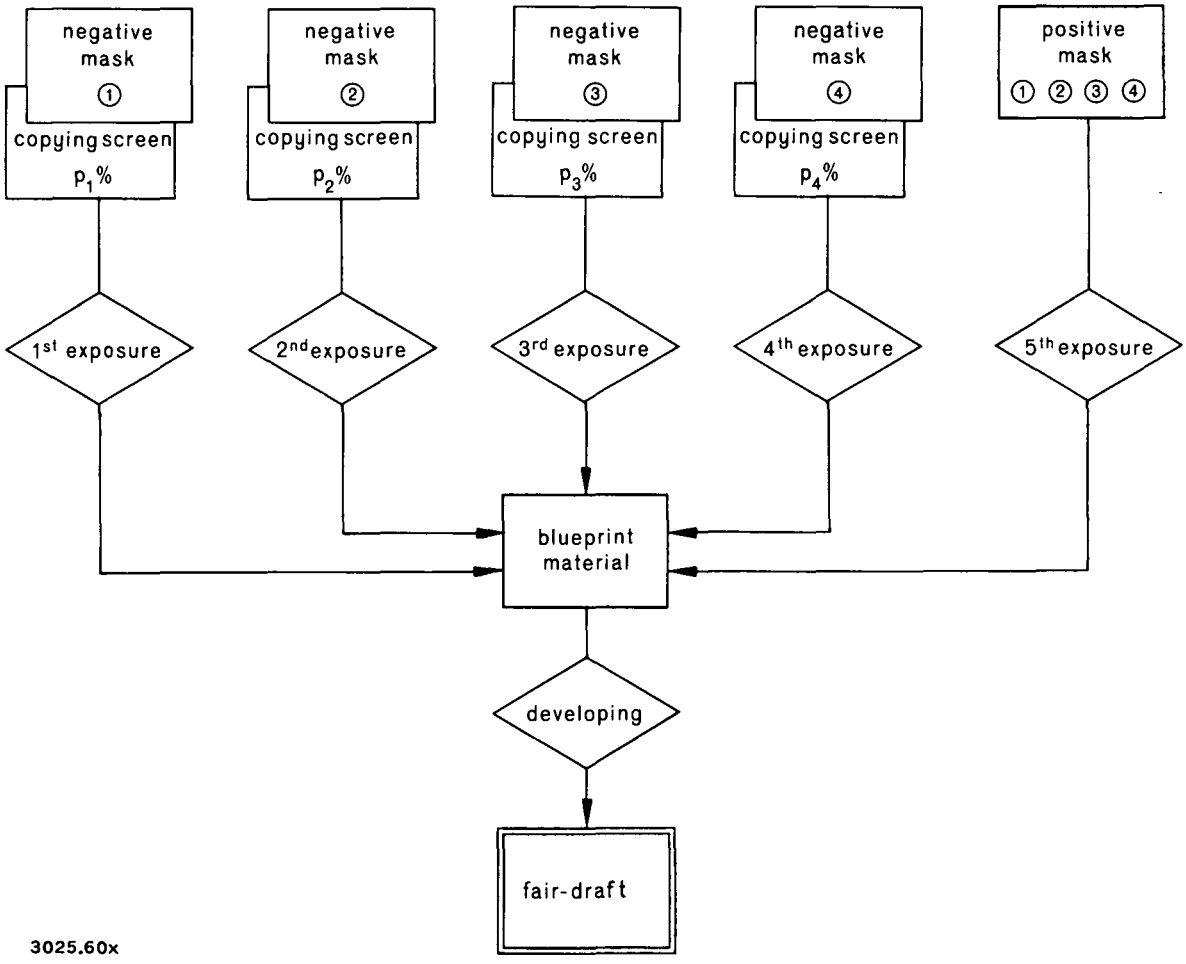



*Figure 85. Federal Republic of Germany: methodical steps of preparing assemblage copy on a blueprinting foil*

## Transfer qualities of density and of tonal value of blueprinting materials

The investigations explained below refer to only one material, which is distributed under the name M-foil by the firm Renker GmbH, Düren (Federal Republic of Germany) and which was at the time of the investigations the only adequate blueprinting material with a dimensionally stable carrier. Meanwhile, a comparable product from Kalle AG, Wiesbaden (Federal Republic of Germany), is sold under the name Repro-Foil.[9]

The graphic relationships between the densities and the tonal values of the original and the reproduction are generally represented by curves, which are called the "transfer function of density" or the "transfer function of tonal value". These functions give a statement of the changes of density or shifts of tonal value that are to be expected during the reproduction process. The functions are determined by means of the projection of standardized half-tone or screen-tint wedges on the material to be examined. Figure 86 (*a*) shows the relationship between the values of density, figure 86 (*b*) the relationship between the half-tone values.

The straight course of the transfer function of tonal value in figure 86 (*b*) shows that during the production of blueprints on this material the surface portions of the screen tints do not vary compared with the original. The M-foil stands out with respect to this advantage as compared with all other materials which are used for the assemblage of screened-up surfaces by means of the copying technique. As this advantage can be expressed by the simple relation:

$\phi_o = \phi_g$

$\phi_o$ = opaque degree of surface covering of the total in the screen diapositive;

$\phi_g$ = opaque degree of surface covering of the total surface in the blueprint;

the otherwise very complicated mathematical relation, with the help of which the density values can be deduced from the differences in the degrees of surface covering,[10] gets the following simplified form:

$$D_L = \log \frac{10^{D_{max}}}{10^{-D}(10^{D_{max}-D_{min}}-1)+1}$$

where

$D_L$ = density of the blueprint;

$D$ = density of the screen diapositive.

With this equation a relation has been set up which allows one to deduce a statement about the variation of density during reproduction from the current optimal transfer of tonal value. This conversion to other unities is necessary to allow a comparison with other processes of the reproduction technique, the variation behaviour of which is always described in this way. The numerically determined transfer function of density is represented graphically in figure 86 (*c*). It proves that with the help of diazo layers on a transparent carrier—certainly for the M-foil, but presumably also for other transparent diazo matérials—the screen tints of the original can be reproduced with true tints.

The other characteristic properties, determined during the investigation of the transfer functions of tonal value and of density of the M-foil are briefly grouped as follows:

(*a*) Carrier material: polyester foil, 0.1 mm thick;
(*b*) Reproducible density range: 0.85;
(*c*) Maximum of density: 0.90;
(*d*) Minimum of density: 0.04.

As previously stated, the advantages of the utilization of transparent blueprinting material are the relative insensitivity to light of the material and the easily standardized development. The reproducible density range is sufficient and suitable without tonal value shift for the following photo-mechanical preparation of the printing-plate in spite of the low maximal density, which is caused by the brown colouring of the layer. However, the brown colouring sometimes leads to difficulties during the optical assessment of the screen tints.

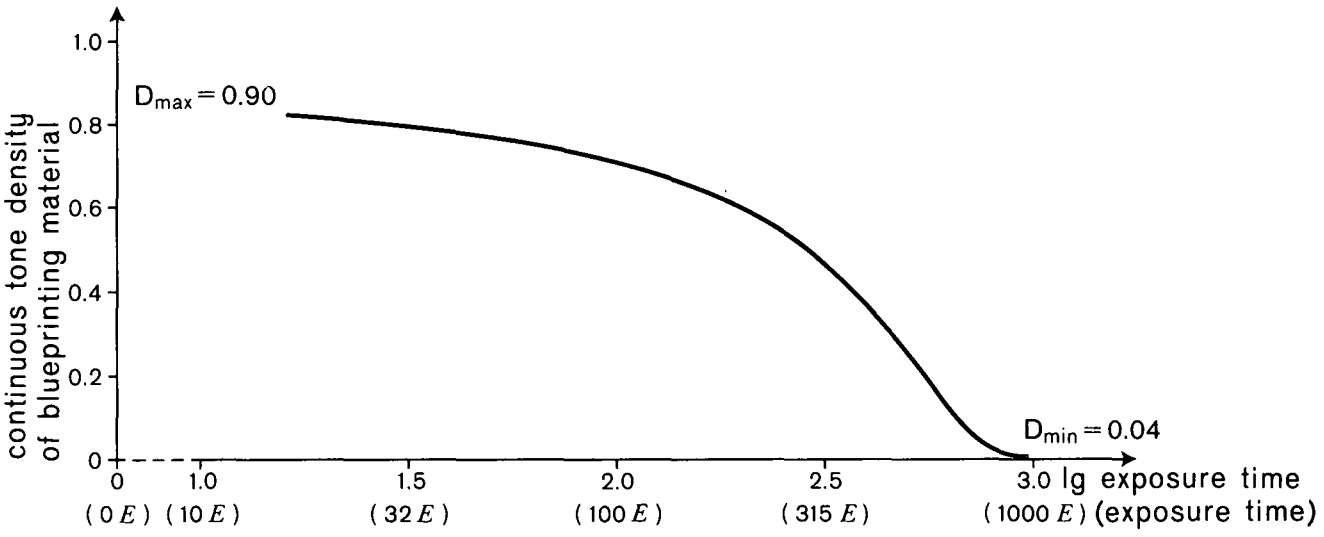
The maximal density attainable not only is low but varies locally; this is a disadvantage of diazo layers. As a consequence, the integral tonal values vary on the printing original though with this method the degree of surface covering is optimal. However, as the density of the opaque surface portions of the tested product is fully sufficient for a following photo-mechanical preparation of the printing-plate with identical areas, this imperfection has no influence on the transfer of tonal value to printing. Only the possibility of visually or densitometrically proofing the printing original is no longer available. As a disadvantage of the method which is caused by the material the limited possibility of check-proofing must be mentioned.

## Conclusion

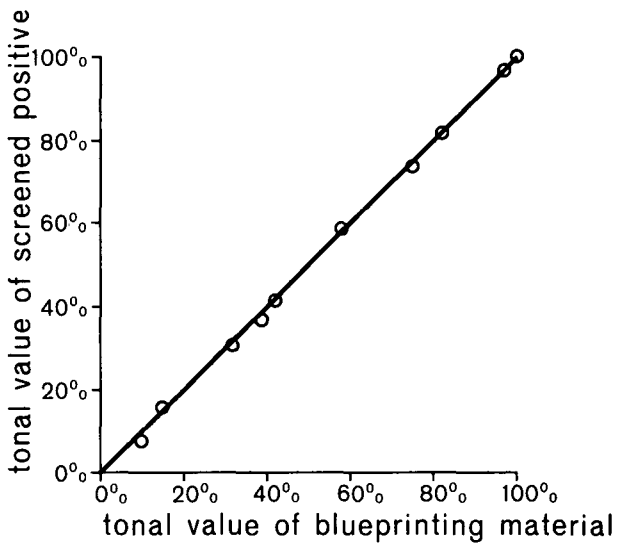
The commercial availability of diazo-coated polyester foils has recently led to the utilization of blueprinting by some cartographic establishments to make assemblage copies. A great practical advantage of the use of transparent blueprinting material is the relative insensitivity to light, which allows processing in subdued daylight. The essential practical advantage of preparing the assemblage copy on a blueprinting foil is that the influences of processing can be standardized relatively easily. It could be proved that the variation of development time has no influence on the screen tint. Thus, it is possible also to obtain safely through this method a degree of surface covering corresponding to the tonal values over a great area, which with the conventional foil copy raises great

[9] Kalle AG, *Der Ozalid-Ratgeber*, Firmenveröffenlichung der Kalle AG (Wiesbaden).

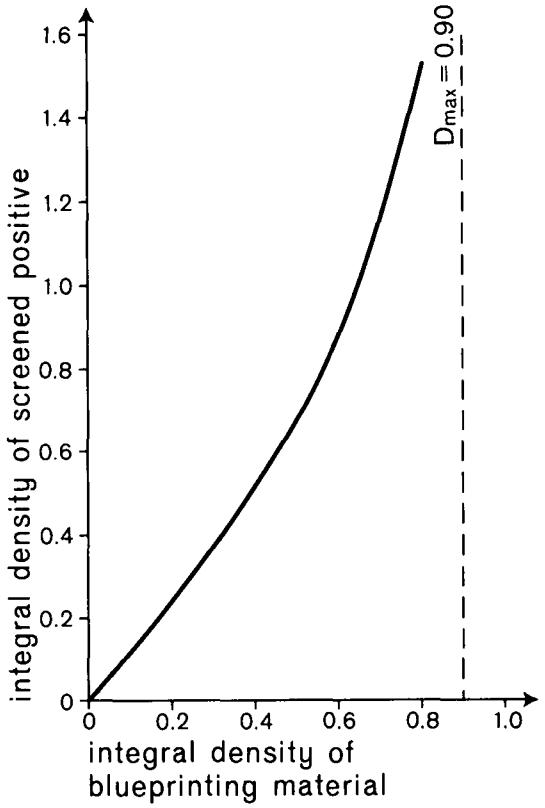
[10] See D. Morgenstern, "Standardisierungsmöglichkeiten der Rasterreproduktion für den Offsetdruck", dissertation prepared at Institut für Kartographie und Topographie der Universität Bonn, 1971.




(a) *Transfer function of density of the investigated blueprinting material*




(b) *Functional relationship between the tonal values of the copying screens and those of the investigated blueprinting material*




(c) *Functional relationship between the integral density values of the copying screens and those of the investigated blueprinting material*

*Figure 86. Federal Republic of Germany: relationship between densities and tonal values of original and reproduction*

difficulties and which cannot be reached every time.[11]

From the point of view of economic efficiency, the assemblage copy on a blueprinting foil is similar in assessment to the photographic assemblage copy.[12] The relationship of expenses in materials for dimensionally stable photographic film and for dimensionally stable blueprinting foil are 2 : 1. This advantage of the blueprinting process is compensated by much longer exposure times. The expenses of time for the subsequent processing, which have a lower economic significance with this kind of assemblage copy, are more limited with a blueprint than with a film. The great advantage from the economic point of view of the photographic copy, and thus of the blueprinting process as compared with the foil copy, is well known.[13]

[11] *Ibid.*

[12] J. Schoppmeyer, *Untersuchungen zur grossformatigen Druckvorlagenherstellung*, Unveröffentlichter Bericht (Boon, Institut für Kartographie und Topographie der Universität Bonn, 1975).

[13] D. Morgenstern, "Die photographische Zusammenkopie als Alternative zur Folienkopie".

## NECESSITY FOR INTERNATIONAL CO-OPERATION IN COMMUNICATION, EDUCATION AND DOCUMENTATION IN CARTOGRAPHY TODAY*

*Paper presented by the Federal Republic of Germany*

### SOME ASPECTS OF INTERNATIONAL CO-OPERATION

The results of recent discussions, meetings and publications on cartography indicate that over the past 10 years goals and contents have changed throughout the world for many topics. On the one hand, cartography has become an independent science—and the dialogue between the makers and the users of maps is gradually increasing. On the other hand, new production and reproduction techniques have been developed to mechanize, standardize and automate the tasks involved in making maps and charts. The language of maps is becoming increasingly comprehensible to map-readers through the use of symbols and colours in both legend and style.

In considering the results of the Sixth and Seventh United Nations Regional Cartographic Conferences for Asia and the Far East and of the First United Nations Regional Cartographic Conference for the Americas,[1] in particular the reports of the committees and, above all, the resolutions adopted, one finds that in the situation today, the working results of specific International Cartographic Association (ICA) commissions can greatly support current and future developments.

Undoubtedly, comprehensive aids for the production and reproduction of maps and charts of all types, concerning many topics, constitute the basic graphic form of providing synoptic presentations to assist in planning the future of mankind. In the Federal Republic of Germany, there are some publications which stress the discussions on ways to foster co-operation by certain contributions both in theory and in practice.

### FACTS OF COMMUNICATION

At the Fifth International Conference of the International Cartographic Association, a paper[2] was presented which became a so-called "milestone" from the initiative point of view. This report did open the way for new considerations,[3] as did a fundamental paper presented at the same conference, which states: "The communication doctrine in general and not only in the restricted sense of cartography may be defined as: *how* do I say *what* to *whom*?"[4]

Cartographers have long drawn attention to the need to portray parts of the earth's surface and various topical relations thereof in such a way as to obtain practical figures which are well constructed and cartographically clear. Now cartographers have begun to see the role of the map intensified as a communication goal between the makers and users of maps and charts. On the horizon one sees the need for a basic alphabet in graphics to permit legible cartographic representations. The unity of

* The original text of this paper, prepared by Karl-Heinz Meine, Head of Cartography and Reproduction, Federal Institute of Geosciences and Natural Resources, Hanover, Federal Republic of Germany, appeared as E/CONF.68/L.107.

[1] For details, see *Sixth United Nations Regional Cartographic Conference for Asia and the Far East, 24 October–10 November 1970, Tehran, Iran*; vol. I, *Report of the Conference* (United Nations publication, Sales No. E.71.I.15); *Seventh United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo, 15–27 October 1973*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.74.I.7); and *First United Nations Regional Cartographic Conference for the Americas, Panama City, Panama, 8–19 March 1976*, vol. I, *Report of the Conference* (United Nations publication, Sales No. E.77.I.13).

[2] A. Koláčný, "The importance of cartographic information for the comprehending of messages spread by mass communication media", paper presented to the Fifth International Conference of the International Cartographic Association, Stresa, Italy, 1970.

[3] A. Koláčný, "Cartographic information—report of the working group", in International Cartographic Association, *International Yearbook of Cartography*, vol. XI (Bonn-Bad Godesberg, Gregor M. Kirschbaum Verlag, 1971), pp. 65–68.

[4] C. Koeman, "The principle of communication in cartography", in International Cartographic Association, *International Yearbook of Cartography*, vol. XI (Bonn-Bad Godesberg, Gregor M. Kirschbaum Verlag, 1971), pp. 169–176.

education, communication and techniques of modern cartography will lead to better possibilities in both map design and map production.

Returning the statement quoted above, one has to observe, however, two different steps for the same task of map-making—the scientific processes and the technical processes—and the thesis is to formulate "how" one must say "what" by which means or expressions to whom or to which types of map-users in order to obtain which results (see figure 87).

In principle, there is only one main question regarding communication by cartographic presentation:

HOW one must say WHAT by which MEANS or EXPRESSION to WHOM or to WHAT TYPE of MAP-USERS to obtain WHICH RESULTS

To do so, the theory and practice of modern cartography must be generally seen as an independent discipline which follows two different processes to produce maps:

| The Scientific Processes | The Technical Processes |
|---|---|
| 1. Resource material and compilation | 1. Drawing and engraving |
| 2. Generalization | 2. Colouring and shading |
| 3. Designing | 3. Lettering and retouching |
| 4. Drafting | 4. Sheet assembly |
| 5. Editing | 5. Reproduction and printing |
| 6. Evaluation of contents | 6. Evaluation of clarity |
| 7. Interpretation | 7. Technical criticism |
| 8. Comparison of task and solution; map revision | 8. Comparison of task and solution; map revision |
| 9. Search for scientific aspects and economy within procedures used | 9. Search for technical effects and economy within procedures used |
| 10. RESULT: Cartographic presentation using scientific methods, elements and graphic rules of perception | 10. RESULT: Cartographic presentation using adequate techniques, automated steps, computers, reproduction and printing |

CONCLUSION: CARTOGRAPHY, AS THE SCIENCE AND TECHNIQUE for discussion, development and teaching of methods for cartographic presentations, APPROACHES COMMUNICATION PROBLEMS concerning spatial information on objects, relations, developments, movements, processes, systems etc. through maps and charts USING LEGIBLE VISUALIZATION FIGURES.

*Figure 87. Federal Republic of Germany: science and technique of cartography*

Within the geosciences, cartography, especially thematic cartography, has become increasingly important. In the general system of the sciences, the scientifically conceived map graphic is considered to be an equal and independent discipline. Building upon the principles and teaching content of topographic and thematic cartography, thematic cartography has become the only form of expression which comprehends the synopsis of procedures, facts and relationships, and shows it graphically classified. The methods of representation, the compilation of material and the development of meaningful map symbols call for international efforts.

Available data or data collected by observation, investigation or measurement are cartographically expressed by means of black-and-white or coloured graduated representations and spatial relations, which should be appropriate to the scale of the map. The didactic conception of the entire map-making process should be addressed to map-users of diverse receptivity. Cartography in the mid-1970s is a part of visual communication and therefore the discussion of cartographic communication must be a major aspect of the theory of cartography. The future development of a cartographic alphabet is also a resulting challenge for cartography as a whole.

To understand the functional connexions needed within the building of cartographic chains of communication, which one must observe (figure 88), one must also perceive the process of formation and transformation within the circulation of cartographic "chains of communication", showing the steps between a given "pattern structure" and the subsequent "pattern recognition" (figure 89). Upon these bases, one may determine the specific requirements for a graphic basic alphabet to be used for cartographic representations (figure 90).

## Demands of education

To see the turbulent cartography[5] of today under such aspects of revolution with respect to points of view in science and technique and, above all, as concerns the main tasks of the discipline, one must study the literature,[6] develop the terminology[7] and also seek new horizons in education and teaching.

Education and training in cartography and of all types of cartographers constitute one of the most important endeavours of an independent discipline. The helpful discussions of Commission I[8] (Education) of ICA since 1964 cannot conceal the fact that the major work of the Commission still must be done. The significance and position of cartography in the various fields of technology and science have changed. The points of view expressed by the States which are most experienced in cartography disclose only their equivalent scientific opinions; the serious differences which exist are not revealed.

[5] F. J. Ormeling, "Turbulent cartography", *ITC Journal*, No. 1 (1973), pp. 13–21.

[6] Christopher Board, *Bibliography of Works on Cartographic Communication. Provisional Edition by Commission IV(V) of the International Cartographic Association* (London, 1976). This work contains 870 references, appendixes and keywords.

[7] E. Meynen, *Multilingual Dictionary of Technical Terms in Cartography: Results of Commission II of the International Cartographic Association* (Wiesbaden, Steiner Verlag, 1973).

[8] Since 1972, Commission I has been headed by Professor C. Koeman, University of Utrecht, Netherlands.

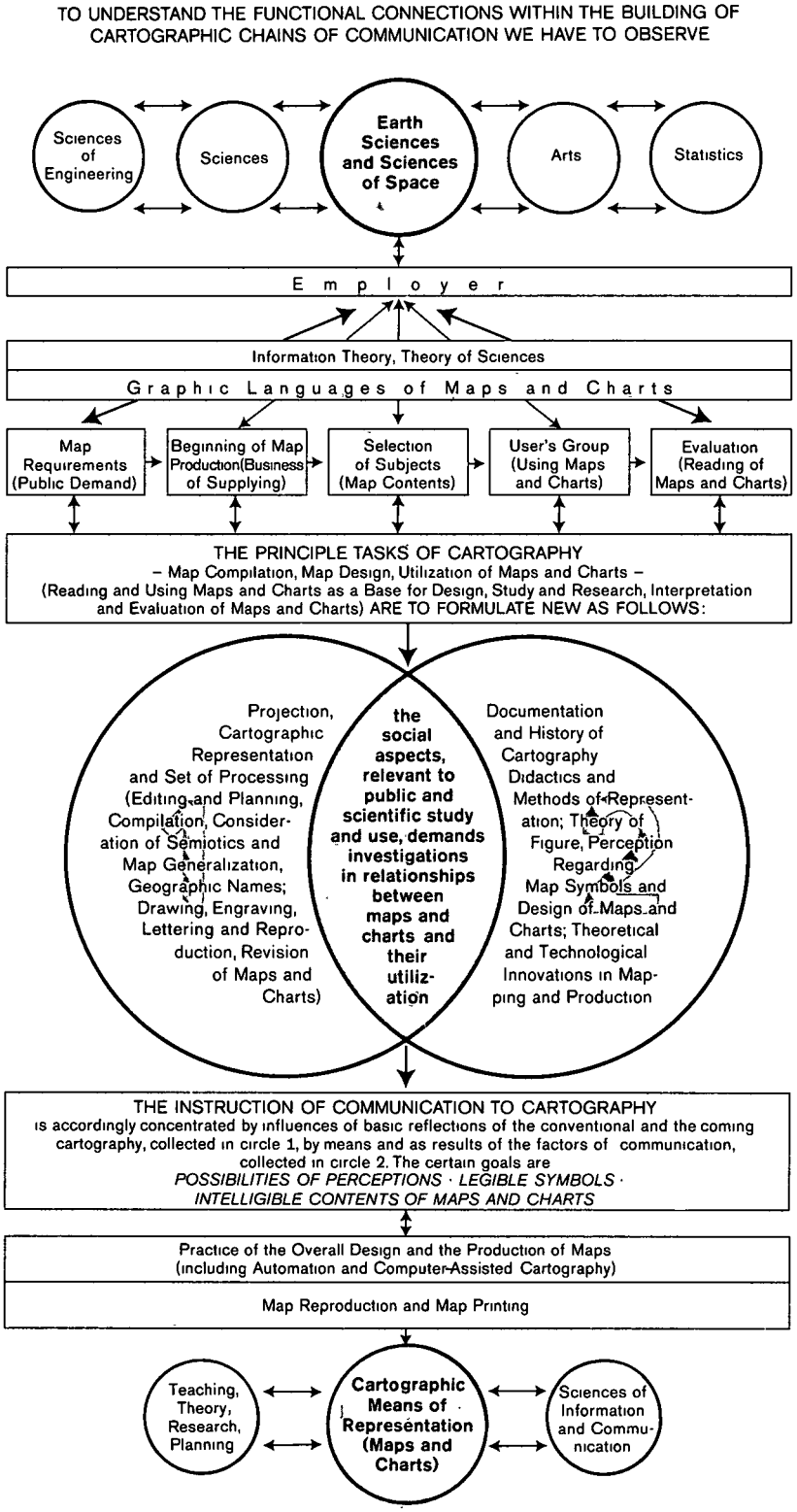



*Figure 88. Federal Republic of Germany: chains of communication*

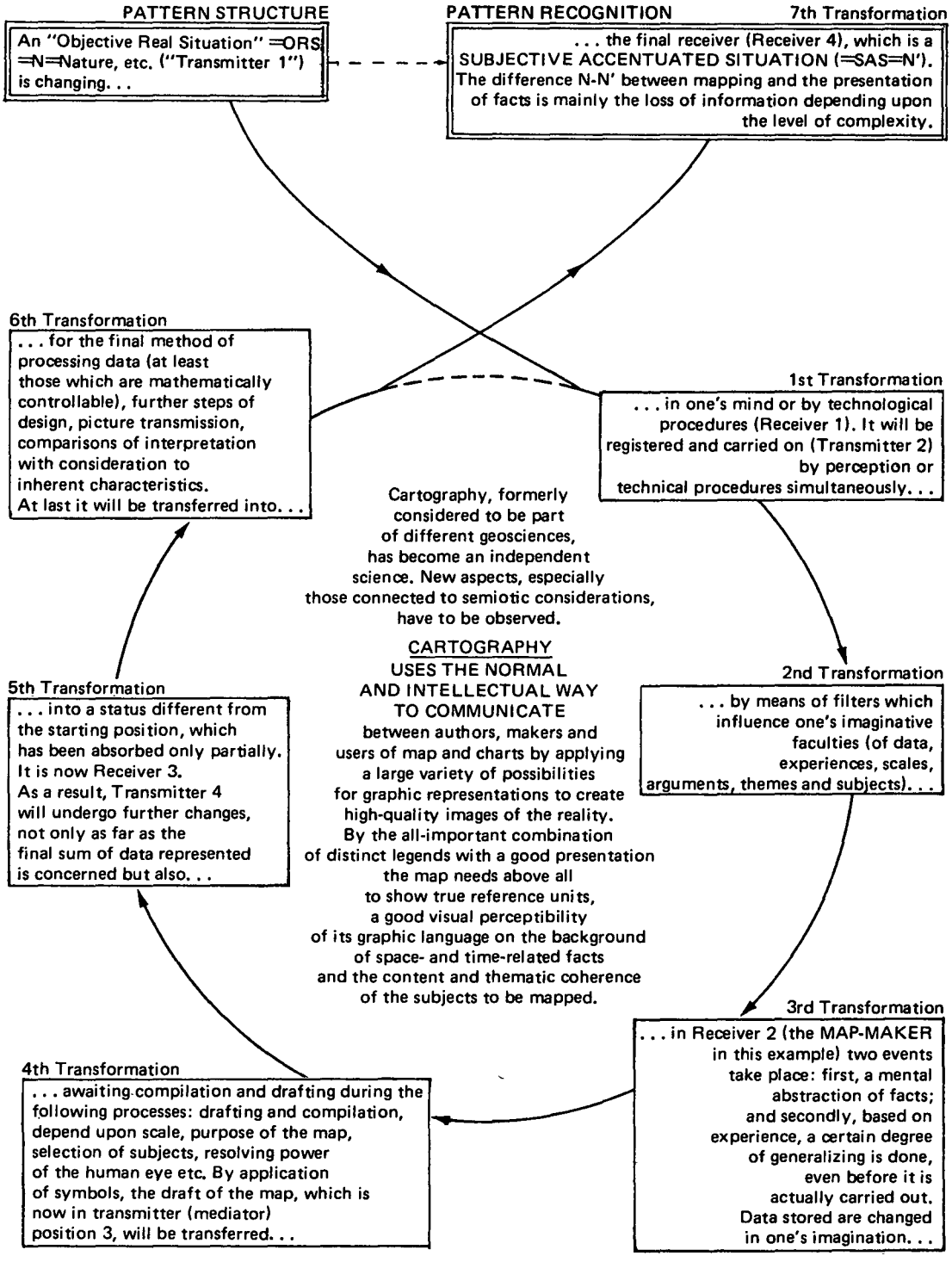
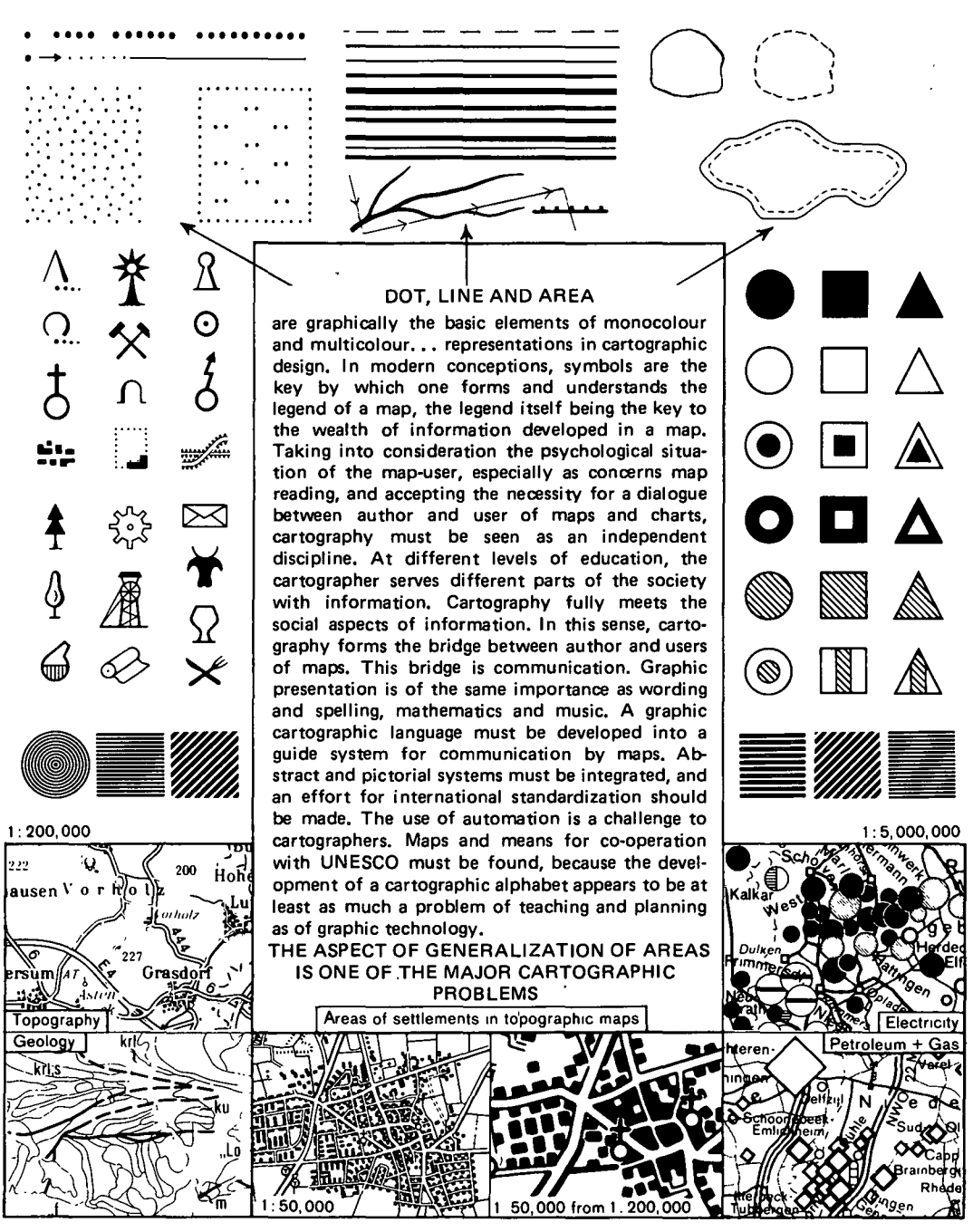



*Figure 89. Federal Republic of Germany: transmissions and interpretations*




Three basic-colours for multicoloured representations

| | blue | red | yellow |
|---|---|---|---|
| | Water | Fire (beacon) | Earth (field) |
| | cold | hot | indifferent |
| | diminution | increase | stagnation |
| | defensive | aggressive | neutral |
| | calm | danger | attention |
| *Orientation* | Waters, Ice, Snow | Political Symbol (Boundaries) | Contour interval |
| *Traffic* | shipping routes | railways | roads |
| *Mining* | salt | iron | precious metal |
| *Industry* | textile, clothing | engineering, machines | chemistry |
| *Functions* | housing | working | recovery |

*Figure 90. Federal Republic of Germany: requirements for a graphic basic alphabet*

In this author's opinion, and for various reasons stated below, only a compromise was reached by Commission I in its agreement on the occupational groups: "W4" (draftsman); "W3" (cartographer with certificate); "W2" (cartographic engineer); and "W1" (scientific cartographer). It is a compromise, first, because the needed discussions of the "W1" category were not held. Secondly, too little consideration was given to the fact that in a comprehensive system of education, the steps from "below" to "above" must remain open, in order that young people may have promotional opportunities. Thirdly, because cartography had formerly been considered dependent upon geodesy and geography, the aspects of graphic arts and techniques, as expressed by Bertin[9] and Imhof,[10] were neglected in the discussions. Fourthly, there must be increasing perception of cartography and its results—the maps—as a means of communication in the future.

There is an urgent need, however, to come to some uniformities of knowledge and efficiency for young cartographers throughout the world.

Fortunately, Professor Koeman took the initiative in preparing a "Multilingual basic manual on cartography", which will become an international textbook. In meetings held at Ottawa, Canada (1972); Madrid, Spain (1974); Swansea, England (1975); and Moscow, Union of Soviet Socialist Republics (1976), the contents were discussed (see table 47).

One of the results of the meeting at Swansea was furthermore the invitation by Professor Koeman to Karl-Heinz Meine eventually to begin a book on 100 exercises in cartography; and Mr. Meine was asked whether a joint working group, composed of members from Austria, the Federal Republic of Germany and Switzerland, could prepare in friendly co-operation such a guide to train young people in drawing, scribing and compiling figures,

**Table 47. Federal Republic of Germany: contents of "Multilingual basic manual on cartography"**

| *Chapter* | *Author* | *Country* |
|---|---|---|
| 1. The task of cartography | Meine | Federal Republic of Germany |
| 2. The history of cartography | Koeman | Netherlands |
| 3. Mathematical cartography | Maling | United Kingdom |
| 4. Theory of graphic representation | Rouleau | France |
| 5. Thematic cartography | Ogrissek/Dahlberg | German Democratic Republic/United States of America |
| 6. Topographic cartography | Djulgerov | Bulgaria |
| 7. Design and drafting | Spiess | Switzerland |
| 8. Cartographic techniques | Kanazawa | Japan |
| 9. Map reproduction | Palm | Sweden |
| 10. Automation in cartography | Kadmon | Israel |

graphics and maps, based on the first book on education and training in cartography[11] which has been written to date.

Four German-speaking countries—Austria, the Federal Republic of Germany, the German Democratic Republic and Switzerland—have firmly established educational systems for two working levels, "W3" and "W2", with an examination degree. For "W4", however, there are only educational training courses available for the purpose of individual firms; and as concerns "W1", one must hope that such training will be available in the future.

The manifold interrelationships of formational problems—technical and scientific, manual and mechanical practices, mechanized and automated acceleration—assure for cartographic education:

(*a*) A clearly defined conception of the tasks of the profession (those tasks are not unconditionally to be internationalized);

(*b*) A clear definition of the proficiencies and requirements of knowledge according to the examination and application degree (and these should be improved from "W4", "W3" and "W2" to "W1", whereby the national requirements of such "degrees" (W1, W2, W3, W4) should also be differentiated in the future);

(*c*) A clear perception that graphic arts and technical procedures, clearness and geometry, and symbols and numbers are common determinants in cartography and its expression; and that designing, engineering and theoretical scientific thinking must be placed commonly into account, especially in connexion with the ICA Working Group on Communication in Cartography (since the meeting in Moscow in 1976, it has become ICA Commission IV).

Cartographic techniques have, from a certain point of view, reached a stage of stagnation, compared with the

[9] Jacques Bertin, *Sémiologie graphique* (Paris and the Hague, Mouton, 1967). This is a grammar of graphics with excellent illustrations.

[10] Eduard Imhof, *Thematische Kartographie* (Berlin and New York, de Gruyter, 1972). Excellent illustrations.

[11] *Ausbildungswege in der Kartographie*, 2 vol. (Bonn-Bad Godesberg, Gregor M. Kirschbaum Verlag, 1975).

time when ICA was established. Further progress can be anticipated in the near future in the fields of map techniques, reproduction techniques and printing; but those changes will influence the existing curriculae in cartographic education only slightly. Automation will develop sufficiently in the next few years, perhaps, to influence some areas of cartographic practice, but it is not expected decisively to influence cartographic education. The need in cartography for persons specialized in automation will continue to be restricted; however, special attention should be given to the training of those leaders as executives and planning experts.

One would expect the influence of developments in modern processes and cartographic techniques on educational and training systems to be extensive. However, little useful influence is evident. This situation is the result of two age-old deterrents—people are unaware of the existing possibilities and the available funds are limited.

In the Federal Republic of Germany, the German Society for Cartography founded a special Working Group on Education in Cartography in 1972, to promote cartographic training systems and studies concerned to the ICA levels of "W3", "W2" and "W1"; the author has the honour to act as chairman of this group.

One of the reasons, of course, that high-quality education is needed is that it will be necessary in future to make many more maps than have ever been made in the past. Those maps also must be produced economically, both in reproduction techniques and in printing.

At Hanover, tests have been made of typical, but different map cut-outs on both large (1 : 25,000) and small (1 : 1,500,000) scales, to see what would happen in extreme circumstances. A limited number of copies have been presented to this Conference.

The technical process based on colour schemes and negative procedures, which is very economical, is as follows:

1. Drawing-key (guide-copy);
2. Scribing of geological boundaries on Astralone;
3. Strip-masking process;
4. Identification of colour plates by determination of the percentage of screen density for the colours yellow, magenta and cyan;
5. Use of screen angle and pre-punched register systems;
6. Simultaneous exposure of the different percentage values of screen density;
7. Use of both film contact screen and film contact copy of the composed original;
8. Sheet assembly of the individual colour plates;
9. Simultaneous exposure of black elements;
10. Proofing of the four coloured plates (black, yellow, magenta and cyan);
11. Copying of printing-plates;
12. Printing on four-colour printing-machines.

The entire technical procedure is possible only in the event that standard printing catalogues are given. However, a reduction of 30–50 per cent of the total cost of reproduction and printing can be achieved.

## Results of documentation

The Sixth United Nations Regional Cartographic Conference for Asia and the Far East and the First United Nations Regional Cartographic Conference for the Americas touched on the necessity of having bibliographies through the adoption of specific resolutions.[12] Some information on the mass of literature currently available is given below.

The United Nations has made cartographic literature available since 1947. In 1951, the *World Cartography* series was launched; this journal has included some material about the field of thematic mapping. The regional cartographic conferences began in 1955 with the First United Nations Regional Cartographic Conference for Asia and the Far East. In 1957, training courses and seminars were initiated. Since 1962, including special conferences, such as those for the International Map of the World on the Millionth Scale and those for geographical names, there have been 28 meetings.

To use the results of the technique and of the science of cartography obtained by different States and international co-operation, one needs, above all, comprehensive documentation showing the various fields in both topographic and thematic mapping as an essential aid to the development of areas and regions. The author is preparing a comprehensive bibliography under the title "United Nations cartography, 1947–1977".

From the scientific and technical points of view, only through the simultaneous study of the literature on the techniques of map-making can a "fertilizing" effect be exerted on the development of any type and style. The compilation and classification of the literature, the study of the source material and the presentation of the material for future research will result in a comprehensive bibliography, which is essential to any scientific work. In some countries, there were precursors of such working groups; their work was either done on a national basis or it served a special topical purpose. Furthermore, the *Bibliographie cartographique internationale*, published in Paris and inaugurated by M. Foncin at the International Geographical Congress at Amsterdam in 1938, deserves great praise and has been a valuable reference for non-textual publications. It led to the consideration that a permanent register of literature on maps and on the science and technique of cartography was required.

Among the references on the literature of cartography as an aid in map design and map production, the attention of experts should also be drawn to the *International Yearbook of Cartography*[13] series, which has been prepared annually since 1961 by the International Cartographic Association. Discussions of problems concerning the techniques and the science of cartography, supported by many figures and multi-coloured map cut-outs, are included in the *Yearbook*,

[12] *Sixth United Nations Regional Cartographic Conference for Asia and the Far East*, vol. I, *Report of the Conference*, resolution 2, p. 14; *First United Nations Regional Cartographic Conference for the Americas*, vol. I, *Report of the Conference*, resolution 12, pp. 27–28.

[13] Edited by Gregor M. Kirschbaum and Karl-Heinz Meine; published at Bonn-Bad Godesberg by Kirschbaum Verlag.

which is a major publication for the study of international cartographic situations throughout the world. The *Yearbook* is a trilingual publication (English, French and German).

Lastly, in 1956, the German Society for Cartography established a working group to compile a bibliography of cartographic literature. From 1956 to 1972, the head of this working group was the author of the present report. The current head is Lothar Zögner; and 44 experts from 37 countries and two organizations (including the United Nations) are involved in the recording of all relevant titles. The collection of all mapping literature other than cartographic research texts is the basis for all related sciences. These efforts either lead to the production of maps; or, by developing new sets of problems by means of maps, they serve to confirm the results achieved. Thus, the work of the group may also be important for fields related to cartography. The scientific problems of cartography have always been closely associated with the preparation and review of atlases, maps, books and articles.[14]

The task of gathering all written materials on cartography can be accomplished only by experts working in close co-operation with one another. More than 28,000 titles have been published since 1957, and it is hoped that the results achieved by the working group will be of interest to all specialists in the various branches of cartography. The results, the contents of the *Bibliographia Cartographica* and the procedure to be followed for registering titles and supplying bibliographic details are described in a paper presented to the Sixth Conference.[15]

## Outlook

As a summary of the thoughts presented above and regarding the published materials one can say that mapping procedures of all the different topics are the primary base to give synoptic impressions to those who must decide the way in which man's environment should or could develop during the near future.

The task was to give some background ideas about relatively new discussions on how to find better ways of using methods for cartographic representations of natural resources and of improving social and economic well-being, seen from the point of view of the necessary interrelationships between map-makers and map-users. The situation of cartography[16] did change during the recent past—not only in techniques but, above all, in the philosophy, understanding and application of maps, especially thematic maps, as models of man's surroundings, to see cartographic representations as a form of scientific models of the reality of earth and life and also of structure and planning systems.[17]

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# ACTIVITIES OF THE FEDERAL INSTITUTE OF GEOSCIENCES AND NATURAL RESOURCES IN THE REGION SERVED BY THE ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC*

*Paper presented by the Federal Republic of Germany*

Geoscientific research and its economic application play a decisive role both in the early recognition of pressing problems of the supply of natural resources and in overcoming those problems. This is true for energy resources and for metallic and non-metallic resources, as well as for water and soil. Consequently, such research is equally important for the industrialized and the developing countries.

By providing technical assistance and experts as consultants, the Government of the Federal Republic of Germany has supported the developing countries for many years in the search for economically useful mineral resources in the use of their ground-water reserves and in the improvement of their agriculture. The Federal Institute for Geosciences and Natural Resources (formerly the Federal Geological Survey) carries out the geoscientific projects for the Government of the Federal Republic of Germany.

The Institute has the following responsibilities:

(*a*) The advise the federal ministries in all questions relating to the geosciences and natural resources;

(*b*) As part of the effort to provide the Federal Republic of Germany with a secure supply of mineral and energy resources:

(i) To carry out systematic research;

(ii) To participate in prospecting and exploration projects outside the Federal Republic;

(iii) To advise business interests in the Federal Republic and foreign authorities in matters concerning the geosciences and natural resources;

(*c*) To carry out scientific and economic evaluation of research, particularly in the fields of geology, geophysics, engineering geology, hydrogeology, pedology mineralogy, petrography, geochemistry, aerogeology, astrogeology, palaeontology and economic and mining geology;

(*d*) To provide technical assistance in all fields of the geosciences;

(*e*) To conduct marine research relating to raw materials;

(*f*) To conduct developmental research on geoscientific methods and instruments;

(*g*) To conduct geoscientific research and to advise on questions of environmental protection;

(*h*) To participate in international seismological research (Central Seismic Laboratory, Gräfenberg).

## MAPS PUBLISHED

One of the results of the geoscientific research in many countries of Asia and the Far East (see figure 91) has been the drafting of geological and hydrogeological maps. The maps that have been published to date are listed below:

(a) *Afghanistan*: geological map of the southern part of Afghanistan on the scale 1 : 500,000, four sheets, 1973;

(b) *Indonesia*: (i) hydrogeological map of the Isle of Madura on the scale 1 : 250,000, one sheet, 1963; (ii) hydrogeological map of the Isle of Bali on the scale 1 : 250,000, 1963;

(c) *Iran*: geological map of the area between Kerman and Sagand on the scale 1 : 250,000, one sheet, 1962;

(d) *Thailand*: geological map of northern Thailand on the scale 1 : 250,000, seven sheets; one sheet published in 1976 and remainder in preparation.

## PROJECTS

The following projects have been undertaken for individual countries:

(a) *Afghanistan*:

(i) German geological mission (1959–1966) and German advisory group (1966–1967): geological investigation, prospection and mining geological evaluation in central and southern Afghanistan;

(ii) Hydrogeological and soil investigations: hydrogeological mapping and geoelectrical investigations for the planning of water-supply projects (1964–1970);

* The original text of this paper, prepared by Wolfgang Heimbach and Andreas Hess, Federal Institute of Geosciences and Natural Resources, Hanover, appeared as document E/CONF.68/L.108.

(iii) Resources investigation for regional development planning in Paktia Province (1971/72);

(b) *Bangladesh*:

(i) German petroleum advisory group in the fields of petroleum and natural-gas exploration and natural-gas utilization for State-owned PETROBANGLA;

(ii) Geoelectrical and hydrogeological investigations for irrigation projects (1960 and 1967–1968);

(c) *Burma*:

(i) German geological mission: exploration work for lead, zinc, silver deposits (Bawdwin mine) and tin deposits (1972–1975);

(ii) German petroleum advisory team for State-owned Myanma Oil Corporation (MOC) in the fields of exploration, including seismic and aeromagnetic surveys, and of production, including measures for secondary recovery (since 1970);

(d) *India:*

(i) Petroleum advisory services: exploration including seismic survey (1958–1959);

(ii) Scientific co-operation with National Geophysical Research Institute in Hyderabad in the fields of hydrogeology and applied geophysics (since 1974);

(iii) Scientific co-operation with Airborne Mineral Search and Exploration Wing of Geological Survey of India in Bangalore in the fields of geochemistry and mineralogy (since 1974);

(e) *Indonesia*:

(i) Prospection and exploration for uranium in central Sumatera (since 1976);

(ii) Hydrogeological and geoelectrical investigations for village water-supply projects in Jawa, Bali, Sumba and Madura (1961 and 1964);

(iii) Advisory services to Geological Survey of Indonesia in the field of map compilation (planned for 1977);

(iv) Mineral investigations and evaluation of tin placer deposits and ore-dressing tests on Bangka Island (1957 and 1960);

(f) *Iran*:

(i) Geological investigation and mineral survey in Kerman Province (1958–1960);

(ii) Co-operation with Geological Survey of Iran in geophysics, geochemistry, palaeontology and evaluation of non-metallics (since 1975);

(g) *Malaysia*: hydrogeological mission, advisory services to the Geological Survey of Malaysia in establishing a hydrogeological section and ground-water exploration in various parts of the country for public water-supply (since 1974);

(h) *Malaysia/Indonesia/Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP)/Economic and Social Commission for Asia and the Pacific (ESCAP)*: investigations of on-shore and off-shore areas of the Strait of Malacca for occurrences of heavy mineral deposits (1976);

(i) *Nepal*: engineering geology for feasibility study of the Kankai Dam project (since 1975);

(j) *Pakistan*:

(i) Geochemical prospection for uranium in the Siwalik area, in co-operation with the United Nations Development Programme (1976);

(ii) German geological advisory group: evaluation of chromite/magnesite deposits and mines of the Muslimbagh area (1976);

(k) *Philippines*: German petroleum advisory team sent to aid the Philippine Energy Development Board in the field of petroleum exploration;

(l) *Republic of Korea*: off-shore survey for heavy minerals and coal (1970 and 1972);

(m) *Singapore*: geoelectrical and hydrogeological investigations for the public water-supply (1970);

(n) *Thailand*:

(i) German geological mission: systematic reconnaissance mapping and mineral exploration in northern Thailand (1965–1971);

(ii) Engineering geology for Electricity Generating Authority of Thailand and feasibility studies for multipurpose dam-site projects (since 1973);

In addition to the projects undertaken directly for individual countries, the following advisory services have been provided to the Regional Mineral Resources Development Centre (RMRDC) of ESCAP since 1970:

(a) *Projects in the field of hydrogeology*:

(i) *Afghanistan*: ground-water development projects;

(ii) *India*: ground-water study in open-cast coal-mining; hydrogeology in ground-water development projects;

(iii) *Indonesia*: hydrogeological mapping programme in West Jawa;

(iv) *Iran*: ground-water balance in basin area south of the Elbruz Mountains;

(v) *Malaysia*: review of ground-water schemes and preparation of hydrogeological map;

(vi) *Nepal*: ground-water investigation in the Tarai region;

(vii) *Papua New Guinea*: review of schemes for water-supply for underground-water sources in coastal towns;

(viii) *Philippines*: ground-water development projects and preparation of hydrogeological map;

(ix) *Sri Lanka*: preparation of hydrogeological map;

(x) *Viet Nam*: drafting of hydrogeological map of former Republic of South Viet-Nam (1974);

(xi) *Western Samoa: Tonga, Gilbert Island and Fiji*: study of the problems of ground-water supply and ground-water investigations;

(b) *Projects in the field of mining geology*: systematic inventory of mineral resources in India, Sri Lanka, Thailand and Fiji.

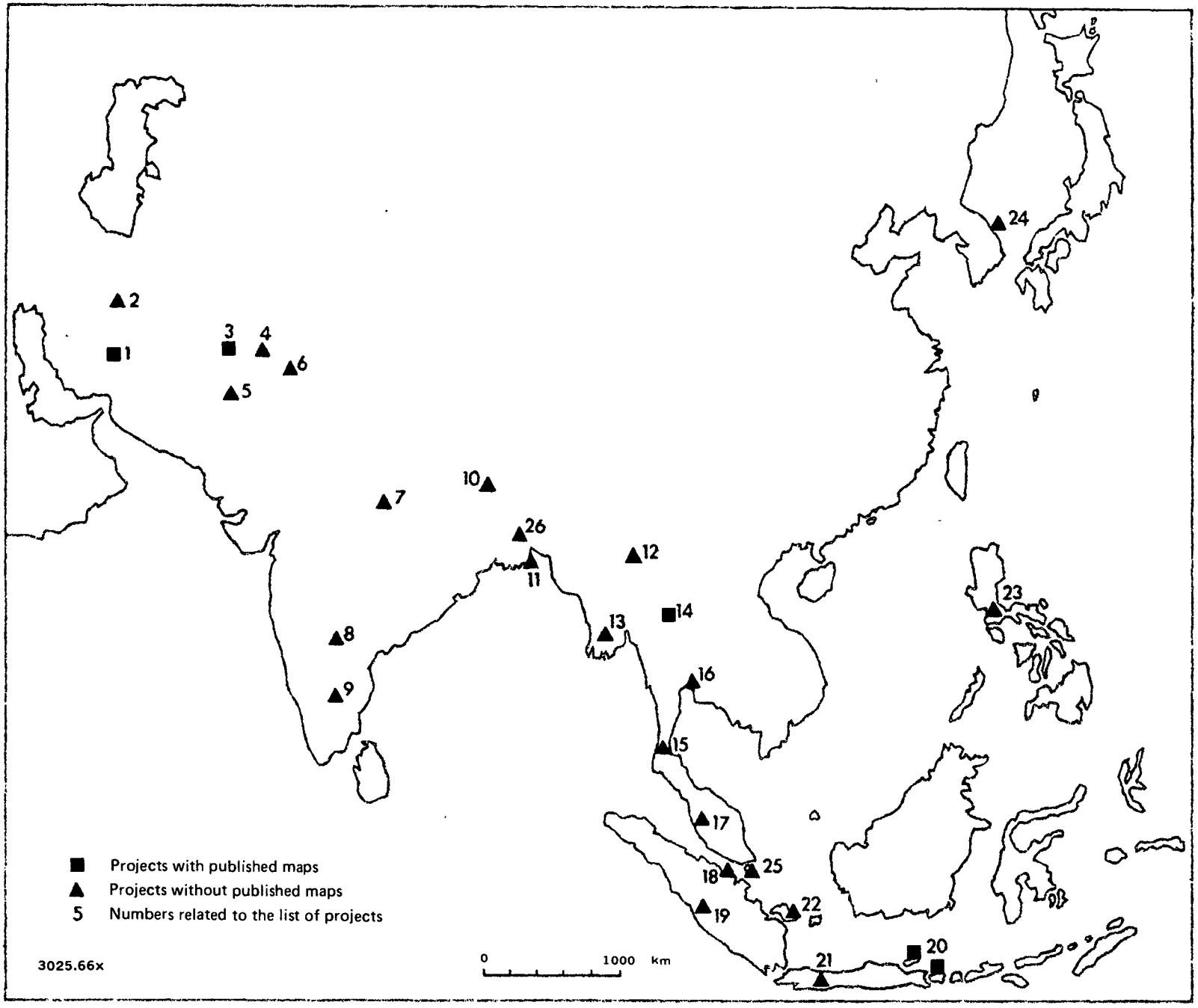



*Figure 91. Federal Republic of Germany: activities of the Federal Institute of Geosciences and Natural Resources in the region served by the Economic and Social Commission for Asia and the Pacific, at 1 : 36,000,000 scale*

# NEW PERSPECTIVES AND TASKS OF CARTOGRAPHY*

*Paper presented by Hungary*

One can know retrospectively the products of cartography, the maps, which have already existed from 4,000 to 5,000 years in the history of mankind; but cartography itself, as an independent science, has only a past covering some decades. For many centuries, cartography was regarded as a work aid of geography.

The exploitation of mineral resources, one of the main factors of the acquisition of economic and political power, plays an extraordinary role in the development of society; and this exploitation rapidly extricated geology from geography, developed it to an independent science and raised it to a higher level. Thus, the geological map, with its topics put on the topographic map, became the first thematic map although this notion and this denomination were not realized for a long time.

After the Second World War, thematic cartography became an independent science which, though it relied at its beginning upon geodesy and geography, has developed in accordance with its specific laws and is in a many-sided interrelation with different technical, economic, natural and social sciences. After all, the progress of cartography is determined by production, that is, by the preparation of the map and by social practice—by the development of the demand for maps.

In a later section of this paper, an attempt is made to describe the general tendencies of development of modern cartography; and on the basis of their analysis, to give a prognosis, from several points of view, of the subsequent advance of this science and also of its influence on progress.

## Differentiation and specialization

One of the permanent and important tendencies of the development of cartography, as of all of the sciences, is the increasing differentiation and specialization. This tendency has became especially strong today, and there are already a dozen main investigation and research trends in the surveying, processing and publication of map data. Through these researches, the quantity of accumulated knowledge is increasing more considerably than the individual specialists can attain. The researcher, the instructor, the economist and the engineer can no longer tackle the growing knowledge and the mass of scientific and practical information with which computers can overwhelm the human brain. In each branch of science, the scope of knowledge is so wide that a human, no matter how gifted, can scarcely comprehend it. And there begins modern cartography, the new epoch of thematic cartography, bursting in with fantastic speed. Thematic cartography can keep up with developments, with its methods, revealing the complicated relations and meeting the demands of complexity and synthesis representation. As Lessing, the great German author, stated, the description and representation of something with words (text) are impossible as the words follow each other; the objects in the space, however, stand beside one another.

Thematic cartography, with its modes of expression, can both represent and evaluate the data not only of geography but of all the sciences having spatial dimensions with quantitative and qualitative differences and categories.

From the point of view of the organization of researches, the differentiation of cartography is connected with the division of labour among specialists. Just as in production, also in the sciences, the division of labour makes it possible to increase the productivity of scientific work in order to achieve a larger quantity of results within the same time invested.

## Interrelationship among disciplines

The other permanent and important tendency of the development of cartography is the creation and development of new branches and new fields on the basis of the interrelationships among the disciplines. Besides the natural sciences, cartography is interrelated with the sciences dealing with society and thinking. For example, the interrelationship among economics, mathematics and cybernetics is fruitful in the mapping of economic planning. The good thematic map is the main basis of planning and of the economic development of the individual countries, and, moreover, of the entire world.

## Influence of mathematics

A further important and permanently influencing tendency of the development of cartography is the increased use of mathematics. The process of "mathematization" in cartography is rapidly advancing. Earlier, only the geometry of projections utilized relatively simple methods of mathematics, but today new, differentiated methods of mathematics are applied.

The recent successful development of thematic cartography may be mainly the result of automation and of the application of mathematical statistics. Rapid cartographic mathematization is promoted by the application of computers, by the initiation of automation in the cartographic institutions.

Modern cartography is becoming more and more industrialized. Not so long ago research projects were undertaken with relatively simple and inexpensive instruments which could be prepared even by the researcher. However, current investigations require complicated and

* The original text of this paper, prepared by S. Radó and I. Klinghammer, National Office of Lands and Mapping, Hungary, appeared as document E/CONF.68/L.65.

expensive devices, such as computers, co-ordinatographs, and photogrammetric and photo-laboratory equipment.

All these examples give evidence of the fact that in a sense modern cartography has acquired an industrial character and further progress requires the large-scale and modern organization of the production and use of machines and devices as a separate branch. Industrialization creates close interrelationships between scientific research and technical development. Technics enrich science; and, vice versa, the theoretical science of cartography enriches technics. As a result of this interrelationship, the development both of science and of technics is considerably accelerated. In addition, practically the cartographic technics and the technology themselves become the object of scientific research; newer and newer procedures and devices are introduced and begin to develop rapidly, already on the basis of their own inner forces.

### Continuity

Continuity is the force of development of cartography, as of all sciences. The current generation of cartographers applies the knowledge obtained by previous generations. Thus, the stock of knowledge is unceasingly increasing. The new generation of specialists can study the totality of scientific facts, accumulated by the forerunners, to a considerable degree in elaborated and systematized form.

Continuity is a factor that accelerates the development of science.

### Law of accelerated development

An extremely important law in the development of modern science is the law of accelerated development. The stock of knowledge of cartography is increasing proportionally with the volume of knowledge accumulated by previous generations, that is, normally by geometrical progression, exponentially. Accelerated development has several causes: the development of the productive forces; the interrelationship between the productive forces and the development of science; the inner forces of the development of science; the interrelation between the sciences and the different aspects of social life.

No doubt, cartography will develop rapidly in future—creating theories that will more and more precisely reflect reality, strengthening its own theoretical bases, penetrating into newer and newer fields and steadily improving its methods of research.

The productivity of scientific research work in cartography is increasing. Thus, for example, cybernetics, the development and use of different electronic devices, makes possible the increasingly rapid enlargement of the stock of scientific knowledge. The extremely rapid development in the field of cartography is illustrated by the fact that the bibliography of cartographic literature (that is, not of maps and atlases) of the 20 years between 1956 and 1976 contains 30,000 entries, from 60 journals dealing partially or entirely with cartography.

The economic development of the world, urbanization and large investments give rise to increasing demands for surveying and geographical cartography; within this field, first of all, there is great interest in thematic cartography.

As a first step, the ensuring of large-scale base maps must be solved in order to satisfy the demands of the administration, planning, property and fiscal matters, and, last but not least, military affairs. The report on the status of topographic mapping,[1] published by the United Nations does not paint the situation of the topographic survey of the earth in rosy colours.

According to this report, as of 1975 only 13 per cent of the territory of the continents (up to 1968, only 6 per cent) was surveyed on the scale 1 : 25,000 or larger; within this figure is 67 per cent of the territory of Europe and in considerably smaller proportions the territory of other continents. Considering the scale 1 : 100,000, which is four times smaller, such less exact maps are available for 43 per cent (in 1968, for 30 per cent) of the area of the continents: 70 per cent of Europe has been surveyed; the other continents have been surveyed in smaller proportions. The report shows the acceleration of the survey in recent years in comparison with 1968.

The topographic survey has not yet been solved on a world scale; but in countries that are developed from the point of view of surveying, there are increasing demands for thematic maps to be applied in the research and planning of territorial and economic possibilities. Therefore, the working programme for the coming years is, on the one hand, to render help to the developing countries in surveying; and, on the other hand, to unify the elements and representation methods of thematic mapping and to develop map series on regional land use, erosion, water balance etc.

### Automation

In the course of development of thematic maps, cartographic tasks grow to such proportions that map-making must be automated in order that the tasks may be accomplished.

The automation of technical and scientific working processes is developing extremely rapidly. The first entirely automatic computer was introduced in 1946; currently, the fourth generation of electronic data-processing equipment is working. Development can be measured not only by the doubling every five years of cartographic knowledge but by the perfecting of automation systems.

The question that arises is how cartography can make use of all this technology.

The first steps for the automation of map-making were taken in the field of photogrammetry. As in the future, during the new development trends, map-making will become increasingly linked with photogrammetry, automation will have greater and greater importance in the

[1] A.-J. Brandenberger, "Study on the status of world cartography", *World Cartography*, vol. XIV (United Nations publication, Sales No. E.76.I.13), pp. 71–96.

production of topographic and general geographical maps. As topography in the future will mean photogrammetry, the development of thematic maps will be determined by cybernetics and mathematical statistics.

With the spread of automation and with the changing of processing technologies, the map image is being considerably "simplified". The aesthetics of maps has deteriorated in comparison with earlier works; however, the reliability of the maps is increasing. Automation contributes to making the contents of maps more objective.

Topographic surveying has a centuries-old tradition in Europe. The detailed topographic surveys are completed; the governmental maps have been prepared. The methods were elaborated; they are only to be applied in correcting and in keeping the maps up to date.

The fair-draft has such qualitative requirements that in comparison, automation means, although it is far more expensive, a certain qualitative decline. In Europe, the automation trends are characterized in the field of topographic and general geographical map production by attempts at digital transformation, made from the point of view of the traditional problem of cartography, the generalization; but the investigations to set up data banks and the researches for the improvement of technological processes are also of importance.

The degree of supply of non-European territories with topographic maps cannot be compared with the degree of the European States, neither quantitatively nor qualitatively. This situation is due, on the one hand, to the lack of traditions and, on the other hand, to the fact that in those countries there is a greater lack of qualified cartographers than in Europe. For cartography in the developing countries, this gap is filled by the adoption of highly developed technics and by the automation of map-making.

The automation of map-making has progressed further in thematic cartography than in the field of topographic and general geographical maps.

Aerial photography is intended to make up the backwardness of topographic maps. Astronautics have already opened the new perspectives of aerial photogrammetry. The tens of thousands of colour photographs taken by the astronauts and the hundreds of thousands of photographs already projected by satellites to the earth by the beginning of the 1970s undeniably proved the cartographic possibilities and advantages of space photographs against the traditional mosaic of aerial photographs. These advantages are:

(*a*) The photographs taken of territories of continent size under the same exposure and weather conditions can be repeated in fixed periods;

(*b*) The multispectral cameras and multispectral scanners used in taking the photographs provide a permanent information supply which is independent from the circumstances;

(*c*) It permits, from new aspects, an approach to generalization, to the basic problem of cartography.

The complex material of photographs—valued from different points of view and for different purposes—ensures the primary source material of thematic cartography; and renders possible such acquaintance and revelation with the human environment as, for example, the creation of the electronic microscope meant for the biological and physiological sciences.

After all these developments, it may seem unbelievable that the question whether cartography is an independent science is still at issue. In this respect, cartography shares the fortune of all new branches of science. However, in most of the countries, the debate on the equity and necessity of independent cartography have been settled. Its eloquent proof is that in several countries it has been recognized as necessary, in order to eliminate the often empirical methods of map edition, to train diplomated cartographic specialists and scientists and to ensure their new generation; the principles, conditions and trends of primary, secondary and higher education of cartographers have been established.

These efforts have been considerably assisted by the fact that in order to satisfy the increasing demand for maps of modern national economics and of the developing countries, the United Nations set up a cartography section at its Headquarters in New York and organizes cartographic conferences for the countries of Africa, of Asia and the Far East, and of the Americas. In addition, the United Nations has set up a commission of experts and has organized conferences to standardize the writing of geographical names on the maps.

The United Nations also supports the efforts that have been made for nearly a century to establish a uniform world map (more exactly, a map of continents) on the scale 1 : 1,000,000. The matter advances slowly. Recently, the major step in this direction was made by seven socialist countries, which produced the World Map comprising 234 sheets on the scale 1 : 2,500,000, which was referred to in several reports also at the international geographical and cartographic congresses held in Moscow in 1976. It is expected that this general geographical map will be the base for the series of uniform thematic world maps, which will emphasize in the most representative way, also on an international level, the interdisciplinary, universal character of thematic cartography in the system of sciences.

# UNIFORMITY IN THE TRANSCRIPTION OF GEOGRAPHICAL NAMES*

*Paper presented by Indonesia*

The increasing effort in mapping in Indonesia requires good and easy transcription of geographical names. This matter was brought up at the Sixth United Nations Regional Cartographic Conference for Asia and the Far East at Tehran in 1970. As a follow-up measure, the National Co-ordination Agency for Survey and Mapping (Badan Koordinasi Survey dan Pemetaan Nasional: BAKOSURTANAL) proposed to the Government that the National Committee on Geographical Names should be established.

One of the Committee's tasks is to standardize the transcribing of geographical names. In standardizing the transcription of geographical names, some factors that influence the transcription should be taken into account:

(*a*) Historical background of the geographical names;
(*b*) Different regional terms or dialects for the same geographical feature;
(*c*) Current spelling.

## Historical background of geographical names

In general, names for geographical features have been adopted as follows:

(*a*) Using names of persons;

*Examples*:
Pegunungan Muller (Muller mountain range)
Bendungan Ir. Haji Djuanda (Ir. Haji Djuanda dam)

(*b*) Based on the specific form or nature of the feature in a particular area;

*Examples*:
Kepulauan Seribu (meaning: one thousand islands)
Tangkubanperahu (meaning: upside down ship)
Tembagapura (meaning: bronze gate)

(*c*) Based on regional myth or legend/affair;

*Examples*:
Jayapura (meaning: Victorious Gate).
Surabaya (Sura fish and crocodile).
Pagaruyung (a fence made of palm-trees).
Ci Tarum (the principal waterway to Taruma Negara).

(*d*) Using names of geographical features (natural and man-made) for towns and villages;

*Examples*;
Ci Kotok (Ci means river)
Ci Julang
Ci Panas
Sungai Liat (Sungai also means river)
Sungai Penuh

*Question*: Are they placenames or river names?

*Examples*:
Gunung Sitoli (Gunung means mount)
Gunung Sumbing

*Question*: Are they place-names or mountain names?

## Regional terms or dialects

Regional terms or dialects have a great influence in the transcription of geographical names reflecting the unique regional characteristic. Therefore, the transcription should be kept according to the regional term. The numbers of terms and dialects on geographical names in use are approximately:

(*a*) For rivers, 69 terms;
(*b*) For mount/hill, 59 terms;
(*c*) For villages, 41 terms;
(*d*) For capes, 13 terms;
(*e*) For islands, 11 terms;
(*f*) For lakes/ponds, 9 terms;
(*g*) For gulfs, 9 terms;
(*h*) For swamps, 7 terms.

## Current spelling

The standardization of spelling for the transcription of geographical names is important, but it should not effect a change of the regional meaning and should conform to the development of the *bahasa Indonesia* (Indonesian language) itself.

## Conclusion

The following general conclusions apply:

(*a*) The standardization of the transcription of place-names and other geographical features is necessary to avoid confusion;

(*b*) Transcription of unique geographical characteristics should be kept according to regional terms and dialects;

(*c*) The current spelling should be used as long as it does not change the meaning of the names;

(*d*) Transcription of place-names using the names of geographical features should be written in one word;

*Examples*:

| | |
|---|---|
| Sungaipenuh | Tanjungpriok |
| Cisalak | Pekanbaru |
| Bukittinggi | Kampungbugis |
| Gunungsitoli | Kotabumi |
| Ujungpandang | |

(*e*) For physiographic feature-names, the name of the feature and the name itself are written separately.

*Examples*:

| | |
|---|---|
| Ci Liwung | Tanjung Cina |
| Gunung Merapi | Ujung Indramayu |
| Bukit Raya | |

* The original text of this paper, prepared by the National Committee on Geographical Names, Indonesia, appeared as document E/CONF.68/L.83.

## INDONESIAN MARITIME AND UNDERSEA FEATURES*

*Paper presented by Indonesia*

Among the tropical countries that lie on the equator, Indonesia is an interesting archipelago to the scientists, especially geologists, because it has such varied undersea features as shelfs, basins, drowned rivers, troughs and deep trenches (see figure 92).

Research of these undersea features was done in 1912 and 1930 by Dutch deep-sea expeditions using HMS *Willebrord Snellius*, which undertook about 35,000 soundings. The result was the discovery of the configuration of basins and troughs, spread out in the eastern part of Indonesia, besides the existence of two shelfs separated by the Wallace and Weber trench. This complicated undersea configuration is also interesting for other scientists, such as oceanographers.

### Mapping the depth of the sea

Undersea contours or isobaths of the Indonesian waters adopted from the Indonesian charts Nos. 2 and 3, on the scale 1 : 4,000,000, illustrate the undersea relief properly.

Using the 100-m isobath as a datum plane, the western part of the Indonesian waters, including the Sunda shelf, appears monotonous. When one goes down to the 2,000-m isobath, many interesting features are encountered, such as the North Banda and the South Banda basins, the Flores basin, the Sawu basin, the Aru basin, the Sulawesi trough, the Timor trough and the Sangir trough.

At the 4,000-m isobath, however, the Sawu basin, the Sulawesi trough and the Timor trough will no longer be found.

### Geographical names of undersea features

As a result of the most recent deep-sea expeditions in Indonesian waters, which date back to 1929 and 1930, the following undersea features were given geographical names:

Sulawesi basin: *cekungan* Sulawesi
Wallace trough: *palung* Wallace
Weber deep: *kedalam* Weber
Ambalau basin: *cekungan* Ambalau
Sangir trough: *palung* Sangir
Morotai basin: *cekungan* Morotai
Ternate trough: *palung* Ternate
Bacan basin: *cekungan* Bacan
Gerontalo basin: *cekungan* Gorontalo
Buru basin: *cekungan* Buru
Northern Banda basin: *cekungan* Banda Utara
Southern Banda basin: *cekungan* Banda Selatan
Makasar basin: *cekungan* Makasar
Flores basin: *cekungan* Flores
Sawu basin: *cekungan* Sawu
Manipa basin: *cekungan* Manipa
Wetar trough: *palung* Wetar
Sawu trough: *palung* Sawu
Flores trough: *palung* Flores
Halmahera basin: *cekungan* Halmahera
Timor trough: *palung* Timor
Aru trough: *palung* Aru
Jawa trench: *palung* Jawa
Bone basin: *cekungan* Bone
Tomini basin: *cekungan* Tomini
Buru trough: *palung* Buru

In addition to the concave forms, there are many other forms of features, such as submarine ridges, which connect the islands, among others, the known Snellius ridge (*igir* Snellius) between Halmahera and Talaud.

* The original text of this paper, prepared by the National Committee on Geographical Names, Indonesia, appeared as document E/CONF.68/L.84.

## PREPARATION OF GAZETTEERS AND NATIONAL STANDARDIZATION OF GEOGRAPHICAL NAMES IN INDONESIA*

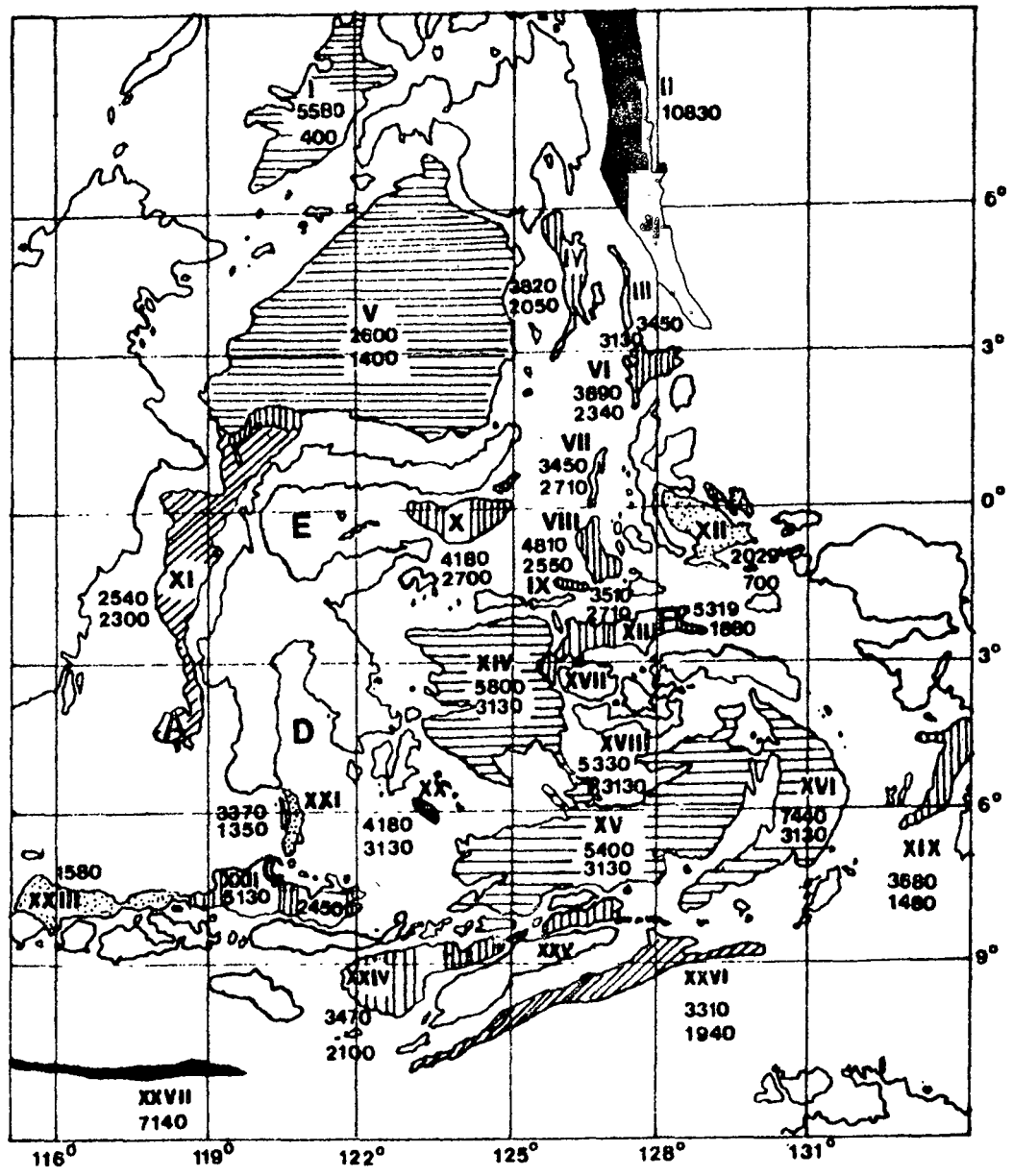
*Paper presented by Indonesia*

In 1964, Indonesia made an inventory of its islands, using the Indonesian hydrographic charts on scales ranging from 1 : 4,000,000 to 1 : 7,000, and the result showed the Indonesian Archipelago to consist of 13,667 islands, of which 6,044 islands have names. A list of island names was issued by the National Scientific Documentation Centre in 1975; updating is still being undertaken.

### Compilation of gazetteer

The listing of Indonesian island names is rather complicated; for example, for indicating the position of large islands, administrative boundaries and other geographical factors must be taken into consideration in

* The original text of this paper, prepared by the National Committee on Geographical Names, Indonesia, appeared as document E/CONF.68/L.85.




DEPTH

- > 1 000
- > 2 000
- > 3 000
- > 4 000
- > 6 000

| | | | |
|---|---|---|---|
| IV | Sangir trough | XIX | Aru trough |
| V | Sulawesi basin | XXII | Flores basin |
| VI | Morotai basin | XXIV | Sawu basin |
| VII | Ternate trough | XXV | Wetar trough |
| VIII | Bacan basin | XXVI | Timor trough |
| X | Gorontalo basin | XXVII | Jawa trench |
| XI | Wallace trough | | |
| XII | Halmahera basin | | |
| XIII | Buru basin | A | Makasar basin |
| XIV | Northern Banda basin | B | Sawu trough |
| XV | Southern Banda basin | C | Flores trough |
| XVI | Weber deep | D | Bone basin |
| XVII | Manipa basin | E | Tomini basin |
| XVIII | Ambalau basin | F | Buru trough |

3025.67x

*Figure 92. Indonesia: Indonesian maritime and undersea map*

addition to latitude and longitude. Furthermore, the forms of large islands are varied; some are long, others are square or round. The positions of smaller islands are determined by using the location of navigation marks, such as light towers, and inhabited places; but for those which do not have such signs, the approximate locations of their middle parts are taken.

Quite a few of these islands are still using old names (Dutch or other languages), of which some are considered to be symbols of colonialism. Such islands should be renamed or regain their original names. The list of names published in 1975 is using the official new spelling.[1]

In addition to the names of islands, names of places and geographical features have already been listed to compile the Indonesian gazetteer.

Names of places, rivers, mountains etc. have been published in alphabetical order by the Geographic Department of the Faculty of Mathematics and Physics, University of Indonesia.

### National standardization of geographical names

After the Second World War, many problems arose with regard to map-making, including questions in the field of geographical names.

The process of naming geographical places, e.g., towns and villages; and naming physiographic features, e.g., rivers, mountains, lakes or islands, has always had a historical background. For example:

Tanjung Priok and Tanjung Awarawar
Tanjung means "cape"

Both are written in the same way (two parts). Because of the similar writing system, it is rather difficult to distinguish which is a geographical place and which one a physiographic feature. Actually, Tanjung Priok is a name of a town; whereas Tanjung Awarawar is a name of a cape, which is a physiographic name.

Other examples are as follows:

| *Place-names* | *Physiographic names* |
|---|---|
| Ujung Pandang | Ujung Indramayu |
| Kali Anget | Kali Brantas |
| Teluk Betung | Teluk Panggul |
| Muara Enim | Muara Mahakam |
| Gunung Sitoli | Gunung Guntur |
| Pulau Mas | Pulau Damar Besar |
| Cirebon | Ciliwung |

[1] Report of the second meeting of the United Nations Group of Experts on Geographical Names, Asia, South-East Division, Jakarta, 25–29 September 1975, annex F, "Country report, Indonesia", p. 3.

Furthermore, quite a few foreign phonetic sounds were used for original Indonesian names, either for names of places such as Denpasser, Pakanbaru, Ayer Tembaga etc. or for names of islands such as Billiton (means Billiton island), Kei and so on. These foreign phonetics have been officially replaced in accordance with the Indonesian phonetic sounds or the original Indonesian names. For example:

Denpasser becomes Denpasar;
Pakanbaru becomes Pekanbaru;
Ayer Tembaga becomes Air Tembaga;
Billiton becomes Belitung;
Kei becomes Kai.

### Change of geographical names

The change of the geographical names from foreign to Indonesian spelling, the adaptation of the geographical names to those which show more national identity, the adaptation of the transcription to the latest official spelling etc. have been much achieved. The Atlas Sekolah (School Atlas), Atlas Indonesia, Atlas of National Resources and so on, which were issued after Indonesia became independent, have also been revised. The World Atlas published by foreign countries and foreign navigational charts have also been adapted to the instructions of Indonesia concerning Indonesian geographical names, such as:

Sulawesi instead of Celebes;
Jakarta instead of Batavia;
Bogor instead of Buitenzorg;
Banda Aceh instead of Kutaraja;
Ujung Pandang instead of Makasar;
Irian Jaya instead of West Irian;
Jayapura instead of Hollandia.

Since the colonial government (Netherlands) and during the Japanese occupation, the procedure of giving geographical names has been the authority of the Department of Home Affairs. After Indonesia became independent this work has continued.

### Executing geographical names

The National Co-ordination Agency for Surveys and Mapping has proposed to the Government to establish the National Committee on Geographical Names as the single authority in solving all aspects and problems on geographical names.

# GEOREFERENCING WITHIN THE FRAMEWORK OF AN INFORMATION SYSTEM*

*Paper presented by Indonesia*

An information system is directed to providing information to users as material for decision-making in research, planning and management.

This paper presents an Indonesian experience in georeferencing within the framework of establishing an information system using grid cells as reference for resource data, for example: (*a*) demographic and education data collected in the Special Region of Yogyakarta using 30 x 30-second cells, and (*b*) natural resources data collected from Muara Bungo Area, Sumatera, using 1 x 1-minute cells.

## GEOREFERENCING

In this experiment, geocoding with cell referencing is used, since the data location is easily known and the data are easily mapped by means of computer. For the map projection, the Universal Transverse Mercator (UTM) projection is used.

The map on the scale 1 : 250,000 is divided into 900 cells of 1° x 1.5°. Every cell is coded with digits, the first two digits indicate the column number and the second two digits indicate the row number. The map at 1 : 250,000 scale consists of six sheets of 1 : 100,000 maps (30 x 30 minutes), and that of map at 1 : 100,000 scale of four sheets of 1 : 50,000 maps (15 x 15 minutes).

### *Demographic and educational data collected from Special Region of Yogyakarta*

The Special Region of Yogyakarta consists of four *Kabupaten* (regencies) and one *kotamadya* (municipality). Two sets of data are collected, the demographic and the education data of 1975, from every village in the four *kabupaten* comprising 392 villages. The method applied is geocoding with 30 x 30-second cell referencing.

The demographic data consist of eight subsets, and the educational data consist of 12 subsets (see table 48).

#### *Data classification*

Demographic and education data are classified into some classes with numerical codes. Every set of data is classified into 10 classes or subsets, except the total population data which are classified into 20 subsets. To fill the code of data in coding form, two ways are applied. First, the code of data is filled directly. Secondly, every subset of data is presented in thematic maps; so 20 maps are compiled. By overlaying the cell grid system at each thematic map, the data can be retrieved in coding form.

#### *Data filling in coding form*

Columns 1–20 of the coding form are for the cell address. Columns 1–10 identify the position of a cell on

**Table 48. Indonesia: column number and demographic and education data collected**

| *Column No* | *Total number of columns* | *Item* | *Code No.* |
|---|---|---|---|
| 1–4 | 4 | Code of base map at 1 : 250 000 scale | 1407 |
| 5 | 1 | Code of base map at 1 : 100 000 scale | 4 |
| 6 | 1 | Code of base map at 1 : 50 000 scale | 4 |
| 7–10 | 4 | Code of 30 x 30-minute cell | 2222 |
| 11 | 1 | Code of island (Jawa) | 3 |
| 12 | 1 | Code of province (Special Region of Yogyakarta) | 4 |
| 13–14 | 2 | Code of regency (Gunung Kidul) | 03 |
| 15–16 | 2 | Code of sub-district (Panggang) | 01 |
| 17–18 | 2 | Code of village (Girikerta) | 05 |
| 19–20 | 2 | Blank | — |
| 21–22 | 2 | Time reference (1975) | 75 |
| 23 | 1 | Blank | — |
| 24 | 1 | Village area (code 5 for area of 1.5–14.9 square kilometres) | 5 |
| 25–26 | 2 | Total population (code 05 for total population of 3 750–4 374) | 05 |
| 27 | 1 | Population density (code 1 for population density of 250–500 per square kilometre) | 1 |
| 28 | 1 | Total households (code 2 for total households of 500–800) | 2 |

**Table 49. Indonesia: column number and natural resources data collected**

| *Column No* | *Total number of columns* | *Item* | *Code No.* |
|---|---|---|---|
| 1–4 | 4 | Code of base map at 1 : 250 000 scale | 0913 |
| 5 | 1 | Code of base map at 1 : 100 000 scale | 4 |
| 6 | 1 | Code of base map at 1 : 50 000 scale | 4 |
| 7–10 | 4 | Code 1 x 1-second cell | 0512 |
| 11 | 1 | Code of island (Sumatera island) | 1 |
| 12 | 1 | Code of province (Jambi province) | 05 |
| 13–14 | 2 | Code of regency (Bangko-Sarolangun regency) | 02 |
| 15–16 | 2 | Code of subdistrict | — |
| 17–18 | 2 | Code of village | — |
| 19–20 | 2 | Blank | — |
| 21–22 | 2 | Time reference (1975) | 75 |
| 23 | 1 | Blank | — |
| 24–25 | 2 | Lithology (glassy tuff and marls) | 07 |
| 26–27 | 2 | Geomorphological zone (Bukit Barisan geanticline) | 06 |
| 28–29 | 2 | Geomorphological unit (southern block) | 06 |
| 30–31 | 2 | Soil type (complex of red-yellow podzol, latosol and litosol) | 13 |
| 32–33 | 2 | Type of land use (forest) | 01 |
| 34–35 | 2 | Group of rainfall (2 500–3 000 millimetres per annum at plain area) | 03 |
| 36–37 | 2 | Ground-water zone (zone of deep ground water, low-moderate permeability) | 06 |

* The original text of this paper, prepared by Faculty of Geography, Gajah Mada University, Yogyakarta, Indonesia, appeared as document E/CONF.68/L.86.

basic maps on the scales 1:250,000, 1:100,000 and 1:50,000. Columns 11–20 identify the position of a cell within the administrative units. Columns 21–22 are used for time reference and columns 24 and so on are used for demographic and educational data (table 48).

As an example, the demographic and educational data collected from Girikerta village (13.59 km$^2$) are presented. Although the boundary line of this village crosses 25 cells, the cells being filled with code 5 (code for the total area of the village) are cells completely situated in this village or more than 50 per cent of the cells included in this village (see figure 93)

*Natural resources data collected from Muara Bungo area of Sumatera*

All natural resources data were plotted on available maps. Most of the natural resources data were taken from LANDSAT-1 imagery (14 June 73, NASA E-1326-02540) and climatic data are taken from meteorological records. The imagery used covers a part of Jambi, West Sumatera and Riau province. The method applied is geocoding with 1 x 1-minute cell referencing (see figure 94).

*Data collected*

Natural resources data consist of six subsets: geology; geomorphology; hydrology; soil; climate; and land use. Each subset could be classified into smaller classes or subsubsets (see table 49).

To fill codes of the data in coding form, two methods are applied. First, the codes of the data are filled directly. Secondly, every subset of data is presented in thematic maps; thus, six maps are compiled. By overlaying the cell grid system on each thematic map, the data can be retrieved in coding form.

*Data filling in coding form*

Columns 1–20 of the coding form are for the cell address. Columns 1–10 identify the position of a cell on

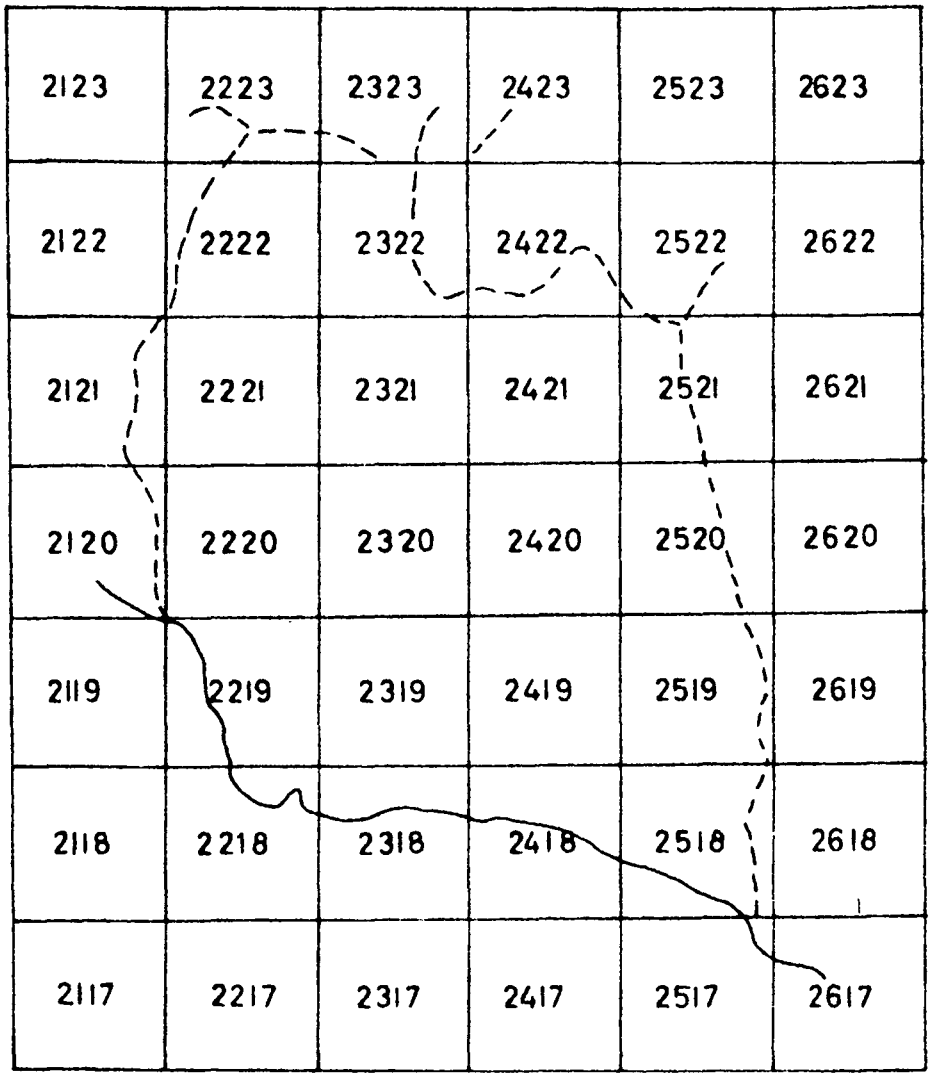



*Figure 93. Indonesia: Girikerta village in cell system*

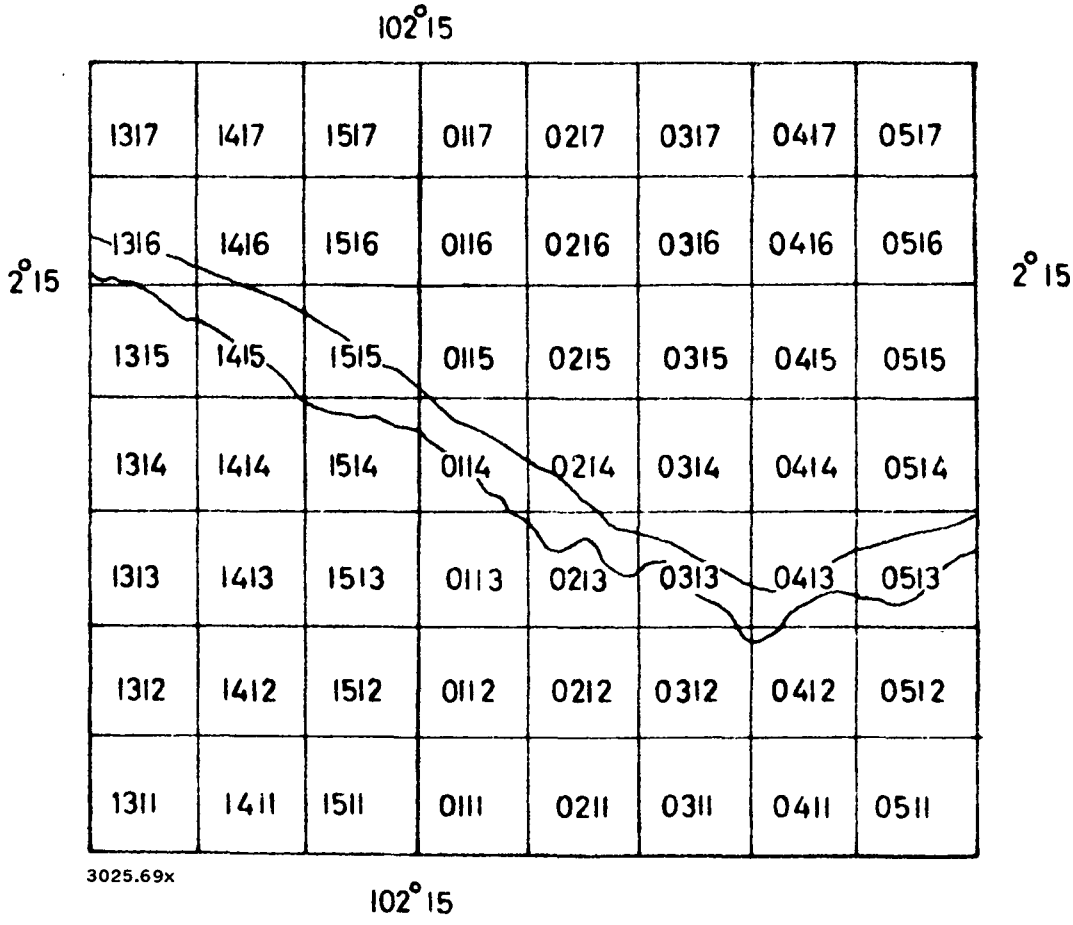



*Figure 94. Indonesia: a 1 × 1-minute cell system of Muara Bungo area*

the base maps on the scales 1 : 250,000, 1 : 100,000 and 1 : 50,000. Columns 11–20 identify the position of a cell within the administrative units. Columns 24 and so on are used for natural resources data.

As an example, natural resources data collected from cell No. 0512, Bangko-Sarolangun, Jambi province is presented (table 49).

## Conclusion

There are some advantages and some disadvantages in utilizing a geocoded cell referencing system. The advantages are:

(*a*) The position of a cell is easily recognized on the map;

(*b*) If the same types of data for different times are taken from one cell, a graph showing the data change can be made;

(*c*) Mapping by means of computer can easily be carried out;

(*d*) There is ease of data integration and manipulation.

The disadvantages are as follows:

(*a*) The real form of an area cannot be obtained;

(*b*) An item that is smaller than one cell cannot be pointed out with this method, such as the area of some *rukun kampung* (like quarters) in urban areas.

# THE NATIONAL LAND INFORMATION SERVICE*

*Paper presented by Japan*

In 1974, the National Land Use Planning Act was enacted to meet the needs for rationalization of land use; the National Land Agency, which was set up to enforce the Act, decided to establish the system of the National Land Information Service. The purpose of the system is to supply the data necessary for the national and regional land-use plans which are to be drawn up by the national Government and local governments under the provisions of the Act.

The Geographical Survey Institute (GSI) has executed three basic parts of the total system: aerial photography in colour; production of the land-use maps; and digitization of national land information.

## Aerial photography in colour

Aerial photographing in colour has been carried out since 1974 to cover the entire country in four years. The entire area of Japan has been repeatedly photographed in black and white by GSI and the Forest Agency. However, this is the first time that the entire country will be covered by colour aerial photographs. Photo scales are from 1 : 8,000 for the flat terrain to 1 : 15,000 for the mountainous regions. During the fiscal year 1974/75, about 158,900 km$^2$ were covered with these colour photographs.

The colour photographs are used not only for compiling the land-use maps mentioned later but directly as basic information for many administrative purposes, such as planning and adjustment for land use, regional development, construction works and environmental preservation.

## Land-use maps at 1 : 25,000 scale

The production of the land-use maps at 1 : 25,000 scale began in 1975 for the purpose of filling an important role in new regional planning. The maps will cover the main habitable areas of the entire country, especially the flat lands and adjoining areas, estimated to be about 90,000 km$^2$. The project will take four or five years to complete. As to the survey for the land-use maps at 1 : 25,000 scale, natural colour aerial photographs are used, within about one year after the photography is done. Therefore, the information from the aerial photographs will be new and contain the most recent data.

The land-use maps on the scale 1 : 25,000, which form a link in the chain of the national land information system project, should keep in step with the topographic maps on that scale which were used as the base map for the land-use map. Since the revisional survey of the topographic maps and the revisional survey of the land-use maps have many points in common, both surveys can be accomplished effectively if they are carried out together. For this reason, almost all legends of the land-use maps are adjusted to the classification of the topographic maps, except that the former map has several legends for differential urban functions etc. First, the land-use pattern is classified into the following three main categories: (1) city, town and village district; (2) farm district; and (3) forest district. These categories correspond to the urban district, rural district and forest district of the basic land-use plan. The city, town and village district is subdivided into 15 items according to their functions. Because these items, in particular, public service items, are related to the zonal district of the City Planning Act, a district on the land-use map can be compared with that of a city plan. The farm district is subdivided into nine items and the forest district is subdivided into 10 items according to their vegetation cover. The classification of the land-use maps is given below:

(a) *City, town and village*:
- General residential district
- Multistorey residential district
- General shopping district
- Business district
- Industrial district
- Government and local public agency district
- Education district
- Welfare district
- Park and green zone
- Athletic sports facility
- Transportation and distribution district
- Facility for supply and processing
- Defence force facility
- Open space
- Land improvement district

(b) *Farm district*:
- Paddy-field
- Upland field
- Orchard
- Mulberry field
- Tea plantation
- Other tree plantation
- Pasture land
- Greenhouse (facility)
- Barn (facility)

(c) *Forest district*:
- Coniferous forest (artificial)
- Coniferous forest (natural)
- Broadleaf forest
- Mixed forest
- Bamboo forest

* The original text of this paper, prepared by the Topographic Department, Geographic Department and Map Management Department, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.68/L.72.

Palmaceous forest
Creeping-pine grove
Dwarf-bamboo thicket
Natural grassland
Waste land

### DIGITAL NATIONAL LAND INFORMATION

The project to digitize the national land information began in 1974. Its purpose is to supply basic information on the current state of the land of the entire country in the form of digital data which can be processed by computers. Table 50 shows the items of the data and their contents. These data are ready to serve for national and regional land-use planning.

The source materials of the data are derived from topographic maps, thematic maps (such as land-use maps), aerial photographs, observation data (such as levelling data), statistical data and various kinds of registers.

The principal characteristics of the work are as follows:

(*a*) All collected data are transformed into digital form and stored on discs and magnetic tapes for computer processing;

(*b*) The work is based on the national standard grid system which was established for the entire country in 1969. The data are coded into approximately 1-km² grid units (basic regional grid units);

(*c*) Digitizers and colour scanners are employed for the measurement of objects. They give not only the length and the area but the location of the objects, which would be useful for extended analyses and the compilation of digital maps;

(*d*) The data are available to the users in the form not only of tables but of maps, which are produced with line-printers and plotters.

**Table 50. Japan: digital national land information**

| *Item* | *Contents* | *Data unit* |
|---|---|---|
| Local government | Boundary location, area | City, ward, town, village |
| Landform | Ground elevation, relief and gradient | 1/16-km² grid square |
| | Valley density | 4-km² grid square |
| | Landform | 1-km² grid square |
| Surface geology | | 1-km² grid square |
| Soil | | 1-km² grid square |
| Levelling data | Bench-mark location (B.L.) | |
| | Levelling data | |
| Ground subsidence | Annual subsidence since 1966 | |
| Lake | Location, area, elevation, depth etc. | |
| Mountain | Location, elevation etc. | |
| Coastal zone | Shore-line length, depth etc. | |
| Legally designated zones | City-planning areas, national parks etc. | |
| Land use | 15 categories | 1-km² gird square |

*Note*: Data for these items, excluding land use, have been completed.

## REPORT OF THE UNITED NATIONS DIVISIONAL GROUP OF EXPERTS ON GEOGRAPHICAL NAMES, ASIA SOUTH-EAST DIVISION*

*Paper presented by Malaysia*

At the Seventh United Nations Regional Cartographic Conference for Asia and the Far East, held in Tokyo from 15 to 27 October 1973, Malaysia was elected as the Divisional Representative for the United Nations Divisional Group of Experts on Geographical Names, Asia South-East Division.

Malaysia therefore took over from Thailand, the previous Divisional Representative, the responsibility of convening regional meetings to enable member States of this region to get together to discuss and to present their views so that a consolidated stand could be taken on problems concerning the standardization of geographical names.

### FIRST MEETING OF THE ASIA SOUTH-EAST DIVISION

The 1st meeting of the Asia South-East Division was convened at Kuala Lumpur, Malaysia from 6 to 10 January 1975.

That meeting was attended by delegates from Indonesia, Malaysia, the Philippines, Singapore and Thailand. Burma, Democratic Kampuchea, the Lao People's Democratic Republic and the former Republic of South Viet-Nam also were invited but did not attend.

* The original text of this paper, prepared by Paul Foo, Director of National Mapping, Malaysia (Divisional Representative of the Asia South-East Division), appeared as document E/CONF.68/L.63.

*Map of South-East Asia*

At that meeting, it was agreed that the countries of the region should get together and publish a map of South-East Asia in which each member would be responsible for the correctness of the names shown for its country. That unique project would at the same time represent a concrete example of regional co-operation.

The Directorate of National Mapping, Malaysia, undertook the preparation and printing of the map.

A three-colour edition of the map was produced in time for the sixth session of the United Nations Group of Experts on Geographical Names held in New York from 5 to 26 March 1975. At first, five countries—Democratic Kampuchea, Indonesia, Malaysia, Singapore and Thailand—had participated in the project in supplying the correct geographical names of places in their countries.

A full-colour version of the map with some modifications in its format was later prepared and published with two more countries participating—the Philippines and the former Republic of South Viet-Nam. Burma and the Lao People's Democratic Republic had also been invited to participate in the project but there had been no response from those countries.

*Paper on the work of the United Nations Group of Experts on Geographical Names*

At the request of the meeting and for the benefit of the members of the region, Major General Banlang Khamasundara of Thailand was requested to prepare a paper on the history, aims, objectives, conclusions, recommendations and other matters connected with the work that had been done thus far by the United Nations Group of Experts on Geographical Names.

The paper was subsequently prepared by Major General Banlang Khamasundara of Thailand, edited by Paul Foo of Malaysia and printed by the Directorate of National Mapping, Malaysia.

Each member of the region was supplied with 20 copies for distribution if they wished, to the government departments, ministries and other agencies of their country.

## Sixth session of the United Nations Group of Experts on Geographical Names

At the sixth session of the United Nations Group of Experts on Geographical Names, the Asia South-East Division was represented by three members: Kok Swee Tuck (Malaysia) as the Divisional Representative; Major General Banlang Khamasundara (Thailand); and Colonel Bunserm Narmwang (Thailand).

The proceedings of the sixth session were reported on by Kok Swee Tuck at the 2nd meeting of the Asia South-East Division, held at Jakarta in September 1975.

Regarding the proposed training course in toponymy, which was to be sponsored by the Government of the Netherlands, members of the Asia South-East Division were at first excluded from participation, but at the expressed persuasion of Mr. Kok, the session subsequently agreed that the course should also be opened to the English-speaking countries of the Asia South-East Division.

## Second meeting of the Asia South-East Division

The 2nd meeting was held at Jakarta from 25 to 29 September 1975.

Delegates from Indonesia, Malaysia, the Philippines, Singapore and Thailand attended the meeting. Burma, Democratic Kampuchea, the Leo People's Democratic Republic and Viet Nam were also invited but did not attend.

*Course in toponymy*

In view of the importance of toponymy, it was proposed that a course should be organized specifically for the countries of the Asia South-East Division, to be held in a country in the Division.

*Concise gazetteer*

It was agreed to prepare a concise gazetteer of the region based on the map of South-East Asia. The Directorate of National Mapping, Malaysia, will undertake the preparation and compilation of this gazetteer.

*Regional gazetteer*

It was decided that the countries of this region should get together and produce a regional gazetteer, which would consist of all names appearing within 30 km on either side of a common international land boundary. The Directorate of National Mapping, Malaysia will also undertake to compile this gazetteer.

*Physical edition of the map of South-East Asia*

At the 2nd meeting, it was also proposed to produce a physical edition of the map of South-East Asia which would show physical features, including marine and undersea features. The Directorate of National Mapping, Malaysia, will undertake the preparation and printing of the map.

*Working group of the Asia South-East Division*

It was agreed to set up a working group to be represented by members of this region. This working group would meet regularly to discuss and deal with all the technical problems connected with the work of the United Nations Divisional Group of Experts on Geographical Names, Asia South-East Division.

## First meeting of the working group

The 1st meeting of the working group was held at Bangkok, Thailand, from 14 to 19 April 1976.

At that meeting, technical details were discussed and agreed upon in connexion with the compilation and production of the physical map of South-East Asia.

Technical details for the production and publication of the concise gazetteer and the regional gazetteer were also discussed and agreed upon. Formats for these two gazetteers were also prepared and adopted.

The meeting took note of the fact that nothing has been heard from the Government of the Netherlands regarding the course in toponymy which was to have been sponsored by that Government and was to have been held between 26 April and 22 May 1976. It was decided that Malaysia, as the Divisional Representative, would write to F. J. Ormeling, the Chairman of the Working Group on Training Courses on Toponymy, to inquire about the proposed course and also to request copies of the syllabus, lecture notes, literature etc. Malaysia has accordingly written to Mr. Ormeling and a reply is awaited.

### Third meeting of the Asia South-East Division

The 3rd meeting of the Divisional Group of Experts, Asia South-East Division, was held at Manila from 10 to 14 June 1976.

Only four member countries of the region invited to the meeting attended: Indonesia; Malaysia; the Philippines; and Thailand.

#### *Course in toponymy*

The chief delegate from Indonesia made an offer at the meeting that the proposed course in Toponymy to be specifically held for the Asia South-East Division could be held in Indonesia subject to the approval of the Indonesian Government.

It was also felt that for practical reasons the course could be held in rotation in each of the countries of the region.

#### *Regional atlas*

As a long-term project, it was agreed that member countries of the region should get together to produce a regional atlas with particular emphasis on geographical names and toponymy. Thailand was requested to prepare the specifications and format for the proposed atlas for distribution to member countries of the region.

#### *News-letter*

In order to disseminate information on current activities of members of the Asia South-East Division in regard to standardization of geographical names and other aspects of map-making, it was decided that a news-letter, which would be known as *Geonames*, should be produced and circulated among member countries.

The Philippines is to undertake the publication of the news-letter based on news items sent by member countries from time to time.

#### *Divisional Representative of the Asia South-East Division*

The meeting agreed to recommend to the Eighth United Nations Regional Cartographic Conference for Asia and the Far East that for the sake of continuity and in view of the fact that there were several ongoing projects which were currently under action, Malaysia should continue to be the Divisional Representative.

## CONDOR: A COMPUTATIONALLY ORIENTED NATIONAL DATA OPTIMUM RETRIEVAL SYSTEM FOR AUTOMATED CARTOGRAPHY*

*Paper presented by the United States of America*

Aeronautical charts of the United States of America graphically depict the national air-space rules and procedures established by the Federal Aviation Administration (FAA) to ensure safe and efficient operations within the multipurpose national aviation system. Aeronautical charts are an integral part of this system, essential both to aviation operations and to safe and efficient management by FAA.

The National Ocean Survey (NOS) has the mission of producing and maintaining the required charts and supplementary information materials under the United States National Aeronautical Charting Program. Because of the growing need for more of these products, combined with manpower restraints, NOS is turning to a new technology in computer-assisted cartography to avoid serious problems in fulfilling its mission.

* The original text of this paper, prepared by F. Robert Niedermair and Dave Pendleton, Office of Aeronautical Charts and Cartography, National Ocean Survey, National Oceanic and Atmospheric Administration, United States of America, appeared as document E/CONF.68/L.49.

### Overview

NOS has developed a computer system which is currently satisfying many operational requirements for constructing aeronautical charts in terms of performing geodetic computations, providing magnetic declination values and executing associated data retrieval operations. The CONDOR system runs on an IBM system 360/65 computer in the time-share mode utilizing remote data terminals located in the operational areas for chart compilation.

Cartographers use the system by typing English commands into the data terminal in order to direct the computer to perform data retrieval and computational operations. The commands are oriented for use by cartographers and require no knowledge or ability on the part of the user in computers and programming.

The system is composed of two major subsystems: (1) the geodetic computational subsystem provides results to geodetic problems using computational algorithms certified accurate by the United States National Geodetic Survey; (2) the data management subsystem

provides automatic linkages to the aeronautical data files for NAVAIDS, OBSTACLES, reporting points, RNAV waypoints, air route traffic control centre boundary points and various chart parameters.

NOS plans to further develop this important data system by exploring the feasibility of adding a graphics subsystem so that the results of performing data retrieval and computational operations can be visually checked.

### Computational subsystem

The commands available to the cartographer are of four basic types: (1) computation commands which indicate the particular computation to be performed; (2) variable commands which indicate which numerical values will be given; (3) function commands which direct the performance of a specific task; and (4) spheroid commands which select the geodetic spheroid model to be used in the computation. The commands may be entered in any sequence into the data terminal in a completely free-form manner.

#### *Fundamental computations*

The fundamental computations performed by the subsystem are: (*a*) bearing-intersections computations; (*b*) bearing-distances computations; (*c*) inverse computations; (*d*) segment-bearing-intersection computations; and (*e*) segment-intersection computations. These basic computations can be combined in groups to solve higher level problems, for example, in determining the set of corrected bearings that a pilot would have to fly to approximate a great circle route while flying along points 200 nautical miles apart. Figure 95 depicts a segment-intersection problem in which it is desired to know at which point the line joining stations 1 and 3 crosses the line joining stations 3 and 4 in terms of latitude, longitude and bearings and distances.

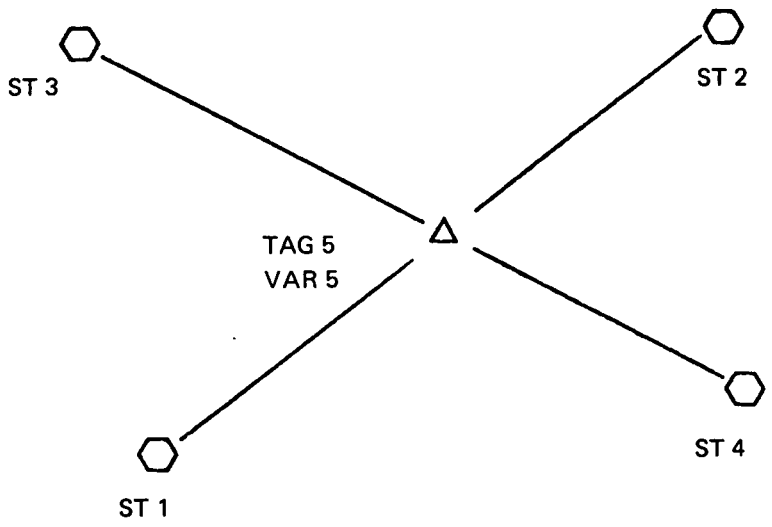



*Figure 95. United States of America: typical segment-intersection problem*

#### *Subsystem intercommunication*

An interesting feature of the computational subsystem is its capability to communicate with the data management subsystem. Using the station command, the cartographer can enter the identifier of a NAVAID, for example, and the system will automatically obtain the latitude-longitude position, the magnetic declination and the name from the data base containing the NAVAID data file. This feature is important in that its use greatly speeds processing and reduces manual typing errors by minimizing the data entry operations performed by the cartographer.

#### *Computational algorithms and geodetic models*

All computations are based on solutions of the geodetic direct and inverse problem, after T. Vincenty, and the modified Rainford method with Helmert's elliptical terms. The unique intersection computation is based on equations from a publication of the United States Naval Oceanographic Office and on work by

Thomas.[1] Forward and inverse computations are effective at any distance short of antipodal. Intersections computations are limited to 1,000 nautical miles for accurate results. All computations are effective in any hemisphere and at any azimuth.

The computational subsystem currently contains eight geodetic spheroid models. Airy; Bessel, Clarke 1858; Clarke 1866; Clarke 1880; Everest; Fisher; International.

## Data management subsystem

The data management subsystem supplies data to the cartographer and the computational subsystem upon request. The data are used for chart compilation and the preparation of supplementary materials, and are also supplied to the Federal Aviation Administration computer centres for use in real-time radar display for air traffic control purposes.

### *Data-base structure*

The data-base contains data files for NAVAIDS, obstacles, reporting points, RNAV waypoints, air traffic control centre boundary points, all national air route models, Standard Instrument Departure (SID) procedures, Standard Instrument Arrival Routes (STAR) and the air route traffic control centre models.

The data base itself is divided into a master data set and an auxiliary data set. The master set contains charting-oriented but chart-independent data; that is, data that may apply to several charts and/or supplementary products. The auxiliary set contains references to specific chart products and is used to link related items in the master data set. This allows the product data to be maintained separately from the product independent data so that the product independent data will not become product-oriented. As an example of an advantage to this approach, geographical position data are stored in the master set only once and can be used in as many products as required, which greatly reduces data storage requirements and, therefore, system operating costs. Another advantage of this technique is that the product information is maintained separately, thereby permitting changes to be made to individual products without making changes to the chart-independent entries.

The master data set is a type of indexed sequential file on disc storage; the auxiliary data set is a strict direct-access file which is also on disc storage. The auxiliary set is used for stacking, chaining and indexing entries to the master data set. For example, as an airway becomes longer over a period of time, more storage area is required on the disc, and cells in the auxiliary data set are linked together to accommodate the extra area. The data-base structure is illustrated in figure 96.

### *Data-base update and affected charts*

As data are added, changed and deleted from the data base, groups of charts are affected depending upon their geographical coverages. The identification of affected charts is determined by reference to a 1° × 1° square grid network defined upon the geographical area bounded by the United States border. The 1° squares are used as an index to a list of charts for which coverage is affected by the 1° square. Each entry in the 1° square cross reference contains pointers to chart records which store such information as chart corner positions and type of data on the charts. If a data item changes, the degrees of latitude and degrees of longitude are joined; and the resulting number is used as an entry point into the cross reference, thereby limiting the search to only those chart records affected by a change within the 1° square.

The corner co-ordinates of each chart are then used by a polygon search routine which determines if the change lies within the chart by testing as few as two sides of the chart boundary. In general, the software makes a gross determination of the area of the change and searches only those charts which overlap the related grid square. This procedure permits the system to determine quickly and accurately all charts affected by data updates made to the data base.

## Chart construction

### *Polygon search*

The cartographer can use the polygon search directly by issuing the appropriate command and providing the identifier of the chart of interest. The system uses the identifier as a symbolic address of the data record in the chart data file. This process greatly reduces the amount of manual input required to compile or recompile charts.

The cartographer simply provides the chart identifier, the remaining parameters are taken from the chart record and the search is applied to the data base.

### *Circle and slope searches*

The system contains other sophisticated data-retrieval commands which allow convenient operation by the cartographer. Table 51 contains a summary of the search commands and their main functions. Note the commands for the CIRCLE, SLOPE, DISAZ and HELP functions.

Using these commands, for example, a cartographer can define a geographical circle centred on the vertex of an inverted cone. The system will search the data base and retrieve only the data (usually obstacles to flight in this case) that lie within the circle and also penetrate the cone. This method is especially useful for compiling Instrument Approach Procedure Charts with the circle centred on the end of a runway. This process is illustrated in figure 97.

### *Command list and file independence*

An important system design concept was used in the implementation of the data-base search techniques. Commands are collected into a list as they are entered into the terminal and are stored independently of the data files.

This list of active commands may be added to or

[1] P. D. Thomas, *Spheroidial Geodesics, Reference Systems and Local Geometry*, Scientific publication No. 138 (Washington, D.C., Naval Oceanographic Office, 1970), pp. 63–86.

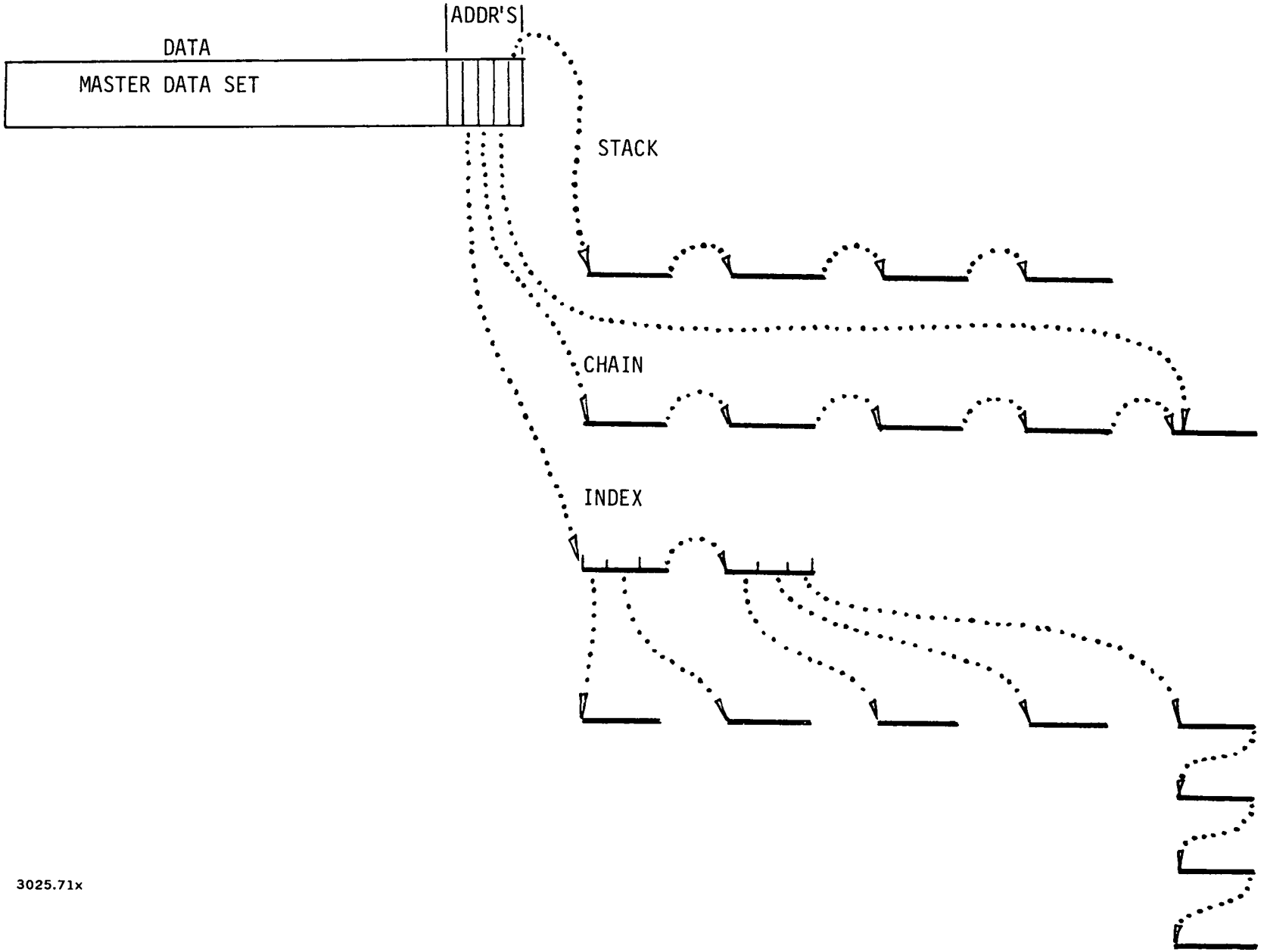
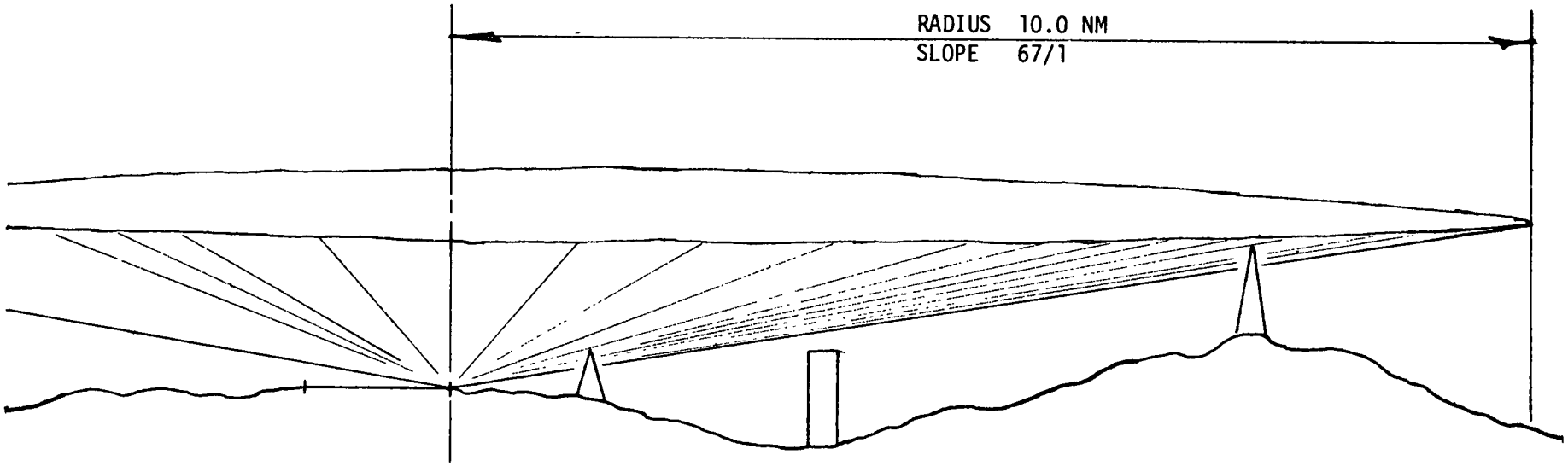



*Figure 96. United States of America: data-base schematic structure*




312

CIRCLE LAT 33 45 16.2 LON 99 10 56.2 RADIUS 10.0 *
SLOPE LAT 33 45 16.2 LON 99 10 56.2 MSL 210 SLOPE 67

3025.72x

*Note*: Drawn foreshortened.

*Figure 97. United States of America: circle-slope data-retrieval model*

**Table 51. United States of America: summary of data management subsystem search commands and functions**

| *Command* | *Function* |
|---|---|
| ACODE | Search by code letter for latest action |
| AGL | Search by height above ground level |
| CANCEL | Cancel active commands |
| CIRCLE | Provides capability for a circle search |
| CLEAR | Clear active operands of a command |
| DEC | Provides computation of magnetic variation |
| DISAZ | Provides computation of forward azimuth, back azimuth, and distance to station |
| DISPLAY | Provides a list of active commands or operands |
| END | Ends find 1 |
| FREQ | Search by frequency of charted AM radio stations associated with an obstacle |
| HARTCC | Search by selected high ARTCC areas |
| HELP | Invoke help processor |
| JDATE | Search by Julian date of latest action |
| LARTCC | Search by selected low ARTCC areas |
| LAT | Search by latitude |
| LON | Search by longitude |
| MSL | Search by height above mean sea level |
| NAME | Search by alpha-numerical name |
| PRINT | Determines if the listing from a search is to be displayed or spooled-off for printing |
| SET | Provides a gate for selected data to be applied and interrogated by the pre-determined search |
| SLOPE | Designated approach slope cone. |
| STATE | Search by selected states |
| STONO | Search by Federal Aviation Administration (FAA) aeronautical study number |
| STROBE | Search by strobe-lighted obstacle |
| TYPE | Search by type of obstacle or facility |

modified by the cartographer as he uses the system to retrieve data. The command list is applied as a unit to the data files of interest. The advantage of this technique is that active commands need not be re-entered each time the data file of interest changes. When in doubt as to the contents of the command list, the cartographer may issue the DISPLAY command which causes the computer to list all active commands.

*HELP: the self-training command*

A unique feature of the CONDOR system is the tutorial facility provided by the HELP command. A cartographer with no more training than the information given in table 51 can use the HELP feature to ask questions about how he should proceed to operate the system.

The HELP feature is structured in two ways: additional information about a particular command and its use can be immediately obtained by typing the word "HELP" into the data terminal followed by the name of the command; and general information about the current active command may be obtained by typing the word "HELP" without following it by a command name. In this manner, the system can prompt the new user when needed, while allowing the experienced user to proceed at his own speed without extensive prompting messages.

### Future plans – computer graphics

Current work on the CONDOR system is directed towards interfacing an interactive computer graphics cathode-ray tube (CRT) capability in order to provide visual checking of output. Plots of airways, navigational aids, obstacles and other important items will reduce the chance of human error in chart compilation.

### Conclusions

The CONDOR system has shown that significant benefits can be obtained by applying computer technology to the task of producing aeronautical charts. The system is in use at the National Ocean Survey and at the National Flight Data Center of the Federal Aviation Administration, and is planned to be installed on computers belonging to other chart producers and commercial airlines. It has also been utilized by the United States Air Force, the Federal Communications Commission and the Customs Service. The most important benefits have been: (*a*) increased accuracy of geodetic computational results as applied to aeronautical chart construction; (*b*) standardization of the use of geodetic computational methods of cartographers; (*c*) built-in levels of quality control with respect both to computational tasks and to aeronautical data validity; and (*d*) a reduction in the amount of human error by consistently applying the same automated operations to repetitive tasks.

## BUILDING A NATIONAL CARTOGRAPHIC INFORMATION CENTRE*

*Paper presented by the United States of America*

In the United States of America, over 30 government agencies actively collect or prepare and distribute cartographic data, including aerial photographs and space imagery, maps and charts, and geodetic survey data of the country in support of their operational missions. Federal agency output has represented an investment of more than $1 billion over the past decade (a reported $250 million in 1972).

As the complex problems of land use, resource development, energy development and conservation of environment are pursued with increasing urgency, the demands for cartographic data continue to increase. Both

* The original text of this paper, prepared by J. R. Swinnerton, Chief, National Cartographic Information Center, United States Geological Survey, appeared as document E/CONF.68/L.50.

experienced users of cartographic products and new users are facing a bewildering task in locating the cartographic data that suit their needs. Decisions are sometimes made without the best data because they were not discovered. Critically valuable time is lost in searching out the many sources of data, and in some cases the same data are obtained from different sources.

The National Cartographic Information Center (NCIC) was established by the United States Geological Survey (USGS) to solve the problem of poor accessibility of cartographic data. The following discussion reports on progress to date and plans for continuing development. NCIC has four major missions:

1. To inventory multipurpose cartographic data, such as maps and aerial photographs, that are available for the United States from government and commercial sources;

2. To organize information about the data and make them conveniently available to users;

3. To help users obtain needed data, a service which includes taking orders for data held by co-operating organizations;

4. To publicize the availability of cartographic data to potential users.

## Operational procedure

### *Types of cartographic data included*

NCIC interests include the products of federal and state government mapping and surveying agencies and also the products of private or commercial firms. Some specific products are:

(a) *Multipurpose maps and charts*:
- Aeronautical charts
- Bathymetric maps
- City maps
- Extraterrestrial maps
- Flood-plain maps
- Forest maps
- Geological maps
- Highway maps
- Land-use maps
- Map and chart feature separates
- Nautical charts
- Orthophoto maps and orthophotoquads
- River surveys and dam-site maps
- Slope maps
- Soil maps
- Topographic maps

(b) *Survey data*:
- First- and second-order control[1]
- Third-order control from any useful source
- Selected fourth-order control
- Photogrammetrically established control
- Selected private survey control
- Land plats
- Census subdivisions

(c) *Aerial photographs and space imagery*:
- Photographs
- Satellite computer-compatible tapes
- Photo mosaics
- Other remote-sensor data

(d) *Closely related data*:
- Cartographic and educational materials, such as atlases, gazetteers and related literature
- Digital data representing detail on maps and charts
- Geographical names

### *Services provided by NCIC*

For each of the above-mentioned categories, NCIC will eventually acquire and distribute as many as three levels of information: the master record; the summary record; and the unit record. The master record provides a description of a series of similar products (such as a set of maps on the same scale) and includes a reference where more detailed information on the series can be obtained.

The summary record provides the geographical coverage or the areas for which a particular series of products is available so that a prospective user can determine whether his area of interest is covered.

The unit record identifies individual products, such as single photographs or a particular map-sheet. The unit record provides a user with all the information needed for selecting and ordering from the agency or firm that can supply it. The level of information (master, summary or unit) that NCIC will acquire and disseminate depends upon the estimated worth of the information, the cost of acquisition and the resources available.

## Organization

NCIC headquarters at the Geological Survey National Center, Reston, Virginia, contains both an active information office and the management centre for a network of information centres and data repositories.

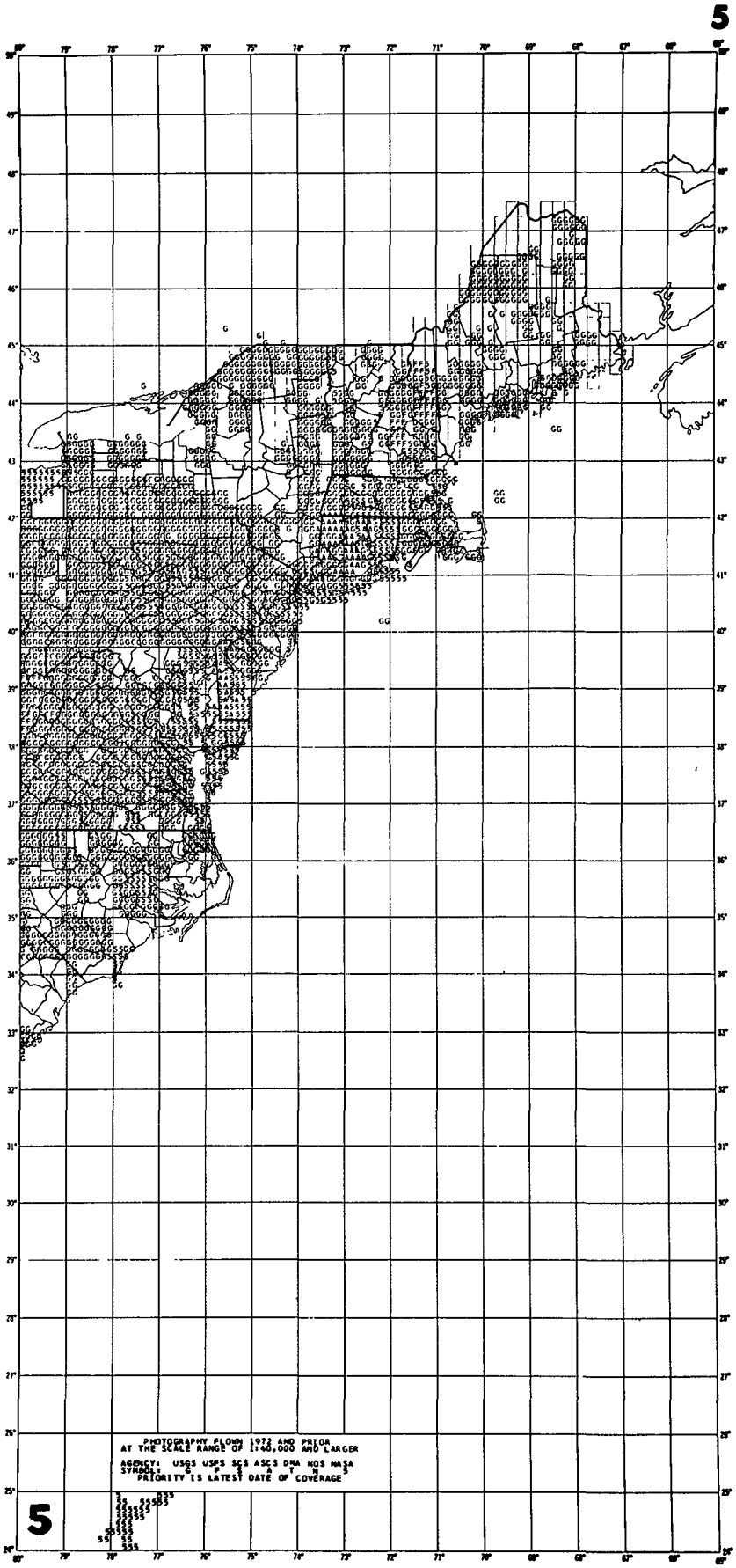
To supplement and localize the national programme, regional NCIC centres are being established in each of the four USGS mapping centres, in Reston, Virginia; Rolla, Missouri; Denver, Colorado; and Menlo Park, California. Each NCIC centre will provide the full array of NCIC functions.

It is also planned to establish co-operative NCIC offices at the state level. Arrangements will be made with local offices of state or federal agencies to house and staff the state centres in return for direct access to NCIC information for that state. The state of Texas, through the Texas Water Development Board, has formalized an agreement with USGS to sponsor the first state NCIC office.

## Interagency co-operation

Representatives from 27 federal offices and four professional societies met in August 1974 at the invitation of

[1] Most data will be held and distributed by the National Geodetic Survey Information Center (NGSIC) of the National Oceanic and Atmospheric Administration (NOAA). NCIC will provide additional access.




3025.73x

*Figure 98. United States of America: Aerial Photography Summary Record (APSR)*

USGS to discuss co-ordination of effort in collecting and distributing cartographic data and plans for NCIC activities. A common theme throughout the discussions was the need for continual liaison so that NCIC could respond to comprehensive needs.

A critical need identified by the conference participants was a central point for information on aerial photographs. Unlike maps, aerial photographs can be obtained rapidly with little or no ground alerting—a condition that easily leads to duplication of effort. The Aerial Photography Summary Record System (APSRS) was developed to meet a specific expressed need. The computer-based system accepts information on aerial-photo projects whether planned, in progress or past, stores the information in terms of 7½-minute quadrangle areas and provides text and graphics (figure 98). The text includes typical aerial photography parameters, such as scale, emulsion, geographical area and date.

The conference was followed by visits to 20 agencies and the drafting of agreements that detailed the responsibilities of NCIC and each agency. By June 1976, agreements were signed with many agencies for cartographic data, and separate agreements on geodetic data and aerial photographs were signed with NOAA. Draft agreements with additional federal agencies are at final stages of review.

With the active co-operation of these agencies and other organizations in the cartographic community, NCIC is making cartographic data more accessible to users in the United States of America.

## THE DYNAMICS OF GEOGRAPHICAL NAMES IN ASIA AND THE PACIFIC*

*Paper presented by the United States of America*

Sophisticated techniques of imagery acquisition and cartographic production currently hold the attention of cartographers, and it is all too easy to overlook the continuing importance of geographical names to maps and charts. Names are, however, essential to cartographic products; and cartographic managers concerned with geographical names are hard-pressed to keep informed about developments affecting names and to employ specialized techniques of dealing with them. Changes in existing names and additions of new names must be dealt with if this aspect of cartography is to be maintained at acceptable levels of accuracy and adequacy.

Commonly thought to be a relatively stable phenomenon, names, to the contrary, are subject to change. Countries are born, and old names are abandoned in favour of names more acceptable to authorities. New settlements are established and extant cities merge and acquire new identification. Increased geographical knowledge results in new features to be named. In addition to such relatively obvious factors of change, decisions by Governments to employ new spelling systems can have a wholesale impact on geographical names by making repositories of name information suddenly obsolete. Changes in geographical names occur in all parts of the world, but perhaps nowhere are they as noticeable as in Asia and the Pacific.

Changes in systems for spelling names in the Roman alphabet are having a particular effect on geographical names in Asia and the Pacific. One country that has a non-Roman alphabet has promulgated a Roman-alphabet spelling system which it has declared official for both internal and external use. Another country has adopted a Roman-alphabet system which differs significantly from one long in use. A third country, which uses the Roman alphabet, has developed a new system for spelling its geographical names. Other instances of change also can be cited.

This paper discusses the character of some of the changes occurring in Asia and the Pacific, and describes the effect such changes are having on cartographic programmes and on communication in general. The involvement of the United Nations in geographical names programmes is also discussed.

### IMPORTANCE OF GEOGRAPHICAL NAMES IN THE CARTOGRAPHIC PROCESS

#### *Communication of information*

Geographical names are an indispensable part of human communications dealing with territory. Whether these communications are graphic or textual, names provide the key to a comprehension of the message. In the case of cartographic products, geographical names serve to locate and describe physical and cultural features, and to inform the user about the nature of the area covered. Names also permit the user to develop conclusions regarding the geographical character of places and to make analyses for a broad range of requirements.

As enunciated by United Nations conferences on geographical names, identification of features is best accomplished when each individual feature is known by only one name. Unfortunately, this ideal is not always attainable. For example, in some countries, the official status of two or more languages may mean that places will be known by two or more names. In countries where a single language is employed, local names may differ from official versions. Also, certain well-known places in a country may be identified by different names in

* The original text of this paper, prepared by Richard R. Randall, Executive Secretary, United States Board on Geographic Names, appeared as document E/CONF.68/L.51.

languages used in other countries. In addition, names are subject to change as a result of the birth of new countries, the establishment of new cities, the official adoption of new writing systems and other factors. Such diversity of names and the continuous changes affecting them challenge map-makers and chart-makers, and the requirement to show accurate and up-to-date names can assume an unexpectedly high proportion of research, compilation and production costs.

### *Sources of names*

In the ideal mapping situation, the compiler would consult a single source from which to select name information. The best single source obviously would be a map produced by the official national cartographic body that contains a full complement of up-to-date names which are correctly spelt and accurately located. The source also should indicate by type style, colour or some other unambiguous means the type of feature which the name identifies. When generic terms are part of the name, they should be included on the source. Lastly, the material should present all names and associated information in the language to be employed by the compiler.

Clearly, such ideal circumstances rarely exist. Even in the compiler's own country, it is quite unlikely that a single map series could provide such accurate information. Constant changes in, and additions of, names would in any case make any series out of date in a short time. The production of information on names to match the levels of quality required for other map specifications, therefore, may necessitate procedures other than those normally exercised by the compiler. Instead of utilizing one or a few sources, the compiler may have to engage in considerable research, and rely not only on cartographic items but on such documents as census reports, statistical pamphlets, textbooks and other publications that contain information about place-names. The very complexity of trying to stay abreast of names is, in fact, one of the primary concerns of the United Nations, and is the principal reason for international programmes to establish national bodies to develop and make available standardized information about names to interested users. Until such practices are established, cartographers will have to rely on available sources and to engage in toponymic research for the sake of adequate name information.

### *Cost of preparing names*

In the traditional environment of cartographic compilation (with manual techniques to accomplish initial design, scribing, selection and application of names and editorial functions) the cost of preparing the names plate may be upwards of 20 per cent of the total compilation cost. Such a cost can be expected even when names are available from one or two sources, and when little if any additional research is required. If sources of names are incomplete, out of data or otherwise less than adequate, then compilers must turn to alternative sources, with a resulting increase in compilation costs. Perhaps the most vexing aspect of foreign sources is working with materials printed in a writing system other than that to be ultimately employed. In this case, transliteration systems must be employed to produce names the intended user can read—with a further increase in costs.

### *Automation*

The advent of automated processes for names promises certain advantages to cartographic production. When computer equipment and programming time are available, a bank of names and associated information on names can be established and maintained in a current status, as new information is added and extraneous or incorrect data is culled. It is possible to select information on names according to category of feature, by area, by order of magnitude or by any other criterion previously registered in the bank. Furthermore, with a complete range of type styles and diacritical marks available, lists of names can be printed automatically on wax-backed paper for application to the type plate. Alternatively, by using a photo-head to project names information on a light-sensitive base, the type plate can be created directly from the computer data file.

The availability of automated processing equipment, however, can speed up only certain phases of name compilation, principally the post-research phase. Until single sources of geographical names are produced to meet mapping requirements, toponymic research is necessary. Once the research is completed and a composite file of names is established, automatic data systems can afford substantial economies. Benefits can be realized in file maintenance, in the exchange of names data; and in the manipulation of data for use in a variety of cartographic products, the preparation of glossaries and place-name indexes, and geographical analyses.

## Scope of Names in Asia and the Pacific

### *Number of names*

It is difficult to calculate the total number of geographical names in an area as large and culturally diverse as Asia and the Pacific. Taking into view the many physical and cultural features that have names (irrespective of whether all names have been officially recorded), there must be many millions. Furthermore, new names continuously manifold themselves in inhabited and uninhabited places alike. Mapping programmes designed to provide large-scale coverage for areas reveal features that for the first time may require names. Newly founded towns and settlements need names. Exploration of undersea areas results in the identification of undersea features which require names. Under these conditions, it is difficult to imagine any cartographic product or any repository of information that could portray all the geographical names in the area.

### *Names and languages*

In Asia and the Pacific, there is a rich variety of languages and writing systems with which cartographers must contend. There are systems based on letters and those based on ideographs; and, in addition, there are some languages which are spoken only and have no

writing system. A publisher of cartographic products covering such areas must in some way convert these systems to an alphabet that his intended audience uses. This problem was recognized decades ago when publishers began to create products to meet a growing demand for information about other countries. To a large degree, it was scholars from a few countries who recognized the need for systems to convert from one language to another if general goals of communications were to be served. The establishment of conversion systems generally was of benefit to all parties, for they permitted avenues for the exchange of ideas. The work of scholars subsequently was exploited for cartographic purposes. The presence of conversion systems often lead to their acceptance by local populations, either as the dominant system or as a partner system. In any event, the use of specific conversion systems by publishers for certain areas, with time, became rather firmly fixed. Publishers also employed spellings of names of well-known features which had evolved over a period of many years. Such names are frequently referred to as "conventional" names. For the publisher with a one-language market, the languages and writing systems of Asia and the Pacific represent a difficult challenge.

## THE ELEMENT OF CHANGE

### *New names*

Changes in names generally are caused by three major factors. First, new countries are born, and individual names associated with previous sovereignty may change. Secondly, new names are required to identify new features. New features on the floors of the seas are delineated and named as oceanographic exploration proceeds. New towns are established and are named. The growth of existing centres of population often results in their coalescence and in the requirement for a new name, either in hybrid or in totally different form. The third and single most important factor is "systemic", and is caused by the introduction of new systems by which names are spelled or written. These systems fall into three categories: basic modifications of the existing spelling system employed in a particular country; local adoption of a conversion system in substitution of one already used by other countries; or local adoption of a new system of writing. Several examples of systemic changes can be found in the area of interest to this conference. Three are described below.

*Modification of spelling*

In 1972, Indonesia and Malaysia, which employ the Roman alphabet, jointly announced a spelling reform to eliminate differences in the spellings of names as practised in those countries. The degree of change for Indonesia is greater than that for Malaysia, and the modification of initial letters alone in Indonesia will affect over 12 per cent of the names. If changes to frequently occurring generic terms also are considered, it is evident that relatively few names will escape modification. Some examples of the new spelling as it affects certain names are given below:

| *Former spelling* | | *New spelling* | *Examples* |
|---|---|---|---|
| *Malaysian* | *Indonesian* | | |
| ch | tj | c | Machang or Matjang becomes Macang |
| j | dj | j | Djakarta becomes Jakarta |
| sh | sj | sy | Shah or Sjah becomes Syah |
| y | j | y | Jogjakarta becomes Yogyakarta |

Although cartographers and others concerned with geographical names in this part of the world can "mechanically" convert names, problems remain. For example, the effect of the reform on Chinese place-names in Malaysia has not yet been fully determined. At the same time, the combinations of letters may not result in the sounds that ostensibly are desired by authorities promulgating the reform. Since the Malaysian and Indonesian languages taken together constitute one of the major tongues of the world, being used by more than 120 million people, the impact of the spelling reform is appreciable, not only to nationals of those countries but to all countries using the Roman alphabet.

*Local adoption of conversion system*

Representing the second class of change is the romanization system recently adopted by the Republic of Korea. Increasingly used in English-language publications in that country, and for road and railway signs, the system (promulgated by the Ministry of Education and referred to as MOE) is used locally in preference to the McCune-Reischauer (MR) system, which has been used extensively by the English-speaking world and by many Roman-alphabet countries. (The use of the MOE system in no way changes the official status of the traditional Korean writing form, but instead it is designed to provide all Roman-alphabet users with a single system which has local sanction.) The difference in spelling affects a high percentage of names, some of them radically so. The way that some names appear in both systems in the Republic of Korea is illustrated below:

| *McCune-Reischauer (MR) system* | *Ministry of Education (MOE) system* |
|---|---|
| Pusan | Busan |
| Chon' Puk | Jeonbug |
| Padŭri | Badeuli |
| Kyŏngch' ŏn | Gyeongcheon |
| Sisŏk | Sinseog |

*Local adoption of new writing system*

The most dramatic recent development affecting geographical names is the programme announced by China to adopt a Roman-alphabet script. Presumably the new system will eventually replace the traditional ideographic writing; and currently it is being used increasingly in schools, in publications and in communications. English-language documents published by China regularly employ the new system, called "Hanyu Pinyin". The system was first developed in the 1950s, and it changes virtually all names in that country previously spelt according to other romanization systems. Perhaps the romanization system most widely employed for the Chinese language is the Wade-Giles system which was first devised late in the nineteenth

century, and with certain modifications, has served much of the Roman-alphabet world, particularly the English-speaking countries since that time. The Hanyu Pinyin system at first glance appears to approximate the Wade-Giles system, but close analysis reveals that the changes are rather fundamental and affect a high percentage of names. Several names spelt according to the two systems, along with the conventional English versions, are:

| *Wade-Giles* | *Hanyu Pinyin* | *English conventional* |
|---|---|---|
| Pei-ching | Beijing | Peking |
| Ch'ing-tao | Qindao | Tsingtao |
| Fu-chou | Fuzhou | Foochow |

### *Response to change*

Widespread and systematic changes, of course, oblige map publishers to make decisions. Should they follow the new procedures as soon as they are announced? Should they wait to test the reaction of other publishers? Should they attempt to convert in a gradual fashion? Or should they take a position of retrenchment and preserve the systems to which they and, presumably, their users are accustomed? If cartographic publishers want to change, can they be assured of acquiring adequate toponymic information? Apart from the impact on cartographic publishers, broad-scale changes in names affect a wide range of other institutions engaged in reference publishing and library work. They too must weigh the consequences of change. Library systems employ catalogue cards that identify foreign places for many reference purposes, and the alteration of even a single name can affect literally hundreds of libraries that use catalogue cards based on the same system. Furthermore, the problem of existing reference works that simply cannot be changed must be taken into account.

## Conclusion

Few if any countries within the region of Asia and the Pacific are immune to changes in geographical names; and given the vast land areas involved and the equally vast numbers of geographical names to take into account, it would appear that publishers would have to revise their products annually to keep current.

Although changes in geographical names may be the inevitable result of today's world, it is to be hoped that name changes of the systemic type might be carried out in a fashion to avoid, as much as possible, sudden and widespread obsolescence. In the final analysis, the purpose of geographical names is one of communication—the transmission of information about places on the earth (or on other cosmic bodies such as the moon.) When depositories of geographical information are precipitously rendered inaccurate because names identifying geographical features are changed by local authorities, the cause of communication is not well served.

The United Nations, among other international organizations, is keenly aware of the need for co-operative efforts to effect methods of dealing with changing geographical nomenclature that will ultimately improve international communications. Certain countries with common problems already have developed useful standardization programmes to meet their mutual requirements. In international and binational discussions on geographical names, it might be beneficial to all if some attention were paid to the effect that name changes will have on users. If this is done, then both parties in the communication link can work to develop systems that will be beneficial to those most directly concerned. The dynamics of geographical names in Asia and the Pacific would appear to make this action essential.

# AGENDA ITEM 8

## Cadastral surveying and mapping (including urban mapping)

### CADASTRAL SURVEYING AND MAPPING (INCLUDING URBAN MAPPING) IN BANGLADESH*

*Paper presented by Bangladesh*

According to the most recent census, taken in 1974, the area of Bangladesh is 55,598 square miles with a population of 71,479,071. Obviously, it is one of the most densely populated areas of the world.

The administrative units of the country and the number of each category are: divisions (4); districts (19); sub-divisions (59); police stations (433); unions (4,055); and *mauzas* (villages) (64,493).

The main unit of cadastral surveying and mapping is the *mauza*, which is a regularly constituted and notified unit. The cadastral mapping of these units is generally done on the scale 16 inches to 1 mile, which is 1 : 3,960. The more congested areas, such as the market-places and the townships, are mapped on the scale 32 inches to 1 mile or 64 inches to 1 mile, according to their importance and the requirements. The municipal area of the capital city, Dacca, is mapped on the scale 80 inches to 1 mile.

Through Regulation I of 1793, the permanent settlement of estates was brought into effect and the land revenue of each estate was fixed for ever. The permanent settlement was not, however, made on the basis of any definite maps prepared for the purpose. The only maps that were then in existence were those of Major Rennell, which were purely topographic maps and did not show the boundaries of the estates; still less did they show the boundaries of villages, tenancies or fields. It was not until about 50 years after the permanent settlement that the Government began the Revenue Survey of Bengal; it was completed in 1878. This was the first scientific and professional survey, generally on the scale 4 inches to 1 mile. The maps showed the boundary of each village or *mauza* as a well-recognized territorial unit. About seven years after the Revenue Survey — in 1885 — the Bengal Tenancy Act was passed. In accordance with the provisions of this Act, survey and settlement operations began in 1898 and were systematically carried out in all the districts of the area then comprising Bengal, excluding the districts of Darjeeling and the Chittagong Hill Tracts, and the city of Calcutta. The mapping system in vogue changed considerably in the course of the operations and the Settlement Department assumed complete control of the cadastral survey under the Directorate of Land Records and Surveys. Previously, the Director of Surveys of the Survey Department had been responsible for the surveying and mapping part of the operation and the Director of Land Records had undertaken the preparation and building-up of the record of rights for settlement purposes. The record of rights (known as *khatians*) shows the rights and title of the owners on their lands and their liabilities to the Government for their holdings. These records of rights, therefore, serve beautifully as the elaborate register of all lands of the country, their ownership and the total land revenue to be desired. The classification of every piece of land is also recorded. This piece of information is of vital importance in the planning of land-use patterns and for development activities.

*Cadastre* is an old French word for a public register. The word, therefore, indicates the record of rights rather than a map. True to its meaning, the cadastral survey and settlement operations in Bengal were undertaken to prepare a correct record of rights for each part and parcel of land and to determine its revenue to be paid to the Government. The detailed maps had to be prepared showing all the plots of lands with their special features to serve as an adjunct to the record of rights of the *mauzas*. The result has been that almost the entire area of what was then Bengal had perfect sets of maps for each village.

When a district was taken up under the cadastral survey and settlement operation, the various stages of work required about five years to complete. In the first year, the Survey Department made a traverse survey of the area. One or more large polygons, known as the "main circuit", were first laid out. Currently, the main circuit covers more or less the area of a police station. The main circuits were then divided into subcircuits; and lastly, the subcircuits were divided into smaller polygons, one for each *mauza*. In large villages, the traverse surveyors ran Subtraverse lines at places through the village polygon to supply more control to the detailed survey workers. Theodolites and chains were used for this type of control survey work. The framework thus prepared was connected with the pre-existing fixed stations of the Great Trigonometrical Survey of India.

In the second year, the land surveyors (who are known

* The original text of this paper, prepared by M. A. Jabbar, Director of Surveys, Directorate of Land Records and Surveys, Bangladesh, appeared as document E/CONF.68/L.122

as *amins*) were supplied with plot-sheets prepared on the basis of the framework mentioned above, in order to begin the detailed 16-inch mapping of the village. This work is in reality known as the "cadastral survey". With the completion of the detailed survey by the chain survey method, necessary checks in the field were made and the sheets were passed for inking in blue. Bearing in mind the purpose for which these maps were prepared, the land surveyors required to have sound knowledge of the use and control of the land which is being surveyed, as they make the village maps and plans. It is they who are then called upon to build up the record of rights at the first stage on the basis of the maps prepared by them at the ground level. The other different stages for the finalization of the records continue for the next two years. The village maps were then sent to the central Drawing and Printing Office in the Directorate for their reproduction.

The system has been working admirably well since the beginning of the twentieth century. In Bangladesh, the organization in the Directorate of Land Records and Surveys has been further streamlined to handle effectively all the requirements of cadastral surveying and mapping, and the building-up of the records of rights for the entire country. The Director General of Land Records and Surveys co-ordinates the activities of the two branches, i.e., the Survey Branch and the Land Records Branch. So far, very senior Civil Servants with a full knowledge of land administration and land reforms and with some knowledge of surveying have been called upon to hold the post of Director General.

Leaving aside the very elaborate process of preparation, letter-printing and the distribution of the millions of records of rights to all owners of land, the activities of the Survey Branch engaged in the surveying and mapping for the purpose are described below.

The Survey Branch of the Directorate of Land Records and Surveys is headed by the Director of Surveys; this post has been filled by officers with a thorough knowledge, training and experience in surveying and mapping. All survey works undertaken by the Directorate are conducted under his guidance and supervision. The reproduction of the village, urban and other administrative maps is also done under his supervision.

As has been mentioned before, the basic maps are the large-scale *mauza* maps on the basis of which other maps are largely compiled in the Directorate of Land Records and Surveys. The *mauza* maps contain very many details, in particular, all the small property boundaries. These maps are first reduced to the scale 4 inches to 1 mile by Pantograph in order to compile the union maps where the periphery of the *mauzas* and the human settlements are shown with other important details, such as roads, canals and tanks. Several *mauzas* comprise a union. These maps are further reduced to the scale 2 inches to 1 mile. These maps are not generally used to compile any administrative unit maps. On further reduction to 1 inch to 1 mile, the police-station maps are compiled, where the village boundary with its name and jurisdiction list number and other details (communication etc.) are only shown. The next smaller scale maps are the district maps where the police-station and sub-division boundaries with other vitally required details are shown. The country map of Bangladesh is compiled from these maps on the scale 1 inch to 8 miles. The different administrative unit maps compiled from the basic *mauza* maps may very well be called the by-products of the survey and settlement operation but they are very important and useful by-products indeed. These maps are widely used in the day-to-day administration of the country as well as in the development activities that are increasingly being undertaken in Bangladesh.

It has to be said that the cadastral maps of the villages were prepared long ago and need revision and updating very badly. That work has been undertaken in Bangladesh on a perspective plan. Thus far, the revisional work in three districts is almost complete and the process is under way in two other districts. it will follow in cycle. Though it is customary that the revisional work should be taken up every 20 years, this goal has never been achieved. It is keenly appreciated that the gap of revision of the maps and records should not be more than 25 years in order to keep pace with the growing population and the intense development activities that are being undertaken in Bangladesh. It is hoped that from now onwards the revision cycle, with that end in view, will be continued.

On the matter of modernization of the methods of survey and the introduction of more automation, it may be mentioned that in Bangladesh it would sometimes be preferable to depend more upon the conventional methods, at least for large-scale cadastral mapping, because there is no dearth of human labour in Bangladesh. They are constantly being trained to handle the jobs in the conventional way without introducing different equipments. Of course, whatever improved instruments and methods are available to run the jobs in the conventional way but more effectively are gradually being introduced. The Directorate is mindful of the fact that for many years now aerial photography has been used in the production of topographic mapping at small scales, but it is only recently that improvements in photogrammetric techniques and machinery have permitted these processes to be considered for cadastral surveys at much larger scales. The inherent weakness of the aerial photograph unsupported by any type of vigorous survey or mapping, as a means of identifying or re-establishing boundaries are also well known. It is rather difficult to award a title to land on the basis of these maps. Then again, "geodetic" accuracy is not necessary for the recording of a boundary position; "graphic" accuracy is good enough. The first need is the physical demarcation of the boundaries, either by cut-lines, fences, ditches and the like, or by artificial beacons at the turning-points between which a line can physically be demonstrated if the need should arise.

It is also known and kept in view that the scales of the maps will have to be changed when the metric system is introduced in Bangladesh. The current map, on the scale 16 inches to a mile (1 : 3,960) can quickly be converted into maps at 1 : 4,000 scale without much difficulty. With

the growth of population, increase in land value and change of land-use pattern, it is felt that the basic maps should be of still larger scale. The ideal scale for these maps would have been 1:2,500, but that scale would entail a lot of survey work which may not be possible to venture at the moment, although it has certainly been kept in view. The other administrative unit maps, when required, can be changed to suitable scales.

Bangladesh is a plain flat land with hardly any appreciable change of heights in most of the area. Even so, to meet the demands of current development activities in all spheres, the depiction of contours or at least from lines with spot heights, may have to be introduced in the *mauza* maps. This matter is under active consideration; and it and the question of uniform symbolization have been experimented in the preparation of the strip survey maps of the boundary between Bangladesh and India. All these elements have shown up very well in these strip maps on the same scale-16 inches to 1 mile.

The survey and settlement operation was never before extended in full scale in the one district of Chittagong Hill Tracts in Bangladesh. It is being increasingly felt that the operation will have to be undertaken in that district also within a very short time. It is going to be a major operation requiring modern survey methods in conjunction with the conventional plane-table surveying.

The Directorate of Land Records and Surveys, Bangladesh, is keeping itself fully aware of all the requirements listed above and will be in a position to report in detail on the achievement made on all these matters at the next Conference.

## THE CADASTRAL MAP AS A BASIS FOR PLANNING AND STATISTICS*

*Paper presented by the Federal Republic of Germany*

The cadastral map is intended to be used by a number of offices and agencies in carrying out their planning and statistical activities. Since, however, the cadastral administration cannot provide a map capable of meeting all the demands of potential users, the maps it offers should merely be regarded as basic information sheets. The contents of these maps are classified into four information groups. Taking this as a basis, the users may enter into the maps their own specific data, thus obtaining thematic maps. The various ways of assembling basic information sheets with the special information required are described in this paper.

Special attention should be given to the maintenance and revision of the data represented in the cadastral maps. This task should not be neglected, as the interested parties need to have the most recent information available. If the cadastral administration is not able to deliver updated cadastral maps, some users might produce their own basic information sheets, which should be avoided because it could lead to disorganization.

### THE CADASTRAL MAP AS A BASIS FOR PLANNING AND STATISTICS

The results of a cadastral survey are shown in registers and maps. The content of the cadastre depends upon the purpose for which it was designed. Currently, it is commonly agreed that the cadastre should be multipurpose in nature; in other words, it should not only serve the purpose for which it was intended but should be of use to other agencies and offices whose jobs are connected in one way or the other with the land. In early times, cadastral maps normally only indicated the boundary outline. In due course, however, other agencies and offices came to recognize the value and possibilities of cadastral registers and maps. Thus, with the growing cultural and industrial development of a country, there was an increased demand for large-scale maps. An outline of the boundary lines was no longer sufficient, and more topographic details were required. Information was needed on the position of houses as well as on the value of the cultivated areas. Public administration offices must determine and group a population according to its dwelling sites. Urban planning agencies need planning maps for urban research and for sewerage and sewage treatment; land reform offices need large-scale maps for land consolidation. Natural resources that include the land require management, which means that an inventory has to be taken. Figure 99 shows some of the agencies that might be interested in cadastral maps. Experience shows that, once cadastral maps are available, more and more agencies recognize the advantages of such maps for their own work. Some offices and agencies want to be able to find their special data requirements represented in the cadastral map. If all the users' demands were accepted and every detail entered, the cadastral map would be such a complex instrument that it would, in the end, be difficult to recognize and find the information needed for a specific purpose. Since the contents of the maps should be clear and legible, some information must be kept separate. Moreover, some users are only interested in finding their own information in a cadastral map and are not at all interested in having their data published in maps which are open to the public. Therefore, it appears logical to offer only a basic sheet, in which the specific details required may be entered by the interested parties themselves. Each party will thus be responsible for its own data. It will have to arrange its own survey and will have to compile and process the data in such a way that they can be connected with the basic information sheet. Also, the maintenance and the revision of these data should be

* The original text of this paper, prepared by Franz Au, Director of Surveying, Nds, Landesverwaltungsamt, Hanover, appeared as document E/CONF.68/L.19.

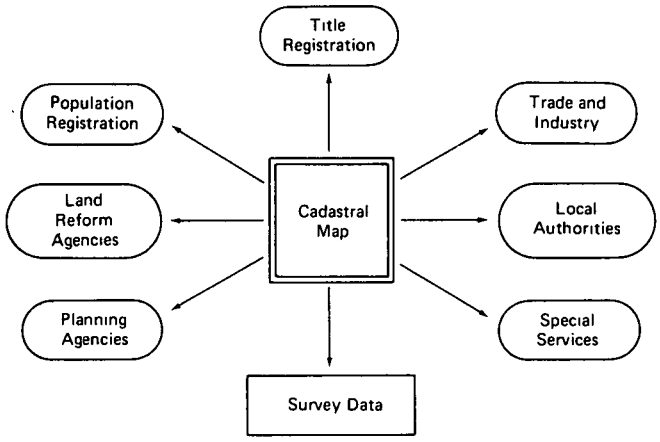



*Figure 99. Federal Republic of Germany: uses of cadastral maps for planning and statistics*

carried out by the agencies and offices that are interested in them. Each party should thus produce and maintain its own maps, which are ultimately thematic maps used only for a specific purpose.

The cadastral administration office should therefore be responsible only for the basic information sheet, namely, the cadastral map. The users will have to add their own data after the map is established. Figure 100 explains this process.

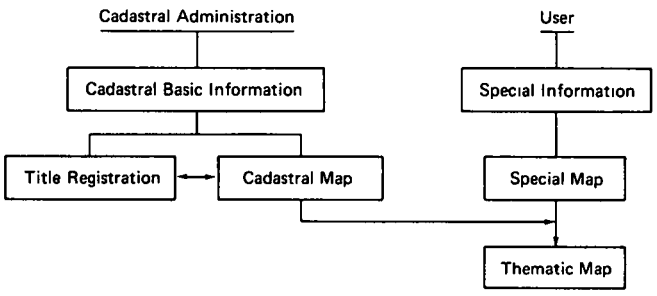



*Figure 100. Federal Republic of Germany: responsibilities of producers and users of cadastral maps*

The information to be compiled by the cadastral administration and depicted in the cadastral map can be divided into four groups:

1. Geodetic control (grid lines, control points);
2. Cadastral planimetry (boundary lines);
3. Topographic information (buildings, walls etc.);
4. Descriptive information (number of parcels, names of roads etc.).

Geodetic control, with its triangulation networks of different orders, forms the national grid system, which is the prerequisite to constructing the map. The maps are placed into this national grid, so that each map covers a clearly defined area. The control points, which have to be especially marked in the field, are the link between the area to be depicted and the map. They are also necessary for the maintenance and revision service after the maps have been established, in order to restore boundaries and connect the new survey with the old ones. Cadastral planimetry shows the boundaries, with the demarcation of the corner points. Topographic and descriptive information is an integral part of the cadastral map and is necessary for the representation and orientation of the area that has been mapped. The cadastral map itself will be numbered according to the grid zone in which the information was placed. To ascertain the connexion between the map and the different registers, each piece of land will be given a number. Ultimately, the map will show the sizes of the parcels and their positions, the buildings and other topographic details.

This cadastral map can then be supplemented by the users. They can produce their own thematic map. If the cadastral and the special information sets contain the same control points of the same grid, there will be no difficulty in assembling them.

There are two ways of assembling the information sets.

In the first method, each party is required to produce its own map. In the reproduction process, the maps are combined and assembled in one piece. This process has to be carried out with great accuracy and care, so that the control and pass points are precisely matched in the final map. To facilitate this task, a pattern of precisely located holes is punched in the margin of the different maps prior to use (see figure 101). Special studs are placed through the holes in the cadastral map-sheet, and the other special map-sheets are overlaid so that the studs pass through the corresponding holes. Thus, the maps are fixed together during the reproduction process, and they cannot be displaced. With this procedure the correct positioning of the maps is guaranteed and the final thematic maps will have the same accuracy as the original maps.

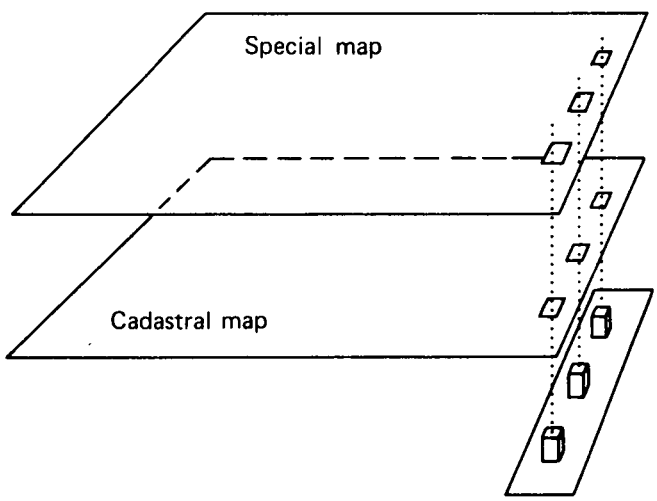



*Figure 101. Federal Republic of Germany: assembly of special maps and cadastral maps*

In the second method, if all surveyed data are co-ordinated in the national grid, the agencies concerned may establish a pool, thus forming a land-data bank.

Some of the data are used to establish registers, others to draw maps. If an agreement exists for a mutual exchange of the data stored in this pool, each participant can enrich and supplement his own thematic maps using the data of other participants. The land-data bank is administered by the cadastral administration. The cadastral administration will produce the thematic maps joining the cadastral information data set with the special information data set. The data sets are joined in the computer and transferred to the automatic plotting machine, which plots the data sets together. The final result will be the thematic map.

The establishment of cadastral maps is an important task of the cadastral administration. In this context, the way in which the mapping operation is carried out is relatively unimportant. The maps can be established by means of field survey procedures and/or photogrammetric procedures. But the main point to be considered is that the maps must be available when needed. Therefore, the cadastral administration has to begin the mapping projects in areas that are destined to become planning areas. The accuracy and speed with which the maps need to be established must be specified. A high degree of accuracy normally means high costs and slow mapping. A compromise has to be found between accuracy and speed, and sometimes time-saving surveying and mapping methods are preferable, even when they demand a lesser degree of accuracy. But such a compromise should not be extended to the control points. They should be determined with the highest possible degree of accuracy, because the accurate assembling of the different data set depends upon these points. At the same time, they also serve as reference points to which any future field survey, for cadastral or other specific purposes, will be tied.

To keep the data pool at a high standard, each participant must be responsible for the updating of his own data set. This task should not be neglected, and the supplier of the basic information sheet—namely, the cadastral administration—must be particularly aware of its responsibility. The contents of the cadastral map have to be maintained and kept up to date right from the beginning. If this task is neglected, all the thought, money and manpower invested in the establishment of cadastral maps will be wasted in a very short time. Therefore, the maintenance service should be regarded as very important right from the beginning of the cadastral administration. If maintenance of the cadastral maps is neglected, the maps will be rejected by the potential users, who might begin to survey cadastral data for themselves. Some agencies and offices might then decide to establish their own cadastral survey offices, a development that could have a disastrous effect on the uniformity of the cadastral surveying and mapping service. And in the end the cost of re-establishing cadastral maps would be higher than the cost of maintaining them would have been.

## A CONTRIBUTION TO ORGANIZATION AND LEGISLATION IN THE FIELD OF SURVEYING AND MAPPING*

*Paper presented by the Federal Republic of Germany*

This paper begins by describing how surveying and mapping institutions come into being. It appears that whenever an establishment finds that it needs to carry out surveying and mapping work for some political, economic or technical purpose, it sets up a division, group or department to do the work. This process results in a proliferation of offices, departments and firms, whose existence poses a threat to the efficient organization of surveying and mapping activities, which could in turn lead to a breakdown in the structure of such activities. Examples are given of ways in which such a development can be forestalled. Countries are warned not to establish too many offices when they first set up a surveying and mapping system. A synopsis is given of ways in which the separate functions of surveying and mapping offices may be combined, based on long experience of such matters in the Federal Republic of Germany.

Legal regulations and technical directives contribute to uniformity in surveying and mapping work, so the paper specifies the kind of legal regulations that are desirable; it goes on to point out that legislation is most necessary in the field of cadastral work. Whether such work is subject to legal regulation or to directives only depends upon the constitutional law of the State concerned.

Only a few examples are given of technical directives. The aim of the paper is to show the importance of good organization and practical legal regulations and technical directives for the smooth running of surveying, mapping and land information systems.

Lastly, it is pointed out that priority must be given to education and training before legal and technical regulations are issued.

### History of the development of surveying and mapping institutions

The subject of organization and legislation in this field is difficult to deal with because the general feeling is that the question is a political one and not a task for an expert in surveying and mapping. However, the political, economic and technical importance of suitable organization

* The original text of this paper, prepared by Johannes Nittinger, Advisory Group for Technical Assistance in Surveys, Mapping and Land Information Systems, Hanover, appeared as document E/CONF.68/L.22.

and legislation in the fields of geodesy, cartography, photogrammetry and cadastral work must be shown from the specialist's point of view, based on long experience in the industrialized countries. The question can be easily settled if the history of the development of surveying and mapping institutions is explored. The fact of the matter is that surveying and mapping institutions are set up for precise reasons, based on the political, social and economic activities of parliament and Governments, for example:

(*a*) The establishment of a fundamental surveying network (triangulation, precision levelling, measuring of gravity) to be used for:

(i) Creating an order system for the integration of all measurements;

(ii) Producing topographic maps, which concern the army and which, in the course of time, serve more and more as a basis for administration and planning; and

(iii) Applied sciences;

Unfortunately, the definition of fundamental surveying and topographic mapping is not uniform throughout the world, the terms used varying from "land survey" to "geodesy", "cartography" and "topographic or geographical mapping";

(*b*) Cadastral surveying and registration for the purpose of land-tax valuation. Obviously, the administrative and technical aspects of cadastral work generally are controlled by the Ministry of Finance;

(*c*) The production of urban maps for use in town planning, which is very important today because the growth of the metropolitan zones is a social problem and the tasks involved are complicated and can only be carried out with the aid of reliable and adequate land data. The establishment of a land information system is important for cities and the responsibility usually lies with the Ministry of Public Works or other planning offices;

(*d*) Land reform activities for the structural advance of agriculture. Boards of agriculture are set up, incorporating a surveying and mapping department and these boards are also responsible for planning activities;

(*e*) Establishment of a land register (register of ownership and title to real estate). In this connexion, surveying and mapping are necessary adjuncts to the work of the cadastral offices. Nearly every planning, performance and survey control for engineering purposes involves measuring, mapping and tracing work, which is carried out by engineering departments and firms. These bodies can be entrusted with other tasks, such as cadastral and land reform activities.

Geodesy, cartography, photogrammetry and cadastral work are thus seen to be necessary for the execution of political, social, technical or land reform projects; and they obviously have their place in the work of every ministry, office and engineering department or firm. A study of the growth of surveying and mapping clearly shows how many offices and departments are set up to carry out special tasks. This inevitable development can lead to a duplication of efforts and a lack of co-operation between offices and departments, and there is a serious risk that the efficiency and economy may be so impaired that the public will not receive the service it should. Care must therefore be taken to see that tasks are not divided up among too many offices. Budgetary or organizational considerations may make the setting-up of a number of specialized departments unavoidable, but such a division should be kept within reasonable bounds.

This restraint is possible if at least the two great mainstays of surveying and mapping—fundamental surveying and mapping and cadastral operations—are directed from one ministry; however, the awarding of contracts to private offices is also a practical way of avoiding the formation of large numbers of public offices.

Tasks can only be delegated if the country's infrastructure permits the establishment of surveying offices and the employment of qualified surveyors. It must be remembered that in order to carry out cadastral surveys of population density, there must be a land office or licensed surveyor in each provincial town.

### Organizational proposals

The suggestions given below are based on the experience of the Federal Republic of Germany.

In model A (see figure 102), the extent to which tasks are delegated is an important factor.

A good example of convenient organization is the combination of cadastral surveying and land registration (as has been done in Thailand, for instance), on the understanding that other types of information received from planning, statistical and land-tax institutions are also taken into consideration (see model B).

In model C, each discipline of the surveying, mapping and cadastral branch sends a delegate to the advisory council, which formulates recommendations for the uniform structure of the whole branch. This type of organization can only be successful, however, if the recommendations are stated to be legal regulations.

The organization of surveying and mapping activities is a state responsibility. The subject is discussed here because countries establishing geodetic and cartographic organizations should learn from the mistakes of the industrial countries and they should be aware that today, once an office is established, it is on a permanent basis and as a rule tasks cannot be transferred to another office. The establishment of surveying and mapping offices must therefore be carefully planned.

The danger of a structural breakdown is always present, so co-operation must be reinforced by legal activities and technical directives which will set guidelines between the offices.

### Legal regulations

The manner in which legal regulations should be conceived in view of the differences in constitutional law in various States is not as important a question as it might

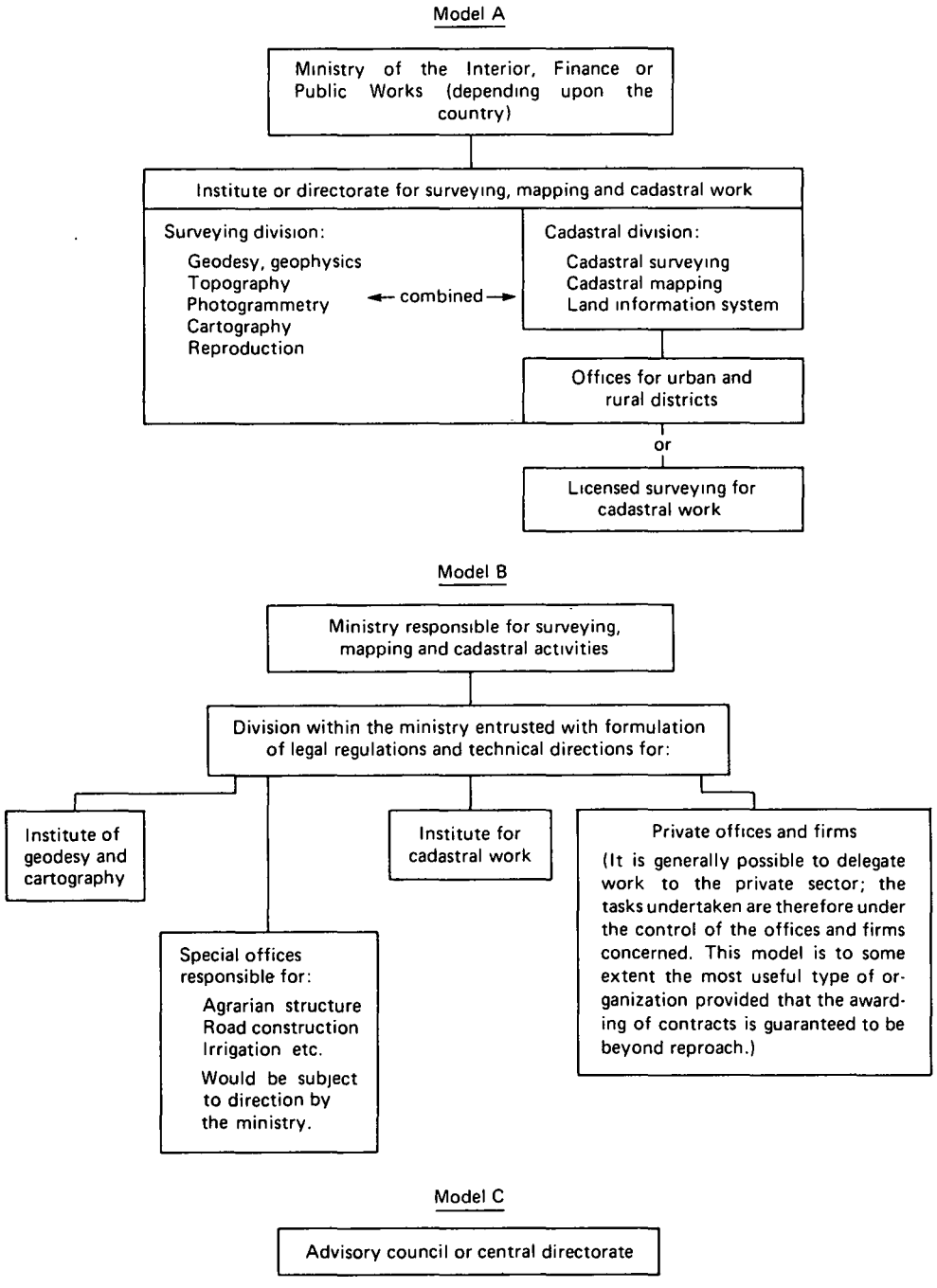



*Figure 102. Federal Republic of Germany: models for organization of surveying and mapping institutions*

appear, because each State is well aware of which instruments need to be drawn up in the form of laws, legal provisions or just directives. The main points to be taken into consideration in organizing an efficient surveying and mapping system are shown below.

First, any law dealing with surveying and mapping work has to cover matters that would indicate an encroachment on the rights of the citizen. Certainly, work in the geodetic field can be carried out in the absence of any law, but with the increase of legal awareness evasion of the law is no longer possible. Therefore, legal regulation will become more necessary as the number of property owners increases. One must also consider a law is necessary to cover the licensing of persons who have to perform public surveying work.

Secondly, special legislation is less necessary if the matter is included in the law covering the reasons for which the surveying and mapping work was initiated,

such as land reform, land tax, cadastral work, cartography and planning.

Thirdly, with the issuance of a special law, the following points have to be covered:

(*a*) Under the special law all geodetic work can be declared to be a national undertaking, which creates a legal basis for the work and could result in a better estimation of the surveying work and budget;

(*b*) Questions of surveying and mapping organization must be considered;

(*c*) In cases in which the State is required to indicate the type of task to be performed:

(i) The names of the offices and persons qualified to carry out the tasks must be provided;

(ii) A declaration must be made concerning the obligations of persons and offices performing the tasks;

(iii) Authorization must be given for the technical directives regulating the conditions for the production and maintenance of the surveying, mapping and cadastral work;

(iv) The obligations and rights of the citizens must be stated.

These obligations consist in:

(*a*) Allowing access to the land;

(*b*) Agreeing to the setting up of fixed points for triangulation and levelling;

(*c*) Agreeing to the investigating of ownership, demarcation and topographic objects on the land;

(*d*) Admitting liability of information concerning any change in the shape of the land; new boundaries are recorded at the expense of the owner; the question of costs is very important because their specifications are decisive for the effective performance of cadastral surveys and land registration; the obligation to mark the boundaries with corner-stones is less significant; if a demarcation line is wanted the costs should be assumed by the owner.

The rights consist of:

(*a*) Approval of the results and the registration;

(*b*) A scale of social fees for the performance of the cadastral survey and land registration;

(*c*) Receipt of a certificate of ownership (land title); this document is very important in many States because it records the change in ownership;

(*d*) Receipt of information regarding name changes etc.;

It can thus be seen that legislation for cadastral operations is more extensive than for fundamental surveying and mapping, which can also be carried out in the absence of legal regulations. It is convenient, however, for both functions to be covered by one law. As was stated earlier, fundamental surveying and cadastral work need uniform legal processing. Of course, opinion held is quite different in many countries but the Federal Republic of Germany has found from experience that close co-operation between both branches of surveying is very important.

## Technical directives

Examples are given below of technical directives that promote the efficient development of surveying and mapping:

(a) *Directive for the establishment and maintenance of networks*: it is important that the directives should include a statement on the integration of all measurements with the networks: planning and execution are to be controlled from an office (institute of geodesy);

(b) *Directive for the establishment and maintenance of topographic maps*: arrangement, scale, form and contents of topographic, urban and cadastral maps should be harmonized;

(c) *Directive for the establishment of cadastral surveying*: the guiding principles should only give an indication regarding uniform formation. It is not important which offices and private institutions execute the work, but all partners must follow instructions;

(d) *Directive for the performance of cadastral work*: this directive is very important because many offices and private institutions participate in the work. The cadastral and land directives should be harmonized.

It is not necessary to enumerate every possible technical directive, but it is important that all offices and other institutions that perform surveying, mapping and cadastral work should take the technical directives into account.

In this connexion, it should be pointed out that technical surveying (roads, irrigation, planning etc.) should be included in the fundamental system. All these engineering surveys have to contribute to the surveying and mapping work.

Technical directives help in education and training, and training has priority over organization and legislation. Therefore, consideration should be given to the establishment of training and education facilities, such as technical schools, job training, seminars and courses. The first and best investment in the future of surveying and mapping—and there is no other way—is education and training.

# CADASTRAL SURVEYING AND LAND REGISTRY IN THE FEDERAL REPUBLIC OF GERMANY WITH SPECIAL REGARD TO THE SITUATION IN BAVARIA*

*Paper presented by the Federal Republic of Germany*

## PRIMARY SYSTEMATIC CADASTRAL SURVEYING

In most German states systematic cadastral surveys were already being carried out in the nineteenth century. The purpose was primarily to create sufficiently accurate bases for the taxation of land, which at that time formed the main source of revenue. The procedure followed and the results achieved by those cadastral surveys varied considerably from one state to another. In Bavaria, which became a kingdom at the beginning of the nineteenth century, the first systematic land survey took place between 1808 and 1863. In view of the primary purposes of taxation and for reasons of economy, the survey was supposed to dispense with the fixation of boundaries by means of durable boundary-marks. For the same reasons, the survey was limited to plain graphic mapping carried out on the surveyors plane-table. On the other hand, the creators of the Bavarian land survey showed astonishing foresight in insisting on a uniform basis and procedure for surveying. The first-order triangulation net was mainly designed and computed by Johann Johann Georg von Soldner, who went down in the history of geodesy as the inventor of the rectangular-spherical system of co-ordinates.

As a result of these earlier surveys, Bavaria now possesses a complete and uniform framework of maps dating from 1864, consisting of more than 20,000 sheets on the scales 1 : 5,000 and 1 : 2,500. From the beginning, in addition to being used for straightforward taxation purposes, this system of maps was intended to serve all other administrative purposes and also to be copied for use by the general public. That this use was possible is mainly due to the fortunate circumstance that, just as work was beginning on the survey, Alois Senefelder invented the chemical printing process known as lithography. Senefelder was an officer of the Bavarian Survey Office for many years and his invention is said to be the forerunner of offset-printing.

The Bavarian set of cadastral maps has been faithfully preserved up to the current time, and all changes in property ownership and land use have been duly recorded.

## VALUATION AND LAND REGISTRY

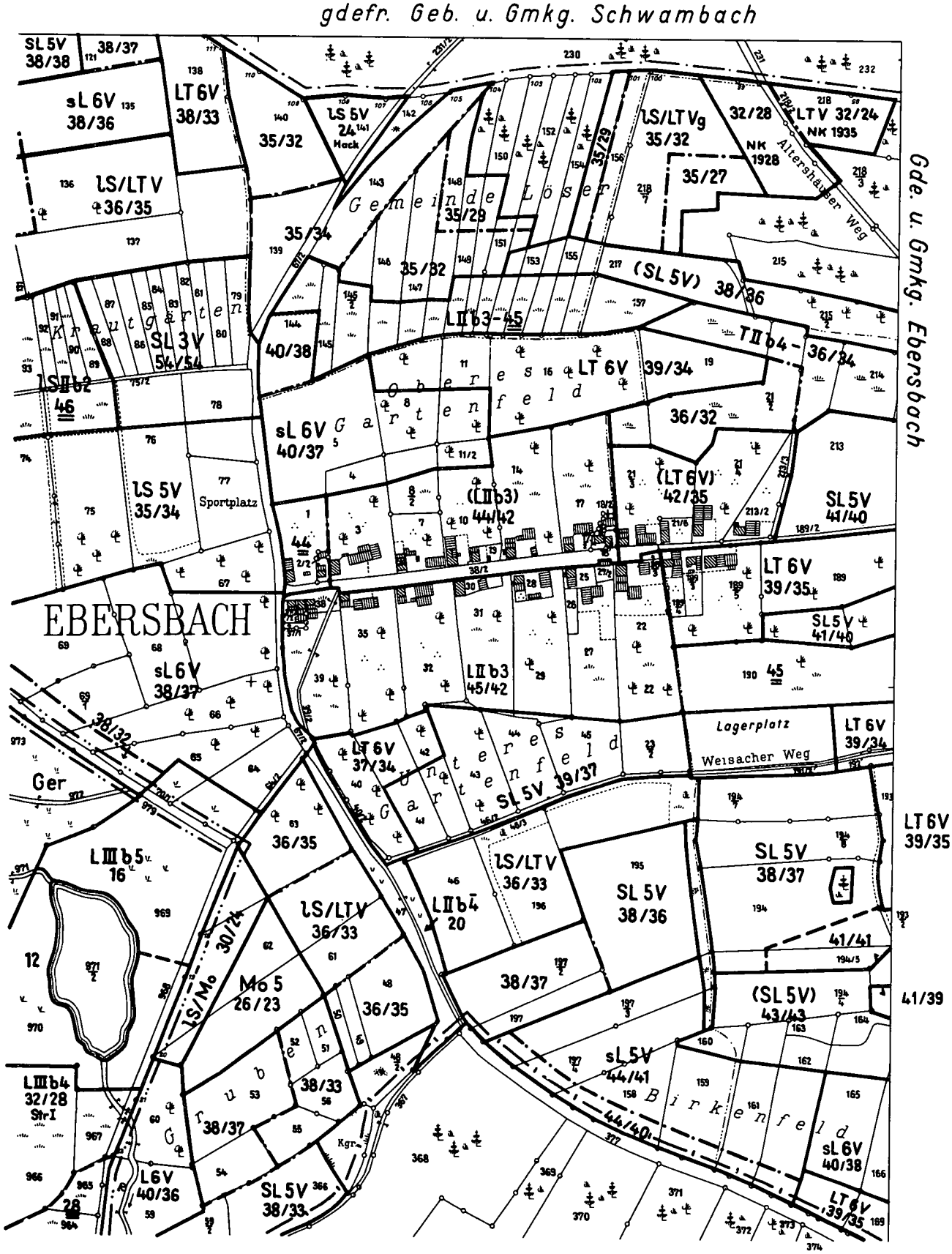
In 1934, a valuation of the agricultural areas was undertaken throughout Germany, to be used for taxation purposes, the setting of prices, the exchange of lots and the preparation of uniform documents on soil fertility. This valuation took about 20 years and the soil in the agricultural areas was examined down to a depth relevant to plant growth. In particular, the composition, quality and origin of the fertile layer, as well as the water-level, local climatic conditions and other factors influencing productivity were noted, using fixed abbreviations and symbols. Natural productivity was signified by valuation numbers between 1 and 100. The results of this valuation are available in Bavaria, where they have been indicated in red or black print on the cadastral maps already in existence (see figure 103).

In order to be able to register the results of the valuation and make them available throughout the country, a new land register has been established over the past few decades. In each community the lots are filed and classified by numbers, by site, by use and by area. In addition, they are assigned symbols describing the composition and condition of the upper layer of the soil, and productivity is evaluated according to a system of numerical classification (see figure 104). A second synopsis is made with respect to ownership for evaluation purposes (see figure 105). The new land registry is just being completed in Bavaria and is already available for much of the country.

## MODERN CADASTRAL SURVEYING

The objective of cadastral surveying has undergone considerable changes over the past three quarters of a century. Today in the Federal Republic of Germany, largely owing to the marked increase in the price of land, the securing of landed property and the ascertainment of accurate aerial measurements are of prime importance. The only way to carry out these tasks is to undertake an on-the-spot marking and accurate numerical fixation of all landmarks. Since 1900, all newly formed or newly surveyed property boundaries have without exception, been marked by solid durable boundary marks, mainly in stone but also in hardwood or metal. The boundary marks, and of course the boundaries too, have to have the signed acknowledgement of the owners and they then enjoy legal protection. Only specifically appointed surveying offices are authorized to put in landmarks and to survey boundaries. The position of the boundary marks is verified (authenticated) by accurate figures of measurement. The orthogonal method was employed for this purpose in the first half of the century; but in recent years the polar method, using electronic tacheometers, has been growing in popularity. Great care is taken to confirm the comprehensive survey of all boundary points by means of independent controls. Therefore, two approximately rectangular distances are measured from each boundary point to neighbouring boundary points or other fixed points. If this method is not possible because of local conditions or if it is not economical, the distance to a neighbouring point of control is measured for the purpose of confirmation only, and it is not necessary to mark the point locally. The same result can be achieved through an independent second survey.

* The original text of this paper, prepared by Theodor Ziegler, Vice-President of the Bayerisches Landesvermessungsamt, Munich, appeared as document E/CONF.68/L.23.




3025.74x

Anmerkung: Obere Hälfte zweifarbige Ausgabe,
untere Hälfte einfarbige Ausgabe

*Figure 103. Federal Republic of Germany: natural productivity map of Bavaria*

# Flurbuch

(verkleinerte Wiedergabe)

Bayer. Landesvermessungsamt

Seite 1

| Fortführung Seite | Nummer des Flurstücks | Flurkarte | Liegenschaftsbuch, Bestand Nr. | Lage | Nutzungsart | Fläche ha | a | qm | Klasse | Wertzahlen | Ertragsmeßzahl | Gesamtfläche des Flurstücks ha | a | qm | Fortführungsrisse u. dgl. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | 8 | 9 | 10 | 11 | | | 12 |
| | | | | 1. Gemarkung Neuried | | | | | | | | | | | |
| | 1 | 27-77-14 | 38 | Neuried HsNr.4 | Hf | | 7 | 80 | | | | | 21 | 00 | 101 |
| | | | | | G | | 13 | 20 | LT6V | 36/36 | 475 | | | | |
| | 2 | " | 38 | Leitensteig | Weg | | 9 | 40 | | | | | 9 | 40 | |
| | 3 | " | 38 | Lehenäcker | A (Obst) | | 37 | 30 | LS4V | 38/38 | 1417 | | 37 | 30 | |
| | 4 | " | 137 | | G | | 15 | 30 | sL2D/LÖ | 73/70 | 1071 | | 79 | 40 | 219 |
| | | | | | A | | 64 | 10 | sL1D/LÖ | 76/73 | 4679 | | | | |
| | 5 | " | 94 | Neuried HsNr.16 | Hf | | 12 | 57 | | | | | 12 | 58 | 220 |
| | | | | | Hf | | | 1 | | | | | | | genaue Fläche - 0,4qm |
| | 6 | " | 3 | Lehenäcker | Hü | | 21 | 90 | Schätz Erg. | nicht übernommen | | | 21 | 90 | |
| | 7/3 | " | 135 | Neuried HsNr.39 | Hf | | 11 | 00 | | | | | 32 | 50 | 68, 219 |
| | | | | | Gr | | 21 | 50 | LIb3 | 58/55 | 1182 | | | | |
| | 13/1 | 27-77-14, -19 | 12 | Windisch | A | | 71 | 09 | SL5Al/V | 40/40 | 2844 | 1 | 70 | 89 | 11, 96 |
| | | | | | A | | 9 | 00 | SL5Al/V | 40/36 | 324 | | | | |
| | | | | | Gr | | 85 | 20 | LIIa3 | 50/50 | 4260 | | | | |
| | | | | | U | | 5 | 60 | | | | | | | |
| | 14 | 27-77 | 3 | In der Höll | LNH | 1 | 16 | 20 | | | | 1 | 46 | 60 | |
| | | | | | Weiher | | 30 | 40 | | | | | | | |
| | 15 | 27-77, 78 | 19 | Ziegelrück | A | | 3 | 60 | sL5V | 48/40 | 144 | 3 | 82 | 60 | 21 |
| | | | | | A (NK 1960) | 1 | 04 | 40 | SL6V | 30/25 | 2610 | | | | |
| | | | | | A | | 26 | 40 | sL5V | 48/46 | 1214 | | | | |
| | | | | | LNH | 2 | 48 | 20 | | | | | | | |
| | 15/2 | 27-78 | 137 | " | A | | 46 | 00 | sL5V | 48/46 | 2116 | | 46 | 00 | 21 |
| | 16 | " | 98 | " | A | | 29 | 40 | sL5V | 48/46 | 1352 | | 42 | 20 | |
| | | | | | GrA | | 8 | 00 | LIIa3 | 50/50 | 400 | | | | |
| | | | | | GrA | | 4 | 80 | LIIa3 | 50/40 | 192 | | | | |
| | 16/2 usw. | " | 102 | " | A (Baupl.) | | 11 | 20 | sL5V | 48/46 | 515 | | 11 | 20 | 144 |

*Figure 104. Federal Republic of Germany: sample page of new land register of Bavaria*

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49

**Gemeinde** Neuried GB 3/45

**Eigentümer:** Klein Georg, Ldw., u. Ehf. Elise, geb. Gstötter, HsNr.28 i.GG

**Bestand Nummer** 137

Seite 1 bis 2

**Bestandsblatt** (Vorderseite)

| Anderweitige Grundbuchstelle | Nummer des Flurstücks | Lage Gebäudebesitz | Nutzungsart | Fläche ha | a | qm | Ertragsmeßzahl | Gesamtfläche des Flurstücks ha | a | qm | Fortführung VN oder VL Nr./Jahrgang | Bemerkungen Gebäudebesitz fremder Eigentümer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | | | 6 | 7 | | | 8 | 9 |
| | 4 | Lehenäcker | G | | 15 | 30 | 1071 | | 79 | 40 | | |
| | | | A | | 64 | 10 | 4679 | | | | | |
| | 15/2 | Ziegelrück | A | | 46 | 00 | 2116 | | 46 | 00 | | |
| | 116 | Neuried HsNr.28 | | | | | | | 14 | 20 | | |
| | | Wohnhaus, Wirtschaftsgebäude, Hofraum | Hf | | 3 | 20 | | | | | | |
| | hierzu | 1/4 Miteigentumsanteil an Flst.114 (BestNr.210) | G | | 11 | 00 | 440 | | | | | |
| | 185 | Hammerberg | A | | 44 | 10 | 1770 | | 44 | 10 | | |
| | 280 | Vogelherd | A | | 95 | 50 | 4775 | | 95 | 50 | | |
| | hierzu | die zu den Wegen Flst.286 u.421 gezogenen Teilflächen (BestNr.1) | | | | | | | | | | |
| | 401 | Auwiesen | Gr | | 82 | 30 | 4115 | 1 | 10 | 70 | | |
| | hierzu | die zum Graben Flst.420 gezogene Teilfläche (BestNr.1) | Gr (StrI) | | 21 | 40 | 642 | | | | | |
| | | | W | | 7 | 00 | 280 | | | | | |

Formbl. 505 Liegenschaftskataster, Bestandsblatt B. LVA

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Bayer Landesvermessungsamt

*Figure 105. Federal Republic of Germany: sample page of evaluation register of Bavaria*

Planning and administrative offices are becoming more and more pressing in their demands for accurate large-scale cadastral maps of villages and construction areas. In order to satisfy these requirements, repeated cadastral surveys have been taken in Bavaria over the past 100 years or so. As a basis for such surveys and also for all other large aerial surveys, a triangulation network was determined and designed in four orders. Currently, in Bavaria a distribution is achieved of one control point per 1.5 $km^2$. For systematic resurveys of towns and other large objects the triangulation network is filled up by traverses, the sequence of the traverse points being from 100 to 300 m. The traverse distances are generally measured with electronic distance-measuring equipment. Detail is if possible determined on a Zeiss Reg Elta 14 electronic tacheometer, the dates being recorded on punch tapes. If no self-registering instrument is available, the dates are entered on forms that can be read automatically. The percentage of figures that cannot be definitely recognized on the automatic reader is extremely low.

Since 1960, all boundary points have been co-ordinated in the general Cartesian co-ordinate system. To compute co-ordinates and the areas, a large-capacity computer is available. Data input is possible by means of punch tapes, forms for the automatic reader and magnetic tapes. To harmonize the results, telescreens have also been used since 1975. The new cadastral maps are on the uniform scale 1 : 1,000 (see figure 106). The boundary lines are magnified for better legibility. The originals are designed by means of automatic engraving on laminated foils.

The necessary pilot orders for engraving the boundaries are received simultaneously with area computation. For engraving the outlines of rectangular buildings only the co-ordinates of two corners of the building are necessary. The other edges of the building are precalculated automatically and engraved in the shape of a closed traverse with 90° angles. A special projector acquired in 1976 will make it possible also to provide topographic signatures and types automatically. The line of automation will be then complete from the automatic registration of the data to area computation and the production of maps.

The co-ordinates of all boundary points and fixed points in the state are filed in a central data bank on magnetic tapes. It is thus possible to obtain the original co-ordinates automatically in the case of sequel surveys. On the other hand, the position of the archived boundary points is re-insured by the stored co-ordinates. In Bavaria, the number of stored pairs of co-ordinates has already passed the 10-million mark.

### Land registry and cadastral maps in future

The enormous progress made by computer technology suggests that the automatic data-processing should be used for the register generally and for the numerical data. In the Federal Republic of Germany, there are already some quite specific ideas as to how the transposition on to electronic data records can be achieved. Thus, it has been decided to include not only the verbal description of the land as shown in books and files but a graphic map representation, including the underlying co-ordinates and dates, with a view eventually to concentrating all the related data currently on register in a number of competent offices in one electronic data record. The contents will be available to every interested party, except for reasons of personal security or general safety. This data bank is expected to store all the data contained in the conventional files of the land registry. The contents of the land register, which in the Federal Republic of Germany records land rights, especially property titles, mortgages and the rights of beneficial interests, will be added. The data bank is also meant to store specific data about buildings, for instance, their area, height and year of construction, enclosed space and the number of floors. In addition, it will be open to data from the domains of planning building laws and tax administration. A uniform symbol for parcels of land will be established for the federal state. The institution of a uniform symbol for each person is still a controversial matter for reasons of personal security. The recording of data will presumably be put on screen, and the output to interested parties will mainly be recorded on high-speed printers. The chief advantage of computer technology is said to be the immediate availability of land data as at the last reading. In addition, the possibilities of statistical evaluation for the manifold domains of administration and planning are very important. It is proposed to determine and to store a representative pair of co-ordinates for every plot of land. By this means interpretations related to the locality will be simpler.

A special data-bank store is provided to take over all data concerning surveying and mapping on electronic data records, the so-called "automated land map". It is intended to store all information necessary for the graphic representation of land, buildings, usage and topographic details, thus providing the means to produce immediate graphic representations as at the last reading, on any scale, with any limitation and with any choice and combination of stored data. However, it will doubtless take some time to achieve this target. The first step will be to establish a data file for all fixed points of the cadastral survey. In this file details concerning the year in which the fixed points were determined, their positional accuracy and the kind of marking used will also be stored. As a base for the numbering of the fixed points, the kilometre squares of the new plane Cartesian system of co-ordinates according to GauB-Krüger are taken into consideration. By using the co-ordinates of all the boundary points the essential data are already recorded and usable. Of course, considerable effort will still be necessary to store all the other data of the map layout on electronic data records.

### Special city maps

In the Federal Republic of Germany, large-scale city maps are generally derived from large-scale cadastral maps. In this case, symbols are added to the contents of the cadastral map; these symbols are important for town planning, for example, the alignment of building sites, pavements, roof lines, house numbers and number of storeys (see figure 107).

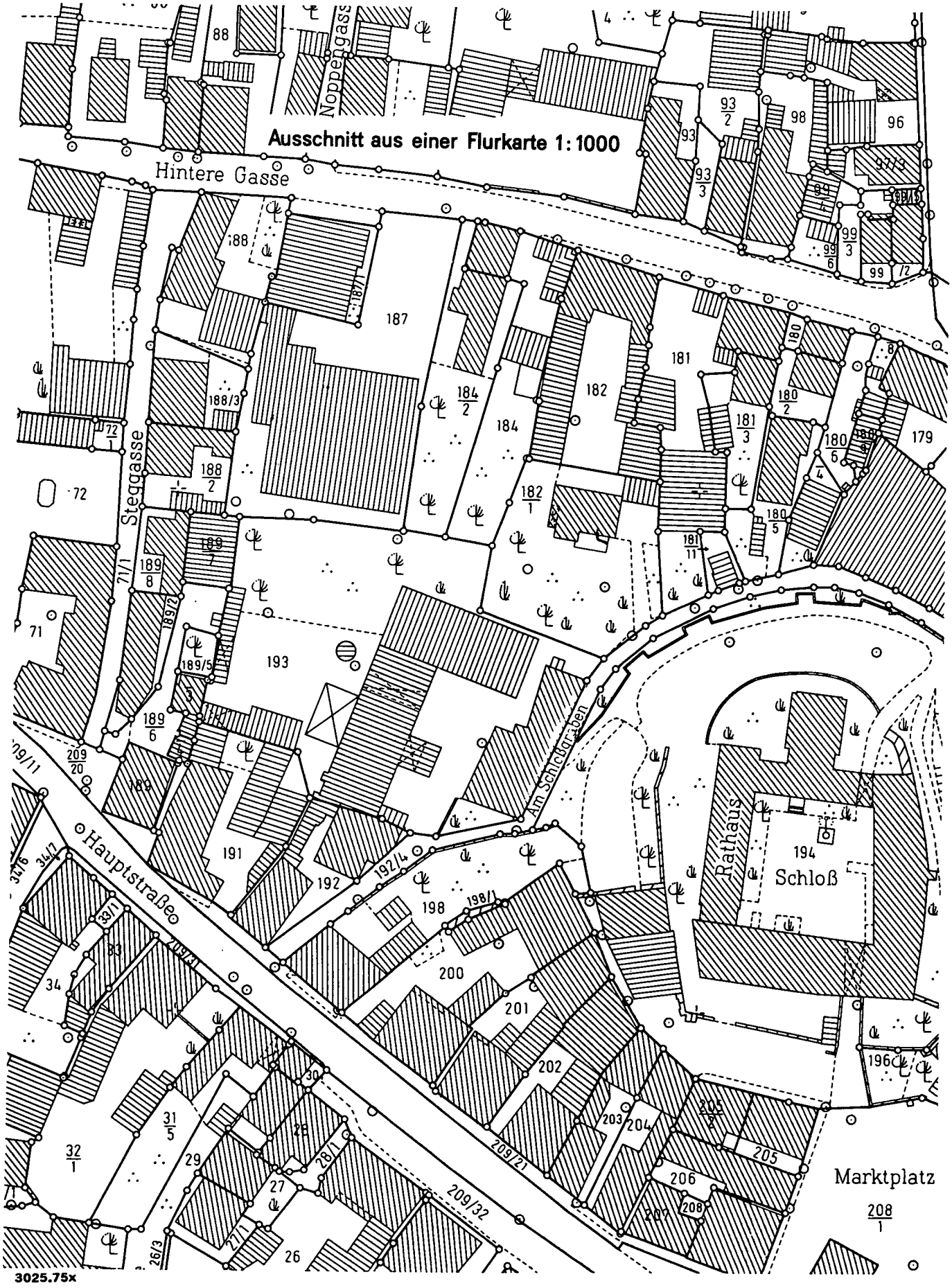



*Figure 106. Federal Republic of Germany: sample of cadastral map at 1 : 1,000 scale*

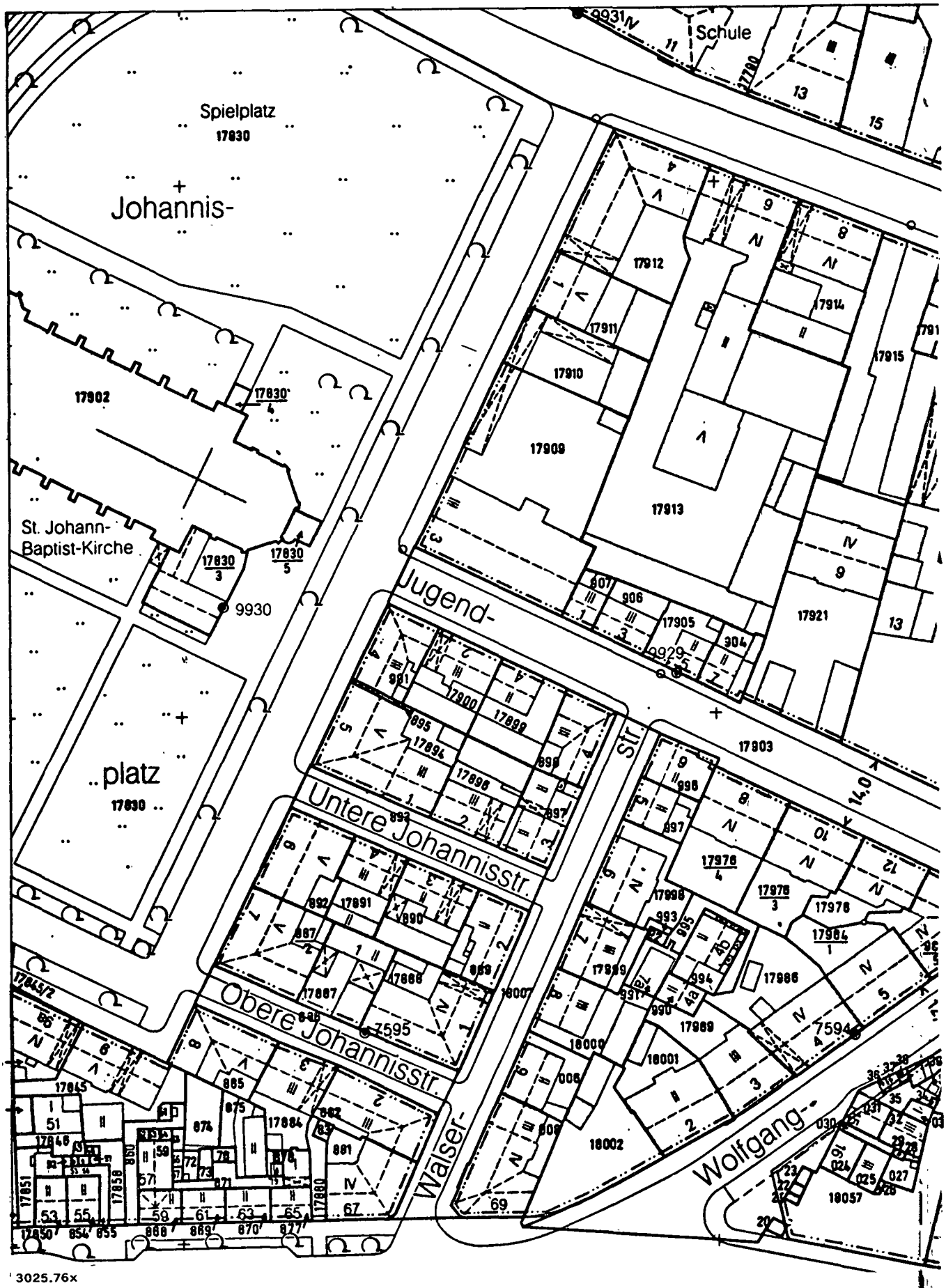



*Figure 107. Federal Republic of Germany: sample of special city map at 1 : 1,000 scale*

# THE INTEGRATED SURVEY SYSTEM IN NEW ZEALAND*

*Paper presented by New Zealand*

Surveys in New Zealand are integrated within one survey system, that is, a system in which all basic survey activities are undertaken within one structure of administration and positional control, where procedures and production are integrated and where associated activities are rationalized and co-ordinated as far as practicable. At all stages of development in this country, there have been benefits to efficiency, economy and production capacity through these operations, and some aspects could have application to the developing countries of the region.

The survey system owes its origin to the comparatively recent history of settlement and survey in New Zealand, to the centralization of the Government and its statutory provisions, and to the status and responsibility accorded the Surveyor-General. The extension and continuance of integrated and co-ordinated procedures is largely due to the effective administration and servicing of all requirements through one organization, to the determination to take all actions that will strengthen one viable system, and to the support of the professional surveyor body. This paper deals briefly with the factors leading to the institution of integrated surveys and the various aspects of the system operated in New Zealand.

## Historical events

Interest in New Zealand was not stimulated until after the epic voyages of Captain James Cook in 1769–1770 when he circumnavigated and charted the coastlines and dominant topographic features. At that time the country was inhabited by the Maori people, a tribal society who recognized topographic features as forming the boundaries of jurisdiction between the tribes.

The first successful organized settlement was sponsored privately by the New Zealand Company in 1840. Some 8 million hectares were purchased from the Maoris and surveys for development commenced. By the Treaty of Waitangi in 1840, the Maoris recognized the sovereignty of the Queen of England and the Crown assumed the sole right to pre-emption of lands not held in Maori ownership. The Royal Instructions accompanying the Charter of 1840 placed under a Surveyor-General, appointed by the Government, the responsibility for planning, survey, mapping, subdivision and registration of lands of the Crown.

With the establishment of decentralized provincial government (12 provinces) in 1853 and the abolition of the Surveyor-General post, varying survey systems lacking triangulation control came into vogue under the provincial Chief Surveyors. The chaotic state of land surveys and titles became very evident when the central Government, in instituting the Land Transfer Act 1870, adopted the Torrens system of land title registration.

In 1876, with the abolition of the provinces, surveys came effectively under centralized control for the first time. The newly appointed Surveyor-General quickly established 12 land districts, each under the direction of a Chief Surveyor, with the relevant survey records being retained in the district office. A system of 28 meridional circuits was formulated and minor triangulations, based on an initial station in each circuit, were quickly extended throughout the country where required for the connexion and check of settlement surveys. Simultaneously with the minor triangulations, topographic surveys were executed presenting the main features of the country. Land title surveys were co-ordinated on a plane grid within each meridional circuit, survey plans prepared; and cadastral maps produced portraying boundaries, area and description of every parcel. In instituting this system due consideration was given to the practices of other countries, in particular Australia, Canada, the United Kingdom and the United States of America; and procedures were adapted according to the requirements of New Zealand.

Although many years were to pass before the national first- and second-order geodetic surveys were completed and the minor triangulations interconnected, the procedures inaugurated 100 years ago provided a sound foundation, appropriate to the situation, for the fully integrated survey system of today.

## Statutory control and regulation

Land statutes passed soon after 1876 gave the Surveyor-General responsibility for direction and conduct of surveys on all Crown and Native Lands. The Land Act of 1948 extended the Surveyor-General's responsibility to all trigonometrical surveys, standard traverses, precise levelling and topographic surveys for the production of maps, and provided for his authorization of entry to any land for survey purposes.

Although earlier regulations governing survey procedures on Crown land were promulgated, the first integrated survey regulations providing for the conduct and standard of title surveys on land of all tenures were instituted in 1897. The first Survey Board, with the Surveyor-General as Chairman, was empowered in 1900.

The current Surveyors Act, which has existed in similar form for many years, provides for the establishment of the New Zealand Survey Board with responsibility for the training, examination, registration and discipline of all land surveyors, and for the formulation of regulations governing the conduct and standards of all land

* The original text of this paper, prepared by W. N. Hawkey, Assistant Surveyor-General, Department of Lands and Survey, New Zealand, appeared as document E/CONF.68/L.38.

surveys—such regulations are subject to the approval of the Minister of Lands before promulgation. Under the Surveyors Act, it is an offence for a person other than a registered surveyor holding a practising certificate to undertake surveys affecting the boundaries of land of any tenure, or of any mining privilege; and it is similarly an offence for any such person to emplace any mark or monument that may reasonably be mistaken for a survey mark placed by a registered surveyor.

The current Land Act deems the land surrounding all trigonometrical stations and the nearest practical access to be Crown land excepted from any alienation, and makes an offence of destruction or disturbance of any survey mark or obstruction of any surveyor in the performance of his duties.

Other statutes limit the preparation of a scheme plan for land subdivision to the registered surveyor, provide for the examination of all survey plans affecting land by the Chief Surveyor of the land district and add further strengths to the positions of registered surveyors and Chief Surveyors in matters affecting land survey.

### New Zealand Institute of Surveyors

The New Zealand Institute of Surveyors, established in 1886, includes the surveyors from all sectors and has played a significant part in the maintenance of integrated surveys by the regulation of ethics, discipline and professional responsibility. It is very active not only in its own affairs but in all matters of public interest impinged upon by surveys or associated activities.

The Institute is constituted under the Surveyors Act which also makes provision for the Institute functions and the formulation of rules and scale fees. All Institute rules and fees are subject to approval by the Minister of Lands.

All members engaged upon cadastral (land title) surveys are registered surveyors and must possess a current practising certificate issued by the Institute. Accordingly, their operations are subject to the control and discipline of the Survey Board and the requirements of the Survey Regulations. The conduct and co-ordinations of surveys and the physical maintenance of the survey control system achieved through these provisions greatly assists the integration process.

### Status of the Surveyor-General

In addition to the statutory responsibilities under the Land Act and chairmanship of the New Zealand Survey Board, the Surveyor-General has other functions that promote the integration and co-ordination of all surveys. As Director of Survey for the Ministry of Defence, he is responsible for the production and distribution of all army and air force maps and charts, is the Chairman of the Geographic Board; and is a member of the Mines Examination Board and of several national committees on geodesy, geo-physics, research and hydrography that involve survey activity and co-ordination. The New Zealand Institute of Surveyors recognizes the Surveyor-General as technical leader of the profession.

He controls all activities of the Survey and Mapping Division of the Lands and Survey Department, including the examination and approval of all land survey plans, the provision of all governmental aerial photography and civil aeronautical charting, the bulk of government survey operations, overseas survey aid projects and the administrative and servicing requirements of the integrated survey system.

### National survey control network and subsidiary control

The extension and maintenance of the triangulation and control traversing system to first-, second- and third-order standards is carried out by Lands and Survey Department staff to specifications approved by the Surveyor-General. This work, both for the purposes of general coverage and strengthening and for specific mapping, development and scientific requirements, is executed by the 12 decentralized district offices; but programming, specification, monitoring and integration are the function of central Head Office. On the infrequent occasion when such surveys are undertaken by other survey organizations, the scheme vetting, integration and approval are similarly undertaken by Lands and Survey Department. No alteration to ground monumentation or beaconing may be undertaken without departmental approval and record.

The early minor triangulations, which were generally within an error tolerance of 1 in 5,000 have been connected and incorporated into the national framework as fourth-order stations.

Following analysis and preliminary computations, all surveys forming the control system are forwarded to the Head Office for adjustment on the geodetic datum of 1949 by standard procedures. Co-ordinates of all stations are computed both on the Transverse Mercator (TM) grid for the appropriate meridional circuits, primarily for land title (cadastral) survey purposes; and on the national yard grid (TM) for mapping production based on old imperial scales and also as required on the New Zealand map grid, a new conformal projection designed for metric mapping recently commenced (1:50,000). Coordinate transformations are comparatively simple with modern computers.

All national control networks and stations are identified and illustrated graphically on index maps of suitable scale and updated microfilm copies are periodically distributed to district offices. Card records portraying co-ordinate values, heights, access notes, monument and beacon details and computational data are prepared in respect of each station; and these records are continuously updated and disseminated to relevant offices and other departments. Lists of co-ordinates and heights based on each individual map-sheet are also provided.

All such data are freely available to users and to the public. The department also supplies data and specialized computations on a specific basis as demanded by other organizations and by private concerns.

A similar system is operated in respect of the operations, recording and data distribution associated with the New Zealand precise level network (first order); and the department also undertakes primary determination of mean sea level at standard ports, the analysis and prediction of tides and the production of tide-tables.

Other associated functions include photogrammetric adjustments and projection computations for all official mapping production, positional computation of all air and marine navigational aids and air routes, and the adjustment of all major earth deformation surveys.

The department also undertakes urban and rural standard traverses on a district basis. These surveys are intensive, permanently monumented traverses connected to salient old marks of previous land title surveys and are co-ordinated on a meridional circuit basis. Plans are prepared, examined and approved by the Chief Surveyors; and all records, which are held only in the relevant district offices, are available to all users without financial charge. They serve the primary purposes of control for future title surveys and the safeguard and redefinition of existing land boundaries. Secondary purposes include the facilitation and integration of localized engineering, utility servicing, mapping and other measurement surveys.

An extensive survey monument maintenance programme is operated by all district offices in respect of stations of the national control network, standard traverses and the salient reference marks of land title surveys. All local authorities, departments and organizations undertaking works likely to endanger such marks must notify the Chief Surveyor.

In summary, there is only one horizontal and vertical survey control system in New Zealand, and the Lands and Survey Department is the only authority for precise position and height fixation and for the provision of data for all major survey and mapping purposes. Clearly this system provides the foundation for the effective locational integration of surveys. The provision of more than one set of co-ordinates does not negate this principle as the position of the control monuments govern, and the geographical values of the primary stations remain unchanged. The co-ordinate systems are designed simply to implement the varied purposes of the surveys; and integration is achieved through centralized and co-ordinated administration, servicing and recording, and not through needless mathematical adjustment.

## Land title surveys and surveys affecting land boundaries

Freehold title to land, under the Land Transfer Act, is guaranteed by the Crown and may issue only on the basis of plans examined and approved by the Chief Surveyor and prepared from surveys executed by registered surveyors in accordance with the Survey Regulations made under the Surveyors Act. Although surveyors from the Government, local authorities and the private sector are involved in this work, the bulk of the land title surveys are carried out by private practitioners who form over 60 per cent of the total registered surveyors in the country. Surveys affecting lands in Crown or Maori tenure, or of lands subject to mining leases or legalization for public works, are similarly made under the Survey Regulations; and the plans are also examined and approved by the Chief Surveyors of Lands and Survey Department. In addition, it is usual to apply similar requirements to any survey, though not directly affecting land tenure, that results in the placement of authorized survey monuments of value as survey control data for future land title surveys. There are some 850,000 survey plans within the system held by the Department throughout the country.

The Survey Regulations, which have existed for many years in the current general format, give broad guidance only on matters relating to methods, equipment and the exercise of "good survey practice" and professional judgement. They are specific on the aspects of measurement accuracies, the requirements of survey and recording of information relevant to title definition and safeguard, and the specification of monumentation. More significantly, they provide for the integration within and the maintenance of the survey control system and the presentation of integral survey plans. Some of the provisions that promote the integrated survey process are briefly as follows:

(*a*) Require the surveyor to study the responsibilities of the Crown that may arise from inaccurate survey: to search for and connect to all monuments necessary to prove the accuracy of survey; supply all information to the Chief Surveyor; report any likelihood of disturbance of any control survey mark; obtain all information and search all relevant survey records;

(*b*) Set conditions for obtaining origin of bearings and co-ordinates from the control survey system or other accepted approved surveys and for co-ordination in terms of the meridional circuits (either TM or plane co-ordinates);

(*c*) Limit the degree of error acceptable in linear and angular measurements and co-ordinate closures;

(*d*) Specify the location, type and permanency of all boundary marks.

More importantly, the regulations comprehensively specify the density, location, construction and permanence of all traverse, witness and reference monuments placed in relation to boundary marks. This requirement not only establishes a self-propagating, subsidiary control pattern as an adjunct to the national survey control system but provides for a major contribution by the private sector practitioners to such control and data record. These monuments are utilized for the definition of new cadastral surveys, the protection of existing boundaries and the basis for control and integration of other survey work.

Specifications are also set for the portrayal of correct land appellations; and although several appellation systems are in vogue, depending upon tenure, there is no duplication and every land parcel has a unique appellation. The department is currently working on the formulation of one appellation system that will apply to land parcels in all tenures created under any enactment.

Lastly, the regulations set requirements for the portrayal, scale, production and integration of all survey plans which are now presented as a title plan and survey data plan in a black-and-white format suited for microfilm reproduction.

### Control of land survey standards

In respect of all land surveys, the plans, field notes, co-ordinate lists and accompanying documents are lodged with the Chief Surveyor of the district in which the survey is situated. Examination is undertaken as to accuracy of boundary definition and parcel description, safeguard of abutting titles and compliance with the Survey Regulations and enactments applicable to the survey purpose. Following correction by the practitioner, where necessary, the plans are approved and become the property of the Crown.

The Lands and Survey Department also maintains a cadre of inspecting surveyors who periodically field-check, on a random basis, a sample portion of the work of every surveyor with respect to standards of measurements and monumentation, and compliance with the Survey Regulations. Action in matters of default are taken through the Chief Surveyor or, in serious cases, through the New Zealand Survey Board.

### Land survey records

After approval, the plans are microfilmed and several sets copied for official use in each district. Sets are also provided to other users on demand; and the ready availability of graphic data, through the microfilm process, has undoubtedly further aided integration. The department also at this stage produces the land title diagrams and again the black-and-white title plan has rationalized this procedure through simple copying processes.

Cadastral index record-sheets are maintained at scales suited to the survey subdivisional pattern. These sheets portray parcel boundaries, appellations, areas, survey plan references, road legalities and other details, and provide an instant, updated record of survey data simply through the daily plotting of parcels and other information created by approved survey plans. The new metric series record-sheets produce the line-work and text on separate overlays; and wherever utilized the base transparencies are supplied to local authorities and to planning and *ad hoc* bodies, in an endeavour to further rationalize the basic use of cadastral records and avoid duplication of effort. The sheet lines of these index record maps are based on subdivisions of the metric cadastral map patterns.

The updated record-sheets in turn provide the production basis for published cadastral maps covering the country on the basic scale 1 : 50,000, and for other cadastrally based records embracing the cities, towns and populated areas on varying scales and for varying purposes.

It may fairly be said that the departmental production of all land survey records, from individual survey plans through to basic small-scale cadastral maps, is fully integrated; and every effort is being made to further integrate by encouraging other organizations to adopt these cadastral bases as a foundation for their overlaid information and other uses.

As in the case of survey control data, all land title survey plans, co-ordinates and documents, and all cadastral records and maps are available for search by the practitioners and the public free of charge.

### Integration and co-ordination of government survey operations

In addition to the operations and administrations already covered, the Lands and Survey Department has endeavoured to apply its objectives and principles to the integration and co-ordination of all government survey activity. It is responsible for the execution of land surveys required for any government purpose, the majority of which are carried out by staff surveyors and the remainder undertaken on contract by private practitioners.

Extensive planning, surveying, engineering and mapping services are provided to the parent Lands and Survey Department, which is the major agency for agricultural and Crown lands development and for environmental and public open-space provision.

Within its own financial resources, the Survey Division provides all aerial photography required for national basic mapping and resources inventory, and also requisitions and controls the provision of all aerial photography for other departments. Integration is achieved through the formulation of an annual flying programme to which all users contribute; flying operation is undertaken by major aerosurvey firms in New Zealand, using aircraft and some cameras leased from departmental ownership.

The provision and co-ordination of civil and air force aerochartering requirements are facilitated through departmental chairmanship of the Aeronautical Charting Committee.

The Surveyor-General provides all survey services to the state housing development organization and undertakes all aerodrome obstruction surveys and aeronautical navigational aid fixations, and many of the surveys required for marine navigation and in-shore hydrography.

All major geodetic surveys and precise measurements for investigation of earth crustal movements and of man-made deformations associated with dams, structures and mining are undertaken for the Departments of Scientific and Industrial Research, of Electricity and of Mines Co-ordination and implementation are facilitated through membership of the Royal Society Committee on Earth Deformation.

Survey services and aid to the Antarctic and to countries in the Pacific and South-East Asia are provided through the secondment of staff and the mounting of specific survey, mapping and training projects.

Measurement surveys are undertaken in respect of tunnels, bridges and pipelines, and survey services are

supplied on demand to the departments of Police, Mines and Meteorological Services and to virtually all other organizations of the State. The two major exceptions are the Ministry of Works and Development and the Forest Service, which maintain their own survey organizations but are confined to localized close-quarter support of their own constructional and development operations.

The Lands and Survey Department is the Government's sole official photogrammetric mapping agency and undertakes all tasks for basic, project, development, planning or other mapping purposes.

Co-ordination and integration of survey and mapping services are facilitated through Lands and Survey chairmanship of an interdepartmental Survey and Mapping Co-ordination Committee.

Similar principles have been adopted with respect to the integration of cartographic activities. The Department undertakes most of the national topographic, cadastral and thematic mapping, and adopts the general policy that the production of such published mapping should remain its general prerogative. Services involving the conversion or adaption of existing maps and records for such purposes as police geocoding systems, statistical and population analysis and valuation recordings are also provided. In certain circumstances, cartographic staff are seconded to other departments for mapping production; and in all other cases, where a full service is not provided, the Lands and Survey cadastral and topographic map bases are made freely available.

The integration and rationalization of governemnt survey operations have therefore been achieved by the provision of survey services to other departments, largely free of charge, through secondment of staff, the joint or co-operative execution of projects, the co-ordination of general or national activities and other approaches suited to the situation. Many of these aims have been accomplished in comparatively recent years and have not been easy to implement within a fixed departmental staff total; and, indeed, they would have been impossible without the introduction of electronic survey equipment and sophisticated developments in the mapping fields.

The rationale behind these efforts has always remained constant; the maintenance of a major viable survey organization with a sound and versatile staff structure capable of servicing extensive and changing demands; the discouragement of fragmented survey units of limited utility that are unsuited to the national requirements; and the co-ordination and rationalization of all survey operations in order to integrate demand and resources to best effect and to avoid duplication of staff, equipment, expenditure and effort.

## Conclusion

The major components and requirements of an integrated survey system have been established in New Zealand, some fortuitously, but many more through sound planning and foresight. There will be many improvements and advances demanded in the future, not the least of which inevitably will be the establishment of an integrated and computerized land resources data bank, for which the survey system is already suitably prepared.

There will also be challenges to the cohesiveness of the system; and these challenges will be met, as in the past, only through vigilance and the determination to plan and achieve those moves which will immediately or ultimately sustain the integrated process. In the final analysis, this goal will be achieved only through a minimum of statutory control; a maximum of communication, co-operation and professional good will; and the acceptance of appropriate leadership in the interests of an effective survey administration.

# AGENDA ITEM 9

## Hydrographic surveying and charting

### AUSTRALIAN BATHYMETRIC MAP SERIES AT 1:250,000 SCALE*

*Paper presented by Australia*

In 1970, the Division of National Mapping of the Department of National Resources was given the responsibility of mapping the continental shelf of Australia on the scale 1 : 250,000. The series will play an important part in the efficient management of off-shore natural resources in the waters surrounding the continent. The immensity of the Division's mapping task can perhaps be realized when it is considered that the Australian continental shelf is one of the largest in the world—about 2.1 million $km^2$—and contains some of the most complicated waters known to man.

The Division is working in very close co-operation with the Hydrographic Service of the Department of Defence, which is responsible for production of hydrographic charts for navigation; and whenever possible, existing naval surveys are incorporated into the bathymetric mapping programme.

The progress of this mapping as at 30 June 1976 is shown in figure 108.

#### THE BATHYMETRIC SURVEY

The area selected for survey is normally covered with a series of evenly spaced, parallel sounding-lines commencing at the 20-m depth contour and terminating at the 300-m depth mark. Sounding-lines are generally oriented at right angles to the isobaths and are spaced at 1,500 or 3,000-m intervals, depending upon the complexity of the sea-bed topography.

Continuous position information is obtained from conventional radio navigation systems or from the Navy Navigation Satellite System interfaced with Doppler sonar equipment to provide dead-reckoning parameters.

Depths are provided by echo-sounder and a continuous profile of the ocean floor is obtained for each sounding-line.

During the surveys, the positioning and uncorrected depth data are plotted at regular intervals so that predetermined lines of sounding can be obtained; positioning data are checked and areas of sea-bed relief requiring further sounding are brought to notice whilst in the area. The plot sheet is then used to provide a base from which the manuscript map is drawn on the scale 1 : 150,000.

All maps of the bathymetric series carry a warning against using the maps for navigational purposes. No particular effort is made to discover new hazards to shipping during the bathymetric survey; and the hydrographic charts, produced by the Hydrographic Service of the Royal Australian Navy always remain the main aid to mariners for safe navigation.

#### ADDITIONAL OBSERVATIONS FOR OTHER AUTHORITIES

In addition to the gathering of basic bathymetric survey information, other scientific data are collected as long as the process does not significantly slow the production rate of the bathymetric survey. Some of the information collected to date has been the following:

(*a*) Sea-surface temperatures have been continuously recorded for the Division of Fisheries and Oceanography of the Commonwealth Scientific and Industrial Research Organization (CSIRO);

(*b*) Weather reports have been telegraphed at six-hour intervals to the Bureau of Meteorology while the survey vessel was at sea;

(*c*) Magnetometer and sub-bottom profile data have been recorded, using equipment provided by the Bureau of Mineral Resources.

#### THE MANUSCRIPT BATHYMETRIC MAP

The first stage in the map production process is the drawing of manuscript bathymetric maps on the scale 1 : 150,000. The projection, spheroid, grid zone etc. are as set out by the National Mapping Council special publication 7, *The Australian Map Grid Technical Manual.* The horizontal datum is the Australian geodetic datum and vertical datum is mean sea level.

Depths below mean sea level are shown at appropriate intervals along the sounding-lines and at significant changes of grade. Depths less than 35 m are shown in metres and decimetres and depths of 35 m or more to the nearest metre.

Bathymetric contours are drawn at 20-m intervals

* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.34.

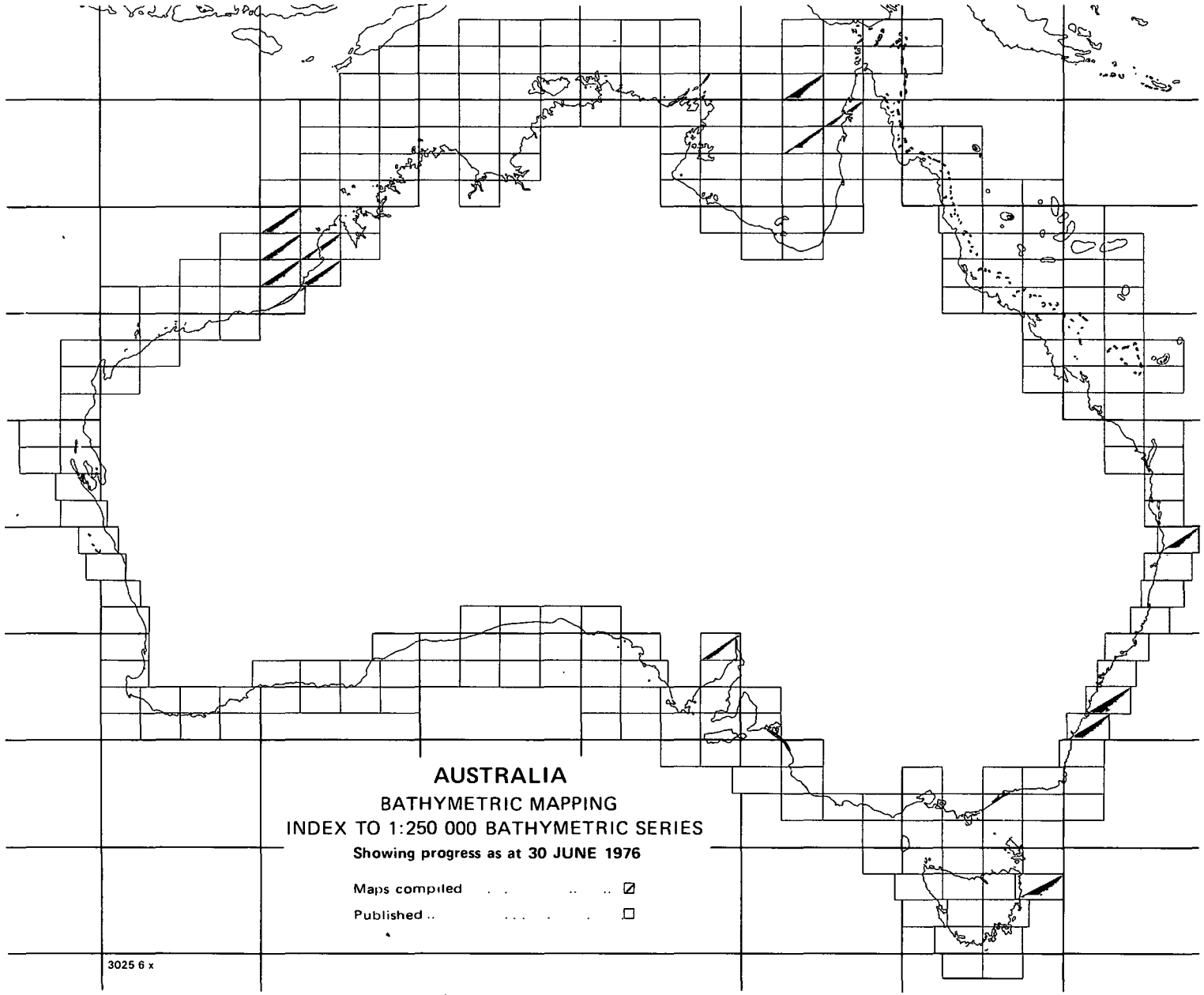



*Figure 108. Australia: bathymetric mapping index to bathymetric series at 1 : 250,000 scale*

between depths of 20 and 300 m. The 100-, 200- and 300-m contour lines are shown as index contours.

The grid is plotted so that error does not exceed 0.25 mm over each sheet or 0.1 mm between adjacent grid marks. The graticule is plotted so that the error does not exceed 0.1 mm in respect of the grid. Soundings and other discrete points of detail are plotted so that errors do not exceed 0.25 mm also in respect of the grid. Bathymetric contours are interpolated so that error does not exceed 5 per cent of the contour value in respect of the adjacent soundings.

The accuracy of the map is in accordance with that specified in the National Mapping Council in its publication *Standards of Map Accuracy*.

## Map design

Each manuscript map is reduced from 1 : 150,000 to 1 : 250,000 and is assembled in four sheets to provide the standard bathymetric map coverage 1° of latitude by 1° 30′ of longitude at 1 : 250,000 scale.

The series is designed to cover the continental shelf, soundings are shown to the 300-m contour and coverage of the sheet limits caters for the addition of a 500-m contour if required at a later date.

All soundings are printed on the reverse side of the bathymetric map.

On the face of the map, the following information described below is depicted.

### *Contours*

The primary information shown is contours of the sea-bed at 20-m intervals below mean sea level.

### *Spot depths*

Primary spot depths are shown for use in interpolation of depths between contours. They are not necessarily on the highest or lowest points at changes of grade but are selected to provide depths between them to within 5 m of the surveyed depths in smooth areas and 10 m in broken areas.

Secondary spot depths indicate isolated features of significant height or depth but of unknown shape or extent. They do not give any indication of the general depth of the area.

### *Coastline*

The coastline is nominally the line of mean high water. The line has been taken from existing topographic maps and has not been precisely determined by field observations.

### *Land features*

Only ports, selected towns and populated places near the coast, and large rivers and lakes open to the sea are shown. Contours and vegetation, except mangroves, are not shown and an over-all grey tone is used on land areas.

Lighthouses and substantial off-shore weather stations whose positions are accurately known are shown but no other navigation aids appear.

Bridges are shown where they cross water 20 m or more in depth.

Heights of islands and rocks above mean sea level are shown next to the feature.

### *Foreshore flats*

Rock ledges, breakwaters, piers, beaches, tidal flats, mangroves, cliffs and other significant features of land-mark value directly associated with the foreshore area are shown.

### *Sea-bed features*

Rocks, shoals, banks, reefs, reefs with cays, permanent cays, tidal flats, bars detached from the shore, wrecks above low water, significant changes in slope and prominent elevations or depressions of the sea floor not-depictable by standard bathymetric contours are shown.

### *Graticule*

Meridians and parallels of latitude on the Australian geodetic datum are shown as full lines every 10 minutes of arc. One-minute ticks are shown along the one degree and half-degree lines and around the edges of the map inside the neat-line.

Where an extended or shifted sheet edge is only 5 minutes from a ticked meridian, the ticks on that meridian are deleted.

### *Grid*

Ticks are at 10,000-m intervals on the Australian map grid, and their co-ordinate values are shown around the edge of the map outside the neat-line. Where an extended or shifted map crosses a zone boundary, the ticks are also shown along that meridian through the body of the map. The Australian map grid co-ordinates are shown in full only at the south-western corner of the map, and if the map crosses a zone boundary, on the map margin at the boundary.

### *Production*

Using the national topographic map series on the scales 1 : 250,000 and 1 : 100,000, hydrographic charts and maps produced by state mapping authorities, a nomenclature selection of towns, coastal features, islands, reefs etc. is carried out.

Two guide images are produced from the 1 : 250,000 manuscript reduction assembly for scribing the contours and change of slope information to be printed in blue and for scribing the coastline and coastal features to be printed in grey.

Two negatives of the type overlay are produced and colour-separated for blue and grey detail. Masks are then made covering the land mass, to be printed in a screen of the grey; and for the gradient of the sea-bed, to be printed in blue.

Gradations of bathymetric tints are produced by the utilization of screened lines and a screen of the full blue colour to depict areas 0–100 m in depth, 100–200 m and 200 m or more.

Laterally reversed clear film positives are made from

all reproduction material prior to plate-making and printing in two colours on the face of the map and one colour on the reverse side.

A section of a completed map is shown in figure 109 in the pocket at the end of this volume.[1]

### USE OF THE SERIES

The series will provide a basis on which scientific and exploratory studies can be undertaken and will portray in some detail the nature and extent of the potentially rich continental shelf. The bathymetric map series will undoubtedly also find other uses and the maps have already been utilized for a study on the distribution of commercial shark species in relation to water depth and the updating of sea-bed topography for submarine navigation.

In addition, survey information in the form of sounding profiles has been used for micro-geomorphological studies and the location of new prawning grounds of the southern Queensland coast.

It appears certain that as the bathymetric mapping programme gains momentum, there will be an increasing use by various disciplines of the information collected during the surveys and the resulting bathymetric maps of the Australian continental shelf.

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figure 109 is in this pocket.

## BATHYMETRIC SURVEY TEST OF POSITIONING ACCURACIES*

*Paper presented by Australia*

This report covers accuracy tests conducted of the Magnavox combination Doppler satellite/gyroscope/sonar Doppler positioning equipment used by the Division of National Mapping for its bathymetric surveys.

The tests were carried out in the vicinity of Jervis Bay off the coast of New South Wales (see figure 110). Direct comparisons were made between positions determined from the Doppler satellite/gyroscope/sonar Doppler equipment and concurrent determinations of position by a combination of theodolite observation and Motorola distances measurement from coastal geodetic stations. It had previously been established that Motorola has a range accuracy of $\pm 3$ m.

### SATELLITE FIX ACCURACY

Forty-four passes tracked while the ship was travelling along a straight line gave the following results:

(*a*) The mean difference of all comparisons between the satellite-derived and shore-based positions was 1 m in latitude and 4 m in longitude. This result is probably fortuitous to a certain degree, but it certainly confirms that the datum shifts that were being used are valid.

(*b*) The standard deviation of the individual satellite positions was 32 m in latitude and 48 m in longitude.

Satellite fix accuracy deteriorated in turns, which is attributable to the fact that dead-reckoning accuracy also decreases in turns. The mean difference between the satellite-derived and shore-based positions for five passes tracked during turns was 40 m in latitude and 28 m in longitude. The standard deviation for individual fixes was 181 m and 147 m.

Satellite fix accuracy varied as expected with elevation angle at closest approach; high passes gave poor longitudes and low passes were weak in latitude.

The following conclusions can be drawn from the satellite fix results:

(*a*) Errors in the datum shift correction are negligible;

(*b*) The standard radial error of a satellite fix tracked while the ship is travelling on a straight line is about 60 m;

(*c*) The standard radial error of a satellite fix tracked while the ship is turning is about 275 m;

(*d*) It is obvious that turns must be avoided while a satellite pass is in progress even if it means extending a sounding-line;

(*e*) Satellite fixes with elevation angles lower than 10° and higher than 70° should not be used to update the dead-reckoning position.

### DEAD-RECKONING ACCURACY

The satellite system was operated with the ship travelling at speeds of 12 knots, 10 knots and 7 knots. In water depths less than about 250 m there was no significant difference in the accuracy of results. Maximum allowable sounding speed appears to depend largely upon sea conditions. In deeper water, and in particular when sounding over the edge of the shelf, slower speeds give better results. It appears that there was no difference in system accuracy as a function of water depth from about 15 to 250 m.

It appears also that sounding can progress at full speed in good weather out to a depth of about 250 m.

Inclusion of velocimeter information in lieu of thermistor data produced no change in the accuracy of results. The velocity of sound in water from the velocimeter and thermistor was monitored throughout the test period.

* The original text of this paper appeared as document E/CONF.68/L.94.

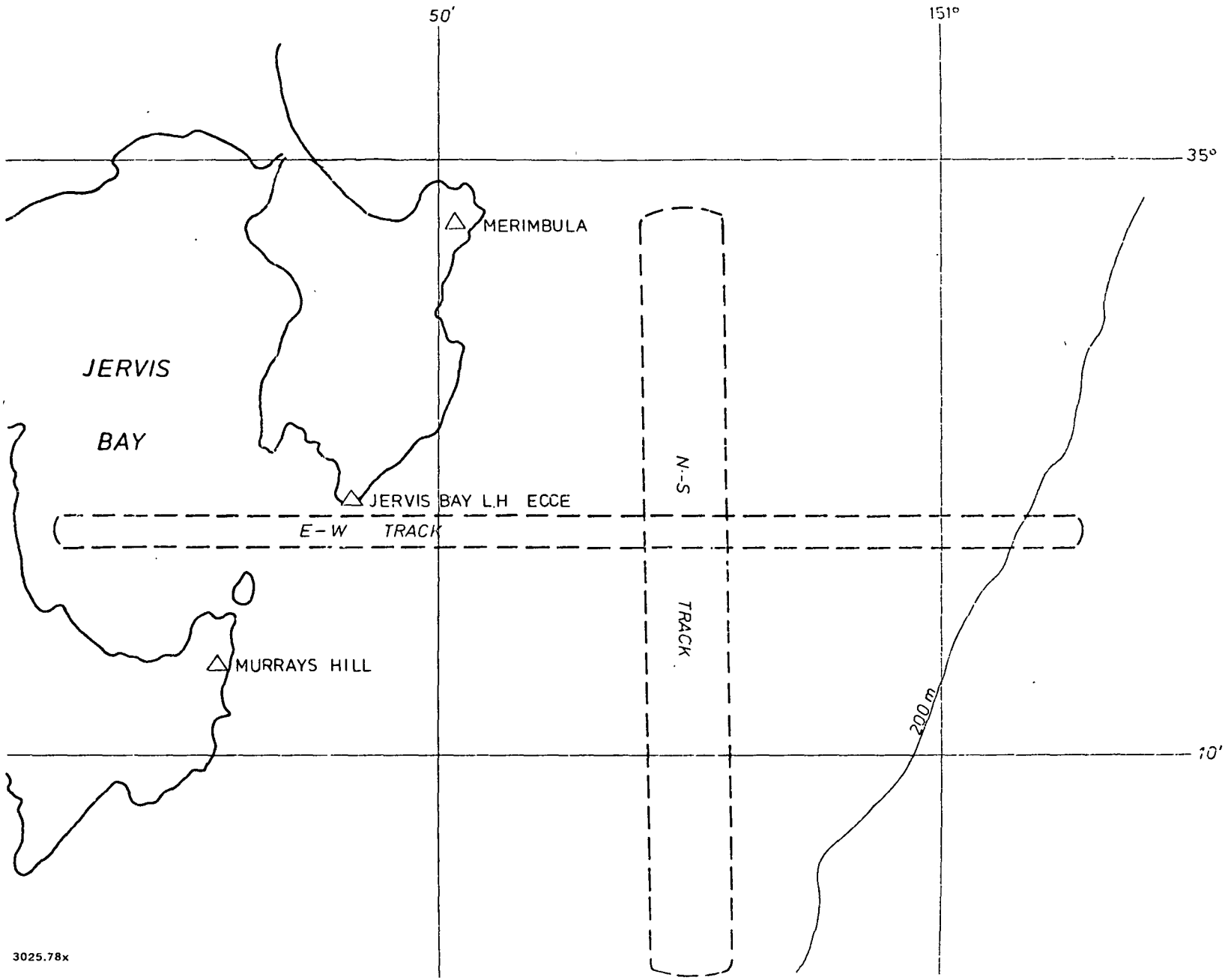



*Figure 110. Australia: accuracy test map carried out in vicinity of Jervis Bay off the coast of New South Wales*

There was a consistent 3 or 4 m per second difference between velocities from the two sources. This difference would have been compensated by the calibration parameters velocity adjustment (VADJ) and thermistor adjustment (TADJ).

There was no discernible difference in results with the inclinometer on and the inclinometer off. Sea conditions were generally good throughout the test period, so it was not a good situation for testing the inclinometer.

Test results show that dead-reckoning error does increase linearly with distance travelled, as long as no turns are made. It is generally safe to assume that error increases linearly with time when numerically adjusting intermediate fixes.

### Minimum variance update

The satellite update process makes the dead-reckoning position identical to the satellite fix position at satellite fix time. The minimum variance routine takes a weighted mean of the dead-reckoning and satellite fix positions and updates the dead-reckoning to this mean position. The weights are determined from empirical formulae developed by Magnavox. Twenty-four minimum variance update positions were analysed with the following results:

(*a*) The mean of all the minimum variance positions differed from the mean of the shore-based positions by 10 m in latitude and 26 m in longitude;

(*b*) The standard deviation of individual differences was 32 m in latitude and 59 m in longitude;

(*c*) Comparison of the figures given above with those given above in the section on satellite fix accuracy (first paragraph) shows that satellite fix positions are significantly better than minimum-update positions. This indicates that the empirical weights assigned by the Magnavox algorithm were not realistic;

(*d*) Intermediate fix points will be adjusted between satellite fix positions rather than minimum variance positions in the future.

### Doppler sonar operation

On seven runs out over the edge of the shelf the Doppler sonar bottom-tracked to an average depth of 327 m. The limiting depths achieved were 380 m and 360 m while doing 7 knots. The limit was 272 m at 10 knots. The sonar regained bottom-tracking at an average depth of 285 m when coming back onto the shelf. In the worst instance, the sonar remained on water-track into a depth of 260 m. The shelf falls off steeply in the test area. On the basis of the test results, it is reasonable to expect that the Doppler sonar may bottom-track out to 400 m at slow speed over a gently sloping shelf.

Attempts to estimate the accuracy of the Doppler sonar in the water-track mode were a failure because operation was very erratic in water-track. It is hoped that at least part of the problem was due to lack of experience with water-track. On several occasions, the sonar lost bottom lock and failed to transition into the water-track mode. This symptom is disturbing because a common fault with earlier sonars was the inability to water-track in very clean water. It is hoped to clarify the water-track problems in the course of future operational surveys.

Several different rates of turn were tried during the test. This aspect of the operation is still being analysed, but it is safe to say that dead-reckoning accuracy deteriorates significantly in any turn. This situation is unfortunate because it means that the linear adjustment procedure for intermediate fix points is not really valid if a turn is made between satellite fixes. At this stage, it seems safe to recommend that sounding operations should be planned so as to minimize the number of turns required.

### Calibration of system

The system was calibrated by satellite fix comparisons prior to the start of the test to determine the calibration parameters in respect of azimuth bias (ABIA), velocity adjustment (VADJ) and thermistor adjustment (TADJ). These parameters produced satellite updates that were consistently less than 1 per cent of distance travelled during the test period.

Calibration between known points yields good results, but it appears that calibration between satellite fixes is equally satisfactory and usually more convenient.

### Navigational techniques

The optimum survey speed is a function of sea condition and water depth. Sounding at full speed (12 knots) is possible in good weather. In rough weather, speed should be decreased so that the Doppler sonar can maintain an acceptable number of bottom signal returns. An error message is printed out when the Doppler sonar loses four successive bottom returns so it is possible to monitor closely this aspect of sonar performance. Speed should always be slowed to about 7 knots when proceeding out over the edge of the shelf.

Turns should be made as slowly as possible and once on line, course corrections should be kept to less than 5°.

A Hewlett-Packard 25 programme has been written to compute a current vector for water-track operation. The programme was used with some success on one survey and will be tested further on future surveys.

### Plotting techniques

Linear adjustment as a function of time will be the most suitable method for adjusting most intermediate fixes.

Linear adjustment as a function of distance travelled should be used when a significant change in speed occurs between satellite fixes.

The graphic adjustment technique assumes that the ship travelled on a straight line at a constant speed between satellite fixes. If the satellite update is small and the ship has tracked closely along the required (SAIL) line and there have been no significant changes in speed, the graphic adjustment method is acceptable.

Decision as to which adjustment method to use must take the following horizontal position accuracy specification into account:

"The system used for positioning the survey vessel

shall be operated so that errors in position shall on the average not exceed 100 metres, shall seldom exceed 200 metres, and shall never exceed 300 metres in relation to the AGD"

Analysis of data of determine the accuracy of adjusted intermediate fix points has not been finalized. However, results of several lines selected at random show that the radial error is 82 m when the ship travels a straight line between fixes and 196 m when the ship turns between fixes. In addition to these errors, there is a random plotting error about 35 m. Based on these figures, the satellite Doppler/gyroscope/sonar Doppler system accuracy marginally satisfies the accuracy specification stated above.

### NOTES ON OPERATIONAL PERFORMANCE

The following notes summarize the operational performance of the system:

(a) *1975*: 86 days operational at sea; equipment failure 5.8 per cent of the 86 days;

(b) *1976*: 112 days operational at sea; equipment failure 6.9 per cent of the 112 days.

## HYDROGRAPHIC SURVEYING AND CHARTING* IN BANGLADESH

*Paper presented by Bangladesh*

Bangladesh, being a maritime country, has its territorial waters and about 4,700 miles of inland navigable waterways. Hundreds of thousands of miles of inland waters, ranging from vast rivers down to narrow creeks, flow through Bangladesh. The cheapest and the most convenient means of communication and the means for the flow of commerce are the waterways of Bangladesh. The fate of the millions of people of this country are closely linked with those waters, upon which depend agriculture, fisheries, communication, industry, commerce etc.

The rivers of Bangladesh have unstable beds; the channels and the shoals change continuously. The banks of the rivers may grow by deposition of sand and silt, or they may be eroded. Steep cliffs are formed, which are caved in by the current. The river-bank may be cut as much as several hundred feet in a year. On the other hand, the bottom topography of the vast coastal areas of Bangladesh is very shallow with several detached shoals and shifting sandbanks. The coasts in the vicinity of the estuaries are low; and visibility in the approaches, except at the change of seasons, is generally hazy. Fog along the river and off the coast occasionally occurs at the change of seasons.

The Bangladesh Inland Water Transport Authority, an organization under the Ministry of Communications, is responsible for undertaking hydrographic surveys of the inland and coastal waters of Bangladesh. To keep a continuous record of the hydraulic changes of the river system and coastal waters of Bangladesh, regular hydrographic surveys and investigations of all the main rivers as well as the coastal areas are being carried out by experienced technical personnel trained both at home and abroad in the fields of hydrography, hydraulic engineering, physical oceanography etc. The hydrographic surveys of inland rivers are generally carried out on the scale 1 : 25,000 or 1 : 50,000; and the survey of coastal areas is being carried out on the scale 1 : 100,000. Bangladesh is maintaining the DECCA navigation chain system MK-10 and a mobile Hi-Fix chain system. The DECCA chain covers the entire country up to 150 nautical miles from the coast towards the sea. Hydrographic surveys of inland and coastal waters are mainly carried out with the aid of the DECCA chain system. The mobile Hi-Fix chain is occasionally used.

Bangladesh generally follows admiralty practices in the preparation of maps and hydrographic charts, and has already published hydrographic charts for coastal waters and seaport approaches in several colours according to the international standard. Hydrographic charts of other inland rivers which are of shifting and changing nature are published from time to time on blueprints. When publishing hydrographic charts, the Hydrographic Department is constantly aware of the lack of modern equipment and of professionally skilled hands needed to bring the level of charting work up to international standards. As Bangladesh is a developing and newly independent country, there is ample scope for improvement by further modernization and by arranging for professional training of personnel. Other developed countries, under the auspices of the United Nations, may come forward to assist Bangladesh in this endeavour.

*The original text of this paper, prepared by the Hydrographic Department, Bangladesh Inland Water Transport Authority, Ministry of Communications, appeared as document E/CONF.68/L.128.

# HYDRO-OCEANOGRAPHIC ACTIVITIES IN INDONESIA IN THE PERIOD 1973–1976*

*Paper presented by Indonesia*

## Organization

In March 1976, a major reorganization of the Indonesian Navy was planned, in which the Naval Hydrographic Office (DISHIDRAL) was to be changed into the Hydro-Oceanographic Service (JANHIDROS) as a central operating unit of the Navy. The new naval organization became effective in August 1976 and subsequently some principal change took place in the organization of JANHIDROS. The structure of the organization has a line and staff characteristic (see figure 111).

## Task and responsibility

JANHIDROS is responsible for directing and accomplishing hydro-oceanographic requirements for naval, security and defence, and armed forces purposes as well as general and national purposes.

To accomplish the task and responsibilities mentioned, JANHIDROS carries out the following functions:

(*a*) Planning and setting up a hydro-oceanographic system within the framework of the armed forces survey and mapping system;

(*b*) Planning and programming hydro-oceanographic activities to fulfil naval requirements;

(*c*) Conducting hydro-oceanographic surveys; and issuing and publishing nautical and aeronautical information, nautical charts, and other sailing directions;

(*d*) Co-ordinating hydro-oceanographic activities with national and international hydro-oceanographic institutions or bodies in accordance with existing regulations;

(*e*) Supervising the execution of its programmes to ensure efficient and effective results;

(*f*) Submitting proposals and advice to the naval chief of staff, in particular with regard to hydro-oceanographic matters.

## Programme and procedure

Prior to 1974, the budgeting system applied was such that funds for surveying in support of development programmes were incorporated in the various project budgets. Thus, funds for surveying and charting were obtained from various departments and agencies. Due to these circumstances, JANHIDROS could not draw up an annual working programme, since the utilization of vessels and personnel is scheduled according to the needs of other agencies.

Since April 1974, the Government has allocated funds for the updating of nautical charts in particular. Although these funds are not directly deposited with JANHIDROS, comprehensive annual planning for surveying and charting has become possible. Annual capability to perform complete surveys, based on vessel and land-based team strength, is nine detailed hydrographic surveys and three oceanographic surveys, in addition to some minor surveys.

## Hydro-oceanographic surveys and cartographic activities

During the period under review, the following notable surveys were carried out:

(*a*) Hydrographic surveys of the Remunia shoals, One Fathom Bank area, and Singapore Straits, carried out by a joint survey team from Indonesia, Japan, Malaysia and Singapore, using vessels from Indonesia, Malaysia and Singapore, from 4 November 1973 to 12 May 1974 and from 8 July 1974 to 29 December 1974;

(*b*) Hydrographic surveying in Lombok and Makassar straits from 10 May to 2 September 1975. That survey was carried out by JANHIDROS with technical assistance from the Hydrographic Department of Japan;

(*c*) Detailed hydrographic surveying in 26 ports, harbours and approaches to promote safety of navigation, in co-operation with the Directorate of Sea Communications;

(*d*) Minor hydrographic surveys for dredging and harbour facilities development projects;

(*e*) Establishment of tidal stations at Tanjung Priok, Surabaya, Cilacap and Ujung Pandang.

Based on the results of the above-mentioned surveys, a total of 32 nautical charts on scales ranging from 1 : 25,000 to 1 : 200,000 have been revised and published as new editions.

In addition, 32 nautical charts have been corrected or revised, based on various data, and published as reprints or new editions.

## Technical assistance

During the hydrographic survey of the Lombok and Makassar straits, technical assistance was received from the Government of Japan. That assistance consisted mainly of providing electronic positioning systems, Navy Navigational Satellite System (NNSS), LORAN C, PULSE 8 and the necessary technicians as well as assistance for the electronic computer programming for data processing.

## Training

Training is undertaken locally or abroad. This training is urgently required to increase the knowledge required, especially pertaining to hydrography and oceanography.

* The original text of this paper, prepared by the Hydro-Oceanographic Department (JANHIDROS), Jakarta, Indonesia, appeared as document E/CONF.68/L.87.

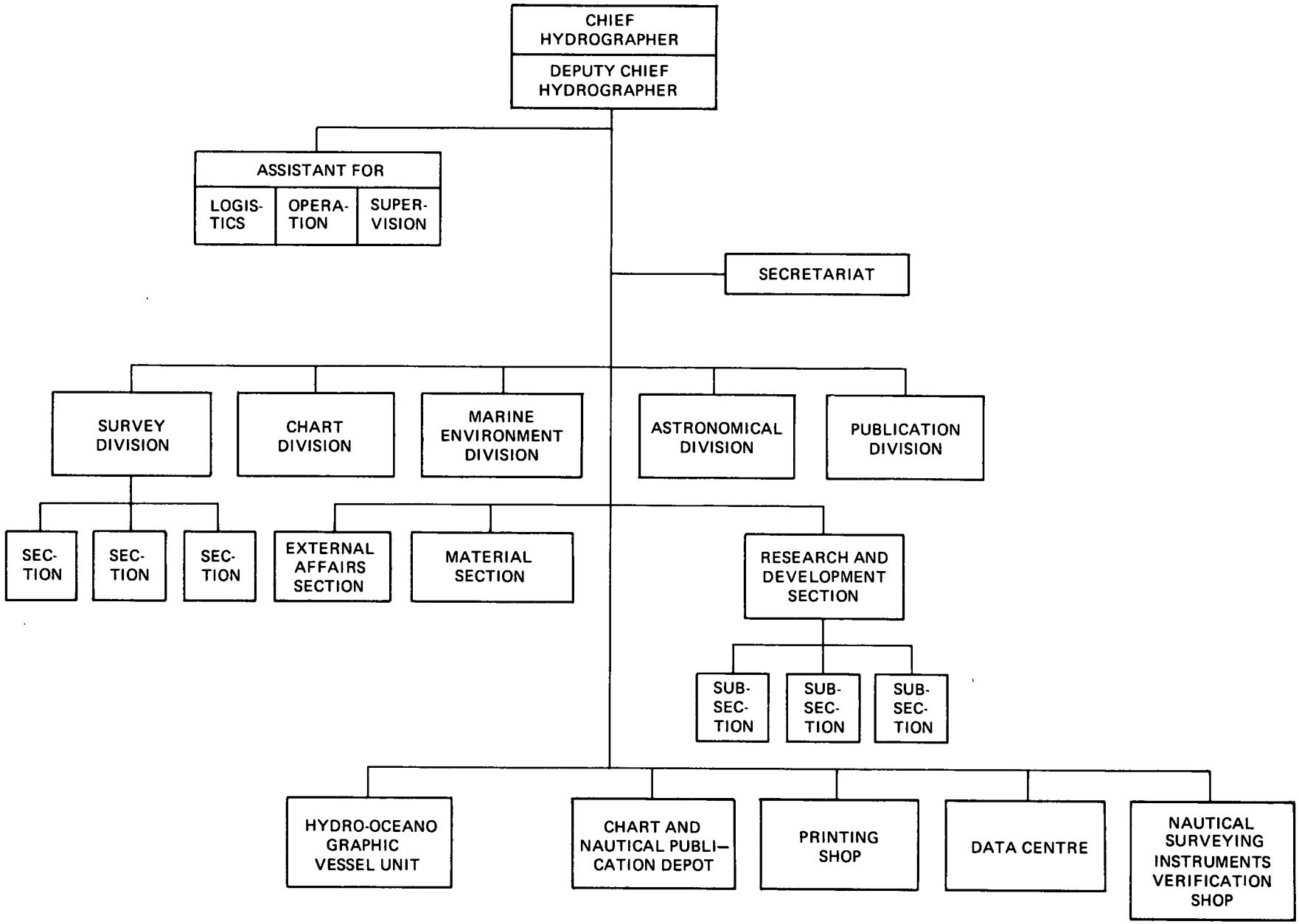



*Figure 111. Indonesia: organization of Hydro-Oceanographic Service*

The training is achieved within the framework of the general Navy programme as well as through JANHIDROS programmes adjusted to the requirements of the task of JANHIDROS.

Training is undertaken abroad in the fields of hydrography, oceanography, cartography, photogrammetry, remote sensing, Tellurometer maintenance, mechanical engineering and printing. Training has been given in Australia, Brazil, Japan, The United Kingdom of Great Britain and Northern Ireland and the United States of America.

Local training consists mainly of training required for promotion of officers, petty officers and ratings in accordance with the Navy programme. In the framework of the JANHIDROS programme, mainly petty officers, ratings and civilian personnel are trained in order to carry out the technical as well as the administrative tasks of JANHIDROS.

### Other matters

As a follow-up of the joint surveys carried out in the Malacca and Singapore straits, the necessity was felt of having common charts of the straits based on a common datum.

Preliminary talks have already been held between Indonesia, Malaysia and Singapore regarding this matter; and Japan has agreed to finance this project. It is hoped that the project will commence some time in 1977. (resolution 6–1973).

The tidal stations at Tanjung Priok, Surabaya, Cilacap and Ujung Pandang which were established primarily for hydrographic and navigational purposes, may also be utilized for national levelling surveys (resolution 16-1973).

The updating of sheets for the General Bathymetric Chart of the Oceans (GEBCO) is hindered by the scarcity of data, since no regular oceanographic surveys were programmed during 1972–1976.

Information obtained is from exchanges with other countries and from research vessels cruising Indonesian waters. The coloured contour sheets have not yet been produced (resolution 24-1976).

During the hydrographic survey of the Lombok and Makassar straits, satellite positioning system (NWL-8D) was employed, but the results were converted to that of Bessel spheroid, which is still officially used for charting. The unified world geodetic datum is still to be discussed at the national level (resolution 15-1973).

## HYDROGRAPHIC SURVEY IN THE LOMBOK AND MAKASSAR STRAITS CONDUCTED BY INDONESIA WITH TECHNICAL ASSISTANCE FROM JAPAN*

*Paper presented by Indonesia*

International co-operation in the field of hydrographic surveying has been achieved by Indonesia, Japan, Malaysia and Singapore since 1968, when those countries began conducting the Four Nation Joint Surveys of the Malacca and Singapore straits, which lasted upto early 1975.

Based on this experience, the Government of Indonesia and the Government of Japan reached an understanding and agreed to conduct a hydrographic survey along the straits of Lombok and Makassar (see figures 112 and 113) to promote safety of navigation, primarily a route for merchant vessels, including tankers, which are unable to navigate safely through other straits.

The main hydrographic survey was carried out using KRI *Burujulasad*. The survey commenced on 10 May 1975 and was successfully completed on 2 September 1975, while the reconnaissance was carried out from 21 February to 31 March 1974.

Data processing of the survey was conducted at Jakarta from 25 September to 25 December 1975. For the execution of surveys, technical assistance was received from the Government of Japan.

It is the purpose of this paper to describe international co-operation in conducting a large-scale hydrographic survey involving a combination of more than two positioning systems and an area 660 nautical miles long and approximately 10 nautical miles wide.

### Outline of operations

#### *Field of operation*

*Sounding*

Sounding-lines at 1-mile intervals traversed the channel, which is approximately 10 nautical miles wide and 600 nautical miles long, on the scale 1 : 250,000. In the vicinity of Pulau Sekala, the sounding-space was every 0.5 mile. In the narrowest part of Lombok Strait, the sounding-space was every 200 and 400 m, on the scale 1 : 20,000.

The echo-sounder used for sounding in waters more than 200 m deep was of type MS-26 J (Kelvin Hughes), and in waters less than 200 m deep, type NS-39 (NEC). Tidal reductions for sounding in the northern part of the survey area were based on the tidal data observed at Donggala. For sounding in the middle part, tidal reduction was based on the observation at Pulau Kalu Kalukuang; and sounding for the Southern part (including specified area), tidal reduction was based on the

* The original text of this paper, prepared by the Hydro-Oceanographic Department (JANHIDROS), Jakarta, Indonesia, appeared as document E/CONF.68/L.88.

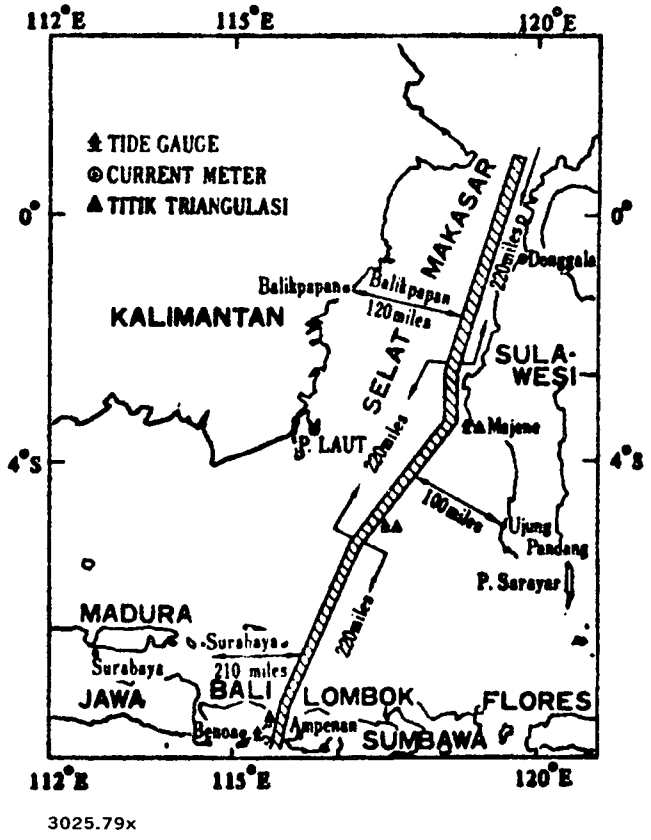



*Figure 112. Indonesia: location of hydrographic survey area along Lombok and Makassar straits in relation to land points*

observation at Padang Baai. Tidal reductions were only applied to depths of less than 200 m.

*Position fixing*

For positioning in the survey area, an automated hybrid positioning system consisting of Navy Navigational Satellite System (NNSS), LORAN-C and PULSE-8 receivers was used. In the northern part of the survey area, LORAN-C (SS 3-Z and SS 3-Y) integrated with NNSS was used; in the middle and southern parts of the survey area, PULSE-8 integrated with NNSS was employed.

In addition to the hybrid positioning system, Audister was employed in the narrowest part of Lombok Strait (specified area).

*Data processing*

*Summary of data processing*

*General data processing*

Preliminary data processing and the progress report of the survey were done on board KRI *Burujulasad* during the survey period, and the final processing was conducted at Jakarta, from 25 September to 25 December 1975.

Six smooth sheets were constructed, five on the Mercator grid and one on the Universal Transverse Mercator (UTM) grid (Bessel spheroid) on the scales 1 : 250,000 and 1 : 20,000, covering the entire area including area V (specified area).

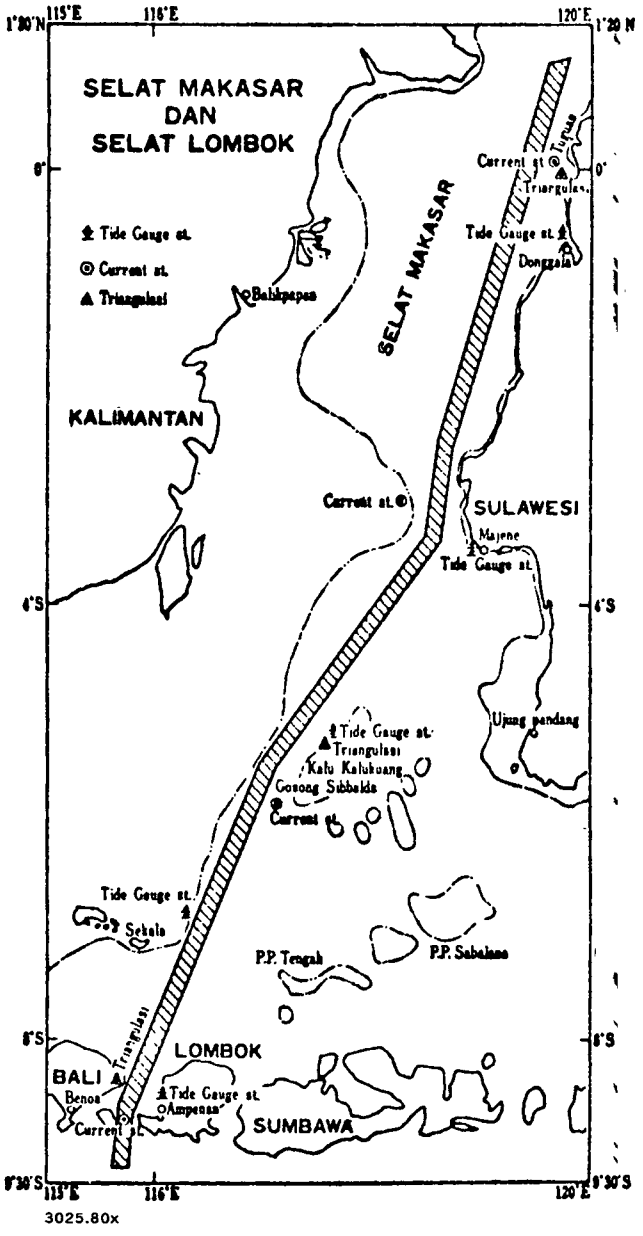



*Figure 113. Indonesia: hydrographic survey along Makassar and Lombok straits*

*Position fixing*

The first phase of data processing was the transferring of NNSS and LORAN-C raw data from paper tapes on to magnetic tapes. The processing of the data was done by computer. The computer programme was designed to perform the selection and adjustment of data obtained and to transform the data on the Indonesian datum. The print-outs were the co-ordinates of sounding fixes ($\varphi$, $\lambda$) and time of sounding.

In area V or the specified area, position fixing was done by Audister in the two-range mode. The ranges at sounding position were automatically recorded.

*Plotting of position*

Sounding-positions, read out from the print-outs, were plotted on aluminium-kent papers as the draft for smooth sheets. The ranges showing fixes of sounding positions in area V were directly read from the Audister print-outs and also plotted on aluminium-kent paper.

*Sounding*

The values of soundings were read out as regular fixes. Shallow-water echo marks betweeen the fixes also were read.

For sounding corrections, the correction values of sound velocity and stylus revolution were applied to the measured depths.

For reductions for sounding, the determination of sounding datum was based on the harmonic analysis of tidal constants at each tidal station. Tidal reductions for soundings in area I were based on the tide data observed at Donggala. For soundings in areas II and III, the tidal reduction was based on the observation at Pulau Kalu Kalukuang. For soundings in areas IV and V, the tidal reduction applied was based on the observation made at Padang Baai. Tidal reductions were only applied to depths of less than 200 m.

*Tide and tidal current*

From the data obtained by the poles and automatic tide-gauges, the hourly tidal values were read and harmonic analyses were made. The periods used for the harmonic analyses were 15 days for Donggala, 30 days for Pulau Kalu Kalukuang and 60 days for Padang Baai. As a two-month observation was made at Padang Baai, the monthly variation was examined; but no appreciable variation was found since the mean sea level was almost at the lowest stage during that two-month period.

For the tidal current, an harmonic analysis was made of the data obtained at the station south-south-westward of Pulau Kalu Kalukuang. From the record, a read-out of mean values of current directions and velocities every 20 minutes was obtained and the curve of tidal current velocity was drawn. From the curve, the hourly values were read and the harmonic analysis was made.

*Conversion of spheroids*

The spheroid on which the survey should be based is that of Bessel (1841) and the geodetic datum should be the Indonesian datum. However, the spheroid employed in the hybrid positioning system is NWL-8D. Therefore, during the data processing, conversion of datum was carried out to eliminate the discrepancies derived from using those two spheroids. Accordingly, conversion from the spheroid of NWL-8D to that of Bessel was made by Moldenskii's conversion formula using those constants obtained from the data of NNSS measurements carried out at Pulau Bali during the reconnaissance.

The computation was carried out separately in the off-line processing by a large computer; a computer programme for that purpose was newly prepared.

In the off-line processing, the UNIVAC 1106 electronic computer was used; the computation was the responsibility of the Computer Science Centre of the University of Indonesia.

### Extent of co-operation

The survey was carried out by Indonesian survey teams using Indonesian vessels: KRI *Jalanidhi* for reconnaissance; and KRI *Burujulasad* for the main operations. The assistance provided by the government of Japan consisted of:

(*a*) Necessary expenses for the survey including that for data processing;

(*b*) Technical assistance comprising survey equipment, such as NNSS, LORAN-C, receivers and some telecommunication equipment.

To ensure smooth operation of the sophisticated equipment, Japan also provided the necessary technicians while Indonesian operators were trained in Japan.

### Conclusion

Indonesia and Japan have shown by example that co-operative surveying is not only feasible but instrumental in promoting good will among countries. Indonesia, as a developing country, is always willing to accept co-operative surveying with a developed country, based on this example.

## WHAT BATHYMETRIC CHARTS SHOULD BE LIKE*

*Paper presented by Japan*

It has long been accepted that a sea map is nothing but a nautical chart. However, as a result of the recent extension of human activities to the ocean in addition to maritime shipping and fishery activities, a wide variety of sea maps other than nautical charts is now being produced. Sea maps dealing with natural geography cover the sea-bottom, sea water and marine biology, and are further diversified into broader fields, while sea maps dealing with human geography cover history, industry, traffic etc.

The bathymetric chart functions as a base map for the various thematic sea maps, just as the topographic map is

* The original text of this paper, prepared by Bunkichi Imayoshi, Director, Chart Division, Hydrographic Department, Maritime Safety Agency, Japan, appeared as document E/CONF.68/L.5.

the base for land maps. In that sense, the bathymetric chart is essential.

A number of bathymetric charts are now produced in various countries, but their specifications are not always uniform.

In 1973, a report[1] was published which compares and examines various bathymetric charts currently in use and considers what form future bathymetric charts should take. On the basis of those considerations, working group 41 of the Special Committee for Oceanic Research (SCOR) worked out the optimal specifications for small-scale bathymetric charts with a world-wide coverage. A fifth edition of the General Bathymetric Chart of the Ocean (GEBCO) sheets is now being prepared with those specifications in mind.

This idea can be developed in a more general way by applying the ideal picture of a bathymetric chart to large-scale charts. Thus, survey specifications for the preparation of such bathymetric charts will be determined and basic specifications will be framed for compilation of the bathymetric chart.

## The bathymetric chart as a base map

The bathymetric chart as a base map should, above all, represent the sea-bottom topography. Apart from a large-scale chart covering a limited area where specially detailed surveys have been carried out, portions of the sea-bed between sounding-tracks are usually left unsounded on bathymetric charts because a bathymetric survey is a survey of lines conducted along sounding-tracks based on the sea-bottom profile. Nevertheless, the unsounded blanks should also be areally expressed by means of depth contours. Accordingly, contouring of the sea bottom not only should adopt all of the existing, carefully selected data but should also take into account all existing geoscientific data. This is because the bottom topography represents the surface of the mass constituting the sea-bottom, so that geoscientific data on the mass are quite effective in interpreting the blank portions of the sea-bottom topography. Hence, even a bathymetric chart prepared in this way is still a chart compiled on the basis of the interpretations of geoscientists at the current level of science. An indication of the amount of data the contouring was based on therefore becomes an indispensable factor in evaluating a bathymetric chart. This information will show that there is room for some other interpretation; and that, for the areas where there are scant data, future surveys can be expected. When a new survey is conducted, the results should be used for correction purposes, and the chart must be constantly updated.

Secondly, in order for the chart to be a base map, it is necessary to have an over-all publication plan; a comprehensive publication plan covering an administrative region or a natural topographic region will facilitate the effective use of the bathymetric chart.

## Basic specifications for a desirable bathymetric chart

To produce a precise bathymetric chart, it is obvious that detailed survey data are required. For this purpose, it is necessary to have specifications for positioning accuracy, sounding accuracy and sounding intervals in the bathymetric survey, but the subject discussed in detail in this paper. Since progress in bathymetric charting will develop with improvements in survey techniques, it may naturally be facilitated by clarifying the purpose of the survey to be carried out, though it is important to specify the degree of accuracy required for individual features. This paper merely points out that there are two ways of determining the survey specifications.

The first approach is to begin by determining the scale of the chart. Then consideration is given to the type of bathymetric survey that should be carried out to determine the smallest topographic feature that can be represented on that scale.

The second approach consists in first determining the scale of the topographic feature to be made clear; then the specifications required for the survey of that feature are decided; and lastly, consideration is given to the chart scale on which the feature can be represented.

In many cases, the first approach is adopted when preparing a bathymetric chart as the base map to cover an extensive area; and the second one is adopted for the preparation of a bathymetric chart covering a small area for a specific purpose.

On the subject of map representation, there is a bathymetric chart giving a three-dimensional effect. This type of chart is a secondary production of an isobath chart for such special purposes as education and wall display and therefore is not discussed here.

Some isobath charts are also multicoloured. As demonstrated by a method such as colour-tinting, colouring does much to enhance the representational ability of a chart, and it is quite natural that production of multicoloured bathymetric charts may be required. However, in order that a bathymetric chart may be used as the base map for various thematic maps, it is clear that a single-colour chart is most important and in fact fundamental. In this sense, multicolouring is not fully discussed in this paper, except to mention that multicolouring is required in order to enrich map representation. Based on the considerations given above, the specifications that would be desirable for single-colour bathymetric charts by means of isobath representation are discussed below in relation to various features.

### *Projection*

On the Mercator projection, parallels and meridians are expressed as straight lines and good continuity with the adjoining sheets can be obtained. So far, bathymetric data have been collected by hydrographic offices, which are the authorities responsible for issuing nautical charts. Accordingly, this projection is adopted for a number of

[1] A. S. Laughton, D. G. Roberts and R. Graves, "Deep ocean floor mapping for scientific purposes and the application of automatic cartography", *International Hydrographic Review*, vol. LI (1973), pp. 125–248.

small-scale bathymetric charts. In nautical charts, the Mercator projection has a remarkable advantage over other projections. With regard to a bathymetric chart, it is convenient for actual use in the survey at sea. However, this projection produces greater distortion in distance, and consequently in area, as the latitude becomes higher. Accordingly, it has a defect that any one topographic feature cannot be compared with others at different latitudes on the same chart scale. Moreover, in these days, when position-fixing systems are highly advanced, the advantage of the Mercator projection for use at sea is considered to be on the decline.

As things are, it is difficult to recommend any one projection as the best for a bathymetric chart. In conclusion, the most reasonable approach would appear to be to select the projection that is most suited for the purpose of the chart. In this case, it is necessary to provide some practical method for conversion of the completed chart into a chart of any other projection. Currently, it would be quite easy to devise such a method.

*Chart datum*

Chart datum is not a significant factor when discussing deep waters in the offing, but it poses a vital problem in charting coastal shallow-water areas, since sounding values may vary greatly depending upon the determination of the chart datum. As concerns nautical charts, the lowest low water in the respective area of the chart coverage is taken according to the purpose of the chart. On the other hand, there are two ways of looking at bathymetric charts. The first is based on the opinion that, when considering the bathymetric chart as a base map, the bathymetric data should be based on the single datum determined for the country as a whole. In this case, a mean sea level in a specific area is taken as the datum level, so that there is an advantage in that there will be continuity in the elevations on land and depths at sea on maps and charts.

The other point of view is that the chart datum should be selected independently for various different places because the height of sea level and changes in tides differ from one place to another. In this case, there are two possible methods of selection: one is to select a chart datum as the lowest low water, as in the case of nautical charts; and the other is to adopt mean sea levels of various places. In the former case, there are advantages in that existing data can be used and that various agreements on the sea are now based on the low-water line, so that the coastline can be used as it is. The latter method is based on the opinion that mean sea levels should be adopted, since actions of sea water, such as waves and swells which influence the topography of the sea-bottom, are best represented by the mean sea level of the place concerned. In any case, the latter consideration has a disadvantage in that there will not be strict continuity between the bathymetric chart and the land map.

It is difficult to judge which of the above-mentioned approaches is the best. However, whichever chart datum is adopted, it will be necessary to clarify its relationship with the other levels.

*Unit of depth*

As the sounding unit, both the metre and the fathom have been used. From now onwards, however, the metre only should be employed. The fathom is a specific unit used solely for water depths, but the metre is a common unit under the centimetre-gram-second system. The metric system has already been adopted by the International Hydrographic Organization (IHO).

Also, the soundings obtained should be corrected for sound velocity to express the true depth of water. The view is held that the sounding value, obtained as is, should be adopted for bathymetric charting because it will reduce the work not only of the chart producers but of navigators, as the latter need not make any corrections to sounding values obtained by their own echo-sounders. However, in order to represent the bottom topography accurately, the correction must be made.

*Depth contours*

Depth contours for undersea topography should be the lines representing the configurations of the sea-bottom. The depth contour on nautical charts is directed to expressing clearly any danger to navigation, so that it is usually delineated on the deeper side of any sounding figure of the same value of that contour. This idea should not be adopted for bathymetric charting. The depth contour should pass through the position of the sounding figure of the same value.

It is a principle that depth contour intervals should be equal. However, on bathymetric charts the intervals are often made finer on shallow, flat continental shelves and coarser on steep continental slopes. Though this procedure is necessitated by the actual characteristics of the sea-bottom topography, such a representation may cause some confusion to the users. In cases where irregularity of depth contour intervals has to be shown on a chart, it is advisable that the contours in the irregular portion should be drawn so as to be supplemented by partial auxiliary depth contours.

It should be established as a principle that equal contour intervals should be based on the decimal division (i.e., every 1 m, 10 m, 100 m, 1,000 m etc.). In cases where it is unavoidable, auxiliary depth contours based on bisection (every 5 m, 50 m, 500 m etc.) may be used. The use of intervals based on quadrisection (every 2.5 m, 25 m, 250 m etc.) or quinsection (every 2 m, 20 m, 200 m etc.) should, however, be avoided. Use of the latter intervals when compiling a bathymetric chart with a wide coverage would cause serious inconvenience.

The fundamental expression of the sea-bed on a bathymetric chart is by means of depth contours. In conventional bathymetric charts, there are many cases where a number of sounding figures are shown. However, it is meaningless to show sounding figures other than those indicating significant places (such as the deepest or shallowest part of the bottom surrounded by an isolated depth contour).

*Expression of sounding density*

As mentioned above in the first section, it is essential

for representation on a bathymetric chart to show what amount of data was used to compile the chart. Usually, there are two ways of doing this: one is to express the density by showing—within the chart—dots, track lines or limits of areas that are densely surveyed; and the other method is to show density on a small index map inserted in the marginal space of the chart. In view of the original purpose of indicating the sounding density, it is preferable to show this information within the chart. Hence, it is suggested that, according to the scale of the chart, the above-mentioned dots, track lines or limits of areas, or a combination of them, should be shown on the chart.

*Updating of bathymetric charts*

The ocean covers a vast area, so that the preparation of bathymetric charts to cover it is quite costly. Hence, a bathymetric chart on a smaller scale is a collective of surveys carried out over a long span of time by many ocean research institutions in various countries. Even in the case of a bathymetric chart on a larger scale, the collection of data and information is quite important. Moreover, in order to keep pace with the development of survey techniques and equipment, it is necessary to replace old data by the most recent bathymetric data of superior quality.

In order to keep bathymetric charts up to date through the collection of bathymetric data, it is necessary to establish a bathymetric data bank. It is also necessary to standardize internationally the codes for data collection. Currently, studies are being made by the International Hydrographic Bureau to codify the quality of bathymetric data under four headings: accuracy in position fixing; accuracy in sounding; fidelity in sounding values read; and data processing.

*Symbols and abbreviations*

There are not many symbols and abbreviations used especially for bathymetric charts. It is usual to employ the symbols and abbreviations used on land maps and nautical charts for topographic and hydrographic information. On small-scale bathymetric charts, different symbols are used by various countries to indicate whether the sea-bottom bounded by an isolated depth contour is concave or convex.

It is quite possible that on large-scale bathymetric charts various new symbols and abbreviations will be introduced in the future. Some may even be in use already. It is important to research and standardize the symbols and abbreviations currently in use.

*Nomenclature and geographical names of ocean-bottom features*

The nomenclature of ocean-bottom features and their geographical names have in many cases been adopted separately and differently by various organizations and countries. Experiments in the standardization of nomenclature have been carried out a number of times, and efforts are currently being co-ordinated by the GEBCO Sub-Committee on Geographic Names and Nomenclature of Ocean-Bottom Features. Once the GEBCO Sub-Committee has finalized the standardized nomenclature, it will be necessary to prepare a glossary of terms of the nomenclature in various languages. These efforts may make it possible to standardize the nomenclature of sea-bottom features in individual countries. As for geographical names, it would be better if an international committee were to determine these names, although it might encounter some difficulties in doing so.

## HOURLY TIDAL PREDICTION BY AN ELECTRONIC COMPUTER*

*Paper presented by Thailand*

### History

The first annual tide-tables of Thailand were issued in 1908 and contained tidal predictions only for the Bangkok Bar. Subsequently, when in 1953 the Hydrographic Department acquired a machine for predicting the tides, it became possible to extend the predictions to cover various locations along the coasts in the Thai waters.[1]

Since 1953, the only tide-predicting machine has remained in excellent condition and has provided good results. The number of stations to be predicted has increased from time to time in order to serve the needs of the public and the military.

When the Military Supreme Command Headquarters established the Data Processing Centre and equipped it with an IBM 360/40 computer, the Hydrographic Department took that opportunity to request co-operation in beginning the development of tidal predictions to be done by the computer. After four months of analysis and programming, the first correct results were obtained.

### Mathematical procedure

The height of tide at any time is as given by Schurman.[2]

$$h = H_o + \sum_{n=1}^{N} f_n H_n \cos a_n t + (V_o + u)_n - K'_n$$

* The original text of this paper, prepared by Lieutenant Commander Thanom Charoenlaph, Hydrographic Department, Royal Thai Navy, appeared as E/CONF.68/L.56.

[1] Hydrographic Department, Royal Thai Navy. *Tide Tables in the Thai Waters* (Bangkok, 1977), p.d.

[2] Paul Schurman, *Manual of Harmonic Analysis and Prediction of Tides* (Washington, D.C., United States Coast and Geodetic Survey, 1958), p. 317.

where:

$h$ = height of tide at any time.
$H_o$ = mean height of water-level above datum used for prediction;
$H_n$ = mean amplitude of any constituent;
$f_n$ = node factor for reducing the mean amplitude to be true amplitude for year of prediction;
$a_n$ = angular speed of any constituent per unit of time;
$(V_o+u)_n$ = value of equilibrium argument of a constituent at the initial instant from which the value of t is reckoned, i.e., when $t = 0$;
$K'_n$ = modified epoch of any constituent;
$N$ = number of constituents;
$t$ = time expressed in mean solar hour.

### Programming tasks

The programme simply reads the data input from cards, processes it and then prints the output values hourly. It does not account for any error which may occur from the input data, since there is no logical way of detecting the relationships of associated corresponding data in the provided circumstances.

It was intended to keep programming as simple as possible, i.e., a set of instructions performs one or two things at the most. The efficiency has not yet been of concern. Thus, the existence of awkwardness is undeniable.

FORTRAN IV was selected as the most suitable language on the available facility. The mathematical model used, which was derived from Schurman; can be written as:

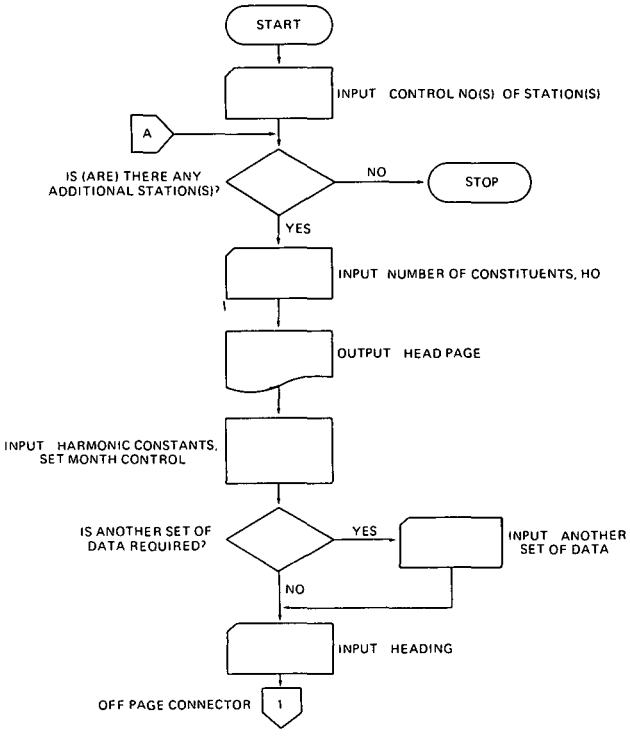
$$h = H_o + \sum_{i=1}^{n} f_i H_i \cos(a_i \cdot t + \alpha_i)$$

where:

$h$ = height of tide at time $t$;
$H_o$ = mean sea level above chart datum (lowest low water);
$t_i$ = factor for reducing mean amplitude to year of prediction;
$H_i$ = mean amplitude of constituent $i$.

The input of $f_i$, $H_i$ and $\alpha_i$ are readjusted every four months in order to minimize the errors occurring due to a prolonged duration of time.

The logical flow chart is presented in figure 114.



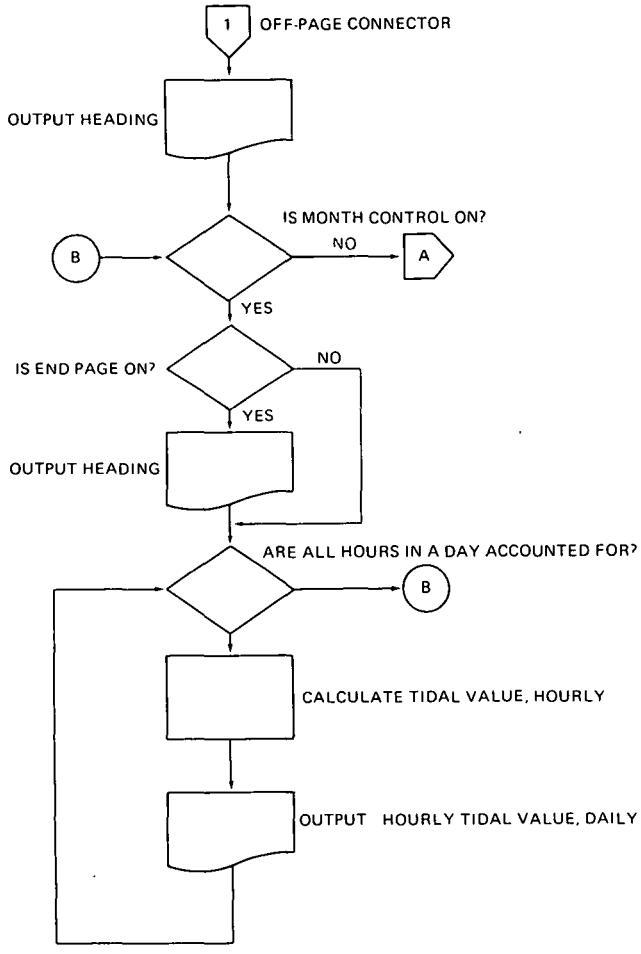




*Figure 114. Thailand: logical flow chart, hourly prediction*

## Conclusion

The logic and the programme, as mentioned, have their weakness which can be improved for better performances, less redundancy and more efficiency in processing.

There is an extension to this project, that is, to write a programme for the harmonic analysis and to computerize the entire system of astronomical tide prediction, for which much more time and more understanding of the problems will be needed.

# SOME BASIC PRINCIPLES IN THE COMPILATION OF NAUTICAL CHARTS*

*Paper presented by the United Kingdom of Great Britain and Northern Ireland*

This paper, which is based on the experience of the Hydrographic Department of the Ministry of Defence of the United Kingdom of Great Britain and Northern Ireland, seeks to give guidance on the insertion or omission of the different types of detail of interest to mariners, according to the various functions and scales of nautical charts and the types of area which they depict. In the space available, only depths and topographic information are considered—to select both of these much judgement is needed. Of the other categories of information shown on charts, the main type, navigational aids, lends itself more readily to rules of thumb. The ways in which information is conveyed—colours, symbols, typefaces etc.—are also outside the scope of the paper.

Of the factors leading to the diversification of nautical charts, the most obvious is the scale chosen. There is a broad classification into four groups:

(*a*) Port plans on large scales;

(*b*) Charts of open harbours, anchorages and port approaches, also on large scales;

(*c*) Coastal charts on medium scales;

(*d*) General charts on small scales.

In groups (*b*), (*c*) and (*d*), there are charts which contain areas of different degrees of scale, that is, a chart may be first-scale in one part, second-scale in another and so on. In groups (*b*) and (*c*), at least, differences in treatment can arise from the varying complexity of different areas and the rate of change of the information presented.

Each individual chart specification may be conditioned by the nature of the source material, which can vary greatly in quality and density. To a certain extent also in areas where hydrographic offices are the original charting authority, particularly national waters, there will be a tendency to include additional information, as the charts will serve as multipurpose information documents.

Charts differ from maps in that standardized specifications cannot be applied indiscriminately to them. In fact, the attempted application of simple rules to govern chart content has been a principal cause of wasted effort in the past. For example, although topographic contours are undeniably valuable on charts of some areas, their addition to others causes an amount of work out of all proportion to its value. Moreover, the drafting of standard rules covering particular features may lead to an attempt to give a chart uniform treatment throughout its whole area, although the essential fact of successful chart compilation is that different considerations apply as a compiler works from in-shore to off-shore areas, or along an open coast towards a shoal-encumbered estuary, or inland from the coastline.

There is, indeed, only one fundamental criterion which must be adopted and rigorously applied. Each detail must be assessed for its usefulness to some important class of chart user in the context of the surrounding details and the scale of the chart. No useless detail should be charted and any minor features whose insertion would tend to obscure more important features should be excluded. The recommendations that follow are largely in amplification of this rule and they suggest ways in which features that are of little or no value to the user can be reduced in emphasis or excluded altogether. There is considerable scope for producing clear, easily maintained charts without adversely affecting the chart user or eliminating the concept by which a chart which is not on the first (largest) scale can be used in an emergency.

## Hydrographic features

### *Depths*

The water area to be covered by a chart should be divided into areas that fit one of the following four categories:

(*a*) Satisfactory depiction requires detailed depths;

(*b*) Rigorous selection of detail is desirable;

(*c*) "Skeleton" depth information is sufficient;

(*d*) No depth information is needed.

*Detailed depth information*

In areas where detailed depth information is required, careful selection of soundings is necessary to allow correct interpolation between them, to reflect the adequacy of the survey and to permit the use of the chart as a plotting-sheet. The following general principles are recommended, observing that their detailed application must be controlled by the various complicating factors described above in the first section:

(*a*) Least depths on shoals and in navigable channels

* The original text of this paper, prepared by D. W. Newson, D. Russom and H. R. W. Halliwell, Hydrographic Department, Ministry of Defence, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.68/L.1.

should be inserted first. The assessment of navigability should take full account of the tidal range;

(*b*) The specified range of depth contours should next be inserted. They should give a reasonably faithful representation of depths and should not be over-generalized;

(*c*) Thirdly, soundings should be selected which show trends of bottom features not brought out by the depth contours, using enough to show clearly shoal areas and the channels between, and bearing in mind that vessels cannot, or do not, always give dangers a wide berth. Changes of slope should also be shown as far as the scale permits without crowding—in general, areas of rocky or uneven bottom will require more detailed and irregular depiction than areas where the bottom is composed of unconsolidated material and the relief is subdued;

(*d*) On large-scale charts and on others where the undersea topography is simple, it may be necessary to complete a uniform pattern of soundings to avoid an impression of incomplete survey. However, even distribution is not an aim in itself;

(*e*) The soundings selected should be complementary to the depth contours—information should not be duplicated by inserting numerous soundings entirely in accordance with expected depths in the vicinity of contours;

(*f*) Enclosed deeps in shoal areas should not be ignored, as some indication of their presence will be helpful to vessels using echo-sounders to confirm position in poor visibility and when anchoring; charts should show depths realistically;

(*g*) In narrow channels of limited depth, soundings should be shown along the line of maximum depth as well as along the sides. In harbour areas, particular attention should be paid to the insertion of least depths in the entrances to harbours and basins. Dredged areas should be shown, as should depths alongside piers and wharves. Occasionally, a table of depths at numbered or named berths may be desirable;

(*h*) The practice of deliberately thickening the pattern of soundings in shallower waters, formerly justified to some extent on single-colour charts, has outlived its usefulness. It confuses the information inserted in accordance with (*c*), (*f*) and (*g*) given above, and is antagonistic to clear depiction of bottom relief. The use of shallow-water tint and the increase in the range of draught of surface vessels call for adherence to the basic principles of selection throughout the water area;

(*i*) The dotted danger-line symbol should be used to supplement depth contours where circumstances require it—for example, in the delimiting of rocky areas, particularly on smaller scale charts—and also to mark shoal areas of unknown depth, isolated dangerous shoals, rocks and islets, wrecks and obstructions.

*Rigorous selection of detail*

The areas where rigorous selection of depth information is desirable fall into two types:

(*a*) Areas subject to continuous and rapid change need special treatment. In extreme cases, the entire water area of a large-scale chart may come into this category. Changes may be so frequent and of such an extent that a survey can become significantly out of date in a very short time, and a chart can never be expected to give an accurate detailed portrayal of depths. The best results can be achieved by using a severely reduced selection of information designed to give indications of the positions of navigable channels and their depths. Shoal areas should be shown by depth contours and a few soundings and drying heights. Where the water areas, as well as being changeable, are also complex at the scale of the chart, selection and generalization should be particularly severe, especially in charts of some navigable rivers. In the areas of anchorages and ports, supplementary detail can be added as scale permits. In such cases, a suitably worded caution is necessary. These types of charts are distinct from the type with only "skeleton" information discussed below because they are the preferred charts for navigation in the areas under consideration and are used for plotting the ship's position. Adoption of this treatment saves much wasted effort, freeing manpower to correct the charts more frequently, enhancing their usefulness and encouraging confidence in them;

(*b*) A chart of which a part is covered by a separate larger scale chart should be carefully considered with a view to reducing depth information within the area of the larger scale chart. It is not suggested that the entire area within such limits should be so treated, because some of it may be navigable at the smaller scale, in which case normal depth information is desirable. In in-shore areas covered by larger scale charts, however, quite drastic selection can be effected, provided that the possible use of the chart in an emergency is not ignored.

*"Skeleton" depth information*

In areas where only "skeleton" depth information should be shown a more drastic elimination of detailed depth information is recommended than that advocated above in subparagraph (*b*). Such areas lie within, but do not coincide exactly with, the limits of larger scale charts which cover complex, changeable areas. On such charts it is possible to determine a line in-shore of which it is not practicable, due to the nature of the area and the unsuitability of the scale for portraying it, to show navigational aids and wrecks generally, though long-range aids and selected wrecks may be shown. In the general absence of aids and wrecks, such parts of a chart are totally unsuited for navigation inside these areas, even for emergency use; and it is clearly desirable that the portrayal of depths in them should be limited to generalized depth contours only. It is suggested that this treatment is particularly applicable to medium-scale charts of estuaries and coasts fringed by off-shore bars. In these cases, the transition from open sea to in-shore navigation is relatively gradual and the abrupt omission of all detail would be cartographically undesirable.

*Omission of depth information*

Areas where depth information should be omitted are indicated by the existence of a more or less well-defined line at which the nature of navigation changes abruptly

because of a transition from open sea to largely enclosed or restricted waters. Examples are sea areas cut off from the main body of the water area by coastline and chart limits; inland waters which cannot be reached by seagoing vessels; restricted waters which cannot be navigated at the scale of the chart; waters within a group of dangerous rocks or coral heads, within which navigation should be discouraged; and terminal port and harbour areas covered by a larger scale plan on the same sheet. It is recommended that the treatment suggested in the second and third cases mentioned should be applicable to first-scale charting in extreme cases only.

*Drying areas*

Drying heights should be selected according to the principles already stated for soundings. Many landings and some ports can only be reached near high water, so that drying heights can in some cases be more important than soundings. When covered, drying areas are often used recreationally by small craft.

*Quality of the bottom*

The aim should be to show all significant variations in bottom quality. Modern surveys are sometimes deficient in such information, and other documents should be consulted if necessary. Areas in which bottom qualities are particularly important are indicated by the following uses:

(a) *Anchoring*. Sand and shingle hold better than soft mud; rock will be avoided. Important locations are recognized anchorages, roadsteads, pilot boarding-stations and fairways buoys, while any sheltered water is a potential anchorage.

(b) *Navigating close to shoals*. Qualities should be shown liberally on shoals, banks and reefs, as a guide to their stability and as a clue to possible undetected pinnacles;

(c) *Taking the ground at low water*. Coasters and small craft are often concerned, for this reason, with the nature of the bottom in shallow or drying areas, particularly near harbours;

(d) *Fishing*. Bottom qualities, especially rock, are of importance to fishermen on the continental shelf.

TOPOGRAPHIC FEATURES

It is highly desirable that the selection of topographic features should be based strictly on the fundamental criterion of usefulness to navigators at the scale of the chart, to maximize the clarification of important features. Furthermore, largely because of restrictions on the number of colours available, it is obvious that no chart can be made to compete with modern topographic mapping in the portrayal of land features. The mariner has little interest in the land beyond his visual or radar horizon. Therefore, except where the appearance of a chart would suffer unduly from leaving blank the central portion of a large island or peninsula, no topographic detail beyond the horizon should normally be shown, unless it be the barest minimum of detail to maintain an appearance of continuity.

Four basic principles, which are particularly applicable to large-scale charts, should be observed:

(*a*) The navigator's interest in land detail is at its greatest at the coastline and falls off rapidly for features some miles inland;

(*b*) It is the unusual or unique feature which the mariner needs for positive identification of the land area he is looking at;

(*c*) Generalize as necessary for clarity but give a realistic visual impression of the landscape, as likely to be seen from seaward;

(*d*) A navigator in well-buoyed and lighted waters has rather less need for detailed topography than one who must locate off-lying unmarked dangers by reference to coastal features.

*Coast*

On larger scale charts, generalization of coastline is normally neither necessary nor desirable, but as the scale of compilation gets less and especially where the coastline is complex, increasing degrees of generalization are called for. The same degree of generalization should be applied to the depiction of complex archipelagos on smaller scale charts, even to the extent of omitting minor islets from areas clearly unsuited for navigation at the scale of the chart.

Attention should be paid to showing differences in type of coast by the appropriate symbols or legends where this information is clearly of use to the mariner, but the same principles of generalization should be applied where demanded by the scale of the chart. For example, on large-scale charts all cliff detail, including variations in colour, should be shown; in contrast, the symbol for a sandy coast would only rarely be useful on scales smaller than 1 : 100,000.

In general, on large-scale and medium-scale charts of low-lying coasts, conspicuous objects are very important; and even minor clues to position—such as sand-dunes, hillocks and low bluffs—may be very useful. On steep coasts, where traffic may be concentrated off projecting points of land, the nature of each headland should be made clear—whether it has vertical cliffs, or a sloping, rounded or low profile. The heights of cliffs and islets, both high and low, are informative.

*Relief*

The simplest and most satisfactory method of depicting on the same plate as other topographic detail a reasonably accurate three-dimensional impression of relief from any seaward viewing point is the use of generalized contours where the relief is sufficiently varied, and its depiction is of definite value to the mariner. To achieve simplicity, the contour interval should be chosen so that the relief can be indicated by a few lines, though it may be necessary to show greater detail in the coastal strip by the insertion of supplementary contours within the range chosen.

On some large-scale harbour plans and on charts of coasts with abundant navigational aids and artificial landmarks and with a terrain lacking recognizable in-

dividual features or fronted by an archipelago, it may be assumed that the identification of relief features plays a small part in navigation and that the insertion of contours would be wasteful of time and effort. In contrast, along a sparsely inhabited coast unmarked by navigational aids, detailed topography in the coastal belt will allow the mariner to clear dangers with the aid of improvised transits of charted features.

On any contoured chart, because the contour interval may not enable the compiler to represent small but locally remarkable features, or emphasize the local range of elevations adequately, supplementary information should be inserted as necessary, in the form of spot heights, descriptive terms, proper names, symbolic representation and views. On charts, other than small-scale charts, where relief depiction by contours is considered undesirable, the latter devices should be used to show any essential details of individual relief features, while a general picture of elevations may be given by the use of spot heights.

Where the source materiai does not provide contours which are accurate at the chart scale, it may be possible, if necessary, to show approximate contours or form-lines. In general, contours should not be inserted on charts of scale smaller than about 1 : 500,000.

### *Drainage*

Much time has been spent unnecessarily in the past on depicting drainage patterns in great detail. In general, only major streams and those which make a significant contribution to relief depiction should be shown, with drastic selection as the horizon is approached. Minor inland lakes and ponds should invariably be omitted since they serve no useful purpose, reduce simplicity and are particularly wasteful of production effort. On the other hand, coastal lagoons may be useful in stressing the low-lying nature of a coastal belt. Navigable rivers and canals should be shown to the head of navigation by seagoing vessels, irrespective of the distance inland, together with names of river ports. Non-navigable canals and drainage ditches should generally be omitted from all scales.

### *Vegetation*

General depiction of vegetation is unnecessary but vegetation features likely to be of assistance to the mariner should be charted. The type of vegetation in the coastal fringe may be shown where it is the dominating feature in a low-lying area. Instead of charting extensive tracts by symbol, however, descriptive terms may be used, such as "wooded", "marsh", "mangrove" and "bushes". Legends may be effectively combined with a delimiting fringe of symbols, if the exact outline is significant. On low-lying coasts, isolated clumps of trees may provide useful clues to a ship's position.

### *Settlements*

On harbour plans, fairly full details of the town plan adjacent to the water will be useful to the mariner unfamiliar with the port in question, buildings of particular interest being named. On large-scale coastal sheets, the coastal fringe of built-up areas is sufficient, but all isolated buildings on the coastline should be shown, reducing one or two miles inland to larger groups of buildings only. On medium-scale and small-scale charts, only towns and villages within the visual or radar horizon should normally be shown, either by a generalized street pattern (but still fine-grained enough to give a realistic impression of a town) or by a conventional symbol (churches or mosques, if known to be prominent, sometimes are used in this role). On steep coasts, settlements may be well separated, and therefore prominent, especially at night.

Isolated buildings of various types should be charted prominently if known to be conspicuous objects or good landmarks. Elevated features like radio masts and tall chimneys often choose themselves. But care may be needed in deducing that a white hotel on a cliff-top should be shown, while the surrounding scatter of buildings may be generalized; or that, in a town with many churches, a pair juxtaposing a spire and a tower are the ones to be highlighted.

### *Roads and tracks*

Much simplification and economy can be achieved in the depiction of roads and tracks. On large-scale charts, all roads that lead to the coast should be shown, though a mile or two inland only larger roads are needed. On medium-scale coastal charts, in areas where aids and landmarks are plentiful, the roads shown should be only main roads and links to ports and coastal installations, although in the rare cases where minor roads and tracks are known to be prominent from seaward and other landmarks are sparse, their insertion should be considered. Details of roads should generally be omitted from charts on scales smaller than about 1 : 500,000.

### *Railways*

Similar selection principles should be applied to railways. In areas where sidings and minor branches are numerous, depiction should be generalized as much as is reasonable on all scales. Enbankments and cuttings should only be shown if they are likely to be of significance to a mariner.

## Conclusion

Charts must respond to the changing requirements of navigators and other specialist users. Major developments affecting their contents include the new emphasis on ship routing in congested waters, the deep draughts of large crude carriers crossing shallow seas and the offshore exploitation of mineral oil (petroleum) on continental shelves. The increased use of charts by cruise liners, yachts and other recreational craft is a lesser, but still important, consideration. Each of these factors presents the cartographer with problems which are not yet fully resolved. The common feature is the acceleration in the rate of change of charted information, which is straining updating procedures beyond their limits. This feature, indeed, is the stimulus for the increasing interest in international co-operation in nautical charting.

# TRAINING OF PERSONNEL ENGAGED IN NAUTICAL CHART CONSTRUCTION IN THE UNITED KINGDOM*

*Paper presented by the United Kingdom of Great Britain and Northern Ireland*

This paper describes the duties, entry qualifications and subsequent training of personnel in the Hydrographic Department of the Ministry of Defence of the United Kingdom of Great Britain and Northern Ireland, who are engaged in nautical chart construction, the stages from the receipt of source material up to the completion of reproducibles ready for photography and plate-making. Both internal and external courses are provided, at several points during an employee's career, and instruction includes theoretical and practical aspects of the work.

Cartographic staff usually spend their whole career of up to 40 years in the Hydrographic Department. There are 64 civil hydrographic officers and 324 cartographic draftsmen, whose main task is nautical chart construction. The civil hydrographic officers and 167 draftsmen are employed on compilation and associated tasks in the Professional Division; 157 draftsmen handle the reproduction stages in the Production Branch. There are two separate—but now co-located—training units, which have provided courses in compilation and reproduction since 1966.

## DUTIES OF PERSONNEL

### *Civil hydrographic officers*

*Civil hydrographic officers* constitute a managerial class, employed in approximately equal numbers on chart compilation and marine science work, and required every few years to alternate between different specializations. In compilation branches, they have responsibility for ensuring the correct use of a variety of data from many sources and for the accuracy and sufficiency of Admiralty charts. In marine science branches, the responsibilities range over geodetic, survey and cartographic computing; photogrammetric compilation; compilation and correction of oceanographic charts and other special-purpose charts and diagrams; editing of marine radio publications; processing and archiving of oceanographic data; investigations of sediment movement; and the application of digital computers and automatic plotters to cartography. The various branches of the Professional Division are headed by principal civil hydrographic officers, while the Chief Civil Hydrographic Officer is the Director of Hydrographic Charting and Sciences.

### *Compilation draftsmen*

Compilation draftsmen assist civil hydrographic officers and prepare nautical charts and other types of compilation drawings, photogrammetric and other plots, book drafts and computer programmes; and operate services such as the archives and library. A small proportion also handle reproduction drawing stages. Their work is directly supervised in each branch by a senior draftsman.

### *Production draftsmen*

Production draftsmen copy the compilation drawings by scribing and other techniques, to prepare reproduction documents from which chart printing-plates can be made. They also keep the plates themselves updated by hand corrections. They are organized in the Production Branch in pools under senior and chief draftsmen under the over-all control of the Production Manager.

## ENTRY QUALIFICATIONS

Civil hydrographic officers are recruited in their early twenties, usually direct from universities, with a good honours degree in geography, geology, mathematics, physics, oceanography, environmental, topographic or computer sciences, or a kindred subject. Occasionally, new entrants hold higher degrees or additional diplomas.

Compilation and production draftsmen, who are members of the cartographic and recording draftsman class, are mainly school-leavers aged 16–18 years. They are required to have passed the General Certificate of Education (GCE) examination at Ordinary Level in three subjects; although four subjects, including mathematics, are preferable to qualify them for an Ordinary National Certificate course (see section on external training). New entrants often have higher qualifications, including passes at GCE Advanced Level. On recruitment, draftsmen are assigned to either compilation or production work, in which they specialize throughout their careers.

## INTERNAL TRAINING

In general, professional and technical training, except that leading to the Ordinary National Certificate, is provided by several courses internally (details of all of these are given in the annexes to this paper). The training is supplemented as necessary by a variety of external courses and practical experience. The training staff of the Professional Division consists of a principal civil hydrographic officer, who also has manual-writing responsibilities; and a senior draftsman, assisted part-time by a higher draftsman and divisional experts in specialist subjects. In the Production Branch, the instructors are a senior draftsman and two higher draftsman. After the initial courses the progress of new entrants is continued by on-the-job training.

Civil hydrographic officers, being a graduate class

* The original text of this paper, prepared by D. W. Newson, Hydrographic Department, Ministry of Defence, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.68/L.2.

employed on a wide variety of specialist tasks, receive only a brief induction training course (see annex I). Heuristic training subsequently plays an important part.

Compilation draftsmen pass through three courses at different stages of their careers:

(*a*) An initial training course on entry (see annex II);

(*b*) An efficiency bar revision course a few years later (see annex III);

(*c*) An advanced training course for supervisory duties (see annex IV).

Production draftsmen attend different versions of two of the latter courses:

(*a*) An initial training course (see annex V);

(*b*) An efficiency bar revision course (see annex VI).

### External training

External courses are selected with two functions in mind: to supplement the general internal courses already described; and to provide special-purpose training which cannot economically be arranged in the Department (see subparas. (c) and (d) below).

(a) *Supplemental courses:*

(i) *GCE Ordinary and Advanced Level.* Young draftsmen are permitted to attend classes in geography, mathematics or physics in official time if they are not qualified in these subjects;

(ii) *Ordinary National Certificate in Cartography and Surveying.* Suitably qualified younger draftsmen are selected to attend the Ordinary National Certificate course (see annex VII).

(b) *Sea experience.* Civil hydrographic officers and compilation draftsmen at all levels and some production draftsmen have been given the opportunity of spending at least one period of from 5 to 10 days afloat to gain a practical insight into hydrographic surveying and ship navigation. Places are made available on ocean and coastal survey ships and the shore-based boat parties. Crossings have also been made on cross-channel ferries to study navigational techniques.

(c) *Special-purpose professional and technical studies.* A few of the numerous subjects covered are:

(i) *Photogrammetry*: two-to-six week courses for civil hydrographic officers and basic grade compilation draftsmen at the School of Military Survey;

(ii) *Automatic data processing*: one- to five-week courses, for civil hydrographic officers and compilation draftsmen/programmers, in computer systems and programming, at official or commercial training centres;

(iii) *Law of the sea*: half-week course for principal civil hydrographic officers at Bristol University;

(d) *Management studies.* As a result of increased attention in the government service to management skills, all civil hydrographic officer grades and chief and senior draftsmen attend management courses lasting from one to four weeks at official training centres.

## ANNEX I

### Induction training course for civil hydrographic officers

*Number in course*: average of six.

*Students*: graduate civil hydrographic officers, newly recruited to the Professional Division.

*Duration and frequency*: full time for 12.5 days once a year.

*Purpose*: to provide in condensed form, for newly qualified direct entrants to a management grade, an introduction to the work of the Hydrographic Department. The principles and procedures of both nautical chart and marine science work are briefly described, and the professionalism required of the grade is explained.

*Syllabus*

Organization of the Hydrographic Department. International agencies associated with hydrography and navigation. The international chart—charting agreements. Charting policy.

Calculating machines—specimen calculations. The geoid—spheroids—spherical trigonometry. Projections—Mercator, True Gnomonic, Gnomonic (modified Polyconic), Lambert Conformal, Polar Stereographic, Zenithal Equidistant, Transverse Mercator. Plane Cartesian co-ordinates—grids and reference systems—computations: grid to geographical and vice versa.

The nautical chart. Characteristics of charts and maps—Greenwich meridian—international date line. Classification of charts—scale and use. Scheming chart limits. The compilation of a nautical chart. The principles of selection—exercise. Tidal theory and chart datum—tidal exercise. Chart correction—procedures.

Hydrographic surveying. Taking soundings. Optical principles of the marine sextant—sounding sextant—station pointer—horizontal sextant angles. Coastal navigation—basic chart work. The function of marine lights. Astro-navigation. Radio aids to navigation and hydrography—propagation—the Decca Navigator (repeatability and predictability) Hi-Fix, LORAN, Omega, Consol, radio direction-finding and radio-beacons radar, Racons, Ramarks.

Curator's archives. Lattice charts. *Admiralty List of Radio Signals.* Submarine cables. Deep-ocean soundings. Sailing directions. Notices to Mariners. Wrecks. Chart histories. Standard copies. Minor revisions.

The Department's interest in geophysics. Some aspects of physical oceanography. In-shore oceanography. Photogrammetry. Automated cartography. Thematic graphics.

The computer. The library. Production Branch. Issues Branch. Sales Branch. Systems of communication and information. The filing system. Forms of correspondence. Staff reports and job appraisal reviews. Promotion procedures.

## ANNEX II

### Initial training course for compilation draftsmen

*Number in course*: maximum of 17.

*Students*: Basic grade cartographic draftsmen, on recruitment before employment in the Professional Division.

*Duration and frequency*: 26 weeks full time, twice a year.

*Purpose*: to teach the skills and knowledge necessary to carry out efficiently the general duties of members of the grade employed in the Professional Division on compilation and comparable tasks.

*Syllabus*

*Mathematics*: the application of graphs; use of logarithms; elementary properties of triangles and circles (geometry); trigonometrical ratios of an acute angle; solutions of problems using right-angled triangles (trigonometry); bearings in various notations; the meaning of scale and problems of conversion.

*Geography*: the earth, its shape and size—elementary ideas about the geoid and spheroid; great circles, small circles, meridians and parallels, night, day, time; units of measurement, geomagnetism, map interpretation, map indexes, contours and profiles; tidal régimes—their cause and effect; planetary winds and ocean currents; aspects of the physical geography of shorelines, coral reefs, elementary oceanography, undersea geology and sea-bed features.

*Cartography*: chart projections in general use, their characteristics and usage; calculations of linear scales from given data; symbols and abbreviations, and familiarization with and ability to draw those most frequently used on maps and charts; types of grids, their properties and uses; examination of data on original surveys and foreign government charts; principles of selection; methods of changing scale, map and chart datums and horizontal datum problems; reproduction and maintenance of charts.

*Hydrography and navigation*: principles of surveying and coastal navigation; the Surveying Service of the Royal Navy, the International Hydrographic Organization and international charting agreements; organization of the Hydrographic Department; use of sextant and station pointer; electronic position-fixing systems; buoyage systems.

*Draftsmanship*: types of drawing media; care and use of drawing instruments; types of lettering and the need to draw alphabets and numerals neatly and accurately; plotting by latitude, longitude, bearing, distance and grid co-ordinates; construction of projections.

*Miscellaneous*: trainees also receive talks on the work of marine science and naval branches, Whitleyism, office discipline, working-hours, further education schemes, sports and social facilities etc. A visit is made to a surveying ship in harbour.

## ANNEX III

### Revision course for Efficiency Bar Examination for compilation draftsmen

*Number in course*: average of eight.

*Students*: basic grade cartographic draftsmen of the Professional Division at age 20 approximately three months before taking the Efficiency Bar Examination, success at which qualifies them for further incremental progress in their remuneration.

*Duration and frequency*: two and a half weeks full time, once a year.

*Purpose*: to prepare candidates for the Professional Division Efficiency Bar Examination. The course provides revision of many of the topics covered by the initial training course, but in a shorter time and more mature way. It also includes other topics with which candidates are expected to be familiar.

*Syllabus*

*Mathematics*: graphs, logarithms, geometry of triangles and circles, triangle of velocities, elementary trigonometry. Scales (ratio), meaning, use and construction. Conversion of scale (natural scale to linear and vice versa); reduction and enlargement factors. Constructions with ruler and compass: division of straight line into equal parts or a given ratio, perpendiculars, tangents, circles, segment of circles and triangles and various data; angles from chord lengths.

*Geography*: latitude, longitude, time, day, night, seasons. Maps: Ordnance Survey and foreign; map-reading; some methods of showing relief; sections, profiles, intervisibility problems. Location of more important countries, seas, straits, islands, ports and harbours. Physical geography of coasts, shorelines, deltas, estuaries, continental shelves, coral reefs. Waves and wave action; marine erosion. Undersea features, sea-bed deposits. Ocean circulation.

*Cartography*: Chart projections in the Hydrographic Department. Grids and their relationship to projections. Compilation methods and correction procedures; types of miscellaneous and specialist charts and graphics. Elementary knowledge of methods of production and printing Admiralty charts after compilation stage. Types of proof available.

*Hydrography and navigation*: departmental organization; elementary principles of hydrographic surveying: methods of obtaining depth, datum used, echo-sounding traces Tides: types and frequencies, tidal theory, simple tidal height and time problems. Gyro and magnetic compasses; magnetic variation, annual change etc., isogonals. Navigational aids: lights and fog signals, buoyage systems; traffic separation; wreck-marking; etc. Electronic position-fixing systems; radio direction-finding, radio-beacons, radar. Coastal navigation, fixing by traditional modern methods. Navigational books: *Mariners' Handbook*, *Admiralty Tide Tables*, *Admiralty List of Radio Signals*; and *Sailing Directions*, *List of Lights*, catalogues.

*Draftsmanship*: plotting by various methods; drawing instruments and drafting media.

## ANNEX IV

### Advanced training course for senior compilation draftsmen

*Number in course*: from six to eight.

*Students*: newly promoted senior grade cartographic draftsmen and experienced members of the higher grade, with over 10 years of experience in the Professional Division.

*Duration and frequency*: from six to eight weeks full time, once a year.

*Purpose*: course members have recently assumed, or may soon assume, first-line responsibility for the work of a small group of compilation draftsmen. The course provides revision and further instruction in the technical aspects of their work and that of their colleagues; it seeks to enhance their critical faculties to fit them for increased responsibility for quality control; it increases their awareness of management techniques; and it endeavours to impart greater breadth of outlook.

*Syllabus*

*Mathematical foundations*: figure of earth; projections; reference system; electronic calculators.

*Navigation, marine geography, hydrographic surveying*: use of charts for navigation; tidal theory and problems; coastal, marine, and sea-floor geography; ports and harbours; horizontal control for hydrographic surveys; data acquisition and rendering the results.

*Procedures in the Professional Division*: departmental and branch terms of reference; over-all and detailed chart policies.

Scheming and chart limits; automatic scribing of chart borders. Archives—source material. Examination of original surveys and foreign government charts for dangers—action.

Compilation principles: graticule, grid, sources, adjustments, criteria of detailed selection (some common errors), bathymetric and topographic details, navigational aids, orthography, compass rose and magnetic information, traffic separation. Compilation records.

Chart updating: notices to mariners, NM blocks, standard copies, revised prints, branch records and procedures. New editions—specifications, verification, the check list, proof revision, records, circulation to specialist branches, publication procedures.

The chart metrication programme. International agencies: International Hydrographic Organization, Inter-Governmental Maritime Consultative Organization, North Sea Hydrographic Commission—the international chart—charting agreements with other countries.

Internal liaison with marine science and naval branches. Filing system, correspondence, signals.

*Production processes and liaison with the Production Branch*: production progress and control. Reproduction drafting techniques—copper engraving, drawing on enamel-coated plates, plastic scribing. Methods of correcting various bases. Photographic section—general processes, cartographic camera. Type composing—hand-setting, hot metal, photo-setting. Plate-making. Proofs of various qualities for different purposes. Printing—types of machines—their uses. Liaison with the Production Branch.

*Work and staff supervision*: duties and responsibilities of senior draftsmen. Work quality *versus* work quantity. Staff reporting procedures—chief and senior draftsmen's panel—branch meetings—flexible working-hours and time-keeping—staff control in drawing offices. Liaison with other managerial grades.

*Field-work*: acquaintance with navigational techniques on cross-Channel ferry. Brief practical surveying revision at Naval Hydrographic School. Study of port activities and management at Avonmouth Docks.

## ANNEX V

### Initial training course for production draftsmen

*Number in course*: maximum of 25.

*Students*: basic grade cartographic draftsmen on recruitment, before employment in the Production Branch.

*Duration and frequency*: 26 weeks full time, twice a year.

*Purpose*: to provide the skills and knowledge necessary to carry out efficiently the general duties of a basic grade cartographic draftsman employed in the Production Branch in the preparation of reproduction documents.

*Syllabus*

*Mathematics*: geometrical construction of the rectangle; calculation of diagonals by arithmetic formula and by logarithms. Calculation of length of scales of various units (sea miles, statute miles, cables, metres etc.) from a given representative fraction

*Geography*: the figure of the earth; great circles, small circles, latitude, longitude, day and night, time; terrestrial magnetism; theory of tides.

*Draftsmanship*: types of lettering; construction of alpha-numerics in various styles; the planning, drawing and spacing of titles, names, notes and legends on all production media. A knowledge of and ability to draw symbols appearing on all types of Admiralty navigation charts and other marine science charts and publications. The use, care and maintenance of drawing instruments. Methods of producing the basic originals of all types of chart to include scribing, positive assembly and hand-drawn work; methods of adjusting compilation material to accord with projection graticules. Methods of ensuring the correct register of colour masks and overlays with basic master drawings. Maintenance of basic originals and printing-plates: correction procedures on all media. Type-faces: recognition and critical appreciation of type-set matter. Knowledge of hand-setting, caster-setting and film-setting. Automated cartography: digitizing.

*Cartography*: plotting by latitude and longitude, bearing, distance and co-ordinates; plotting courses incorporating the rate and direction of tidal streams, magnetic variation and magnetic deviation. Chart projections: Gnomonic and Mercator. Hyperbolic fixing systems and radio aids.

*Lithography*: production and printing methods; the history and development of the lithographic process. Illustrative and colour reproduction and registration; imposition work and planning.

*General*: general knowledge of procedures and methods of preparation within the Department and preparation and printing in other interrelated sections within the Production Branch. Outline of the organization and task of the Nautical Chart Branch and the Marine Sciences Branch. The responsibility of the Production Branch. Outline knowledge of other forms of nautical and navigational information produced by the Department for the aid of mariners.

## ANNEX VI

### Revision course for Efficiency Bar Examination for production draftsmen

*Number in course*: average of eight.

*Students*: basic grade cartographic draftsmen of the Production Branch at age 20, approximately three months before taking the Efficiency Bar Examination, success at which qualifies them for further incremental progress in their remuneration.

*Duration and frequency*: two weeks full time, once a year.

*Purpose*: to prepare candidates for the Production Branch Efficiency Bar Examination. The course provides revision of many of the topics covered by the initial training course, but in a shorter time and more mature way. It also includes other topics with which candidates are expected to be familiar.

*Syllabus*

Mathematics: calculation of square roots (arithmetic and logarithms). Scales: representative fractions; converting RF to linear-exercise.

Lettering: history and development, lettering styles in cartography.

Chart 5011—study of symbols etc. Printing plates: types of plate, correction methods. Typography: type-setting—hand, keyboard/caster, photo-composition.

Automated cartography: Kongsberg plotter, AEG plotter, Ferranti digitizer.

Latitude and longitude, Mercator projection—plotting exercises (true bearings). Tides: theory, chart datum. Terrestrial magnetism, the compass rose—plotting exercises (magnetic bearings). Gnomonic projection—plotting exercise. Lights: description and function. Lattice charts: DECCA, LORAN, Consol, Omega—basic theory. Radio-beacons: description and function. "Western approaches to Falmouth inner harbour"—an exercise in appreciation of chart content at various scales.

Production methods: new charts, new editions (metric charts), new editions (fathoms charts). Lithography: history and development. Plate-making: lithographic plate-making, methods, chemicals and equipment. Lettering: history and development, lettering styles in cartography.

Office procedures: notices to mariners, standard copies. Reproduction material: exchange arrangements with foreign offices, production methods. Professional Division: task, organization, methods. Revision: chart tests, "quiz" etc.

## ANNEX VII

### External course leading to Ordinary National Certificate in Cartography and Surveying

*Number in course*: maximum of 20.

*Students*: selected basic grade cartographic draftsmen during their first years of service. Mainly drawn from the Professional Division, some from the Production Branch.

*Duration and frequency*: two academic years, one day per week; new courses are utilized biennially, or annually if justified by student numbers.

*Purpose*: to provide systematic technical training for cartographic draftsmen early in their careers and enable them to compete for a nationally-recognized qualification: the Ordinary National Certificate in Cartography and Surveying. The course is given by the Somerset College of Arts and Technology and meets the requirements of the Hydrographic Department. It is particularly useful for compilation draftsmen.

*Syllabus*

*Mathematics with statistics*: circular measure, trigonometrical ratios and equations. Solution of triangles. Linear and quadratic simultaneous equations. Simple matrix methods. Change of base in logarithms. Co-ordinate geometry. Polar co-ordinates. Differentiation of simple algebraic functions and trigonometrical functions etc. Definite and indefinite integration of simple functions. Spherical trigonometry. Digital computing

Concept of population and sample, discrete and continuous variables. Computations, rounding Class intervals and limits. Frequency distributions etc. Arithmetical mean, median, mode. Range and standard deviations. Probability as the limit of relative frequency, probability distributions. Simple linear regression. Sampling techniques.

*Environmental science—physics*: units, gravitation, expansion of solids, liquids, gases. Gas laws. Conduction, convection, radiation. Hydrometry and barometers. Light propagation. Current electricity, conduction. Thermionic emission, cathode rays and X-rays. Wave propagation.

*Environmental science—landscape analysis and regional studies*: natural and cultural elements of landscapes. Geomorphological processes, evolution of landforms. Shoreline processes. Settlement forms and transport systems. Detailed landscape studies of urban area, mining region, mountain zone, densely populated agricultural lowland, desert irrigation, plantations, coastal zones.

*Principles of surveying*: propagation of light through lenses, prisms etc., application to and study of survey instruments, especially theodolite. Measurement of distance, direct and indirect, taping, chain surveys, tacheometry, electronic distance measurement. Types of survey, accuracies and consistency. Systems of field survey, control methods and equipment, triangulation, traverse, trilateration, plane-table, stations and marking, signals, levelling and heightening. Computations and adjustments. Survey records. Practical surveying (two weeks). Aerial photographs, geometry, etc.; photogrammetric measurement and compilations. Multiplex.

*Principles of cartography*: problems of cartographic representation of earth's surface, geoid, spheroid, elementary projections. Meaning of scale, symbols, various ways of showing relief, map detail. Mapping agencies. Map design and appreciation. Reproduction processes and printing methods. Thematic maps and graphics, methods of compilation, methods of presenting statistical data, choropleth, dot, isoline etc. Use of photogrammetric plotting machines, map revision, radial line etc., relief from aerial photographs, mosaics, photo maps.

*General studies*: structure and functions of government, Civil Service, local government etc. Information and communication, use of libraries, information retrieval, writing reports and presenting cases.

# APPLICATION OF AUTOMATION TO NAUTICAL CHART COMPILATION AND PRODUCTION IN THE UNITED KINGDOM*

*Paper presented by the United Kingdom of Great Britain and Northern Ireland*

Automated equipment in the United Kingdom Hydrographic Department includes digitizers, plotters and photogrammetric equipment, operated off line to a central computer. The main applications so far of automation to chart production have been in the plotting of borders and radio-navigation system lattices, the presentation of information from data-logging systems and data banks, and the conversion of compilation drawings into reproduction documents.

The Hydrographic Department has been actively engaged in automating its cartographic activities over the past

* The original text of this paper, prepared by G. E. Murt and J. M Adams, Hydrographic Department, Ministry of Defence, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.68/L.3.

eight years. The principles have been to select those projects for which potential economies are clear and those for which automation gives greater accuracy or increases the speed at which a job can be completed. Removal of repetitive tasks and the release of manpower for more creative work have also been significant factors in the choice of tasks. Facilities must be brought into productive use as quickly as possible, developing suites of programmes to carry out individual tasks rather than an all-embracing cartographic system. Such a procedure carries the danger of duplication of effort, but avoidance of overlapping projects and common use of libraries of subroutines have kept this risk to a minimum. Long-term targets are to assist chart compilation wherever practicable and to automate printing-plate production and correction as much as possible so as to enable the available manpower to concentrate on the vital decision-making aspects of the task.

### Computer power

The work of the Hydrographic Department has been assisted by digital computers since 1964. In that year members of the staff began to write mathematical programmes to handle computational work and to run them at computer bureaux. All main-frame computing is now carried out on site by the Department's central processing computer, currently an International Computers Limited (ICL) 1903T. Details are as follows:

(*a*) An ICL 1903T computer with 64,000 (24-bit) words of core store and floating-point hardware;

(*b*) Four seven-track, 556 bits per inch NRZI magnetic decks with a capacity of 20,000 characters per second (CPS);

(*c*) Four nine-track, 1,600 bits per inch phase-encoded magnetic-tape decks (80,000 CPS);

(*d*) Four exchangeable disc units (60 million characters, 416,000 CPS);

(*e*) One card-reader (300 cards per minute);

(*f*) Two paper-tape reader/punches (1,000/110 CPS);

(*g*) Two line-printers (300 lines per minute).

### Computer languages

All systems analysis and programming work are carried out in the Department, except where the software is needed for the control of specific equipment, for instance, plotter, interactive digitizer or ship's computing system. In these cases, software, usually written in a low-level language, is purchased from the equipment manufacturers who normally accept full system responsibility.

The most commonly used language is FORTRAN, with some COBOL used for commercial applications and purely data-processing tasks. The practicability of using CORAL, a high-level language with real-time applications, is under consideration, as this language is proving particularly suited to automated cartography applications at the United Kingdom Ordnance Survey.

Attention is already being given to the forward planning for the conversion of all programmes to run in an ICL 2900 series machine and a beginning has been made in writing new FORTRAN programmes to forward compatibility standards. There is a continuing programme to improve the efficiency of computer usage and to add facilities to production computer programmes.

### Automatic drafting equipment

The Department obtained its first automatic drafting system, a precision Kingmatic 1215 flat-bed table and its mark II director (a hard-wired non-programmable computer) from Kongsberg in 1968. The second system, an Aristo flat-bed table with control and light-head by Allgemeine Elektrizitäts-Gesellschaft (AEG), was obtained in 1974. Its control computer is an AEG 6010 with 16,000 12-bit words.

Principal details of these systems are:

| | *Kongsberg* | *Aristo/Allegemeine Elektrizitats-Gesellschaft* |
|---|---|---|
| Table size | 1 500 × 1 200 millimetre | 1 950 × 1 500 millimetre |
| Input | Paper tape | Paper tape or seven-track magnetic tape |
| Output | Pen or scribe | Pen, scribe or light-head |
| Minimum programmable step | 0.1 millimetre | 0.01 millimetre |
| Resolution | 0.025 millimetre | 0.01 millimetre |
| Positioning accuracy of table | ±0.1 millimetre | ±0.03 millimetre |
| Repeatability of table | ±0.05 millimetre | ±0.02 millimetre |
| Maximum axial speed | 5 metres per minute | (12 metres per minute (pen up/light off)) (8 metres per minute (drawing)) |
| Acceleration | | 74 centimetres per second squared |

The AEG light-head uses discs which can have up to 100 symbols. The size of symbol depends upon the number of symbols on the disc; and it may be 2.5 × 10 mm, 5 × 10 mm, or 10 × 10 mm.

A general-purpose plotting programme written in the Department allows either of the two plotters to be addressed by FORTRAN subroutine calls, so that applications programmes can be written without reference to the plotter that will be used.

### Digitizing equipment

Details of current equipment are as follows:

(*a*) Two off-line Ferranti digitizing tables, consisting of: a 60 × 42-inch Bendix board; a seven-track magnetic-tape output; and a 32-character alpha-numerical display. One of these digitizers has recently been interfaced to an EMI/Threshold VIP-100 voice recognition system with a vocabulary of 16 words. The magnetic tapes from these off-line digitizers are read on the Ferranti work-station for reformatting and editing;

(*b*) Ferranti interactive work-station, consisting of:

(i) A 60 × 42-inch Bendix board;

(ii) A Digital Equipment Corporation PDP-11/40 support computer with 28,000 (16-bit) words of core memory;

(iii) A 1.2 million character disc pack;
(iv) A seven-track magnetic-tape deck;
(v) A Tektronix 611 storage tube display;
(vi) A Calcomp 30-inch drum-plotter.

It is felt that the digitizing of complex graphics of the chart type and the need to carry out frequent updates in an efficient manner fully justify having interactive editing facilities, instead of digitizing off line and having separate edit stages. Unfortunately, the cost of the interactive work-station is relatively high and the Department has compromised by having one interactive station and two off-line stations. The data digitized on the off-line equipment can subsequently be edited on the on-line system. Current thinking is that the interactive station will have the facility to carry out the editing stages for four off-line tables.

### Photogrammetric equipment

Equipment currently in use consists of one Wild A8 autograph stereoplotter and one Wild B8 aviograph stereoplotter. Both are coupled to an EK22 data-acquisition system. Currently, the EK22 output is paper tape only; output to magnetic tape is being considered.

### Current production work

The production work currently in progress is described below:

(a) *Automatic drawing of graphics where input data is generated from formulae in the central processing computer, such as chart borders, grids, graticules, nests of scales and navigational lattices.* New facilities are continuously being added. The most interesting additions recently have been the automatic drawing on some 100 charts of magnetic isolines for the 1975 magnetic epoch and the production of graphics required in support of median-line negotiations;

(b) *Automatic plotting of selected data held in data banks.* The principal data banks currently in use are:

(i) Wreck data for the United Kingdom and adjacent waters;
(ii) Positions of well-heads, ceded areas, median lines, and bay-closing lines in United Kingdom coastal waters;
(iii) Coastline data, currently confined to the British Isles and parts of north-western Europe on a relatively small scale;

(c) *Fair-drawing of parts of nautical charts, to supplement conventional manual drafting techniques:*

(i) *Line-work.* The Department is digitizing coastline, land and sea contours, limits of low-water rock and cliffs, roads, railways, buildings etc. A negative can then be produced on the AEG plotter with this information within the appropriate border type in its correct line-widths and styles, which also permits the automatic production of land-tint and shallow-water tint masks using cut-and-peel techniques;

(ii) *Soundings.* Since the installation of the voice-recognition equipment, the Department has been developing procedures for the digitizing and fair-drawing of soundings. The source document is put on the off-line digitizer linked to the voice-recognition system. The cursor is moved on to each sounding in turn, and its value is spoken into the VIP-100 as a sequence of figures, so that the depth is recorded, together with its position on magnetic tape. This tape is then passed to the work-station, where a check-plot of the soundings can be drawn on the drum-plotter and any alterations made using the keyboard. The final plot is made using the light-head on the AEG plotter. It is believed that entering depths by the voice-recognition system will give fewer errors and less operator fatigue than using a keyboard. An extension of the facilities to incorporate certain hydrographic symbols is imminent, but the Department is not currently contemplating automating the production of names.

### Hardware development projects

The most important current projects in hardware development are:

(a) *Plotting.* Although most plotter output is still scribed, an increasing amount is being produced by the light-spot projector on the AEG equipment. It is planned to acquire an additional plotter with this facility;

(b) *Line digitizing.* Although it has been found that the current generation of manually operated digitizers has a part to play in hydrographic cartography, there are a number of limitations on the use of such digitizers:

(i) Operation is slow and laborious, and therefore labour costs are high;
(ii) Errors inevitably occur both in line-following and in entering related information through a keyboard;
(iii) Smooth curves such as contours are recorded by widely spaced points and the intervening points inserted by a curve-linking routine in the central processing computer, which gives rapid digitizing and economical storage of data and adds interest to the digitizing task, but involves a considerable amount of computer processing;
(iv) Following a groove in a photo-etched copy of the document being digitized is quick, but many of the originals are of inadequate photographic quality for copying in this way.

Currently, the Department considers that the most promising system for fully automatic line-following is likely to be developed from a bubble-chamber track-follower, but the systems that have been seen are based on documents on small-format film, which would involve considerable changes in working procedures.

### Software development projects

The major software development projects under way are:

(*a*) Extensions to the automatic fair-drawing of nautical charts;

(*b*) The use of soundings logged digitally at sea and by means of the digitizer and voice-recognition equipment to provide the input to a system of programmes for sounding selection and automatic contouring to assist nautical chart compilation; in view of the effort needed to write a contouring programme it is possible that a commercially available package will be used, if a suitable one can be identified;

(*c*) Automation of the production of the chart-limit indexes in the *Catalogue of Admiralty Charts*;

(*d*) Investigation of the practicability of incorporating navigational aid fixed errors in lattice plots.

### The future

Future developments are expected along the following lines:

(a) *Hardware*. The Department maintains continuous monitoring of hardware developments with a view to considering their inclusion where appropriate in the production work-flows. Automatic digitizing systems have already been referred to. Other developments that would be of interest include precision drum-plotters, cathode-ray tube light-heads, larger (possibly full chart size) interactive displays and faster precision plotters;

(b) *Digital charts*. The time when a majority of ships will carry chart data in digital form is in the distant future, but there are already collision warning systems which have provision for superimposing bathymetric contours and other navigational information on the radar display. These data may be held in digital form, and the Department is studying the implications of this development. Contours may have to be defined by a small number of points, owing to the limited store of the display system, and procedures will have to be laid down for correcting the data;

(c) *Archive automation*. Consideration is being given to a computer-based index of survey documents to assist retrieval, which may well be the Department's first project to use on-line file access;

(d) *Chart compilation automation*. Following initial projects (see subparagraph (*b*) of the preceding section) which will enhance experience in this area, it is intended to investigate procedures to develop further stages of automatic chart compilation;

(e) *Chart production and maintenance*. The systems analysis of stages needed to store a complete nautical chart on magnetic tape, for efficiently carrying out all updating and for reproducing the entire chart whenever necessary is being studied;

(f) *Generalization*. The solution of the problem of generalizing the data needed for smaller scale charts is identified as a challenging major requirement.

## NATIONAL OCEAN SURVEY STUDY OF APPLIED PHOTOBATHYMETRY*

*Paper presented by the United States of America*

### Background information

The role of the National Oceanic and Atmospheric Administration (NOAA) of the United States of America as a provider of environmental services to the country includes the need to furnish oceanographic and hydrographic information that will advance the safety and well-being of the population. Such information will promote navigational safety, increase the ability to collect food from the sea and exploit the rich resources of the ocean floor, improve weather forecasts, warn of impending dangers, aid national defence and help people to use the sea more efficiently.

In pursuit of its role over the past 160 years, NOAA has surveyed and resurveyed the coastal waters of the country in order to maintain its nautical charts in an up-to-date condition. The immense scope of this mission is indicated by table 52, which shows the length of the general coastline to be 12,383 miles while the tidal shoreline is some 88,633 miles in length. Bathymetric maps are a more recent development and are designed to detail the rich continental-shelf lands in the deeper waters of the United States. The continental shelf, which varies in width from a few miles off parts of California to over 200 miles off Cape Cod, comprises an area of more than 300,000 square miles in the conterminous United States and 550,000 square miles in Alaska.

The nautical charts are used for navigational and non-navigational purposes by government organizations, private firms and the general public. The largest user of charts for navigation is the federal Government, with the Navy taking over 50 per cent of the total production. Among the other federal agencies using large quantities of charts are the Unites States Coast Guard and the Army Corps of Engineers. The largest private user of charts for navigation is marine shipping which relies on them to safeguard passengers and merchandise from the many dangers besetting water-borne transportation. Commercial fishing interests also utilize nautical charts for navigation and to determine bottom conditions and potential feeding grounds. Lastly, the explosive growth of recreational boating activities has markedly affected the requirements for nautical charts and has extended the coverage to include the additional waterways used by these boats.

* The original text of this paper, prepared by Morton Keller, Office of Marine Surveys and Maps, National Ocean Survey, National Oceanic and Atmospheric Administration, United States of America, appeared as document E/CONF.68/L.52.

**Table 52. United States of America: coastal waters surveyed by National Oceanic and Atmospheric Administration**
*(Miles)*

| | *General coastline*[a] | *Tidal shoreline*[b] |
|---|---|---|
| Atlantic coast | 2,069 | 28,673 |
| Maine | 228 | 3,478 |
| New Hampshire | 13 | 131 |
| Massachusetts | 192 | 1,519 |
| Rhode Island | 40 | 384 |
| Connecticut | – | 618 |
| New York | 127 | 1,850 |
| New Jersey | 130 | 1,792 |
| Pennsylvania | – | 89 |
| Delaware | 28 | 381 |
| Maryland | 31 | 3,190 |
| Virginia | 112 | 3,315 |
| North Carolina | 301 | 3,375 |
| South Carolina | 187 | 2,876 |
| Georgia | 100 | 2,344 |
| Florida (Atlantic coast only) | 580 | 3,331 |
| Gulf of Mexico | 1,631 | 17,141 |
| Florida (Gulf coast only) | 770 | 5,095 |
| Alabama | 53 | 607 |
| Mississippi | 44 | 359 |
| Louisiana | 397 | 7,721 |
| Texas | 367 | 3,359 |
| Pacific coast | 7,623 | 40,298 |
| California | 840 | 3,427 |
| Oregon | 296 | 1,410 |
| Washington | 157 | 3,026 |
| Alaska (Pacific coast only) | 5,580 | 31,383 |
| Hawaii | 750 | 1,052 |
| Arctic | 1,060 | 2,521 |
| Alaska (Arctic only) | 1,060 | 2,521 |
| United States | 12,383 | 88,633 |
| Conterminous United States | 4,993 | 53,677 |
| Outlying areas of the United States | | |
| Canal Zone | 20 | 126 |
| Atlantic Ocean | 433 | 880 |
| Navassa | 5 | 5 |
| Puerto Rico | 311 | 700 |
| Virgin Islands | 117 | 175 |
| Pacific Ocean | 212 | 322 |
| Baker | 3 | 3 |
| Guam | 78 | 110 |
| Howland | 4 | 4 |
| Jarvis | 5 | 5 |
| Johnston Atoll | 5 | 5 |
| Midway Islands | 20 | 33 |
| Palmyra Atoll | 9 | 16 |
| American Samoa | 76 | 126 |
| Wake Island | 12 | 20 |

[a] General coastline figures are lengths of the general sea-coast outline.

[b] Including tidal shoreline of outer coast, off-shore islands, sounds, bays, rivers and creeks to the head of tide water or to a point where tidal waters narrow to a width of 100 feet.

In the non-navigational area, bottom topographic maps are essential in exploring and developing the potential resources of the continental shelf. The extraction of oil in the Gulf of Mexico provides the best example of the extension of industrial operations to the greater depths of the continental shelf. The data portrayed on NOAA nautical charts have facilitated the drilling of wells on the outer continental shelf of the Gulf of Mexico and the sale of mineral leases as far as 85 miles off shore from the Louisiana coast.

Competition for the use of the limited coastal zone is intense, and detailed charts are necessary for developing comprehensive land-use plans and in the implementation of zoning and conservation measures. Toxic effluents pouring into the sea, pesticides flushed down the rivers and sudden accidents—such as oil spills from tankers—have created ecological and environmental problems in these tide-lands. In order to regulate and control these abuses, the engineers and officials must have the data shown on large-scale charts before these polluted marginal waters can be restored to a healthy and viable condition.

### *Nautical charts*

The responsibility for the collection and charting of hydrographic information in NOAA rests with the National Ocean Survey (NOS), Office of Marine Surveys and Maps. The nautical charts published by this office are a reproduction, on a reduced scale, of some portion of the oceans, seas, lakes and rivers. Although the adjacent land areas are included on the charts, their principal function is to show the depths of the water, the dangers to navigation, artificial aids to navigation and those shore features of most use to the mariner.

Each nautical chart must include near its limits suitable features for use as points of departure, and adjacent charts must overlap so that they include a common prominent feature. These requirements make it customary to plan charts in series even though there is no immediate need for more than one or two of the series.

Even in one area there is a variety of chart needs; a transoceanic liner entering a port and being restricted to the main channels does not need the same information on a chart as a tugboat, which may not follow the regular channels and may venture into unfamiliar places. Thus, a variety of chart scales is required to meet these various needs. Most NOAA/NOS charts and all new charts are constructed on convenient standard scales which are almost invariably multiples of the proportion 1 : 10,000.

### *Hydrographic surveys*

Nautical charts are compiled chiefly from field hydrographic surveys. The principal field-work of a hydrographic survey party consists of three essential operations—depth measurements (sounding); location of soundings and of aids and menaces to navigation; and records. A hydrographic party is said to be engaged on combined operations when its duties include sounding and other activities, such as triangulation, topographic surveying, tide and current observations and magnetic observations. The primary tasks are described below.

(*a*) A systematic coverage of depth measurements or soundings is made throughout the area to ensure that all dangers to navigation shall have been found. This task includes determining the nature of the bottom at selected

intervals and measuring some of the physical characteristics of the water, such as temperatures and salinities at various depths. The survey party must develop all underwater features of significance to navigators, such as channels, reefs, banks, shoals and characteristic submarine features and determine the least depths on all dangers to navigation;

(*b*) The soundings, dangers, undersea features and aids to navigation are located and examined so that they may be correctly charted;

(*c*) All data are recorded and plotted during the survey to provide permanent records and to serve as a basis for the construction of nautical charts.

The depths of the water are measured with the greatest accuracy consistent with efficient progress. No depth-measuring method is used to sound over relatively even bottom or in critical depths which does not measure depths less than 11 fathoms accurately within 0.5 foot and greater depths within 1 per cent, unless specifically authorized. In rapidly changing depths and over irregular bottom, the requirements may be lowered to 1 foot depths less than 11 fathoms and 2 per cent in greater depths.

The basic scale for hydrographic surveys is 1 : 20,000 with no in-shore survey being on a smaller scale except by specific authority. All important harbours, channels and many coastal areas where dangers are numerous or navigation difficult are plotted on scales of 1 : 10,000 or larger. Varying scales smaller than 1 : 20,000 are selected for off-shore surveys according to the depth of water and the distance off-shore.

### *Soundings*

A methodical system of sounding-lines must be adopted for a hydrographic survey that will develop and delineate the undersea relief in a thorough and economical manner. A proper sounding system will furnish a realistic representation of the sea-bottom relief, disclose any uneven bottom where additional sounding-lines must be run so that depth curves can be drawn with certainty, and indicate the need for further development to determine the least depths on rocks and shoals. The proper spacing of the sounding-lines and the interval between successive soundings along the line depends upon the scale of the survey, the depth of the water the proximity to shore, the character of the undersea relief and the importance of the region.

Probably more than 99 per cent of the soundings are now echo-soundings. Echo-sounding is a method of measuring the depth of water by determining the time required for sound-waves to travel, at a known velocity, from a point near the water surface to the bottom and return. Thus, half of the time interval is used to determine the distance to the reflecting sea-bottom. The range of water depths that can be measured by echo-sounding is practically unlimited, and soundings have been taken in depths of 6,000 fathoms.

In rocky regions, even closely spaced sounding-lines are insufficient to ensure that all existing obstructions, pinnacle rocks etc. shall have been found and the least depths determined over them. Such areas are examined by employing the wire-drag. This equipment consists of a horizontal wire which is towed through the water by a vessel at each end and which will strike or hang on any obstruction rising above the depth at which it is set. The wire is maintained in a horizontal position at any desired depth by means of weights suspended from floating buoys by cables and by submerged floats attached to the wire at regular intervals.

### *Depth curves*

Depth curves are indispensable for interpreting and examining a hydrographic survey. An adequate representation of the undersea relief by depth curves is similar to the representation of land topography by contours, except that the topographers can visually examine the topography whereas the hydrographers have only the measured depths as their guide.

## Objectives of bathymetry by photogrammetric methods

Classical hydrographic mapping in shallow waters with surface craft is slow, hazardous and expensive. The remarkable water penetration capability of several currently used film emulsions and their dramatic presentation of submerged detail provides an alternative tool and supplement for mapping the sea-bed in shoals and waters of moderate depth. Photogrammetric surveys preceding hydrography can show many of the rocks, reefs, shallow areas, photogrammetrically observed depth measurements and depth curves, and other features; and thereby assist the hydrographers whose work is more difficult because they do not have the over-all view of the bottom to guide their operations in developing important details.

Photogrammetric bathymetry has the potential to provide the following benefits:

(*a*) Improvement of the accuracy and completeness of the hydrographic survey;

(*b*) Reduction of the cost of and time required for the field hydrographic survey;

(*c*) Reduction of ship requirements for a particular hydrographic survey, thereby releasing some of the craft for other assignments and/or enlarging the size of the coastal water areas that can be surveyed within a given time-frame.

## Photogrammetric bathymetry procedures

Photogrammetric operations are conducted by the Coastal Mapping Division (CMD) of the Office of Marine Surveys and Maps. CMD is an unusually complete organization in that it owns and leases aircraft, and has its own pilots, navigators and photographers; it owns its aerial cameras and processes the film, prints and transparencies; it has a series of stereoscopic plotting instruments and comparators; it operates mobile field-parties and compilation offices; and it implements the results of the work of the Photogrammetric Research Branch, which studies new photogrammetric techniques and strives to improve old methods.

The photogrammetric bathymetry procedure consists of six distinct phases, described below.

*Field establishment of photo control*

Photo control refers to the establishment of horizontal positions and/or elevations with respect to the basic geodetic control network monuments of objects which create sharp and easily identifiable point images on the photography. It is not feasible to establish in the field the large number of photo control stations needed to orient all of the stereo models covering the project area. Instead, a small sufficient number of photo control points are established in the field, and the additional photo control points (pass points) are determined in the office by analytical aerotriangulation.

*Securing aerial photography*

Natural-colour film emulsion is most useful for photo-bathymetric operations because of its deep-water penetration capability, which ranges from 5 or 10 feet in coastal turbid waters to 75 feet in the clear waters of the Caribbean Sea. In addition, natural colour is ideal for the photo-interpretation of under-water details. The flight lines are arranged and flown at the time of day that will minimize the obscuring of imagery in critical areas of the photos by sunspot. The optimum time for bathymetric photography occurs when the sun angle is between 20° and 25°. This sun-angle provides a maximum illumination of the ocean bottom and also minimizes the problem sunspot by causing it to lie off or along the edges of the pictures.

Aerial photography at 1 : 20,000 scale is taken with a 3.5-inch focal length Wild RC10 camera mounted in a DeHavilland Buffalo aeroplane whose operational costs are borne by NOS. This camera has a wide angular field of view which enhances stereoscopic acuity and yields a larger ground coverage per photo when compared with a 6-inch focal length camera flown at the same altitude of 5,800 feet. The photography is taken at 80 per cent end lap and 60 per cent side lap to combat the problem of sunspot and the meet analytical aerotriangulation needs.

*Photo-laboratory operations*

The photo laboratory is equipped to handle black-and-white photography from the processing stage through the making of prints and transparencies. The laboratory no longer has facilities for the processing of the original colour film rolls because of the change made by Eastman Kodak several years ago, to a high-temperature and very toxic chemistry processing procedure. For this reason, the colour film rolls are processed by a private firm. The photo laboratory has the capability to produce colour prints and colour transparencies from the returned developed film rolls.

*Office analytical aerotriangulation operations*

Analytical aerotriangulation is a method for accurately determining the ground positions of objects throughout a strip or block of overlapping aerial photographs, using relatively few known ground positions, by means of digital calculations based on co-ordinate measurements of pertinent image positions on each photograph. The analytical method offers certain worth-while advantages over stereotriangulation employing analogue devices (first-order stereoscopic plotter). These advantages accrue from automation, digital accuracy, least-squares adjustment and freedom from the mechanical discrepancies contributed by the plotting instrument. In addition, the systematic errors, such as camera-lens distortion, film shrinkage and atmospheric refraction, can be more effectively eliminated by analytical methods than in analogue stereotriangulation procedures.

The pass points, whose positions are determined in the analytical aerotriangulation solution, are used to orient the stereoscopic models on the stereoscopic plotting instruments for compilation purposes. The 1 : 20,000 scale of the aerial photography allows the analytical solution to provide the vertical control well within the necessary accuracy.

*Map compilation of stereoscopic models*

The stereo models provided by the natural-colour photography are used to compile the under-water details and to contour the mean low water (MLW) line which is the datum for the water depths. Sometimes both natural-colour and black-and-white infra-red photography are taken of the area. The black-and-white infra-red photos yield the MLW line directly if the pictures are taken exactly at MLW tide. The MLW line helps as vertical control for levelling the natural-colour stereo models used to map the under-water details. If the black-and-white infra-red photos are not taken exactly at MLW tide, then a water-land interface line is obtained whose elevation can be ascertained by referencing the photo time to the tidal records. The interface line helps as vertical control for levelling the natural-colour stereo models to be used in contouring the MLW line and mapping the under-water features.

The principal plotting instrument employed by CMD for stereocompilation is the Wild B8 plotter. Current methods for the photogrammetric compilation of bathymetric detail require a graphic correction for the deformation of the stereoscopic model introduced by the B8 plotter, the aerial camera lens and earth curvature. The effect of refraction at the water-air interface is compensated for by constructing a depth correction graph which enables the plotter operator to convert the photogrammetrically observed apparent depth of water to the true depth. The correction factor by which the apparent depth must be multiplied is a variable whose magnitude depends upon the apparent water depth, the index of refraction and the location of the submerged feature in the stereo model.

On the 60 per cent end lap stereo model at 1 : 10,000 scale provided by the B8 plotter, 90 per cent of the vertical readings made by the operator on discrete under-water points are within ± 0.5 feet. After allowing for the accuracy of the office-established vertical control, the final accuracy for 90 per cent of the discrete photo-soundings is about ± 1.2 feet.

CMD has recently purchased a Wild B8S stereoplotter

**Table 53. United States of America: summary of proposed photobathymetry on the eastern coast and the Gulf of Mexico**
*(Time in man-days; cost in dollars)*

| Project name | Area (square metres) | Field-work | | Photography cost | Photo-lab cost | Analytical aerotriangulation | | Stereocompilation | | Drafting | | Totals | | Total time per square mile | Total cost per square mile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time | Cost | | | Time | Cost | Time | Cost | Time | Cost | Time | Cost | | |
| Cape Cod Bay, Mass. . . . . | 148 | 450 | 70 000 | 5 000 | 6 000 | 522 | 45 000 | 695 | 59 000 | 139 | 12 000 | 1 806 | 197 000 | 12.2 | 1 330 |
| | | | | | | | | 278* | 24 000* | 70* | 6 000* | 1 320* | 156 000* | 8.9* | 1 055* |
| Tampa Bay, Fla. . . . . | 125 | 430 | 65 500 | 3 500 | 4 500 | 356 | 30 000 | 488 | 42,000 | 98 | 8 400 | 1 372 | 153 900 | 11.0 | 1 230 |
| | | | | | | | | 195* | 17 000* | 49* | 4 200* | 1 030* | 124 700* | 8.3* | 1 000* |
| Florida Keys, Fla. . . . . | 503 | 500 | 77 000 | 9 300 | 11 000 | 981 | 84 000 | 1 635 | 140 000 | 327 | 28 000 | 3 443 | 349 300 | 6.8 | 700 |
| | | | | | | | | 654* | 56 000* | 164* | 14 000* | 2 299* | 251 306* | 4.6* | 500* |
| St. Andrew Bay, Fla. . . . . | 19 | 100 | 15 200 | 400 | 600 | 38 | 3 250 | 50 | 4 250 | 10 | 850 | 198 | 24 550 | 10.4 | 1 295 |
| | | | | | | | | 20* | 1 700* | 5* | 450* | 163* | 21 600* | 8.7* | 1 140* |
| St. Joseph Bay, Fla. . . . . | 27 | 140 | 21 300 | 850 | 1 000 | 84 | 7 200 | 105 | 9 000 | 21 | 1 800 | 350 | 41 150 | 13.0 | 1 525 |
| | | | | | | | | 42* | 3 600* | 11* | 1 000* | 277* | 34 950* | 10.4* | 1 295* |
| Pensacola, Fla. . . . . | 41 | 156 | 24 400 | 1 500 | 1 800 | 150 | 12 750 | 193 | 16 500 | 39 | 3 350 | 538 | 60 300 | 13.1 | 1 470 |
| | | | | | | | | 77* | 6 600* | 20* | 1 700* | 403* | 48 750* | 9.9* | 1 190* |
| Mexican border to Port Mansfield, Texas . . . . | 175 | 200 | 31 000 | 2 600 | 3 300 | 270 | 23 000 | 375 | 31 900 | 75 | 6 400 | 920 | 98 200 | 5.3 | 560 |
| | | | | | | | | 150* | 12 750* | 38* | 3 250* | 658* | 75 900* | 3.8* | 435* |
| Port Mansfield to Port Penascal, Texas . . . . . | 258 | 280 | 43 000 | 3 100 | 3 700 | 323 | 27 500 | 478 | 40 650 | 96 | 8 200 | 1 177 | 126 150 | 4.6 | 490 |
| | | | | | | | | 191* | 16 250* | 48* | 4 100* | 842* | 97 650* | 3.3* | 380* |
| Port Penascal to Demit Island, Texas . . . . . | 81 | 140 | 21 500 | 1 100 | 1 500 | 111 | 9 500 | 165 | 14 000 | 33 | 2 800 | 449 | 50 400 | 5.5 | 620 |
| | | | | | | | | 66* | 5 600* | 17* | 1 450* | 334* | 40 650* | 4.1* | 500* |
| Water Exchange Channel to Rockport, Texas . . . | 65 | 100 | 15 500 | 1 450 | 1 800 | 150 | 12 750 | 218 | 18 550 | 44 | 3 750 | 512 | 53 800 | 7.9 | 830 |
| | | | | | | | | 87* | 7 400* | 22* | 1 900* | 359* | 40 800* | 5.5* | 630* |
| TOTAL | | 2 496 | 384 400 | 28 800 | 35 200 | 2 985 | 254 950 | 4 402 | 375 850 | 882 | 75 550 | 10 765 | 1 154 750 | | |
| | | | | | | | | 760* | 150 900* | 444* | 38 050* | 7 685* | 892 300* | | |

*Notes*: Asterisks indicate figures for use of digitized Wild B8S plotter. All figures including cost of conventional shoreline mapping.

interfaced with digital output devices to assist in a more rapid and accurate compilation of photobathymetry models. The cumbersome graphic correction routines currently employed will be replaced by computer programmes which use the digital data to compensate mathematically for stereo-model deformation and the effect of refraction at the water-air interface.

CMD is in the process of purchasing an analytical stereoplotter. This instrument consists of a conventional stereocomparator interfaced with an electronic computer to provide real-time computations. It is planned to use this analytical stereoplotter, which is scheduled for delivery in late 1977, in conjunction with the Ultra-Precise Numerical Photogrammetric Geodesy (UNPHOG) computational solution now being programmed to effect an even more rapid and accurate compilation of bathymetric detail.

*Drafting the map manuscripts*

All soundings, MLW line, shoals and other pertinent data compiled from the stereo models on the Wild B8 plotter are hand drafted by the plotter operator. The use of the digitized B8S plotter will permit the drafted sheet to be constructed by means of a flat-bed plotter. These map manuscripts at 1 : 10,000 scale are sent out to the field editor for verification and to the hydrographic party to assist them in their surveying operations.

## Time/cost data for photogrammetric bathymetry

The study of the potential for accomplishing photogrammetric bathymetry was confined to 10 regions of high priority along the Atlantic coast and the Gulf of Mexico. It was assumed that 6-ft depth curves would be drawn photogrammetrically in all the regions and that a significant number of discrete photo-soundings would be made. The B8 plotter has a C-factor of approximately 1,250 when drawing contours on soft under-water bottoms. Thus, an aerial photograph at 1 : 20,000 scale (flying height equals 5,800 feet) would be more than adequate to meet the accuracy requirements for 6-foot under-water contouring on a Wild B8 plotter.

More than 325 rolls of natural-colour aerial photography were examined to ascertain those areas in which photobathymetry could be undertaken. No evaluation was made of the stage of tide on these film rolls and, consequently, the figures given in table 53 represent the minimum amount of photobathymetry that can be accomplished because greater depth penetration would be obtained on photography taken at or near low water.

The figures shown in table 53 include the cost of preparing conventional shoreline manuscripts for the area. However, the cost of establishing and operating tide-gauges has been ignored since those gauges would be established by the hydrographic party regardless of photobathymetric considerations.

The photobathymetry programme would require about 10,765 man-days of work and would cost an estimated $1,154,750, based on the use of a Wild B8 stereoscopic plotting instrument. Employment of a digitized Wild B8S stereoscopic plotting instrument reduces the programme work to 7,685 man-days and the cost to $892,300. A minimum of five years is assumed necessary for CMD to accomplish the proposed photobathymetry project.

## Conclusion

Photogrammetric bathymetry operations conducted by CMD in recent years show it to be a practicable method for mapping the shallow waters of the country which can be implemented using currently available equipment and techniques. Photogrammetric bathymetry can serve to improve the accuracy and completeness of the hydrographic survey while simultaneously reducing the time and cost of the field operation. As a consequence of this study, the National Ocean Survey is now considering the desirability of initiating a comprehensive photobathymetry programme in shallow waters of high priority.

# AGENDA ITEM 10

## Conventional and satellite remote-sensing applications and techniques

### USE OF LANDSAT IMAGERY IN LAND-USE MAPPING IN AUSTRALIA*

*Paper presented by Australia*

A wide variety of land-use maps has been produced in Australia in the past decade. The maps range from large-scale regional maps to small-scale national maps; but until recently no attempt had been made systematically to cover the continent, or significant parts of it, with a series of land-use maps having a uniform classification.

To fulfil the apparent need for such a series of maps, the Division of National Mapping of the Australian Department of National Resources recently commenced preparation of a series of reconnaissance land-use maps on the scale 1 : 1,000,000 using sheets in the International Map of the World (IMW) series as base maps.

Satellite imagery, especially that obtained by LANDSAT-1—formerly known as Earth Resources Technology Satellite (ERTS-1)— is playing a major part as source material for the series. In addition to the satellite imagery, other published source data, such as thematic and topographic maps, aerial photography, cadastral plans, statistics and descriptive reports, are being utilized. Most of the research and interpretation are being carried out in the office at Canberra, with some data compilation being undertaken from unpublished records held by state government authorities, in particular the Lands Departments.

As a convenient means of bringing together a wide range of information, three overlays are being prepared for each IMW sheet area. These are entitled "Land cover", "Land tenure" and "Land use", the last sheet being essentially a composite of the first two but with some reinterpretation and reclassification of data for presentation in terms of the land-use categories shown in table 54.

Early in the planning stage for the series it was decided that a classification of the type developed by the United States Geological Survey[1] would be advantageous because it incorporates various levels of detail. Such a classification permits areas to be assigned a broader class if source material is limited. It also allows for new categories to be added if required as work progresses. The classification may also be extended for larger scale mapping by merely adding more levels of detail.

To satisfy particular needs and to allow more detail to be shown than is practicable on the land use overlay alone, the land-tenure and land-cover overlays, although prepared mainly as aids in producing the land-use overlay, are being retained as integral parts of the land-use map series. The three overlays for each sheet area will be issued as single colour maps by combining the overlay (in black) with the IMW base map (in screened black). Current plans for the series do not include multicolour printing.

#### *Use of satellite imagery*

It was realized from the outset that a data source providing a broad overview was needed for mapping land cover at 1 : 1,000,000 scale. To use conventional photography at 1 : 80,000 scale, even without stereoscopic coverage, would require over 1,300 photographs for each IMW sheet area in the 32°–36° latitude band, whereas with LANDSAT imagery only about 15 scenes are needed.

Most of Australia has been covered by LANDSAT imagery since the first satellite was launched by the National Aeronautics and Space Administration (NASA) of the United States of America in July 1972. Almost all of the imagery of Australia was obtained by the Multispectral Scanner (MSS) system on board LANDSAT 1, recorded in the satellite, and later relayed to a ground receiving station in North America.

The MSS system is a line-scanning device operating two bands in the visible spectrum (bands 4 and 5) and two in the near infra-red (bands 6 and 7). First-generation LANDSAT imagery is in the form of computer-compatible tapes but can be transformed into a range of optical products. These products usually take the form of positive or negative images of each band at 1 : 3,369,000 scale (on 70-mm film) or 1 : 1,000,000 scale (on 24-cm film). From these products, black-and-white prints of each band or false colour composites (usually of bands 4, 5 and 7) can be made. For the current programme of land-cover mapping, colour composite film positives have been found to be the most useful imagery for manual interpretation.

Each LANDSAT scene (which measures 185 × 178 mm

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* The original text of this paper, prepared by the Division of National Mapping, Department of National Resources, Australia, appeared as document E/CONF.68/L.35 and Add. 1.

[1] James R. Anderson and others, *A Land Use and Land Cover Classification System for Use with Remote Sensor Data*, United States Geological Survey professional paper 964 (Washington, D.C., Department of the Interior, 1976).

**Table 54. Australia: classification of land use for reconnaissance land-use mapping**

| *Level 1* | *Level 2* | *Level 3* |
|---|---|---|
| 1 Urban | 11 Built-up area | |
| | 12 Other | |
| 2 Cropland | 21 Cropping and grazing | 211 Cereals for grain (excluding rice) and grazing |
| | | 212 Fodder and grazing |
| | | 213 Irrigated fodder and grazing |
| | | 214 Other crops and grazing |
| | 22 Cropping | 221 Orchards, plantations and vineyards |
| | | 222 Horticulture |
| | | 223 Rice |
| | | 224 Sugar-cane |
| | | 225 Cotton |
| | | 226 Oil-seed |
| | | 227 Other cereals |
| | | 228 Other crops |
| 3 Grazing | 31 Natural or improved pasture | |
| | 32 Limited grazing—mainly uncleared land (including some areas either grazed infrequently or not grazed) | |
| 4 Forestry | 41 State forest or equivalent reserve | |
| | 42 Timber reserve | |
| | 43 Privately managed forest | |
| 5 Recreation and/or environmental protection | 51 National park or similar reserve | |
| | 52 Other nature, scenic or recreation reserve | |
| | 53 Water-supply | 531 Water-supply reserve |
| | | 532 Domestic water-supply catchment (restricted use or access) |
| 6 Institutional use | 61 Defence reserve | |
| | 62 Aboriginal reserve | |
| | 63 Other | |
| 7 Mining | 71 Open cut | |
| | 72 Reserve (use restricted) | |
| 8 Unused for above-mentioned purposes | 81 Crown land | 811 Reserved Crown land |
| | | 812 Unreserved Crown land (may include temporary grazing) |
| 9 Water feature | 91 Artificial storage | |
| | 92 Natural lake, coastal lagoon etc. | |

at 1 : 1,000,000 scale) is taken from an altitude of nearly 920 km and covers almost 33,000 km$^2$ of country. This is a significant advance on conventional photography for small-scale mapping as the LANDSAT imagery, because of the altitude of the satellite, not only provides a broad overview of large areas at a single point in time but usually provides about the right degree of detail for distinguishing the different patterns of land cover at 1 : 1,000,000 scale.

For some areas the available LANDSAT imagery is of doubtful reliability for land-cover identification at the level of detail required because of different sets of ground conditions producing similar spectral "signatures" or similar broad patterns. Such factors as soil composition, soil moisture or variations in the condition or stage of growth of vegetation can, either in isolation or combination, result in incorrect interpretation. Supplementary information, such as conventional aerial photographs (mainly black and white), vegetation and other thematic maps, photo mosaics and topographic maps, is used in conjunction with the satellite imagery to verify areas mapped from LANDSAT. After the discrete patterns of land cover have been identified, each area is classified according to the classification shown in table 55.

The office interpretation of the LANDSAT scenes is subsequently compiled onto an overlay to the entire IMW sheet. This task is done either by eye, using topographic and cultural detail from the base map as controls, or by means of a zoom transferscope, which permits the imagery to be optically superimposed over

**Table 55. Australia: classifications of land cover for reconnaissance land-use mapping**

| *Classification* | | *Description* |
|---|---|---|
| A Forest land | Aa Native forest | Foliage cover of about 30 per cent or more |
| | Ab Forest plantation | Generally pine forest of exotic species |
| B Woodland | | Generally intermediate between forest land and grassland. Foliage cover up to about 30 per cent. Also including mixtures of A, B and D |
| C Shrubland | Ca Tall shrubs | More than about 2 metres high; including mallee, some alpine and coastal shrubs etc. |
| | Cb Low shrubs | Less than about 2 metres high; including saltbush, bluebush, some alpine and coastal heaths, salt-marsh shrubs etc. |
| D Grassland | | Native and/or improved pastures. Few trees or shrubs |
| E Cultivated land | Ea Extensive cultivation and pastures | Cereals, sown pastures, fodder and fallow; including some grassland |
| | Eb Improved pastures and intensive cultivation | Mainly improved pastures with some areas of fruit, vegetables or other non-cereal crops |
| | Ec Improved pastures and fodders (mainly irrigated) | |
| | Ed Intensive cultivation | Including orchards, vineyards, horticulture, cotton, sugar-cane etc. |
| F Wetland | Fa Forested | Including mangroves |
| | Fb Non-forested | |
| G Barren land | | Unvegetated areas, generally rock-sand, salt, clay-pans, mud-flats etc. |
| H Water feature | Ha Artificial storage | |
| | Hb Natural lake, coastal lagoon etc. | |
| J Built-up area | | |

the base map and stretched, shrunk or otherwise distorted to obtain the best fit.

Imagery taken in summer over south-eastern Australia has so far provided the most useful differentiation between cropland categories and in separating grassland from cropland; but, unfortunately, repetitive coverage of imagery taken at different times of the year is often not available to highlight seasonal variation in the spectral response of different types of land cover. Furthermore, in some areas the usefulness of the imagery has been considerably reduced by extensive cloud cover.

Figure 115[2] is a reproduction of a false colour composite of bands 4, 5 and 7 of a LANDSAT-1 scene of part of the central-west of New South Wales in the Canberra IMW sheet area; it illustrates some of the problems encountered so far in mapping land cover from satellite imagery. This scene covers the Orange-Parkes-Cowra area and includes the Lachlan River from Wyangala Dam to east of the town of Condobolin. The intensively cultivated river flats, such as those along the Lachlan River from Cowra to Forbes, contain areas of irrigated horticulture, fodder crops and sown pasture. On summer scenes such as those in figure 115, the irrigated areas are clearly discernible because of the contrasting spectral responses of growing crops compared with those of mature crops and harvested areas in the vicinity. However, subdivision of areas of irrigation into component crops for the final land-use overlay has often been impossible without reference to other sources. Other problems have included the separation of grassland and shrubland in the western part of the Canberra sheet area; the separation of grassland from woodland/forest land in dissected hill country (such as north and north-east of Orange) using summer imagery alone; the identification of areas of vineyards; and determination of the western margin of the "wheat belt" north of the Lachlan River.

Expert local knowledge of difficult areas as well as the documentary, photographic and other sources mentioned above, are used to verify interpretations of the satellite imagery. In complex areas, or areas of particular difficulty, heavy reliance is also being placed on conventional photography and other supplementary sources; but even on large-scale photography it is sometimes difficult to identify types of cropping. Recent state and federal topographic mapping on the scales 1 : 100,000, 1 : 50,000 and 1 : 25,000 is proving very useful in classifying areas of intensive cropping, such as orchards, plantations and vineyards; but from this source it is often still not possible to identify component crops for the land-use overlay.

[2] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figure 115 is in this pocket.

The land-use maps of the New South Wales Soil Conservation Service have been used as aids in determining a mean boundary for the arid edge of the "wheat belt" and information prepared by officers of the Division of Land Resources Management of the Commonwealth Scientific and Industrial Research Organisation assisted in distinguishing areas of shrubland from surrounding land-cover types.

Because of the large area of each IMW sheet (between 220,000 and 280,000 km$^2$) and the small staff engaged in the land-use mapping programme, field checking of entire sheet areas is not practicable. However, the need for at least some field inspection of limited areas was recognized from the outset to verify office interpretation in doubtful areas, to update some information and to resolve other outstanding problems such as the identification of individual crop types. During the preparation of each land-cover overlay and, subsequently, its land-use overlay, particular problem areas are identified and after completion of the draft overlays, a field check of as many of the problem areas as possible is made. Field trips lasting one or two weeks have been undertaken for four sheet areas by the officers who prepared the initial compilations. Selective aerial inspection has also been used for checking large areas of relatively homogenous land use where available information did not allow adequate identification to be made.

In the course of preparing the land-cover overlays, the potential usefulness of several experimental aids has been assessed. For example, a greater degree of flexibility as well as a significant reduction in costs has recently been achieved by the use of a compact Diazo transparency printing and developing machine. This equipment allows colour composite LANDSAT imagery of adequate quality to be prepared from positive transparencies of individual bands. Contact film copies of each band are prepared in the desired colour (normally yellow for band 4, red for band 5 and blue for band 7) and by overlaying the transparencies colour composite images are built up. The intensity of colour can be varied on any band to highlight particular features of interest.

Similar results can be achieved with a colour additive viewer but the Diazo process provides an inexpensive and permanent record in colour composite form.

A potential use for the Diazo process which has not yet been fully investigated is the production of negative as well as positive transparencies of individual bands in

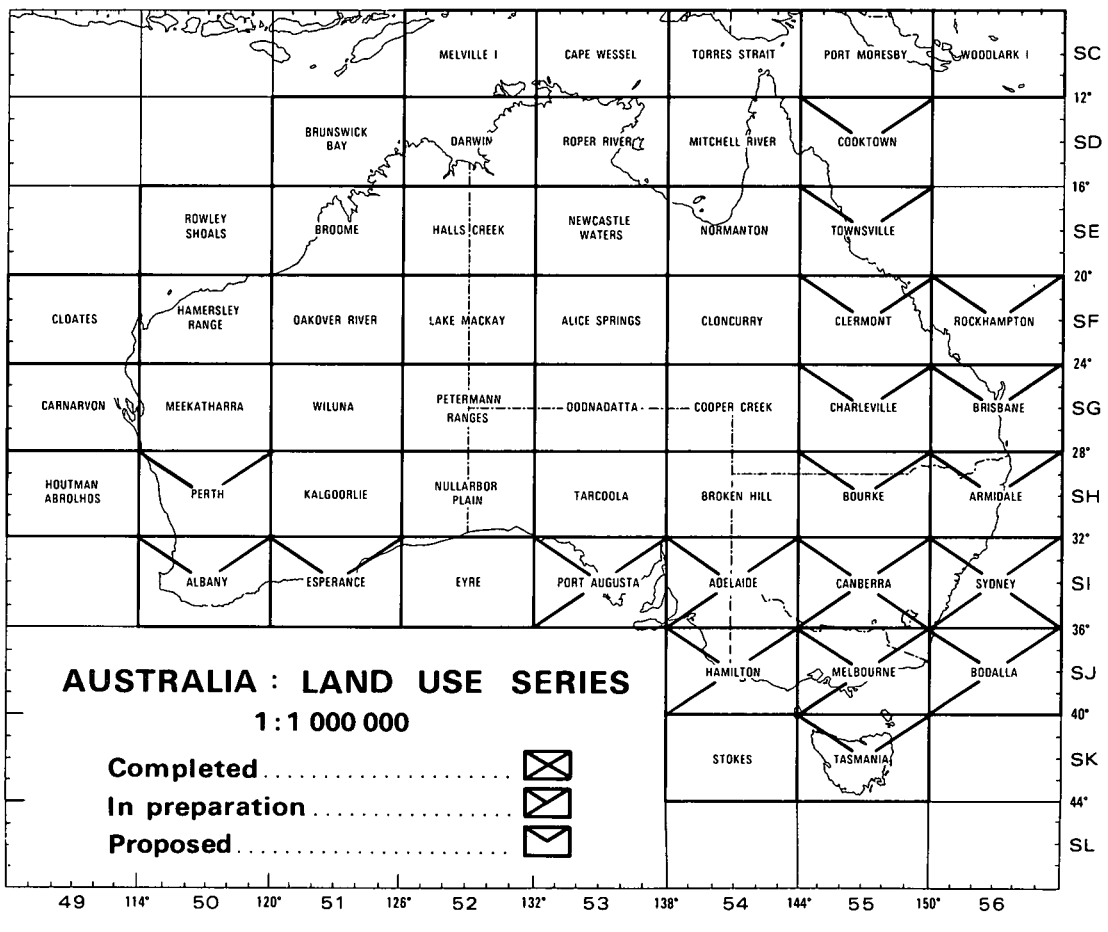



*Figure 116. Australia: land-use series maps at 1 : 1,000,000 scale*

different colours to build up non-standard colour composite imagery. Some experimenters have been able to achieve more useful distinctions between certain categories of land cover/land use by this means. For example, the combination of positives and negatives of bands 5 and 7 in selected colours can highlight the distinction between rain forest, wet sclerophyll forest and dry sclerophyll forest and between unimproved grassland and improved pasture/crops. Much experimentation still is needed but this procedure could prove useful as an aid in land-cover identification.

Some recent developments in conventional aerial photography have also been assessed for their usefulness in the land-use mapping programme. High-altitude black-and-white photography on the scale 1 : 140,000 has been taken over parts of south-eastern Australia; and indications are that, because of its excellent resolution and small scale, it would prove more suitable than existing larger scale photography for land-cover/land-use mapping at 1 : 1,000,000 scale if widespread coverage becomes available. A similar trial with high-altitude colour photography has recently been undertaken over Canberra and, if the quality can be improved, such photography could well become the primary back-up material to LANDSAT imagery.

Most satellite imagery of Australia was acquired by LANDSAT 1 between mid-1972 and early 1974. Although limited numbers of scenes obtained by LANDSAT 2 (launched in January 1975) were acquired for approved special investigations, there has been no general acquisition of imagery over Australia since early 1974. However, consideration is being given to establishing a ground receiving station in Australia. This facility would permit up-to-date imagery to be obtained as required, including seasonal coverage.

Because of the relatively small scale and the need to cover large areas in a reasonably short time, the Australian land-use series at 1,000,000 scale will obviously not be the last word in land-use mapping. It should, nevertheless, provide a framework for the integration of more detailed local maps and serve well as source material for various smaller scale maps.

Preparation of material for the series is carried out by a team of three geographers in the Division's Geographic Section. The maps are then made ready for single-colour reproduction by the Map Production Branch. Even though only a small staff is involved in the project, it is expected that at least two sheet areas will be completed each year.

It is planned that the land-use series (about 18 sheet areas) will ultimately cover the more closely settled parts of Australia, and in fact most of the sheets in the south-eastern part of the continent from Adelaide to Sydney are either completed or well advanced (see figure 116). Copies of the three maps for the first two sheet areas, covering the Canberra and Sydney IMW sheets, were in press at the time of writing (October 1976) and will soon be available for release to the public.

## REMOTE SENSING AT THE INSTITUT GEOGRAPHIQUE NATIONAL*

*Paper presented by France*

The mission of the Institut géographique national (IGN) is topographic mapping, that is, the description of the earth's surface, first by work on the ground; and, secondly, by aerial photographs which constitute a remote recording of the physical characteristics of the terrain. But topographic data represent only one of the many types of information which can be collected; they cover only one of the physical phenomena which can be recorded. Furthermore, light radiations constitute only a small portion of the electromagnetic spectrum which can be used to convey information.

With the rapid expansion of industrialization, urbanization and population, consideration must be given to safeguarding nature, protecting the environment and making an inventory of natural resources; techniques have been developed which make it possible to record the phenomena related to these fields. The study of these phenomena as an extension of the study of the earth's surface is part of the mission of IGN just as it is part of the mission of all major world geographical services, such as the United States Geological Survey, which is responsible for the survey for the topographic map.

### Problems presented

The problem of the environment and pollution, although it may be particularly acute today, is not new; Julius Caesar long ago laid down rules designed to ensure the conservation of certain animal species such as hedgehogs, while Horace complained of the infernal noise made by chariots in Rome at night. But, of course, the industrialization which has taken place over the past century and the current population explosion constitute causes of pollution of a much greater magnitude, particularly in view of the degree of urban and industrial concentration resulting in 80 per cent of the world population being crowded into only 2 per cent of the earth's surface.

The traditional activities of IGN are already enabling it to embark on estimates of natural resources and to contribute to the protection of natural beauty spots

* The original text of this paper, prepared by A. Boudoin, A. Decaé and P. Demathieu, Institut géographique national, France, appeared as document E/CONF.68/L.10.

through the use of its aerial photographic coverages and of the maps on various scales which can be established from them. Photographs on infra-red sensitive films or on so-called "false colour" films[1] provide information on vegetation and the different crops, water resources, coastal areas, forest species, land-use patterns and land-forms. In addition, the information contained in these documents makes it possible to safeguard human populations against natural catastrophes such as avalanches, floods and fire.

Conventional photographic recordings, however, have limitations in that they are dependent upon the transparency and purity of the atmosphere, and upon sunlight, and because a large number of the features of the terrain are not discernible on them. It is for this reason that increasing use is being made of remote sensing using various airborne devices known as sensors, which permit phenomena to be recorded by electromagnetic waves with frequencies very different from those of the visible-light spectrum and extending to the X-band of radar (SHF).

The advantage of these remote-sensing methods lies in the wide range of problems that can be studied, it being possible to use one procedure for research of very different types, and also in the rapidity of access to information, laboratory processing generally being minimal. In addition, this rapid access to information makes it possible to describe the environment in terms of both time and space, allowing the evolution of a phenomenon to be followed by means of a series of sensings carried out at regular intervals over a period of time. Lastly, as these methods are not dependent upon the optical transparency of the atmosphere in the visible-light spectrum or upon sunlight, it is possible to operate in overcast conditions or at night, which has many advantages.

## The remote-sensing process

The basic elements in remote sensing are the recording devices, or sensors which are carried on platforms. These platforms may be aircraft, balloons or satellites; and IGN is fortunate in possessing such platforms in its aircraft pool which comprises 15 aircraft ranging from the Aero Commander to the Mystère 20 twin jet and including also B17s and Hurel Dubois. It is therefore possible to operate at altitudes from 300 to 13,500 m, at cruising speeds of between 250 and 850 km per hour. IGN also has the possibility of participating in a programme of environmental study using the Earth Resources Technology Satellite (ERTS-B) of the satellite of the Earth Resources Observation System (EROS) which were especially launched by the United States of America for this purpose, and for which each country can establish a research programme. As a result, IGN will be able to gather information on the development patterns, in terms of both time and space, of snow-cover in the mountainous areas of France, by virtue of recordings made at regular 18-day intervals and retransmitted to the ground. These earth resources research satellites are termed synchronous because they pass twice daily over the zenith of points of the same latitude, at the same local solar time. To achieve this, they are programmed to follow a near-polar orbit at an altitude of about 910 km. By virtue of the ellipsoidal shape of the earth, the irregularities of the outer gravity field and planetary influences, the orbits undergo changes which cause the satellites to pass approximately once every 18 days over the zenith of a given point on the earth's surface at the same local solar time, i.e., in the same position in relation to the average sun despite the variation in the angle of the sun's declination. If there were no orbital changes, it would be sufficient to programme the satellites to follow a strictly polar orbit at an altitude such that their periods were submultiples of the solar day (e.g., 1,660 km for two hours), so that each day they would pass over the zeniths of the same points at the same solar time.

The first sensors to be brought into service at IGN, and which are still given considerable use, were of course conventional cameras which could be used with lenses of different focal lengths, different emulsions and at a variety of flying altitudes and scales, thus providing a wide range of possibilities.

The most interesting instrument that IGN currently has, however, is a device which permits the temperature of the points on the ground over which the aircraft is flying to be measured to within a fraction of a degree centigrade. While the plane is in motion, the apparatus successively scans narrow strips of terrain to 60° on either side of the line of flight by means of a mirror which rotates at 70 revolutions per second. As the intensity of the signal emitted by the detector cell increases in proportion to the temperature of each point examined, an electrical image of terrain temperatures, or videogram, is obtained and recorded on magnetic tape. This videogram may be either transformed immediately into an optical image on an on-board television screen, on which the details appear brighter in proportion to their temperature, or can be transformed by a laboratory transcription unit into a black-and-white image on paper, showing the temperatures of the strip of terrain flown over. This apparatus is known as a scanner and the documents obtained are called "thermal images". The entire procedure is termed "airborne infra-red thermography".

## Principle of thermography

The radiation recorded comes in part from the reflection of solar radiation from the elements constituting the terrain and in part from the radiation emanating from the objects themselves. Between the ground and the sensors, this radiation is modified by atmospheric absorption and diffusion.

The reflected radiation is generally of no interest and can be considered superfluous radiation which must be eliminated. The simplest way of achieving this objective is obviously to carry out the photographic coverage by night, but this method is not always possible, as for example when one wishes to study diurnal temperature

[1] For these emulsions, the first layer (non-colour sensitized emulsion, selecting in the blue) is omitted and a third layer is added for selection in the infra-red.

variations. Mathematical elimination of this radiation is made very difficult by virtue of its highly anisotropic nature (i.e., the energy received depends more upon the shape of the figure formed by the sun, the sensor and the point to be studied than upon the nature of this point). Of course, quantitative studies of anisotropy have been conducted on different types of soil and vegetation covering, but to use these results in making a correction is at best a laborious procedure and at worst impracticable for highly heterogeneous areas.

The problem caused by reflected radiation can be expressed in terms of the ratio of the energy from this radiation to the energy from the emitted radiation. This ratio is appreciably lower at about 10 microns than at 5 microns, a fact which may influence the choice of the sensor to be used in a given situation.

The important radiation is the emitted radiation because it permits the temperature to be deduced. In effect, the spectral emissivity curves of a black-body radiator at different temperatures show that for those temperatures most frequently found on the ground (about 300° K), the maximum radiated energy is in the region of 10 microns, and that this energy remains appreciable up to 2 microns (see figure 117). It is therefore tempting to conclude that the ideal arrangement is to have an apparatus sensitive to a band in the region of 10 microns. In practice, the differences of temperature must generally be shown and a more detailed study shows that the curves become further apart at wave lengths slightly below the maximum wave length.

In effect, only a very approximate comparison can be made between black-body radiators and actual bodies. In order to make the transition from one to the other, it is necessary to introduce the concept of emissivity. This is the ratio of the energy actually emitted by the body in question to the emissive power of the corresponding black-body radiator at the same temperature. At its maximum, this ratio is equal to 1 (in the case of the black-body radiator) and can vary considerably: between 0.9 and 0.8 for water, according to circumstances; and as low as 0.4 or 0.3 for rocks.

But the atmosphere also plays an important part in

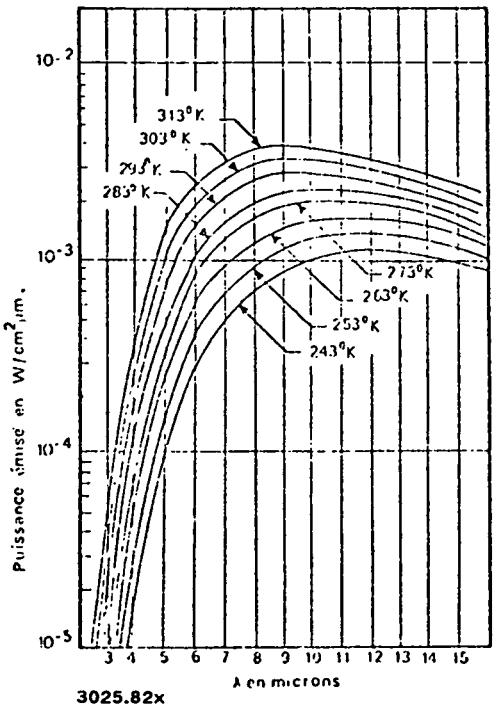



*Figure 117. France: spectral emissivity of black-body radiator at different temperatures*

absorbing and diffusing a certain amount of the radiation. With regard to absorption, there are a number of transmission windows in the atmosphere, as shown in figure 118. In the area of concern here, the following absorption bands are due essentially to transitions in the rotation of molecules of water (vapour) and molecules of carbonic gas (2.5–3 microns, 4.3 microns, 5.8–7.3 microns and 14 microns—1 mm). This means that atmospheric absorption does not present any great problem.

Furthermore, theoretical calculations show that diffusion for particles which are small in relation to the wave length is proportional to $\lambda^{-4}$, where $\lambda$ is the wavelength.

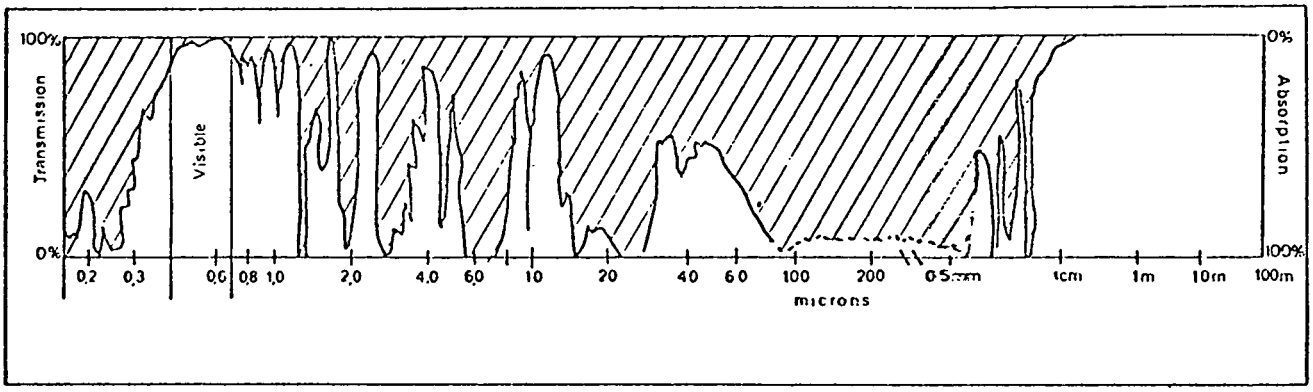



*Figure 118. France: atmospheric absorption of the electromagnetic spectrum*

This phenomenon is therefore very weak in the infra-red—less than 1‰ of the energy lost by diffusion at 1,000 m.

In the case of larger particles, the infra-red is substantially more penetrating than the visible-light wave bands, which is a considerable practical advantage: mists and fine fogs are relatively transparent, which permits photographing to be carried out in mediocre weather conditions. But the size of the particles must not be too great, as the wave length cannot be increased indefinitely (absorption from 14 microns; beyond this, the extremely high frequency (EHF) band is reached).

Other phenomena, such as the emissivity of the atmosphere, may come into play. In the wave lengths that correspond to the absorption bands, the atmosphere behaves like a black-body radiator. In addition, thermal phenomena in the atmosphere, such as temperature inversions, can impair the image of the ground. These questions will be taken up again later in the study of atmospheric pollution.

Lastly, there is the question of transparency in liquid or solid media: whether it is possible to see, or merely detect on a thermograph, an object which is buried below the ground or which is lying on the sea-bottom. There can be no blanket answer to this question. Theory shows that the transparency of liquid water, rocks or soils under infra-red light is extremely low—in the region, say, of a few fractions of a millimetre.

Nevertheless, the answer to this question is not totally negative. The temperature of the surface, or at least of a very fine surface film, is recorded, but this temperature is influenced by deep-seated thermal phenomena. Take the case of a homogeneous soil in which an object of a very different specific heat is buried with the whole being subjected to thermal fluctuations. Through thermal conductivity, the soil can be considered as transmitting to the surface an image of the object; this image may, of course, be distorted. In liquids, convection appears to play the predominant role. An attempt may be made to pin-point the phenomenon by calculating from models but, as is well known, actual conditions are more complicated than the most complex models. The role that this pseudo-transparency can play will be considered for each type of application (geology, hydrology etc.).

### Equipment used

To obtain a thermograph a series of devices must be used: (*a*) one or more sensors (the infra-red scanner);

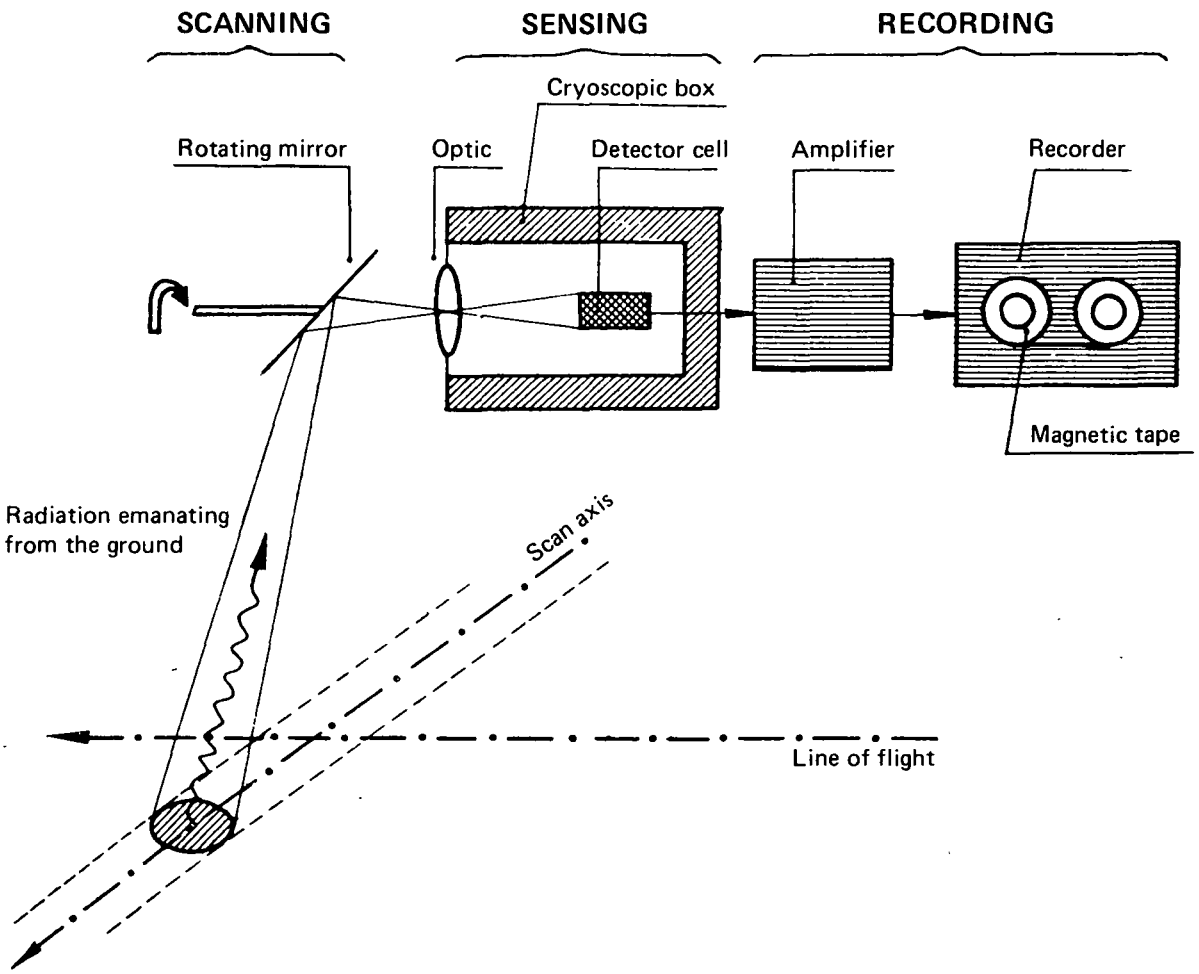



*Figure 119. France: theoretical diagram of a scanner*

(*b*) a recorder; (*c*) a unit for the transcription of the recorded signal on to a sensitive film.

Although the sensor and recorder are installed on board the aircraft, the transcription unit usually is not (it permits the information collected to be processed later).

*The sensor: general layout of infra-red scanners*

The scanner is a device which measures the energy of the radiation received. This is a passive measurement (in that it does not call for the emission of a reference radiation) and is carried out using the three parts constituting the scanner (see figure 119):

(*a*) An optical-mechanical device which collects the radiation emanating from the ground. It consists of a mirror which rotates about an axis parallel to the line of flight and inclined at 45° to it; in this way, the mirror scans the terrain at right angles to the direction of movement of the aircraft. A focusing system permits the energy received to be concentrated on to the detector cell;

(*b*) A cell sensitive to the infra-red radiation received, consisting of the detector proper, housed in a cryoscopic box ensuring a good signal-to-noise ratio;

(*c*) An electronic measuring system consisting basically of an amplifier which permits the signal to be communicated to the recorder.

The first sensors, introduced in 1950, used heat-sensors: the infra-red radiation heated a sensitive element, the resistance of which varied in relation to this temperature. The advantage of those sensors was that they could be used at atmospheric temperature, but their response time was very long (several milliseconds). Those sensors were replaced by photo-sensors which transform the energy of infra-red photons into kinetic energy of electrons which, once liberated, modify the electrical properties of the cell. These devices have a very short response time (less than one microsecond) but can be used only at low temperatures.

The two types of cell mainly used are:

(*a*) The indium antimonide (InSb) cell, sensitive from 3 to 5 microns at a temperature of 77°K (the sensitivity curve can be shifted towards the longer wave lengths—up to 8 microns by causing a magnetic field to act on the cell);

(*b*) The mercury-doped germanium cell (Ge:Hg), sensitive from 8 to 14 microns at the same temperature of 77° K. Figure 120 shows the relative sensitivity curves of the InSb and Ge:Hg cells;

(*c*) Other substances may be used as detectors, such as mercury-cadmium telluride (Cd Hg Te), sensitive from 8 to 14 microns at 77° K.

The temperature of the cell is maintained at approximately 77° K in a cryoscopic tank of liquid nitrogen or, for lower temperatures (a few degrees Kelvin for certain Ge:Hg cells), liquid helium.

The essential characteristics of the scanner used in the infra-red[2] are as follows:

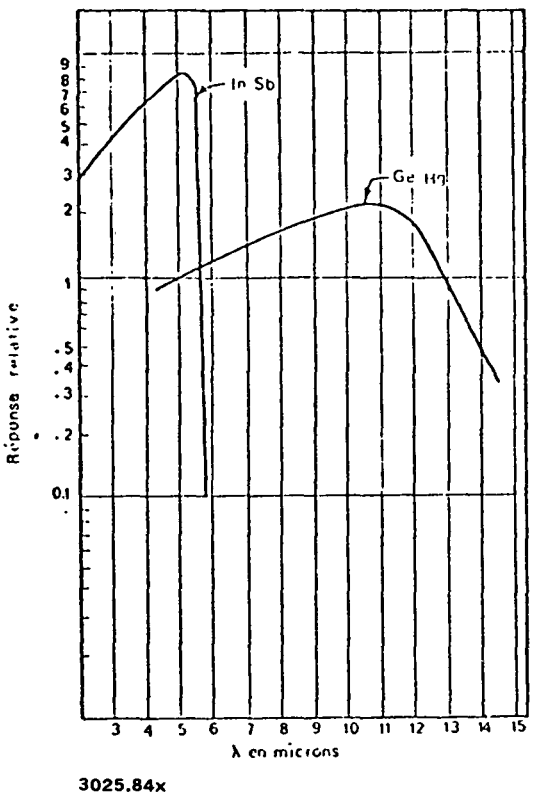



*Figure 120. France: relative spectral responses of indium antimonide (InSb) and mercury-doped germanium (Ge:Hg) cells*

(*a*) *Mirror*:
- (i) Speed of rotation: 70 revolutions per second (it was reduced by almost half following the first trial tests);
- (ii) Scanning angle: 120°;
- (iii) Angle of analysis: 5 milliradians;

(*b*) *Cell-type: InSb:*
- (i) Cooling to 77°K by liquid nitrogen;
- (ii) Independent operation time: 5–6 hours;
- (iii) Temperatures detected: from −30° C to +60° C;
- (iv) Thermal resolution: 0.25°C.

The electrical signal emitted by the Cyclope analysis head does not provide an absolute value for the ground temperature; it provides only a relative indication, so that it is necessary, for accurate interpretation of the measurements, to know the values of certain additional parameters:

The scanner is coupled to a radiometer, which measures the absolute temperature of the ground along the line of flight. This radiometer consists of a germanium heat-sensor type of cell. The response of this cell, which is sensitive to thermal radiation between 8 and 14 microns, is compared with that for the radiation from a black-body radiator used as a reference, thus permitting the signal values to be converted into temperatures. These temperatures are termed absolute because two points on the

[2] For further technical details concerning the scanner, the Cyclope of the Société anonyme des télécommunications, see "Le scanner infrarouge Cyclope", *Bulletin d'information de l'IGN*, No. 10 (March 1970).

ground with the same emissivity and temperature produce the same signal value. Nevertheless, to obtain true temperatures, it is necessary to check the radiometer response against measurements made on the ground.

The radiometer measures radiation in one direction only (it is not possible to conduct an analysis with a rotating mirror because of the excessively long response time of the cell) and in a relatively open cone (the angle of analysis being 2°). It is sensitive to a temperature difference of the order of one tenth of a degree and permits absolute measurement of about half a degree.

The scanning of the terrain depends to a considerable extent upon the movements of the aircraft and determines the quality of the final image for measurements purposes. Currently, the flight parameters (heading, position, roll, altitude etc.) are not recorded; it is possible to envisage the use of sensors which, while measuring these parameters, would be connected to a recorder to allow for better correction during processing of the information given out by the scanner.

*The recorder*

As concerns the recorder, the signal that comes directly from the detector cell is known as the input signal and the signal recorded from the amplifier is known as the output signal.

The output signal is kept between $-1$ and $+1$ volts to permit it to be recorded. This procedure calls for two amplification adjustments:

(*a*) Adjustment of the average level so that the output signal oscillates around a zero average value;

(*b*) Adjustment of the gain (ratio of the output signal amplitude to the input signal amplitude) so that the output signal is not chopped off when it should have been outside the $\pm 1$ volt limits (corresponding to areas that are too hot or too cold).

These two settings provide good thermograph legibility by giving a better rendering of half-shades and consequently better relative discrimination between temperatures.

These adjustments can be made either manually or automatically. In the latter case, the adjustments are made on the basis of the preceding signal values and vary from one point on the thermograph to another, which prevents any direct evaluation of temperature because such an evaluation can then only be made by taking account of these adjustments, which must be recorded, or by referring to an independent datum like that provided by the radiometer.

Currently, signals to be used for measurement purposes are recorded on an analogue basis on magnetic tape (the signal is recorded in a continuous manner, as opposed to digital recording which retains only the signal values taken at regular intervals). A periodic signal of 54 kHz is used as a reference and is recorded on one of the seven tracks available. This signal is frequency-modulated for the low signal frequencies (below 100 Hz) and recorded on a second track. Frequencies of more than 100 Hz are recorded directly on to a third track. A fourth track is used for frequency-modulation recording of the signal emitted by the radiometer.

In addition, a "pip" signal marking the beginning and end of each scanning sweep is recorded, thus permitting the two-dimensional reconstruction of the image (see section on processing of data). The remaining tracks could be used (up to 14) to record the flight parameters or to check the scanner signal with a view to later processing of the analysed image for better interpretation. The tapes used are half-inch tapes, 1,100 m long; these tapes run at a speed of 76 cm/s, giving about 20 minutes of recording time.

Other recording systems can be used. It is, for example, possible to store the information and display it on a cathode-ray tube, in order to obtain a real-time image, thus permitting rapid identification and detailed study of the most interesting areas.

The processing equipment, which currently consists of a unit for transcribing the magnetic-tape information on to film, is described in greater detail below.

*Implementation*

Examination of the principles and techniques used in establishing a thermograph demonstrates the importance of the conditions under which the thermograph is made and the data processed to the final interpretation.

Two factors determine the methodology to be used. The first factor is the choice of the optimum thermographic conditions, not only to show up the phenomena to be studied but to check the results obtained; (*a*) in the aircraft, through the use of appropriate additional sensors; and (*b*) on the ground by the selection of test samples. The conditions that are most suitable depend to a large extent upon the result desired; but, in general, it can be said that the optimum conditions are those which favour the best differentiation of temperatures related to the phenomenon being studied. For example, in looking for fresh-water springs along the coast, the surface thermal effect of these springs must be at its maximum; this means that the sea must be at low tide, that the season must be the one in which the flow of these springs is at its peak and that the scale used must be large enough to show up these springs, which are little more than pinpoints.

It is also necessary to work at night in order to avoid unwanted reflections. Weather conditions can also play a role: thawing snow, for example, favours archaeological exploration.

*Processing of data*

Having gathered a mass of data, it is necessary to extract from them information of interest to the specialist, who will then interpret the documents produced. At IGN, data processing is carried out by electrophotographic methods, but the future solution will undoubtedly be digital processing by computer. The recorded magnetic tape is read by a transcription unit which reconstitutes the signal emitted by the reading head and uses it to modulate the intensity of a light ray, which in turn simulates the scanning and produces an image on a

70 mm black-and-white film. This simulation is made possible by the "pip" signals marking the beginning and end of scanning sweeps which are registered during the recording. The film obtained constitutes the thermograph original and can be reproduced on paper or can be used to produce a positive or negative enlargement.

The use of certain special techniques makes it possible to obtain other types of document by filtering the signal, i.e., by letting through only a certain intensity value in order to produce on the film the representation of a line of isodensity; or, by using colour film and filter combinations, to obtain a document resembling a temperature map. The recorded signal is broken down by means of electronic thresholds which select a certain signal pitch interval. Each partial signal is associated with a coloured filter and is translated on the film by a certain colour. Together, the partial signals reconstitute the initial signal, with the different colours making the different shades of this signal more visible.

The use of these documents facilitates interpretation but does not permit quantification of the phenomena. It is not possible in this article to discuss the necessity of recording the ground temperature on an absolute basis. Nevertheless, the use of digital methods would make it possible to reduce the unwanted effects produced by the aircraft (geometric corrections) and by the sensor (signal corrections). The final document would be a more faithful image of the terrain and would consequently facilitate interpretation.

### *Methodology*

The basic principles of methodology are the same as those for photo-interpretation, i.e., the document obtained from airborne apparatus must be completed by information collected on the ground. This information has two quite distinct purposes: (*a*) to "verify", so to speak, the recording in order to permit a fairly detailed interpretation; and (*b*) to check the validity and the accuracy of this interpretation.

Here the problem is made particularly difficult by the transience of the parameter being recorded—the temperature. In other words, the appearance of any given area on aerial photographs changes slowly over a period of time, one of the most rapidly changing phenomena being, for example, the appearance of the vegetation in the spring. Even in this case, the change over a few days is negligible. For thermographs, on the other hand, the change over a one-hour period is appreciable. It may therefore be necessary to carry out examinations on the ground which are strictly synchronized with the passing of the aircraft. To avoid the locations of these examinations subsequently proving to have been badly chosen, a real-time visual display of the recording can be very useful.

## Multiband remote sensing

A number of such scanners can be used in combination to constitute a multiband remote-sensing device capable of making simultaneous recordings of radiations from the ground in different bands of the spectrum with wave lengths which are not absorbed by atmospheric gases, i.e., the atmospheric transmission "windows". The comparison of the recordings obtained with different wave lengths makes it possible to collect data which would not be discernible on a single document, just as the comparison of photographs of a given area taken simultaneously on normal panchromatic and on infra-red emulsions provides more information than a single photograph. In effect, the different radiations received can be subjected to much finer analysis with the aid of airborne spectrometers. These devices examine the entire spectrum of the radiation received, which is spread out after reception, by measuring the intensity of each individual radiation.

These spectra can comprise up to 17 channels, corresponding to different wave lengths from the ultra-violet to the infra-red. The radiations emanating from each point examined by the scanner are directed towards a prism which spreads them into a spectrum. Optical fibres then conduct each of the chromatic bands chosen to separate photo-multipliers so that the energy of each radiation can be measured and the spectral composition of the radiation emitted by the different points on the ground and transmitted through the atmosphere can be determined. To permit these operations to be carried out, the aircraft must remain at an altitude of less than 3,000 m, the most effective flying height being 600 m above the ground surface. Just how the recordings permit the tone signature of a given type of object to be identified, its presence in the biosphere to be recognized and even its density to be estimated is discussed below.

## Use of radar

The use of much longer wave lengths naturally leads to the use of super-high-frequency radar bands, which have the advantage of penetrating much denser cloud cover than would be possible with infra-red radiations.

Everyone is familiar with the now widespread use of these waves to obtain radar images of the terrain directly below the aircraft, but they are given only limited use in the study of the environment because of the poor image resolution resulting from the minute variations in the reflecting power of the different ground details struck by vertical radar beams and from the small differences in relative distances. If, on the other hand, the beams are directed sideways from the aircraft, the relative distances vary rapidly with the angle of the beam, thus increasing resolution in proportion to the differential coefficient of this distance; in addition, the different details will show highly different reflecting powers, thus giving much better image contrast. Salient features of the terrain—rocky peaks, for example—will diffuse the radar radiation received much more than flat surfaces and will consequently appear as lines, or bright points on the image, thus making it possible to study the morphological, tectonic or structural features of the terrain. Similarly, different crops have different reflecting powers, as do wet and dry rocks, and calm or rough water, which permits detailed interpretation of the documents obtained. This device, known as side-looking airborne radar (SLAR),

operates by sweeping areas situated on either side of the line of flight of the aircraft; the responses provided by the reflected radiation receiver make it possible to establish a document showing the perspective of the terrain adjacent to the line of flight. As, at the same time, the distances between the aircraft and points on the ground are determined by measurement of the time delay in the return of the reflected signal, it is possible to rectify these perspective views and to convert them into the form that they would have had if they had been taken vertically, i.e., to make them directly usable for measurement purposes, which is obviously of great importance in mapping applications.

### Role of remote sensing in the study of the environment

The study of the environment can be considered simply as an aspect of physical planning. Its purpose is to prevent such planning from leading to a deterioration in the quality of life in all its aspects, be they physiological (purity of air and water, conservation and development of natural resources), psychological (the protection of natural beauty spots and of recreational areas), or intellectual and scientific (protection of flora and fauna). This conception of the environment brings an added dimension to physical planning, which previously has been only a matter of economics.

It should be realized that 80 per cent of the world's human population occupies only 2 per cent of the earth's surface, and that such a concentration can lead only to a deterioration in living conditions. Even in less densely populated areas of the world, human actions can have disastrous consequences for the environment. For example, the practice of burning-off accelerates the formation of hard lateritic crusts in tropical regions, and the water in irrigation canals becomes a breeding-ground for bilharzia.

One should not, however, make the error of going too far in this direction or of blindly following certain current doctrines which take the form of a sort of Manichaeism; excessively critical of mankind and excessively idealistic in the image of nature which they project, where everything left in its natural state is perfect and everything produced by the hand of mankind is depredatory. It is beyond argument that there are also natural phenomena which have devastating effects, that efforts must be made to circumscribe these phenomena and that, in any event, it is impossible to revert to a pre-industrial stage of development. One must therefore adjust to the industrialization of the developed countries and to the burgeoning populations of the developing countries, and find means of limiting the damage wrought and of reducing its awesome consequences. This is the role of environmental protection.

IGN now has staff and material resources which it can place at the disposal of the country for the study of the environment, the management of natural resources, the establishment of inventories of these natural resources and the protection of natural beauty spots, and for combating all forms of pollution. This is the principal role of the remote-sensing facilities at IGN.

## EARTH RESOURCES TECHNOLOGY SATELLITE NO. 1—APPLICATIONS IN CONVENTIONAL MAPPING ON THE SCALES 1:1,000,000 AND 1:500,000*

*Paper presented by France*

Earth Resources Technology Satellite No. 1 (ERTS-1)[1] was launched on 23 July 1972 by the National Aeronautics and Space Administration of the United States of America for the purpose of obtaining further information on this planet in the earth sciences—oceanography, geology, hydrology and land-use patterns. Although very significant results relating to the inventory of natural resources have been published by researchers involved in different programmes, no research appears to have been conducted in France into the very important topic of the application of satellites in conventional mapping for the revision or even the remaking of small- and medium-scale maps.

In this regard, the Institut géographique national (IGN) has developed a methodology for updating documents on scales between 1:1,000,000 and 1:250,000.

### Information supplied by ERTS-1

Without going into the technical details regarding the on-board equipment, it is worth recalling that the satellite is equipped with a multispectral sensor operating in the electromagnetic wave lengths of the visible and near infra-red spectrum from 500 to 1,100 nanometres spread over four bands. The ground resolution of the imagery makes it possible to pick out objects of an average size of 80 m and sometimes less because of the sharp contrast of the feature with its surroundings.

#### *Band 4 (500–600 nanometres)*

Band 4 operates mainly in the blue-green, thus providing valuable information in the areas of water transparency, the reflectance of land which is under cultivation or being redeveloped and the frozen regions.

* The original text of this paper, prepared by C. Cazabat, Institut géographique national, France, appeared as document E/CONF.68/L.11.

[1] Earth Resources Technology Satellite No. 1 (ERTS-1) is now being replaced by a second satellite equipped with the same sensor, known as LANDSAT-2.

The first of these topics, although important in oceanography and coastal geomorphology, is of little interest as far as conventional maps are concerned; the second, on the other hand, can be used to establish the alignment of highways during construction or of major civil engineering projects, together with details of the development of urban, industrial or residential areas covering several hectares; the third, relating to perpetual snow and ice, makes it possible, using recordings made in mid-summer, to prepare or to update topographic maps of high mountain areas. In France, for example, snow lines have receded several hundred metres over a 30-year period; this withdrawal can therefore be shown on a medium-scale or even a small-scale map. It should be pointed out in connexion with this very special area that even major alpine avalanches are visible.

*Band 5 (600–700 nanometres)*

Band 5, which operates mainly in the orange and red, provides information virtually comparable to that obtained on panchromatic emulsion.

This band is ideal for recording natural vegetation and crops and is essential for determining directly the limits of woodlands and forests, the contours of which are shown on all existing general or tourist maps.

*Band 6 (700–800 nanometres)*

Band 6, which operates mainly in the red and infra-red, records a large proportion of the above-mentioned information regarding the various aspects of vegetation. In the area of forestry, for example, deciduous trees are recorded more clearly than on the preceding Band in both winter and summer; in some cases, it is possible to distinguish them from coniferous trees. This contribution is not unimportant.

*Band 7 (800–1,000 nanometres)*

Band 7 corresponds approximately to conventional infra-red emulsion. It can be used therefore to distinguish dry or burnt areas from hydromorphic areas. For the purposes of the topic in question here, it provides precise information of a hydrographic nature (bodies of water, ponds and ballast pits, river courses, meanders), on canals and also on the land occupied by urban centres and suburbs.

## Methodology

The Data Center of the Earth Resources Observation Systems (EROS), located at Sioux Falls, South Dakota (United States of America), decodes and forwards to IGN the information on the magnetic tapes of the bands, in the form of photographic films the format of which covers a ground area of 185 × 185 km.

The documents obtained on the scale 1 : 1,000,000 make it possible to cover the whole of France in 40 recordings of 18.5 × 18.5-cm format. To photograph the same area from an aircraft on the scale 1 : 25,000 using an 18 × 18-cm format required more than 95,000 photographs[2] taken over a period of more than five years—from 1950 to 1956; this is the length of time generally needed for each new aerial coverage of French territory.

The simple relationship between these different figures demonstrates the unusual advantages of ERTS-1 with regard to the revision of existing maps; the small number of documents to be interpreted and the homogeneity of the recordings over large areas are factors of cardinal importance.

The operation is carried out by taking the information from the recording in the band on which it is recorded, for example:

(*a*) Planimetry of frozen regions, highways and areas under construction in band 4;

(*b*) Contours of woodlands, forests and heath lands in bands 5 and 6;

(*c*) Alignment of watercourses and bodies of water in band 7.

Two methods can be used, depending upon the quality of the satellite recordings.

*Visual updating*

When the ERTS documents are of average or mediocre quality and fine interpretation of the documents is needed, or when only a few details are to be modified or added to the map, the best method is to make a revision by tracing directly from the photographic document obtained from the ERTS imagery, brought to scale—1 : 1,000,000 or 1 : 250,000. The operation consists simply of superimposition and retracing of the contours.

*Equal-density updating or revision*

When the ERTS documents are of high quality, the equal-density technique[3] permits masks of sheets showing woodland and water systems to be made very quickly and directly. For example, it is possible to obtain the necessary masks on the scales 1 : 1,000,000 and 1 : 500,000 by processing films enlarged to these scales.

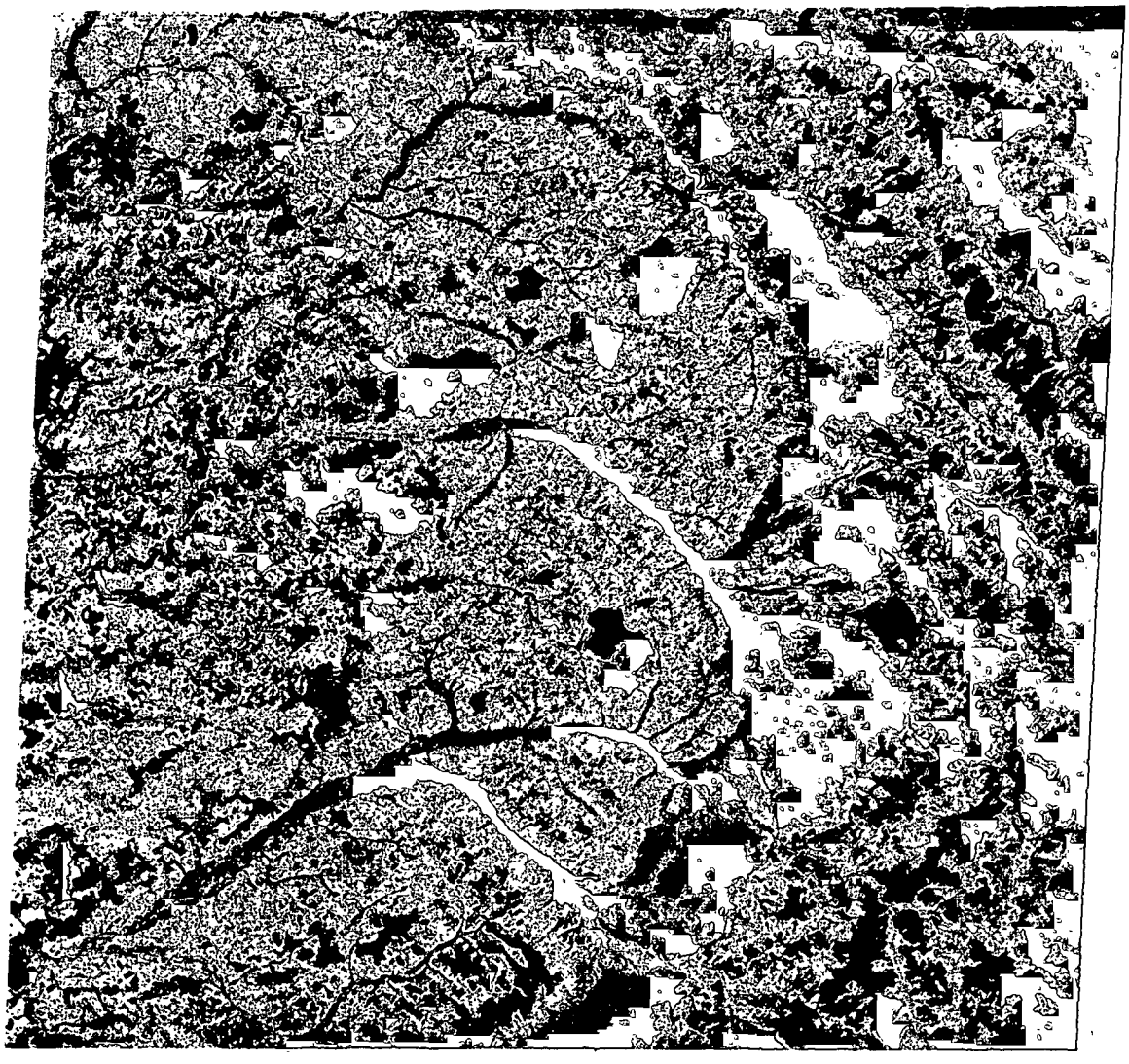
Sheets of wooded areas on the scale 1 : 250,000 can be revised and, in certain circumstances, remade entirely by direct enlargement of masks on the scale 1 : 500,000. Depending upon the quality of the recording and of the equal-density process, the contour detail is shown with the highest degree of accuracy.

The following examples of work done in the Champagne region (see figures 121–123) serve to illustrate what has already been said: revision of the map of France at 1 : 1,000,000 scale; and new edition of the map of France at 1 : 500,000 scale.

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[2] Using a 24 × 24-cm format, 25,000 pictures are needed on the scale 1 : 30,000 and about 4,000 on the scale 1 : 100,000 in order to cover an area of 550,000 km².

[3] Charles Cazabat and J. P. Nony, "Les équidensités colorées: applications à la photo-interprétation", *Bulletin de la Société française de photogrammétrie*, No. 43 (July 1971); C. Cazabat, "L'intérêt de la méthode des équidensités: application au milieu littoral d'après ERTS", *Bulletin de l'Association des géographes français*, Nos. 411–412 (Nov.–Dec. 1973).



3025.85x

*Figure 121. France: ERTS-1 imagery of Champagne*

*Legend:*

Recording conditions: 22 March 1973, 10.07.30; elevation of sun, 37°; bearing of sun, 147°—band 5.

The multispectral sensor recording makes it possible to obtain, through band 5 (600–700 nanometres), an image practically identical to that obtained on a conventional panchromatic emulsion. The various grey densities show the rings of the Paris basin with Soissonais and Brie to the west; the mountain of Reims and Champagne in the centre; Argonne and the Côte des Bar to the east; and the beginning of the Côte de Meuse and Lorraine to the north-east and of the Côte d'Or to the south-east.

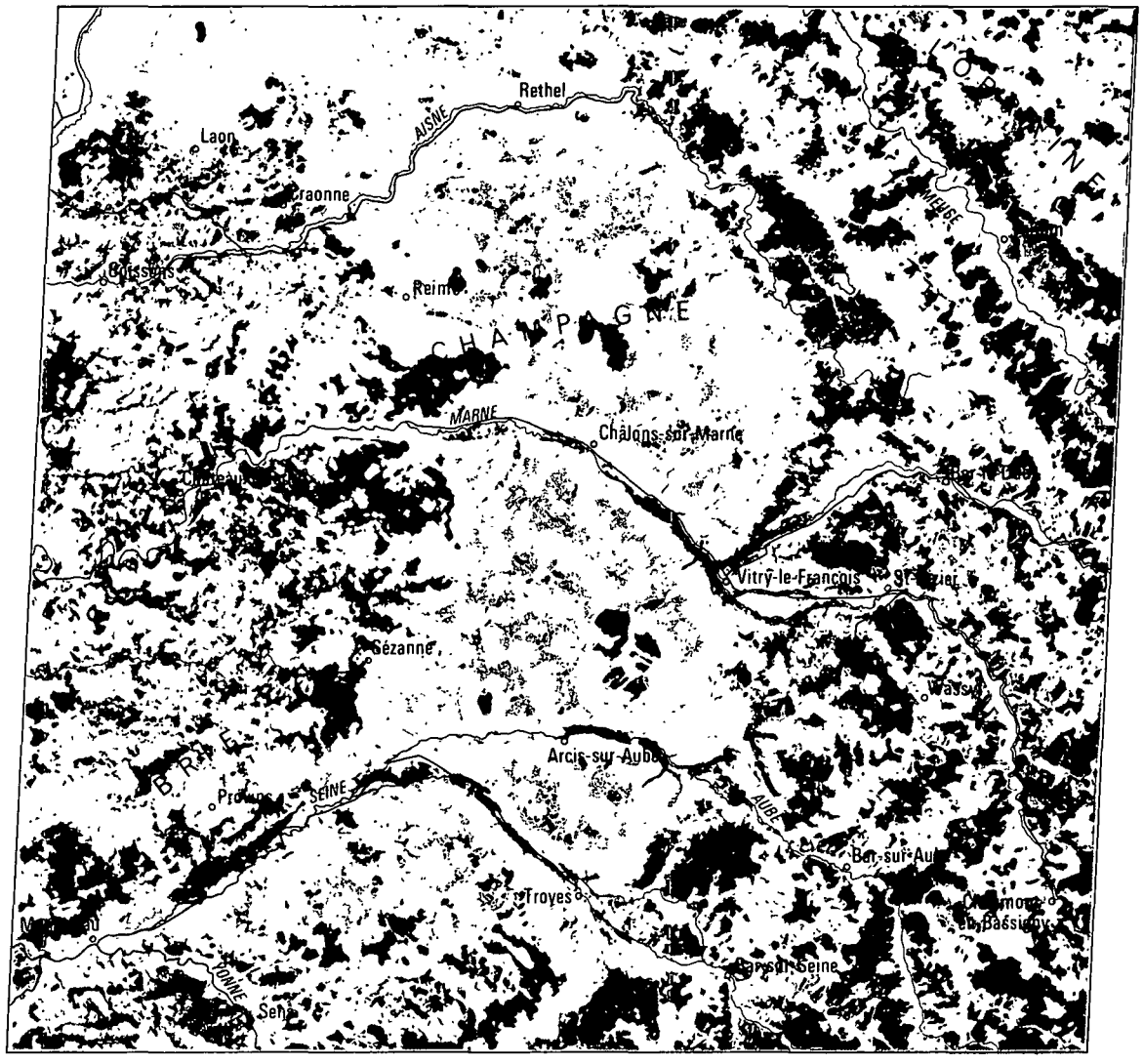



*Figure 122. France: revision of the map of France at 1 : 1,000,000 scale showing changes in Champagne area*

*Legend:*

A comparison of the light-grey base map corresponding to the areas of woodland shown on the map of France at 1 : 1,000,000 scale with the existing situation as seen on the ERTS imagery of the Champagne area and shown here in black illustrates the complete change in the agricultural structures of the region during the period 1960–1973.

Total deforestation has taken place over an area almost 50 kilometres wide and more than 150 kilometres long. Only the military camps remain in the middle of the new farmland. A revision was called for.

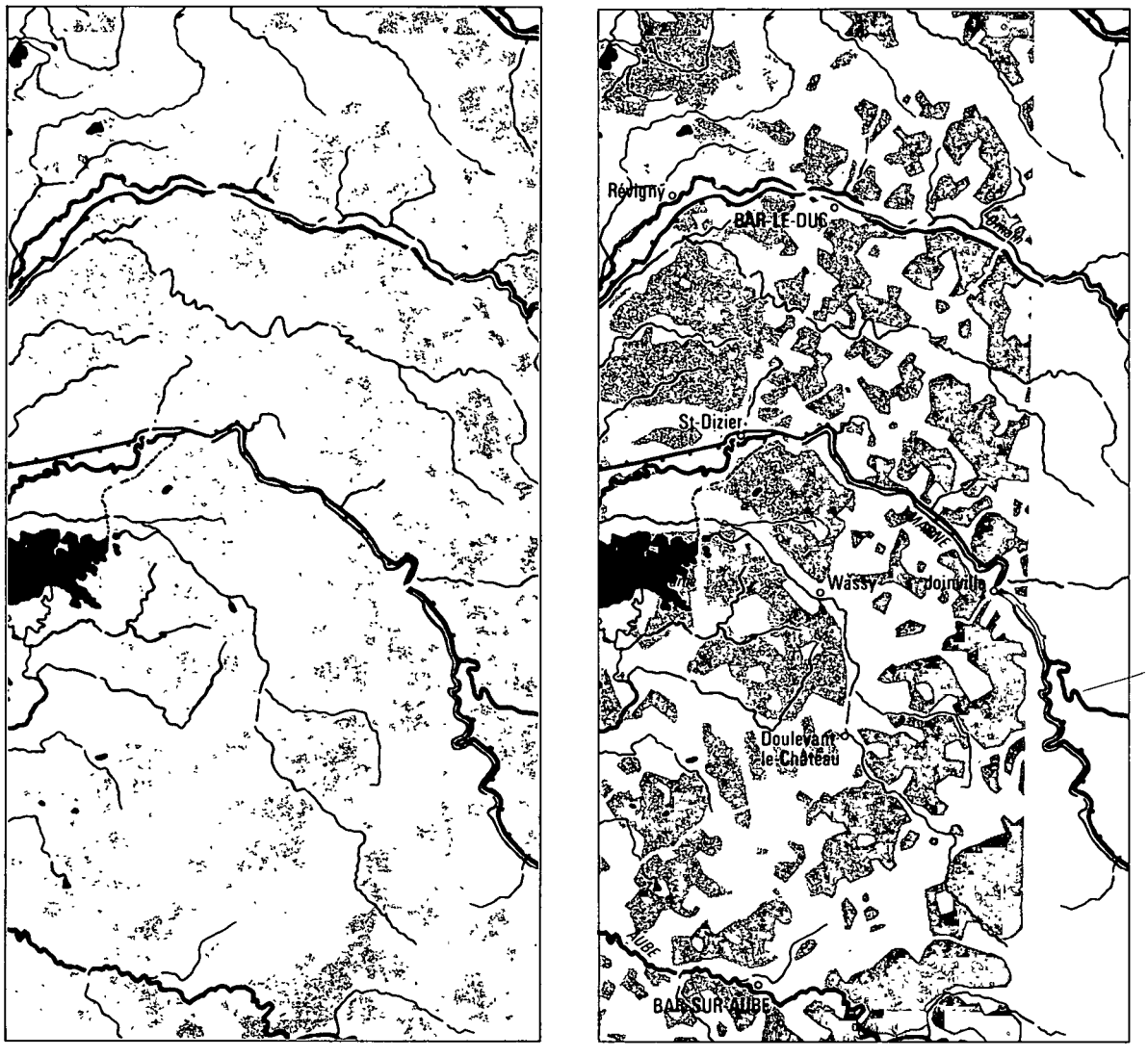



*Figure 123. France: new edition of the map of France at 1 : 500,000 scale: Côte des Bar region*

(*a*) Portion of new map (*b*) Portion of ICAO map

*Legend:*

In the heavily wooded Côte des Bar region, the stands of trees have remained the same; little change has occurred in land-use patterns. The map at the left (*a*) represents the existing situation taken directly by equal density from ERTS imagery; the map at the right (*b*) shows the International Civil Aviation Organization (ICAO) base map at 1 : 500,000 scale. A comparison of the two maps illustrates the wealth of detail that can be drawn from the satellite recording as opposed to the hypertrophied compilation of conventional mapping. The new edition was produced by almost totally automatic means without any cartographic drawing.

### Advantages of the method

The use of ERTS imagery has many advantages:

(*a*) It requires only from one quarter to one fifth—one tenth if the equal-density method is used—of the time needed for traditional revision using conventional aerial photographs;

(*b*) The number of documents to be handled, such as photographs and maps, is from 100 to 1,000 times smaller; and, consequently, the repetitive and irksome aspect of the work is avoided;

(*c*) The documents used are all of the same type and have been produced under the same conditions over a very short period of time; consequently, they can be interpreted by a single operator, which allows greater homogeneity;

(*d*) From the cartographic point of view, the accuracy and fidelity of ERTS imagery and of photographic enlargements made from it make it possible to show objects at their exact dimensions without any of the hypertrophy generally found in maps prepared by successive derivations;

(*e*) It is possible not only to revise but to remake totally old documents obtained from heterogeneous bases;

(*f*) For the mapping of new sheets being prepared on large or medium scales, when the adjoining sheets are not available (as is the case for the map of Africa at 1 : 200,000 scale), it is possible to standardize large quantities of material. On topographic maps emphasizing geomorphological phenomena, the nature of desert pavements, dunes, the effects of silting, fracturing or extensive erosion and even the continuity of the drainage network can be interpreted without difficulty. This topic alone would require a separate publication.

### Limitations of the method in France

The method has certain limitations, however:

(*a*) The use that can be made of ERTS documents depends upon the quality of the imagery received, which itself is a function of local climatic conditions. In France, the weather is favourable for recording on average only from 25 to 30 days per year; furthermore, the satellite must pass over the country during that time. However, with a little luck, one complete coverage per year can be expected. This goal was more or less achieved in 1972–1973, although some areas could not be covered in their entirety, namely, the mouth of the Seine, Cotentin, Armagnac, the Central Pyrenees and the Languedoc-Roussillon area, even though the last-mentioned is one of the sunniest regions of France;

(*b*) Winter recordings are the most numerous and often prove to be of better quality; unfortunately, deciduous vegetation is difficult to see on them and the mountainous regions contain very large areas of shadow which effectively mask the woods and forests located on the ubacs (shady slopes);

(*c*) Apart from two cases in which no rectification or adjustment was made, the metrics of the imagery are generally good, and with local adjustment on existing features it is always possible to bring the Mercator Transverse Projection of the ERTS imagery into line with the projections in general use in France.

### Conclusions

The use of satellite imagery, and in particular of ERTS imagery, is a logical step in the development of mapping procedures; it forces the cartographer not only to reappraise the question of compilation but to ascertain what can in fact be shown on a map at a given scale.

The use of satellite data should in future be made part of the training of topographers and cartographers.

## INTERPRETATION OF DRY-FARMING CROPS IN TROPICAL REGIONS: AN EXAMPLE FROM THE *DEPARTEMENT* OF DOSSO IN THE NIGER *

*Paper presented by France*

With the experience it has gained during its photo-interpretation and remote-sensing work in Africa, the Institut géographique national can produce land-use maps of tropical regions and provide accurate statistical data. The example given here derives from the work carried out in the *Département* of Dosso, in the Niger, with regard to the crops at Bengou.

The original survey, covering an area of 12,000 km², was carried out on behalf of the Agricultural Engineering Department and required photography with panchromatic emulsion on the scale 1 : 20,000, in mid-September. It was essential to choose that time of the year, when practically all the dry-farming crops in the region reach maturity. The possibility of utilizing earlier missions was ruled out because they were inappropriate for the purpose of the study owing to either the scale or the timing of the photographs.

### Methodology

A quick pass over the terrain enables the photo-interpreters to:

(*a*) Compare typical features of the aerial photographs

* The original text of this paper, prepared by Special Techniques Services, Institut géographique national, France, appeared as document E/CONF.68/L.12.

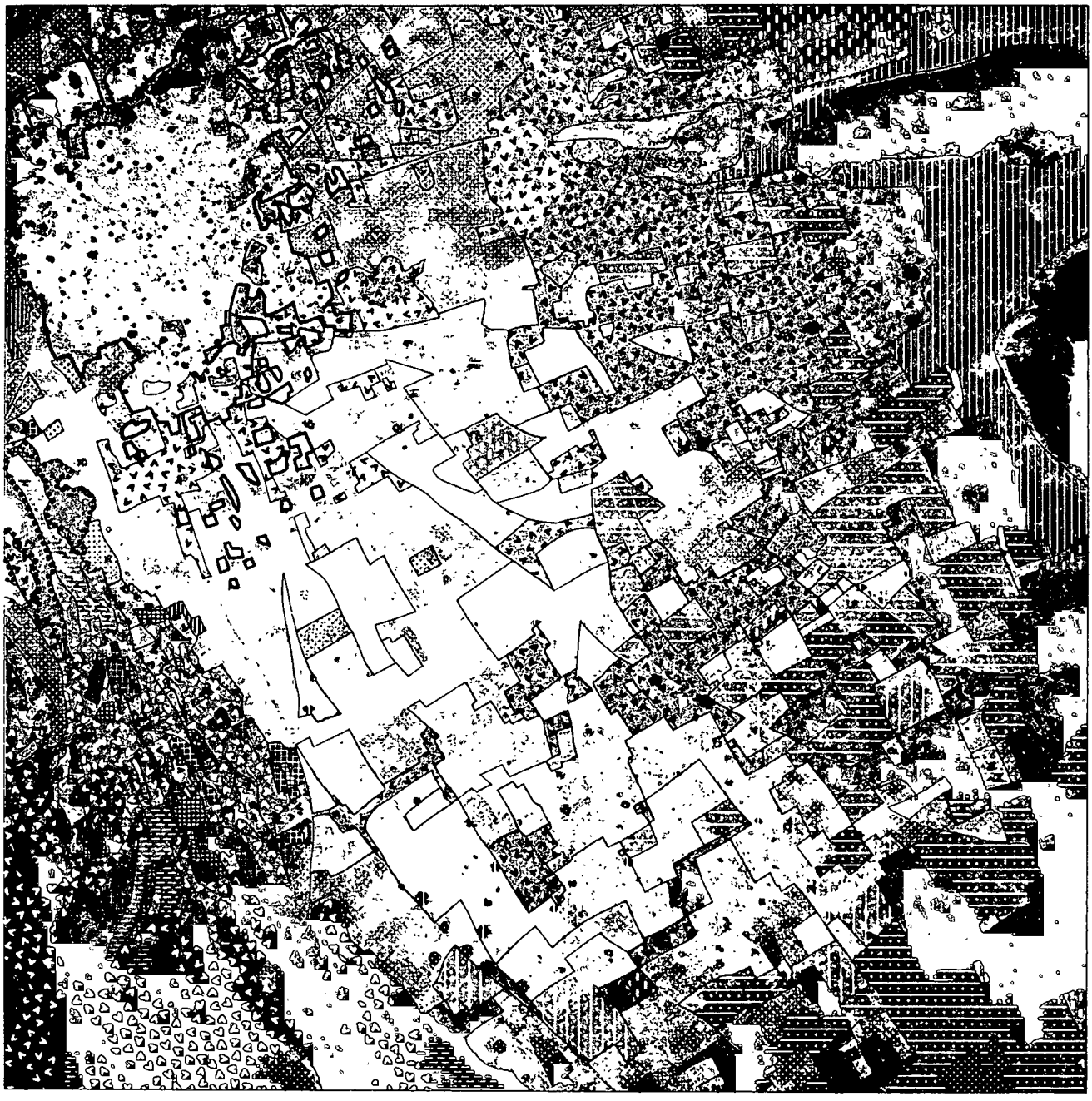



*Figure 124.* *France*: les cultures de Bengou

with the corresponding details on the ground in order to obtain the "keys" to interpretation;

(*b*) Make a thorough survey of the agrarian structures and forms of cultivation peculiar to the region;

(*c*) Gather the basic elements of toponymy.

Once those data have been obtained, the photographs are interpreted in the office. The results are given in the form of conventional signs superimposed on a photographic mosaic on the same scale as the photographs.

The statistical data are obtained through electronic measurement of areas on the basis of the elements gathered.

### Documents

The work resulted in the production of 180 panels covering sections 0°5′ × 0°5′ (approximately 45 × 45 cm) and each comprising two documents: (*a*) an uninterpreted photographic mosaic on the scale 1:20,000; (*b*) A half-tone positive film, interpreted, reproducible by the heliographic process.

The land-use maps made it possible to determine the exact location and extent of:

(*a*) The main types of crop: millet, ground-nuts, millet/bean and millet/ground-nut combinations;

(*b*) Secondary crops (undifferentiated);

(*c*) Fallow land;

(*d*) Cultivable and uncultivable areas;

(*e*) Settlements and means of communication;

All the elements listed above are essential for agricultural development surveys of a region.

In addition, the photographic mosaics provide a substantial basis for map-making.

The documents contained in this publication are on the scale 1:10,000 (see figure 124) but are of the same kind as those actually produced for the above-mentioned study. The difference lies in the fact that, when the photographs are also on the scale 1:10,000, a greater degree of interpretation is possible and thus more information can be obtained.

## METHODS OF REMOTE SENSING IN DATA ACQUISITION AND PROCESSING AND THEIR POTENTIAL FOR COLLECTING ENVIRONMENTAL INFORMATION*

*Paper presented by the Federal Republic of Germany*

The purpose of the United Nations Regional Cartographic Conferences is to exchange information on mapping techniques and on the state of mapping in various countries as a basic requirement for the planning of natural and human resources. The agenda of recent conferences acknowledges that in addition to conventional techniques to derive topographic maps (geodetic control surveys, photogrammetric mapping) and to obtain other information for thematic mapping (ground data collection, census, photographic interpretation), newly developed remote-sensing techniques should also be considered potential alternatives to collect environmental information. Although the classical use of aerial photography (photogrammetry, photographic interpretation) has been part of the activities of the Conferences since their inception, the interest in non-classical remote-sensing techniques was primarily sparked by the launching in 1972 of the Earth Resources Technology Satellite (ERTS-1), which incorporated a multispectral scanner in the visible and near-visible infra-red spectrum (ERTS has since been renamed LANDSAT). At the same time, the declassification by the United States of America of military sensor systems, such as the airborne thermal scanner, side-looking airborne radar (SLAR), multispectral airborne scanner and the imaging microwave radiometer, has helped to introduce those remote-sensing tools as data-acquisition devices.

The purpose of this paper is to outline the need for environmental information, to report on developments in the Federal Republic of Germany to test remote-sensing tools and to create data-processing facilities, and to assess the potential of remote-sensing methods for collection of environmental thematic information.

### Need for environmental information

The need for environmental information is closely linked with the level of economic development of a country. Economists distinguish between three levels of development: pre-industrial; industrial; and post-industrial.[1] The characteristics of these levels are given in table 56; a comparison of the land areas of the earth according to the different levels appears in table 57.

The need for and availability of topographic maps—basic maps—at various scales are given in table 58. Studies[2] indicate that the current rate of progress to complete mapping needs is very inadequate. On a world-wide basis, there is currently available 21 per cent of the

* The original text of this paper, prepared by Gottfried Konecny, Professor of Photogrammetry, Technical University, Hanover, appeared as document E/CONF.68/L.115.

[1] H. Kahn and A. J. Wiener, *The Year 2000* (New York, Macmillan Company, 1968).

[2] See A.-J. Brandenberger, "Macro-economic investigations into photogrammetric mapping activities", invited paper for Subject area 1, Commission IV, International Society of Photogrammetry Congress, Ottawa, Canada, 1972.

**Table 56. Federal Republic of Germany: world need for environmental information according to economic development**

| Type of economy | Gross national product (dollars) | Predominant production type | Need for information: Small scale | Need for information: Large scale |
|---|---|---|---|---|
| Pre-industrial | 50–500 | Agriculture | Transportation: mapping at 1:250,000 scale<br>Defence: mapping at 1:50,000 scale (where required) | Tax Cadastre<br>(Where required) |
| Industrial | 500–3,000 | Consumer goods | Planning of natural resources: mapping at 1:50,000 scale | Construction: management of valuable resources; property protection, mapping at 1:5,000 scale (where required) |
| Post-industrial | Over 3,000 | Services | Derived from large-scale maps | Planning and management of natural and human resources, scales from 1:5,000 to 1:1,000 (data banks) |

**Table 57. Federal Republic of Germany: world distribution of land areas according to types of economy**

| | Size of area (million square kilometres) | Percentage of total area |
|---|---|---|
| Land area of the earth | 136 | 100 |
| Independent countries | 127.9 | 94 |
| Pre-industrial (84 countries) | 60.8 | 44.7 |
| Industrial (42 countries) | 46.1 | 33.9 |
| Post-industrial (11 countries) | 21.1 | 11.5 |
| Territories | 8.1 | 6 |
| Inhabited areas | 85 | 62.5 |
| Agriculturally used areas | 38.1 | 28 |
| Cropland | 13.6 | 10 |
| Forest land | 39.4 | 29 |

SOURCE: Compiled from G. Fochler-Hauke, *Der Fischer Weltalmanach 1975* (Fischer Taschenbuch-Verlag, 1975).

**Table 58. Federal Republic of Germany: need for and availability of maps in the world**
(*Percentage*)

| Scale | Need | Availability |
|---|---|---|
| 1:250,000 | 100 | 35 |
| 1:100,000 | 50 | 21 |
| 1:50,000 | | 10 |
| 1:25,000 | | 5 |
| 1:5,000 | 5 | 1 |
| 1:1,000 | | |

SOURCE: "The status of world topographic mapping", *World Cartography*, vol. X (United Nations publication, Sales No. E.70.I.4), pp. 1–96.

maps required on the scale 1:100,000 or larger. Annual progress in map production is 0.35 per cent, which implies that at the current rate of progress, it will take 225 years to meet the requirements.

The problem of obtaining environmental information on the basis of topographic maps takes on a new meaning in the light of future predictions which deal with the shortages of resources and of food-supply and the maintenance of the environment.[3] Table 59 shows that due to population increases and urbanization, these problems will primarily confront the developing countries.

**Table 59. Federal Republic of Germany: world population and urbanization**

| | Population in 1975 (millions) | Annual growth (percentage) | Population in 1985 (millions) |
|---|---|---|---|
| Industrialized countries | 1,147 | 1.1 | 1,275 |
| Urban | 770 | 1.9 | 928 |
| Rural | 377 | −0.8 | 347 |
| Developing countries | 2,881 | 2.5 | 3,673 |
| Urban | 826 | 4.5 | 1,270 |
| Rural | 2,055 | 1.6 | 2,403 |
| World | 4,028 | 2.1 | 4,948 |

SOURCE: Compiled from G. Fochler-Hauke, *Der Fischer Weltalmanach 1975* (Fischer Taschenbuch-Verlag, 1975).

The density of information required is expressed by the population density. The quality of information which it is reasonable to obtain is proportional to the ratio of gross national product per unit area. Table 60 gives these ratios for countries of Asia and the Far East and for other selected countries. Figures for countries with the greatest mapping needs are underlined; such countries have a

[3] See, for example, Donella H. Meadows and others, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York, Universe Books, 1972).

population density greater than 100 inhabitants per square kilometre and an urban population over 5 million.

Meaningful planning of resources will require a basic map on the scale 1 : 50,000 of all usable land areas. The planning of population centres requires basic maps on scales ranging from 1 : 5,000 to 1 : 10,000.

Owing to the incapacity of existing conventional methods to provide environmental information at the necessary pace, it is natural to look into the possibility of using new technologies, such as remote sensing, to collect thematic information, possibly even without topographic mapping as a base or at least with topographic mapping in a simplified manner.

Although earth scientists are currently exploring the many different ways in which remote sensing may be applied to solve their particular problems, the concern of the mapping community should be the use of remote sensing to collect thematic environmental data in a systematic manner.

## Data acquisition

Conventional black-and-white, colour and false-colour infra-red photography from mapping cameras mounted in aircraft continues to be the prime source for collection of thematic information by standard photographic interpretation techniques for all areas and scales at which it becomes prohibitive to collect thematic data (with perhaps higher accuracy) on the ground. Yet, photographic interpretation is still a marginal data acquisition method within the Federal Republic of Germany.

**Table 60. Federal Republic of Germany: parameters expressing need for mapping information in countries of Asia and the Far East and in other selected countries, 1971**

| Country or area | Inhabitants per square kilometre | Gross national product per capita (dollars) | Gross national product (thousands of dollars per square kilometre) | Urban population (millions) |
|---|---|---|---|---|
| Afghanistan | 29.8 | 1 100 | 2.98 | 2.9 |
| Australia | 1.7 | 4 760 | 8.0 | 11.7 |
| Bahrain | 417 | 2 250 | 938 | 0.2 |
| Bangladesh | 533.4 | 100 | 53.3 | 5.4 |
| Bhutan | 23.4 | 56 | 1.31 | — |
| Burma | 46.0 | 90 | 4.14 | 6.3 |
| Brunei | 26.0 | ... | ... | ... |
| China | 88 | 300 | 26.4 | 209.7 |
| Cyprus | 69.2 | 1 113 | 77.0 | 0.3 |
| Democratic Kampuchea | 44.8 | 70 | 3.14 | ... |
| Democratic People's Republic of Korea | 130.9 | 390 | 51.1 | 6.3 |
| Democratic Yemen | 5.7 | 120 | 0.68 | 0.6 |
| Fiji | 31.6 | 720 | 22.7 | 0.2 |
| India | 182.3 | 130 | 23.7 | 120 |
| Indonesia | 67.6 | 150 | 10.1 | 25.6 |
| Iran | 20 | 1 060 | 21.2 | 14.2 |
| Iraq | 25.5 | 970 | 24.7 | 6.7 |
| Israel | 168.6 | 2 370 | 399.6 | 2.8 |
| Japan | 298.1 | 3 880 | 1 157 | 83.2 |
| Jordan | 27.5 | 400 | 11.0 | 1.2 |
| Kuwait | 56.1 | 11 640 | 653.0 | 0.7 |
| Lao Peoples' Democratic Republic | 13.9 | 70 | 0.97 | 0.5 |
| Lebanon | 275.9 | 1 080 | 298.0 | 1.7 |
| Malaysia | 36.6 | 660 | 24.1 | 6 0 |
| Maldives | 412.7 | ... | ... | — |
| Mauritius | 1.2 | 480 | 0.58 | 0.4 |
| Mongolia | 1 | 620 | 0.62 | 0.7 |
| Nepal | 89.1 | 110 | 9.8 | 0.9 |
| New Zealand | 11.5 | 4 100 | 47.1 | 2.5 |
| Oman | 3.6 | 1 250 | 4.5 | ... |
| Pakistan | 87.3 | 130 | 11.3 | 19.0 |
| Papua New Guinea | 5.8 | 440 | 2.55 | 0.3 |
| Philippines | 141.7 | 310 | 43.9 | 14.9 |
| Qatar | 17.2 | 5 380 | 92.5 | ... |
| Republic of Korea | 344.6 | 1 060 | 365.3 | 14.3 |
| Samoa | 52.7 | ... | ... | — |
| Saudi Arabia | 3 | 2 080 | 6.2 | 1.5 |
| Seychelles | 124.4 | ... | ... | — |
| Singapore | 3 872 | 2 120 | 8 209 | 2.2 |
| Sri Lanka | 213.2 | 130 | 27.7 | 3.1 |
| Syrian Arab Republic | 38.4 | 490 | 18.8 | 3.4 |
| Thailand | 81.4 | 300 | 24.4 | 8.4 |
| United Arab Emirates | 2.7 | 13 500 | 36.4 | ... |
| Viet Nam | 134.2 | 130 | 17.4 | ... |
| Yemen | 34.2 | 120 | 4.1 | ... |
| Canada | 2.2 | 6 080 | 13.4 | 17.3 |
| Congo | 3.9 | 390 | 1.5 | 0.4 |
| Egypt | 37.1 | 280 | 10.4 | 16.8 |
| Finland | 13.9 | 4 130 | 57.4 | 2.7 |
| France | 96.7 | 5 190 | 501.9 | 36.9 |
| German Democratic Republic | 156 | 3 430 | 535.1 | 12.7 |
| Germany, Federal Republic of | 248.6 | 5 890 | 1 464 | 54.4 |
| Hungary | 113.3 | 2 140 | 242.4 | 5.3 |
| Libyan Arab Jamahiriya | 1.4 | 3 360 | 4.7 | 0.5 |
| Netherlands | 332.1 | 4 880 | 1 621 | 10.7 |
| Norway | 12.3 | 5 280 | 64.9 | 1.8 |
| Poland | 109.2 | 2 450 | 267.5 | 18.5 |
| Portugal | 95.6 | 1 540 | 147.2 | 3.5 |
| Sweden | 18.2 | 6 720 | 122.3 | 6.7 |
| Switzerland | 155 | 8 430 | 1 307 | 3.8 |
| USSR | 11.5 | 1 530 | 17.6 | 154.0 |
| United Kingdom | 229.3 | 3 360 | 770.4 | 43.7 |
| United States of America | 22.9 | 6 640 | 152.1 | 161.2 |

*Note*: Figures for countries with the greatest mapping needs are underlined.

Drawbacks of aerial photography are the non-simultaneous time-consuming (and therefore usually non-repetitive), non-systematic and weather-restricted coverage. The advantages consist in virtually unlimited scale range and the highest attainable angular resolution of the available sensor systems.

Both SLAR (which can be rented from industry in the United States of America) and the satellite scanner that the United States uses in LANDSAT have been able to overcome some of these limitations of aerial photography, but only at very small scale and at very coarse ground resolution (15 m for radar, 78 m for LANDSAT). They are therefore of limited value within the Federal Republic of Germany for image interpretation and have been mainly used in experiments testing the sensor capabilities for applications outside Europe. For that reason, the Federal Republic of Germany has thus far decided against operating its own LANDSAT receiving station until a satellite is capable of providing a ground resolution of at least 10 m. To test the capability of using such images, the Government submitted an experiment for the first European Spacelab mission (h = 250 m) in 1980 to carry a metric camera (Zeiss RMK 30/23). This experiment has been accepted by the European Space Agency and test areas are currently being selected and negotiated for the mission in July 1980.

To test the multispectral and multitemporal potential of remote sensing, the science ministry instituted a federal test programme, which provided for the Deutsche Forschangs-und Versuchsanstalt für Luft-und Raumfahrt (DFVLR), the national space agency, an 11-channel Bendix M²S multispectral scanner along with metric and multispectral aerial cameras, radiometers and a movable ground station.

From March 1976 to March 1977, four test areas were continuously being flown to test the thematic extraction capability of remote sensing from the visible to the thermal range:

Area I: coastal areas near Wilhelmshaven, to study marine pollution, sediment transport in tidal zones and coastal ecology in an industrial environment; co-ordination rests with the Technical University, Hanover (TUH);

Area II: industrial and urban environment of Frankfurt am Main for regional planning and environmental pollution; collaborator is the Institut für Angewandte Geodäsie, Frankfurt (IFAG).

Area III: agricultural and forested areas near Freiburg i. Br. for vegetation and crop mapping; collaborator is the Forschungsinstitut für Mustererkennung Karlsruhe (FIM);

Area IV: Pre-alpine region of Murnan for geological, ecological and hydrological tasks; co-ordination is the responsibility of the Zentralstelle für Geophotogrammetrie and Fernerkundung, Munich (ZGF). Thus far, each area has had between 10 and 20 subsequent coverages. The result will be correlated with known ground data.

## Data-processing facilities

To test adequately the large volume of material, the data-processing facilities described below have been built up:

(*a*) DFVLR has a bulk facility to produce computer-compatible tapes from raw Bendix M²S data;

(*b*) Each area co-ordination centre was equipped with an Interpretation Systems Inc. image-analyser television system which is capable of colour-level slicing (eight colours), false-colour image mixing and ratio processing of the images, while several hundreds of images can be contained on disc storage. In addition to providing visual selections of bulk images, the system serves as a "quick look" device;

(*c*) Each area co-ordination centre also possesses (or has access to) digital drum read-write devices to permit precise digital image processing (e.g., Optronics P1700) for images of special interest;

(*d*) DFVLR also has an interactive image-analysis facility built together of three read-write devices (Linoscan, Dicomed, Hall Chromagraph), an interactive television monitor and a powerful computer. This facility is open to all experimenters.

The facilities are also capable of handling LANDSAT and other satellite imagery.

## Data-processing software

All laboratories involved have during the past year developed interchangeable software to service the national and local data-processing facilities. It consists of the following tasks:

(*a*) Reformatting of data tapes (DFVLR);

(*b*) Radiometric corrections (ZGF, DFVLR);

(*c*) Geometrical corrections on the basis of either recorded parameters or possibility of including corrections for a given digital terrain model (TUH);

(*d*) Grey-level manipulations (edge enhancement, level stretch etc.) (DFVLR, FIM, TUH);

(*e*) Filtering using fast Fourier transforms (FIM);

(*f*) Multivariate classification methods for multispectral data (principal component transformation, maximum likelihood classification) (ZGF, DFVLR, TUH, University of Karlsruhe);

(*g*) Classification methods involving texture (FIM).

## Results from aircraft programme

The preliminary results obtained thus far confirm the following statements:

(a) *Data acquisition*:

(i) The thermal 8–14-nanometre range is the most effective sensor to monitor water pollution on an operational basis in analogue or analogue enhanced form;

(ii) The multispectral concept in digital form (visual and infra-red) is the most useful to determine land use;

(iii) The multitemporal concept in digital form offers the best means to determine vegetation classification;

(b) *Densitometric image processing*:

(i) Standard photographic processing favours visual texture detection over the total contrast range of a photograph. It therefore does not favour specific contrasts. Contrast enhancement by image analysers or by digital processing is generally able to improve such latent image contrasts (up to five times). Digital edge enhancement techniques are a very useful tool to bring out latent line structures. Digitally processed images are much more suited for interpretation purposes than are conventional products;

(ii) Unfortunately, digital image-processing is still time-consuming and costly and will be until special image processors can be built. Therefore, currently digital image-processing methods can only be recommended where high-quality image analysis is necessary;

(c) *Geometrical image processing*:

(i) Too often it has been overlooked in the remote-sensing community that proper analysis of the data is possible only with proper digital rectification procedures;

(ii) This permits one to produce multispectral orthophotos from either satellite or aircraft scanner data to about half-pixel (satellite) to three-pixel (aircraft) accuracy. Such a geometrical restitution is also the basis for digital multitemporal classification methods. Although such processing also is still time-consuming and expensive, special processors can already be built if the demand arises (design FIM-TUH).

(d) *Image classification*:

Digital image-classification is still the most expensive data-processing method outside of Fourier Filtering.

For a current study to evaluate multitemporal LANDSAT scenes over an area in the south-western region of the Federal Republic of Germany, to derive land-use maps on the scale 1 : 50,000, they are proving indispensable to arrive at information usable in densely populated countries. This study is currently being made for the Federal Research Institute of Regional Planning, Bonn, under contract to DFVLR with the co-operation of several institutions.

### Remote-sensing uses in developing countries

The Federal Research Institute for Geosciences and Mineral Resources, Hanover, uses visual interpretation of LANDSAT imagery in routine applications in developing projects (geological mapping of the Afar region, draught survey of the Sahel zone, flood-plain studies in northern Argentina). For special but limited purposes, digital analyses are being made.

Umwelt-Data, Offenbach has developed an operational multilevel approach of remote sensing for use in developing countries in co-operation with government departments of Indonesia and Nepal. In this approach, ground data are used to calibrate aerial photographic interpretation areas. Such areas in turn calibrate the LANDSAT imagery analysed by digital means over the total area of interest. The data obtained from object classification are put in a geographical data bank which is then utilised to deduce planning information for specific tasks. This approach holds promise for application in developing countries. The Federal Republic of Germany was host for a United Nations Seminar on Remote Sensing for Resource Inventories, held at Lenggries, Bavaria, in July 1976. At that meeting, the remote-sensing data-processing facilities of DFVLR in Oberpfaffenhofen and those of other associated institutions were offered for training to other countries.[4]

[4] Information can be obtained by writing to Beratungsgruppe für Entwickhugshilfe in Vermessungswesen, c/o Professor J. Nittinger, Walmodenstrasse 46, D-3000 Hannover 61, Federal Republic of Germany.

## EXPERIMENTS AND APPLICATIONS OF REMOTE SENSING BY THE NATIONAL CO-ORDINATION AGENCY FOR SURVEYS AND MAPPING*

*Paper presented by Indonesia*

Remote sensing has been experimented with and applied by various institutes, departments and universities in Indonesia; experiments and applications at the National Co-ordination Agency for Surveys and Mapping (Badan Koordinaci Survey dan Pemetaan Nasional; BAKOSURTANAL) are geared to support resources surveys and mapping and the monitoring of the environment. For the production of topographic base maps, the entire country will be covered by aerial photographs on the scale 1 : 100,000; and for detail samples and priority areas for immediate resources development, certain areas will be covered by larger scale aerial photography. Those aerial photographs, LANDSAT data and other remote-sensing imagery will be the major source of data.

* The original text of this paper, prepared by Professor Kardono Darmoyuwono, Deputy Chairman, National Co-ordination Agency for Surveys and Mapping (BAKOSURTANAL), Indonesia, appeared as document E/CONF.68/L.104.

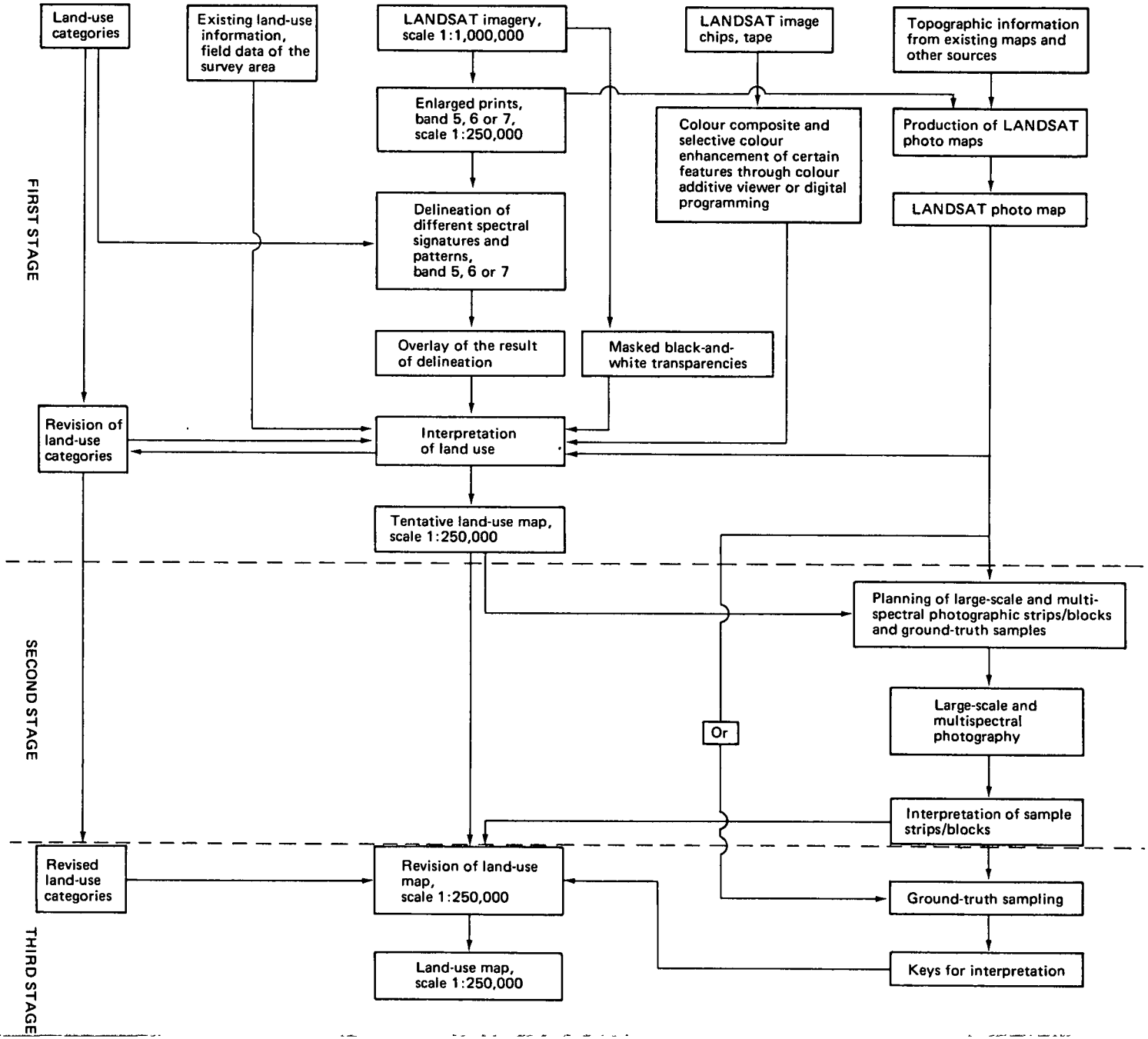



*Figure 125. Indonesia: multistage land-use survey*

### Multistage survey system

A multistage survey system has been used in the resources survey. The first stage is the acquisition and interpretation of data based on small-scale aerial photography (1 : 100,000) and LANDSAT imagery. The second stage will be the study of sample plats or strips through larger scale aerial photography (both in black and white and in colour) and multispectral sensing data (scale 1 : 50,000 or larger). The third stage will be the ground sampling. An example of the multistage survey applied to the land-use survey is given in figure 125.

### Resources inventory programme

The inventory and evaluation of natural resources are explained in figure 126.

The activities in the programme could be explained successively as follows:

(*a*) Various government institutes have compiled data on natural resources, but are less directed towards integrated inventory. Thematic map scales being produced vary widely;

(*b*) Existing natural resources information and maps would be compiled on a standardized base map scale 1 : 250,000 for which the required input would be base maps at 1 : 250,000 scale and LANDSAT photo maps on the same scale.

(*c*) The gaps of natural resources information would be filled in with aerial photographs on the scale 1 : 100,000 and LANDSAT imagery;

(*d*) For updating the natural resources information and maps, aerial photographs on the scale 1 : 100,000 and LANDSAT imagery would be used;

(*e*) Natural resources data would be entered and stored in a computerized natural resources information system;

(*f*) Natural resources potentials for regional development would be evaluated.

Six provinces in the southern part of Sumatera have been chosen for pilot areas.

### Experiments on the application of LANDSAT imagery

The experiments on the application of LANDSAT imagery were carried out in the context of the development of the national integrated resources inventory and evaluation system. The four types of application experiments done on Sumatera are described below.

#### *Production of photo maps*

The photo map is basically an enlargement of LANDSAT imagery on the scale 1 : 250,000. Imageries of band 6 or 7 were chosen for enlargement because of their superior relief information. On the enlarged image, geographical grids, geographical names, symbols and spot elevational are imposed. Identified roads are enhanced; and where they do not show up on the image, they may be drawn based on existing data.

#### *Updating of topographic maps*

Identifiable topographic features on the image are: river courses; roads; land cover and land use; river patterns; waterlogged areas; shorelines; and pseudo-relief. In this experiment, topographic sheets of the Riau Daratan area at 1 : 250,000 scale were compared with the LANDSAT photo map of the same area on that scale.

Remarkable changes in land use were obvious and the extent of non-forested area had changed significantly. Riverbanks and sandbars also were remarkably changed. New roads were identified and a disagreement between the existing map and the LANDSAT photo map was seen over a certain road track.

A major problem in this comparative study was dissimilarity between the Universal Transverse Mercator (UTM) projection of the topographic maps and the Space Oblique Mercator projection of the LANDSAT photo map, which could be solved by partial rectification.

#### *Land-cover and land-use mapping*

Three LANDSAT imageries have been interpreted. In the mapping process, the multistage survey system was applied as shown in figure 125.

#### *Data compilation using LANDSAT photo map as base map*

The experiments was meant as an exercise to use LANDSAT photo maps as base maps for the inventory, especially in areas where the topographic maps on the scale 1 : 250,000 are not available. As base maps, LANDSAT photo maps have proved their benefits for certain aspects compared with topographic maps. Drainage patterns on the photo map could show better details, and pseudo-relief gives a better overview of the terrain configuration and also distinctive physiographic boundaries of land units.

The results of the experiments lead to a number of conclusions:

(*a*) LANDSAT imagery can be utilized as an information source for updating older maps;

(*b*) LANDSAT photo maps on the scale 1: 250,000 can be utilized as substitutional topographic base maps on the same scale;

(*c*) In a preliminary or reconnaissance survey, LANDSAT photo maps can be regarded as the main information source;

(*d*) LANDSAT imagery may be utilized as a complement to aerial photographs of 1 : 100,000 or larger scale for areas which have aerial coverage;

(*e*) For natural resources mapping at reconnaissance level (especially for land use/land cover), useful information can be drawn from the visual interpretation of LANDSAT imagery. The interpretability in visual interpretation depends upon the contrast in spectral reflectance between an object and the surrounding features;

(*f*) Multistage resources survey, which include the use of LANDSAT imagery at the first stage, is an efficient and time-saving survey method.

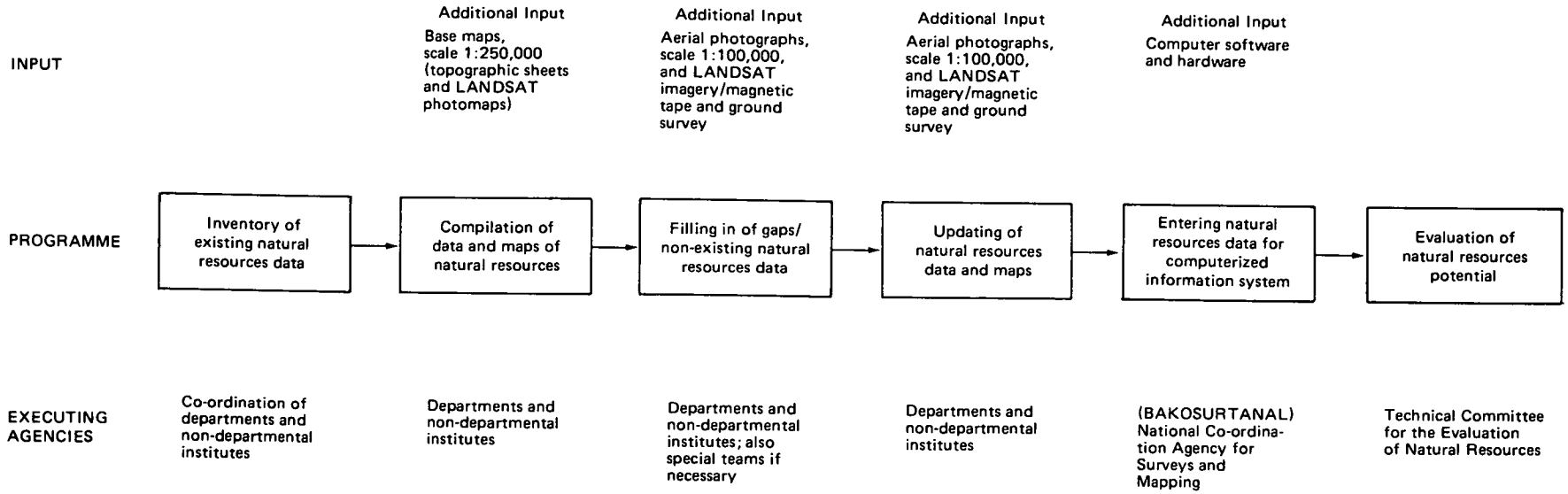



*Figure 126. Indonesia: data management programme for inventory and evaluation of natural resources*

### Other remote-sensing activities

Another remote-sensing activity is the monitoring of the environment. Experiments of remote sensing using a four-band multispectral camera were conducted in Bali with material and technical assistance of the United States Agency for International Development. An areal application was the sensing of oil pollution during the Showa Maru grounding in the Indonesian territory in the Strait of Singapore.

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## APPLICATION OF REMOTE-SENSING TECHNIQUES TO THE RESEARCH OF UNDERSEA VOLCANOES*

*Paper presented by Japan*

There are roughly 70 active volcanoes in Japan, of which about 20 are undersea volcanoes or volcanic islands.

Active volcanoes are unevenly distributed between the two great volcanic zones of eastern and western Japan; and in each zone there is a volcanic island range—Nanpo Islands in the eastern zone and Nansei Islands in the western zone.

Volcanic eruptions occur suddenly and volcanoes that erupt periodically are very rare. In order to carry out research on volcanic eruptions, continuous observation would be desirable, but to maintain a watch on a total of about 20 undersea volcanoes and/or volcanic islands would be an impossibility.

At the current time, only a few actively volcanic islands are kept under continuous surveillance, while no observations have been taken of the other volcanic islands and undersea volcanoes.

When a volcanic island or undersea volcano erupts, it seriously affects ships navigating near the spot and sometimes men lose their lives as a result. The Hydrographic Department of the Maritime Safety Agency of Japan began a series of periodic observations and measurements in 1974, in order to determine the actual condition of undersea volcanoes and volcanic islands by the use of remote-sensing techniques from an aircraft; and it has developed analytical methods for obtaining data, the procedures of which are outlined in the present paper.

### Instruments

The volcanic earthquake currently is considered to be the most useful source of information about the conditions of volcanic activity, but a method has not yet been devised to detect earthquakes from an aircraft in flight.

There are many cases where even the existence of an undersea volcano cannot be confirmed from an aircraft if its volcanic activity is low, because the summit is hidden below the surface of the sea. If it happens to erupt, however, the sea surface around it is dirtied (discolouration of sea water) by extrusive volcanic materials and the temperature of the sea water rises as a result of the thermal energy released.

On the other hand, the degree of activity of a volcanic island can be inspected from an aircraft, and any increase in activity is revealed by such volcanic phenomena as an increase of extrusive volcanic materials and a rise in ground temperature.

* The original text of this paper, prepared by Masakazu Tsuchide, Hydrographic Survey Officer, Surveying Division, Hydrographic Department of the Maritime Safety Agency, Japan, appeared as document E/CONF.68/L.4.

The Hydrographic Department has therefore obtained two instruments: a multiband camera for examining discolouration of the sea water; and a thermal infra-red camera for measuring the sea-surface temperature. Observations of undersea volcanoes and volcanic islands have been begun, using the two instruments simultaneously from an aircraft. These two instruments are briefly described below.

*Multiband camera*

The specifications for the multiband camera are:

(a) *Model*: MK-1, International Imaging Systems (United States of America);

(b) *Lenses*: four each, Schneider Zenotar, 150 mm f/2.8.

(c) *Shutter*: focal plane, 1/150–1/350 second;

(d) *Filters:* one each, No. 47B (blue), No. 57A (green), No. 25 (red), No. 88A (infra-red). Infra-red blocking filters are included in filters 47B, 57A and 25;

(e) *Masked format*: 9 × 9 inches with four each 3.5 × 3.5-inch images;

(f) *Angle of field*: 22.5° half-angle at diagonal.

A multiband camera records the spectrum on the film as an image; the spectrum of the visible region from 0.4 μm to 0.7 μm and the regions of the adjoining lower and higher bands, i.e., ultraviolet from 0.3 μm to 0.4 μm and "near"-infra-red from 0.7 μm to 0.9 μm, are divided into several spectra bands by means of a number of band-pass filters.

There are three types of multiband camera: single lens and multifilm; multilens and single film; and multilens and multifilm. The camera used by the Hydrographic Department is a multilens and single film type that records a wave-length spectrum from 0.4 μm to 0.9 μm, divided into four bands.

Each of the four images recorded on the film indicates, in light and shade, the difference in spectral reflection characteristics of various materials in each divided wave-length region.

Every material has its own peculiar spectral reflection characteristics, so that materials in the image can be distinguished by discerning their spectral reflection characteristics after different types of analysis are made of the images obtained.

*Thermal infra-red camera*

The specifications for the thermal infra-red camera are:

(a) *Model*: thermal camera, model 209, Nikon (Japan);

(b) *Detector*: InSb (must be cooled by liquid nitrogen);

(c) *Spectral ranges*: from 2 μm to 5.6 μm;

(d) *Temperature ranges*: from 20° C to 150° C (up to 1,800°C with filters);

(e) *Temperature resolving power*: 0.5°C (at 25° C);

(f) *Instantaneous field-view*: 1.7-m radian;

(g) *Angle of field*: 7° half-angle at diagonal.

Every material always emits some quantities of energy and these quantities of energy are the function of the material's own temperature (Planck's Law), so that the temperature of the material can be calculated by measuring the quantities of energy emitted.

The thermal infra-red camera measures those quantities of energy and displays them on a cathode-ray tube as a black-and-white image. The higher the temperature of a material, the whiter the image displayed on the cathode-ray tube.

When measuring the quantities of ground (and/or sea-surface) energy from an aircraft, it is difficult to measure the true temperature of objects on the ground because of the considerable energy absorption and scattering by the atmosphere existing between the ground and the airborne detector of the instrument. Then the data are interpreted to show the relative temperature differences of objects on the ground.

## Data analysis

*Multiband camera*

Analyses of multiband photographs are roughly divided into two groups—analogue analysis and digital analysis. In the Hydrographic Department, analogue analysis is used, and this method is described below.

Many devices have been contrived to extract the necessary information effectively from images. One of the devices, superimposition, which is comparatively simple and requires no special instrument, is described here.

The only data needed are two sets of images: one set of original images; and another of positive images transformed from the original negatives. The only instrument required is a contact printer.

The general characteristics of the four images taken through water by the multiband camera—blue, green, red and infra-red—are described below:

(a) *Blue band* (0.4 μm–0.5 μm).

Blue light is apt to suffer from scattering due to fine particles in the atmosphere, so that the image often shows low contrast. As blue light penetrates sea water best if the water is extremely clear, it can photograph under-water features at depths of 10 m or more should atmospheric conditions permit it;

(b) *Green band* (0.5 μm–0.6 μm).

Scattering caused by fine particles in the atmosphere is less evident than with the blue band, and the contrast in the image is much brighter. As green light penetrates ordinary sea water best and the image obtained has bright contrast, it provides the most useful images for determining under-water features;

(c) *Red band* (0.6 μm–0.7 μm).

Red light can best penetrate the muddy water found in the vicinity of a river mouth, but its penetration capability at most is less than several metres;

(d) *Infra-red band* (0.7 μm–0.9 μm).

The infra-red image shows the highest contrast of all because of the four bands it is the least affected by scattering due to fine particles in the atmosphere. Lights

in this wave-length region are almost totally absorbed by water, so that the water areas show up as coal-black in the image. Clouds over the sea show up as white, so that the image is useful for distinguishing clouds from sea water.

When the sea is photographed from an aircraft it is impossible to avoid the occurrence of glitter, caused by the reflection of sunbeams on the waves, except when the sky is fully overcast. However, it is possible to render the glitters unrecognizable by printing a composite image, superimposing negative and positive film images of the same scene developed to suitable densities, as the glitter on those negatives will thus be cancelled out.

For example, if an infra-red-band positive is superimposed upon a green-band negative, details over the sea, such as clouds and sunbeams reflected by the waves, are obliterated since they are photographed in both band images and do not appear in the composite image. Because bathymetric information photographed in the green-band image is not included in the infra-red-band image, it is not cancelled by the superimposition and therefore appears in the composite image. That is to say, clouds and reflected sunbeams are photographed brightly in the green-band image and the contrast on the film between them and the surrounding sea waters is very high, so that low-contrast information photographed in the same frame, such as discolouration of sea water and/or under-water features, does not show up. However, by superimposing an infra-red-band positive (negative in cases where the green-band image is positive) on it, highly contrasted details, such as clouds, lose their brightness so that low-contrast information, such as discolouration of sea water, stands out from obscurity and is never missed.

Needless to say, if clouds show up in the picture, no information can be gained about sea water below the clouds, even though the clouds are cancelled in the composite image by superimposing, because the image does not include any information on the sea water below.

Superimposition means extracting low S/N ratio signals, which have been masked by high S/N ratio signals, from much of the information included in an image.

As for the investigation of discolouration of the sea water, little such information is included in the infra-red-band image, so that its composite image with the infra-red band gives a good picture of the distribution of discoloured sea water, which has a high spectral reflection on the wave-length region corresponding to the visible band image used; a composite image that is composed of two bands out of the three, not including infra-red, shows differences in spectral reflection characteristics of discolouration of the sea water shown in each band. Accordingly, information about the characteristics of discoloured sea water, such as distribution and colour, can be obtained by comparing various composite images.

The principle of superimposition is simple but actually it is troublesome work, since a number of uncertain elements are involved.

Positive and negative films used for superimposing change their densities according to the way in which they are processed and therefore the resulting composite image changes its density with respect to the density of the positive and negative films used. Moreover, the characteristic curve of a film is generally non-linear, so that it cannot be corrected after processing. In other words, a composite picture cannot be reproduced and a method that has succeeded in giving a good superimposed image cannot always be applied to superimposing other images. It is not too much of an exaggeration to say that any good result is the outcome of trial and error.

### *Thermal infra-red camera*

Data obtained from the thermal infra-red camera are close-up black-and-white photographs displayed on a cathode-ray tube; and the whiter an area shows up, the higher the temperature in it.

Ground temperature can be inferred from the density values of photographs; but, as already mentioned, because of the extremely complicated calculation of the effects of atmosphere, only relative temperature differences between two objects can be revealed. Because this relative temperature also differs from actual temperature difference as it is affected by the atmosphere, comparison with other data obtained on a different date under different weather conditions is, strictly speaking, meaningless, while the temperature difference at any one time has a meaning as such.

Lights of the detector's sensitive wave length, the so-called "thermal infra-red region", are almost totally absorbed by sea water. Accordingly, the temperature measured is only skin temperature at a depth of about 0.02 mm below the surface of the sea, so that in a strict sense this temperature is somewhat different from the temperature measured directly by ordinary thermometers.

As for thermometry from an aircraft involving the use of thermal infra-red, there are many other complicated problems. However, if one limits the use of thermal infra-red temperature measurement techniques to detecting abnormal temperature of the surface of the sea caused by an undersea volcanic eruption and ground temperature changes in volcanic island activity, comparison between the various data taken on different dates can easily be made on the basis of fundamental knowledge about volcanoes, because observed phenomena are local and show great changes in temperature. Sometimes, under bad photographing conditions, sunbeams reflected by waves are measured as the sea-surface temperature, but their temperature is so high that it can never be mistaken for it.

However, as a result the information regarding the surrounding sea-surface temperature is masked. A method for eliminating the reflected sunbeams at the analytical stage of the image has not yet been devised. The best way is to prevent them from breaking into the image data before detection, for example, by making observations at a time when the sun is at a low altitude.

## Results and future work

The undersea volcanoes and volcanic islands mainly being observed at the current time are as follows:

(a) *Shin-Iojima Island*: volcanic island formed about 40 years ago, now quiescent; quiet;

(b) *Shin-Nishinoshima Island*: new volcanic island formed only three years ago, currently not erupting;

(c) *Fukutoku-Okanoba*: volcanic island formed twice in the past, now actively erupting under water.

As the undersea volcanoes and volcanic islands that are the subjects of research are situated in the ocean, it is difficult to know in advance what the surrounding weather conditions are. Moreover, volcanic islands are often capped by clouds, so that the best conditions for photographing—with no wind and no clouds—seldom occur.

Since observations were begun in 1974, they have been taken three times at Shin-Iojima Island and Fukutoku-Okanoba and five times at Shin-Nishinoshima Island. Weather conditions at the time of observation varied, ranging from the best conditions with fine weather and no wind, to the worst, with cloudy weather and strong winds. The better the weather conditions, the clearer and more effective are the data obtained.

However, even data obtained under the worst weather conditions can be analysed. In the case of photographs taken by the multiband camera, analysis is done by processing superimposed images on two bands, as described before. As for data taken with a thermal infra-red camera, an analysis can be made by comparing the data with multiband photographs taken at the same time and making the correction or by referring to the former data.

Study on the correlation between discolouration of the sea water, sea-surface temperature or ground temperature and eruption of undersea volcanoes or volcanic islands is still at the stage of data collection, as examples are few. However, time changes in volcanic activity can be investigated to some degree.

Data currently are analysed by an analogue method known as "photo-processing". This method is simple and can process a large amount of information; but it has some disadvantages, in that individual differences by composers or analysers are apt to show on the image because the method is visual and the reproduction of an image can hardly be expected.

To compensate for these defects, analysis by a digital method such as measuring the density of the photograph is useful; but digital input data are obtained from photographs, so that digital analysis by completely objective numerical data cannot be made consistently.

Moreover, digital analysis has a weak point when it has to process a great deal of information, so that a method combining both analogue and digital analysis is considered most effective compensating for mutual defects, and the analytical method by digital processing of data from a multiband camera and thermal infra-red camera is being investigated.

### Conclusions

To apply remote-sensing techniques to phenomena at sea, such as undersea volcanoes, is in principle the same as applying them to objects on land. Actually, however, in the case of sea phenomena there are many occasions when it is impossible to obtain the ground truth (sea truth for the sea) that is one of the important requirements for remote sensing. Moreover, the objective is a volcanic eruption that occurs suddenly and is not repeated, so that remote-sensing techniques developed for those objects on land do not apply to the phenomena at sea without modification. Accordingly, the practical use of remote-sensing techniques for the investigation of undersea volcanoes is not expected in the near future.

Investigation of undersea volcanoes by the Hydrographic Department is at the stage of data collection, and the resolution of such problems as data analysis, prediction of volcanic eruption, and elucidation of mechanism of volcanic eruption will come in the future.

## SAMPLES OF MULTISPECTRAL PHOTOGRAPHIC INFORMATION OBTAINED FROM LONG-TERM SPACE SHIP "SALUT-4"*

*Paper presented by the Union of Soviet Socialist Republics*

The photographs shown in figures 127–131[1] were obtained on 27 June 1975 by the pilot-cosmonauts P. I. Klimuk and V. I. Sevastianov, during the second expedition of the long-term space ship "Salut-4".

The photography was carried out by a four-camera block with a focal distance of 80 mm from a height of 340 km, which produces synchronous imageries of the same area of the earth's surface in different bands of the electromagnetic spectrum in its visible and near-infra-red part. Figure 127 shows the original pictures taken at 1 : 4,200,000 scale; figure 128 shows the enlargement printing made from the originals, at 1 : 2,000,000 scale.

Imagery of a mountainous area is shown on the photographs. Alpine regions are covered with snow; settlements and arable lands, including irrigable agricultural lands and pastures, adjoin valleys located between mountain ranges at an altitude above 1,500 m. On the mountain slopes, at different altitude levels, one finds various types of natural vegetation. Below the snow and glaciers one can see alpine meadows, sparse growth of coniferous trees and forests, and leaf-bearing arboraceous shrub associations; and further below, steppes and semi-desert landscapes.

* The original text of this paper appeared as document E/CONF.68/L.97.

[1] Certain unnumbered maps have been placed in the pocket at the end of the volume. References in the text indicate the numerical listing of these figures in the table of contents. Figures 127–131 are in this pocket.

The photography in each of the spectral bands selected for the experiment provides specific information on natural formations. For example, band 500–600 nanometres is the most informative for the research of shoals and river-mouth sediments; band 600–700 is preferable for registration of various objects with a limited surface because it provides the best space solution; and in band 700–840, dark tones feature water surfaces and in this band also the structural-geological composition of the territory can be seen most clearly.

Figure 129 is a further enlargement (at 1 : 1,000,000 scale) made in spectral band 600–700 nanometres; figure 130 is an enlarged colour photograph at 1 : 1,000,000 scale.

Black-and-white images taken from the different bands of the spectrum served as basic data for the synthesis of the colour-composite pictures shown in figure 131 (*a–d*). Differences in spectral reflections of natural formations have different colour tones on the colour-composite images. The use of variants of colour coding in the initial band pictures during the process of image synthesis affords the best possibilities for distinguishing the objects of research and for substantially facilitating decoding.

Figure 131(*a*) shows band 500–600 nanometres in red, band 600–700 in blue and band 700–840 in green. As shown on the picture, the differences in landscape are dependent upon the elevation of the site. In this case, the composition of the mountain vegetation is easily recognizable; each pink, red and brown colour fits well with its various characteristics.

In figure 131(*b*), band 500–600 nanometres is green, band 600–700 is red and band 700–840 is blue. The reddish-brown tone indicates forest and bush types of vegetation, the meadow type and the agricultural crops on the irrigated land.

Figure 131(*c*) shows band 500–600 nanometres in blue, band 600–700 in green and band 700–840 in red. The soil types in the valleys can be clearly identified.

The colour picture shown in figure 131(*d*) was made by the optical-electronic method. For coding of the intervals of the optical densities of the original black-and-white picture, use was made of a discrete scale of colours. The colours indicate the borders of different types of soils.

To determine the specific characteristics of the objects, optical-electronic quantification on certain levels of optical densities and colour coding of those levels are to be done.

The data thus obtained from space surveying are destined for complex research and mapping of the natural conditions and resources of the country.

## EXPLORATION OF THE EARTH'S NATURAL RESOURCES BY REMOTE SENSING*

*Paper presented by the Union of Soviet Socialist Republics*

Since the Union of Soviet Socialist Republics launched the first artificial earth satellite in 1957, programmes on scientific and practical application of space technique have been carried out systematically and regularly. Today, earth-orbiting artificial satellites are a component of the meteorological ensuring of long-range radio communication and television, navigational ensuring of ship navigation, geodetic and cartographic services, as well as a rich source of information for other systems.

In particular, the application of space means in obtaining initial information for exploration of the earth's natural resources and for environment control has major scientific and practical importance.

Remote-sensing methods of obtaining information about natural resources and the environment from the scientific-technical aspect are based on the fact that investigated objects reflect, absorb or generate electromagnetic emission of a definite spectral structure and intensity. These emissions may be registered many times by corresponding information receivers carried by space vehicles.

The subsequent interpretation and analysis of information registered by receivers permit the selection of concrete natural objects and phenomena according to a necessary trend of the exploration of the earth's natural resources. In some aspects of natural resources and environmental explorations, the space information has some valuable advantages over conventional methods of investigations. The main advantages are:

(*a*) In a short period of time receiving of photo-visual images of large areas is reduced practically to one time moment;

(*b*) Synchronous fixing of observation objects in their natural intercommunication is achieved;

(*c*) Broad opportunities exist for obtaining natural generalization of information, depending upon conditions of the investigation programme, which allows the selection of data about natural resources and environment;

(*d*) Opportunity is given to organize exploration on principles ranging from the general to the individual, that is to say, an opportunity for direct and rather rapid revelation of general objective laws of natural phenomena. Traditional methods of solving such problems are based upon accumulation, systematization and generalization of numerous observation results during a considerable period of time, which complicates the ascertainment of objective laws of natural intercommunication of phenomena;

* The original text of this paper appeared as document E/CONF.68/L.98.

(*e*) Wide utilization of standards and analogue methods for interpretation is made possible through the availability and comparison of initial data about a great number of objects in equal conditions;

(*f*) There is broad utilization of information about natural resources and the environment, and high technical and economic effectiveness of exploration results.

Explorations carried out in the USSR have proved the expediency of differentiation of space information according to nature of its use into two categories:

(*a*) Operative information about quickly changing processes and phenomena (meteorological conditions, natural disasters etc.);

(*b*) Information about slow natural processes and phenomena (geological structure of the earth, technogenous landscape changes, ecological balance changes, land-use dynamics etc.).

The materials and data for both categories of space information about natural resources and the environment are not merely for a limited purpose; on the contrary, they are also of interest to many branches of the national economy. In particular, information about slow processes and phenomena has a multipurpose function because it may be used many times.

As a result of processing materials and data about natural resources and the environment obtained with remote-sensing methods, the main materials used in different branches of the economy for study of prolonged natural processes and phenomena are photo-visual images (photographs, photo schemes, photo plans, photographic maps). As a rule, at the end of all investigations of natural resources, the resultant material is produced in the form of thematic maps with different special contents. At the first stage, methods of processing space information are adopted from the arsenal of topographic photogrammetry.

As a result of the multipurpose investigations that have been conducted, problems of perspective of remote-sensing development have been examined circumstantially; and in some branches, they have obtained practical results of space data application. Among them, one should note the updating of topographic maps for areas that are difficult to negotiate and highly mountainous areas, making small-scale photographic maps in cartography.

Small-scale mapping with the help of aerial photographs was not used before because of great difficulties of obtaining good-quality photographic images, and high labour consumption entailed in the photo-laboratory processing of a large number of aerial photographs. In those cases, when an aerial photogrammetric map was plotted, it inevitably had an aerophotographic mosaic of different tones.

The process of photo mapping has been greatly simplified. Space photographs as a rule are of high quality which makes it possible to magnify them 8–10 times, thus providing an opportunity to plot several standard photomap sheets from one frame of a space image.

Technical means are currently available for multiband surveys from space and for the synthetizing of images obtained. This method allows the production of special photo maps to satisfy the requirements of users in a concrete branch such as agriculture; forestry or geology, among others. For example, a photographic map or photo plan made from photographic imagery of the near-infra-red band of electromagnetic waves has no vegetation image that satisfies completely the requirements for interpretation of the geological structure. On the photographs taken in a green part of the visible band, one can see an image of the sea-bed in depths up to 10 m, which is important for the study of water spaces.

The examples given characterize the new possibilities of cartography with the use of space information.

Space information in the geological service has provided greater accuracy of geological mapping methodology, revaluation of former idea of a geological structure of some regions, and new and more accurate forecasts for mineral exploration, which have changed the trend of exploration works. Space information is of great importance for evaluating the seismic-tectonic situation; and for technical-economic substantiation of researched regions during the planning and building of large hydroelectric stations, industrial complexes, towns, gas-oil pipelines, trunk-lines and other constructions. On the basis of data derived from space surveys of steppe and semi-desert territories, some measures have been taken for the protection and restoration of pastures, which were divided in accordance with seasonal exploitation and the system of driving away the cattle, and the network of watering-places was developed.

There are many examples defining the advantages and special features of space information.

An important feature of remote-sensing data and materials is that with their help complex exploration of the natural resources may be carried out; and at the first stage, their systematic registration and documentation with corresponding forecast evaluations. As a matter of fact, using comparability of different specialized investigations obtained on the basis of space information and using a wealth of actual material or study derived with conventional methods presents great opportunity for scientifically based complex valuation of natural potential of either region. Such opportunities are of great importance for the perspective planning of the economy, regaining of the balance of production forces, placement of the population and rational use of natural riches within the limits of separate regions and the country as a whole.

As is usual for the exploration of the earth's natural resources with remote-sensing methods, the space surveys first are taken in five spectral bands of the visible and near-infra-red spectra in combination with under-satellites aerial photography taken with the same equipment carried both by a satellite and an aircraft.

The use of space techniques in the interest of national economic development in current conditions is the most important element of a scientific and technical progress depending upon integration of the achievements of different areas of knowledge and the exchange of experience and mutual scientific and technical information.

# AGENDA ITEM 11

## Technical assistance (including training)

### ASSISTANCE REQUIRED FOR THE EXECUTION OF A TOPOGRAPHIC AND CADASTRAL SURVEY IN THE CONGO*

*Paper presented by the Congo*

From the document entitled "Brief notes on a draft programme for a topographic and cadastral survey in the Congo"[1] it will be seen that the Congo does not possess the means of financing the large-scale cartographic survey so needed for its development and that of its Topographic and Cadastral Services.

The Government of the Congo is therefore seeking outside assistance with a view to implementing such a project. Such assistance, however, would have to include, in addition to the execution of the survey, the training of personnel and the provision of material and equipment.

In line with the foregoing statement, experts from donating countries or from donating organizations would have to collaborate closely with the senior officers from the Topographic and Cadastral Services responsible for the execution of this project.

The goal is twofold : (*a*) to obtain up-to-date topographic and cadastral data; and (*b*) to assure the formation of the requisite staff able to carry on the work produced by the survey.

*The original text of this paper, prepared in French, appeared as document E/CONF.68/L.124.
[1]See agenda item 6.

### THE ECOLE NATIONALE DES SCIENCES GEOGRAPHIQUES AND ITS CONTRIBUTION TO THE TRAINING OF FOREIGN ENGINEERS AND TECHNICIANS*

*Paper presented by France*

The Ecole nationale des sciences géographiques (ENSG), which is situated at Saint-Mandé, in the immediate vicinity of Paris, is part of the Institut géographique national (IGN). It was established in 1941 in order to provide basic training for civil servants intended for IGN and rapidly expanded its functions to include the training of foreign students and trainees, including 392 from Asia and the Far East. Table 61 gives a breakdown by country.

* The original text of this paper, prepared by R. d'Hollander and J. Commiot, Institut géographique national (IGN), France, appeared as document E/CONF.68/L.13.

#### INSTRUCTION

The school offers instruction in the disciplines that are basic to the development of geography and cartography in a country:

(a) *Geodesy*: field astronomy, triangulations, levelling, gravity surveying;

(b) *Topography*: field surveying, tacheometry, direct survey and field completion of photogrammetric plane-table surveys, toponymy;

(c) *Photogrammetry*: aerial photography, physical aspect of aerial photographs, development of a framework of control points for stereoplotting (aerial triangulation), plotting;

(d) *Remote sensing*: reading of aerial photographs, photo-interpretation, modern methods of remote sensing;

(e) *Topographic and thematic cartography*: preparation, graphic techniques.

The school also offers additional instruction in the scientific disciplines needed in the application of geographical techniques: mathematics, applied mathematics, physical sciences (optics, photography, mechanics, electricity and electronics), data processing, management techniques, earth sciences (geology, geomorphology, pedology, magnetism, oceanography), social sciences and ecology.

Lastly, the school offers future engineers instruction in certain disciplines related to geographical disciplines in which the latter play an important role: civil engineering techniques; and agricultural engineering techniques.

Instruction is given only in French and is of three types:

(*a*) Academic instruction, provided in lessons and lectures;

(*b*) Supervised instruction given in small classes, in which there is a continuing dialogue between professor and students; the students are asked to go to the blackboard for practical exercises or to give a report to their class-mates on a subject assigned in advance by the professor. These small practical classes or sessions have an important function: they indicate to the professor whether the students have properly understood the instruction;

**Table 61. France: breakdown by country of Asian students and trainees trained at the Ecole nationale des sciences géographiques up to 1 October 1976**

| Country | Number of students | Number of trainees (auditeurs or stagiaires) | Total |
|---|---|---|---|
| Afghanistan | 8 | 13 | 21 |
| Bangladesh | | 1 | 1 |
| Burma | | 4 | 4 |
| Democratic Kampuchea | 10 | 26 | 36 |
| India | | 20 | 20 |
| Indonesia | | 7 | 7 |
| Iran | 42 | 62 | 104 |
| Israel | | 4 | 4 |
| Japan | | 8 | 8 |
| Jordan | 1 | 2 | 3 |
| Lao People's Democratic Republic | 11 | 13 | 24 |
| Lebanon | 12 | 41 | 53 |
| Malaysia | | 3 | 3 |
| Nepal | | 1 | 1 |
| Pakistan | | 1 | 1 |
| Philippines | | 2 | 2 |
| Saudi Arabia | | 3 | 3 |
| Singapore | | 1 | 1 |
| Syrian Arab Republic | 38 | 20 | 58 |
| Thailand | | 4 | 4 |
| Viet Nam | 17 | 17 | 34 |
| TOTAL | 139 | 253 | 392 |

(*c*) Practical instruction conducted by teaching assistants. Since the assistants co-ordinate theoretical instruction and its application in practical work sessions, they must work in close co-operation with the professors.

These three types of instruction are offered to most of the students over a period of seven months, from October to April. During the four months from May to August, the school organizes actual practical projects in the field: astronomy; geodesy; levelling; gravity surveying; stereo preparation; tacheometry; topography; and field completion. ENSG has its own facilities in Haute Provence for this purpose, especially for astronomy.

Although instruction in a discipline for a given category of students is of three types, as indicated, the discipline is taught at several different levels corresponding to the programmes indicated below.

The teaching body is composed essentially of IGN engineers selected on the basis of their competence and experience in each field. The school calls in university professors to provide instruction in earth sciences and the social sciences.

### PROGRAMMES OF INSTRUCTION

The programmes of instruction are:

(a) *Geographical engineers programme (programme A)*. This programme recruits foreign students holding the equivalent of the master's degree in science, corresponding to four years of scientific study after the baccalaureate. In a two-year course, it trains engineers in several fields to hold positions in upper-level management, research and higher education. Under programme A, it is possible to complete only one year of study and obtain a certificate of advanced study in astronomy-geodesy or photogrammetry;

(b) *Field engineers programme (programme B)*. This programme recruits foreign students who have completed the equivalent of the class of special mathematics or hold the equivalent of the degree of Bachelor of Science (DUES) in mathematics and physics, corresponding to two years of study beyond the baccalaureate. In a three-year course, it trains engineers assigned to direct field missions and production workshops. Under programme B, it is possible to complete only one year of study and obtain a certificate in a specialized field, such as astronomy-geodesy, photogrammetry or topography-topometry;

(c) *Surveyors programme (programme C)*. The programme recruits foreign students holding the equivalent of the baccalaureate in sciences. In a two-year course, it trains high-level technicians in geographical studies and projects who are qualified to supervise operational personnel or to carry out themselves certain highly specialized work in geodesy, topography and photogrammetry. Under programme C, it is possible to complete only one year of study and to obtain a certificate of qualification in large-scale surveying or field completion or photogrammetric surveys, triangulation, stereo preparation and levelling;

(d) *Cartographers programme (programme D)*. This programme also recruits at the baccalaureate level foreign students with a genuine aptitude for cartography. In a two-year course, it trains high-level cartographic technicians who are qualified to carry out projects of a

cartographic nature and to manage cartographic editing workshops;

(e) *Cartographic technicians programme (programme D')*. The programme recruits, at a lower level (sixth year of secondary school), foreign students with an aptitude for cartographic design. In a two-year course, it trains cartographic technicians who are qualified to supervise draftsmen or to do fine cartographic editing themselves;

(f) *Officers programme*. French and foreign officers are trained in an 18-month course. The instruction is related to that given to surveyors (high-level technicians);

(g) *Non-commissioned officers programme*. French and foreign non-commissioned officers are trained in an 18-month course.

### Admission requirements

The school distinguishes between two types of students:

(*a*) "Students" and "official trainees" (*auditeurs titulaires*), who participate in an entire programme and are entitled to a diploma on the completion of the course;

(*b*) "Trainees" (*auditeurs* or *stagiaires*), who in principle participate only in part of a programme, in accordance with a schedule established by agreement with the agency by which they are employed.

Students and official trainees are generally admitted on the basis of an examination which candidates may take at the local French Embassy in the last half of May. The tests are either the same, or on the same level, as those which are used for the competitive examinations used to recruit French candidates for IGN. Foreign students must receive an average mark at least as high as that required for French students. Official trainees are admitted with a somewhat lower average. Official trainees who hold a bachelor's degree (DUES) in mathematics and physics or an equivalent diploma corresponding to two years of scientific study beyond the baccalaureate may be admitted to the field engineers programme on the basis of their qualifications, but they must pass tests in mathematics and physics to confirm their qualifications.

Official trainees may become students at the beginning of the second academic year if they have received a sufficiently high grade during the first year; they cannot, however, repeat the first year.

Trainees are admitted on the basis of the qualifications they hold and according to the number of places available. Depending upon the programme, they may receive a certificate of higher studies, a certificate in a specialized field or several qualifying certificates.

All foreign nationals must pay tuition fees. Students, official trainees and certain trainees who take an entire year's course pay the tuition fees in a lump sum for the entire year, the sum varying according to the programme. Trainees who remain at the school for only a short time pay by the week. As part of its programme of technical co-operation, the French Government offers tuition scholarships to most foreign nationals admitted to ENSG.

### Administrative organization and facilities

The school is a non-resident school, but lunch may be taken at the IGN restaurant. Students may be housed in student residences or hostels or with private families.

An engineer who is a member of the school administrative staff is responsible for the reception of foreign students and handles all problems concerning them.

The school occupies a huge six-storey building at Saint-Mandé, with 4,300 $m^2$ of floor space. In addition to administrative offices, the complex also includes:

(*a*) Study halls and workshops, where students are divided into groups of approximately 10 each;

(*b*) Seven classrooms, two of which have a seating capacity of 75;

(*c*) A large lecture hall seating 296, a projection booth for 16- and 35-mm films and a screen of over 4 m;

(*d*) Three photogrammetry studios equipped with many plotting machines of various types;

(*e*) Photography laboratory, rock collections, maps, slides etc.

(*f*) A graphic techniques laboratory.

The school can provide material used for practical work in geodesy, topography, computation etc. Students also normally have access to: (*a*) the general library of IGN; (*b*) the map file of IGN, which keeps a large quantity of old and new maps, both French and foreign, in its archives; and (*c*) the national photographic library, managed by IGN, which has on file several million aerial photographs covering extremely varied regions.

Students may also have access, if necessary, to various facilities of IGN: various kinds of photogrammetric equipment; research and control laboratories; computers; workshops for computation; drawing; relief maps; instrument collection.

### Degrees awarded

The students' knowledge is tested regularly through compositions and oral examinations spread out over the academic year.

In order to be admitted to the next year's course and to graduate on completion of the programme, students must satisfy a number of conditions set out in the rules of the school. Among other things, they must achieve: (*a*) a minimum annual average mark of 10 in all oral examinations and compositions; and (*b*) a minimum annual average mark of 12 in all practical exercises and field work.

Foreign students who satisfy these conditions are awarded the following degrees and certificates:

*Programme A*: diploma in civil geographical engineering;

*Programme B:* diploma of graduate engineer of the Ecole nationale des sciences géographiques;

*Programme C:* certificate of higher level technician in geographical surveys and operations;

*Programme D:* certificate on completion of studies certifying that the holder has been trained as a higher level cartographic technician.

*Programme D'*: certificate on completion of studies certifying that the holder has been trained as a cartographic technician.

The engineering diplomas are recognized by the Commission du titre d'ingénieur diplômé in accordance with the Act of 1934 (*Journal Officiel* of 21 July 1971).

The Director of the Ecole nationale des sciences géographiques is authorized to award the certificate of higher level technician in geographical surveys and operations under a legal decision made in response to a petition submitted by the Commission des titres d'ingénieurs of 19 March 1973.

It should be pointed out that trainees may be entitled, under certain conditions listed in the school rules, to:

(*a*) A certificate of advanced studies under programme A;

(*b*) A certificate in a specialized field (topometry-topography, geodesy-astronomy, photogrammetry) under programme B;

(*c*) Qualifying certificates (large-scale direct survey, field completion of photogrammetric surveys, triangulation, precision levelling, stereo preparation) under programme C.

### Consolidated training periods and other courses of instruction

Each year ENSG, under the auspices of the Organisation française pour l'enseignement de la télédetection (OFET), organizes two training periods and two courses of instruction open to foreign nationals. The training periods are the following:

(*a*) The training course in the use of aerial photographs (*stage d'exploitation des photographies aeriennes* – SEPA), which lasts six weeks and takes place in May–June. It offers two options—photogrammetry and photo-interpretation;

(*b*) The informational course on aerial photography (*stage d'information sur la photographie aérienne*—SIPA), which lasts two weeks, takes place in September and is oriented exclusively towards photo-interpretation.

The following courses of instruction last an entire university year:

(*a*) The course of advanced studies in remote sensing (*cycle d'enseignement approfondi de la télédetection*—CEAT). The instruction, at the third-cycle level, is oriented towards sensor technology, the acquisition of information by scanners and the numerical processing of images. Foreign candidates must be sponsored by an official body, hold a *licence* or master's degree in mathematics or physics or an engineering degree and pass aptitude tests in mathematics and physics, which are held at the French Embassy. On completing the course, students are awarded a certificate of advanced studies in remote sensing;

(*b*) The course of instruction in photo-interpretation and cartography (*cycle d'enseignement de photo-interprétation et de cartographie*—CEPIC) is oriented towards photo-interpretation and requires a certain knowledge of geography or earth sciences. Foreign candidates must be sponsored by an official body and hold one of the degrees required for CEAT or a *licence* or master's degree in one of the following disciplines: geography; earth sciences; natural sciences. On completing the course, students are awarded a certificate in the specialized field of photo-interpretation and cartography.

Lastly, the school is authorized to offer the degree of Doctor of Geographical Engineering. Candidates must already have a French engineering degree recognized by the Commission des titres or a foreign engineering degree recognized as the equivalent. To obtain the doctorate, it is necessary to devote one year to obtaining the advanced studies degree (*Diplôme d'études approfondies*—DEA) and two years to research in the IGN laboratories.

Engineers who have obtained a diploma under programme A or programme B are not required to obtain a DEA.

## TECHNICAL ASSISTANCE IN SURVEYING AND CARTOGRAPHY PROVIDED BY THE FEDERAL REPUBLIC OF GERMANY*

*Paper presented by the Federal Republic of Germany*

The unprecedented progress in economic, social and technical fields throughout the world has given rise to the need for a system which will offer reliable data about the land and its ownership in order to build up statistics in the form of large-scale maps and records, which are considered basic data for further planning in various fields. In other words, the countries have recognized the value of a multipurpose cadastre. This need for a cadastre is often very urgent and the respective Governments want to have the results quickly; but the cadastral administrations in developing countries usually lack the necessary personnel and skilled officers to establish a modern cadastre with the required cadastral maps. Recognizing the difficulties in this field, the Federal Republic of Germany has concentrated its activities within the technical assistance programme on assisting the local cadastral administrations to establish the cadastre and to draw cadastral

* The original text of this paper, prepared by the Advisory Group for Technical Assistance in Surveys, Mapping and Land Information Systems, Federal Republic of Germany, appeared as document E/CONF.68/L.114.

maps. The Federal Republic of Germany has therefore offered and performed technical assistance mainly for cadastral purposes in the fields of education and training, and surveying projects.

### Education and training

The Federal Republic of Germany is fully aware of the urgent need for adequate training of the surveying and mapping staff of the cadastral organizations in developing countries. Therefore, it considers the training to be a main point of the technical assistance programme. The technical universities and technical colleges in the Federal Republic of Germany are open to foreign students above the secondary school level. The Federal Republic grants a variety of scholarships through such organizations as Carl-Duisberg-Gesellschaft and Deutscher Akademischer Austauschdienst. Thus far, more than 130 students have finished their studies in surveying and mapping.

In-service training is arranged by the different states of the Federal Republic of Germany. This training is provided for surveyors and cartographers who have already a certain knowledge or experience. The duration of such training courses is from one year to two years. The subjects of the courses are:

(*a*) Cartography (Institute for Applied Geodesy, Frankfurt am Main);

(*b*) Photogrammetry (State of Baden-Württemberg);

(*c*) Land information systems (State of Niedersachsen);

(*d*) Ground control survey (State of Nordrhein—Westfalen).

Based on the experience of its surveying projects in Central America, the Federal Republic of Germany has established the Technical School for Surveying and Cadastre in Costa Rica as an interregional institution. This *sur place* education for the medium level proved very successful because the students do not have to learn foreign languages. In the course of four years, the Federal Republic of Germany has granted 150 scholarships for students to attend this school and has provided teachers and equipment.

The Federal Republic of Germany offers another training possibility for highly specialized surveyors through the conduct of seminars, which are held at irregular intervals. The most recent seminar, on the subject "Cadastral surveying and urban mapping", took place at Berlin in 1974 and was arranged in co-operation with the United Nations. The next seminar will be held in Costa Rica in February 1977, on the topic "Land information systems". Because of the success of the seminar held at Berlin it is planned to repeat it in 1978.

### Surveying projects

The Federal Republic of Germany has conducted projects in some developing countries which were meant to establish or to accelerate the establishment of cadastral maps and cadastral records. Among such projects were those conducted for the states in Central America and in Thailand. Similar projects were performed in Tunisia and Iran. Within these projects the necessary personnel and counterparts were trained, and some of them were sent to the Federal Republic of Germany to be trained in special fields.

To concentrate the technical assistance in geodetics and cadastral surveys, a group has been established in which several surveying organizations of the Federal Republic of Germany are represented. The group offers its service both to the developing countries and to its own Government without any pre-conditions in order to canalize the demands for assistance or to initiate surveying projects or to organize training possibilities for foreign cadastral personnel or officers.[1] The group also offers its advice for special questions which arise during the establishment or maintenance of a cadastre in a developing country.

[1]For information, please write to Professor J. Nittinger, Advisory Group for Technical Assistance in Surveys, Mapping and Land Information Systems, Wallmodenstrasse 46, D-3000 Hannover 61, Federal Republic of Germany.

## SPECIAL MAPPING WORK CARRIED OUT IN HUNGARY ON SOUTH-EAST ASIA AND CYPRUS*

*Paper presented by Hungary*

In connexion with the work of specialists from countries of South-East Asia who were receiving post-graduate training in Hungary, several special maps have been compiled concerning South-East Asia during recent years. The maps are the results of a general data-collecting work, embracing the entire world:

1. Tectonic map of Indochina; 1 : 5,000,000
2. Geological structural units of Indochina; 1 : 10,000,000
3. Basaltic volcanism in Indochina; 1 : 5,000,000

*The original text of this paper, prepared by Professor Stegena, Lajos—Department of Cartography, Eötvos Loránd University, Budapest, Hungary, appeared as document E/CONF.68/L.102.

4. Crustal thickness map of Indochina; 1 : 10,000,000
5. Bouguer anomaly gravity map of Indochina; 1 : 10,000,000
6. Lithosphere thickness map of Indochina and Indonesia; 1 : 25,000,000
7. Ophiolit rocks of Indochina and Indonesia; 1 : 25,000,000
8. Geothermic map of Indochina and Indonesia; 1 : 25,000,000
9. Seismic map of Indochina and Indonesia; 1 : 25,000,000
10. Horizontal component and isopores of the geomagnetic space of Indochina and Indonesia; 1:25,000,000
11. Inclination of geomagnetic space and its changes (1965.0) in Indochina and Indonesia; 1:25,000,000
12. Declination of geomagnetic space and its changes (1965.0), in Indochina and Indonesia; 1:25,000,000
13. Vertical component and isopores of the geomagnetic space in Indochina and Indonesia; 1:25,000,000
14. Total component and isopores of the geomagnetic space in Indochina and Indonesia; 1:25,000,000
15. Archaeological map of Cambodia; 1:1,250,000
16. Tourist map of Cyprus; 1:500,000

## INTERNATIONAL TECHNICAL CO-OPERATION BY THE GEOGRAPHICAL SURVEY INSTITUTE*

*Paper presented by Japan*

Japan has actively promoted international co-operation for contributing towards the development of economic conditions and the advancement of technologies to developing countries. As one form of co-operation, the Geographical Survey Institute (GSI) has recently begun international technical co-operation and aid in mapping work through the Japan International Co-operation Agency (JICA), including formation of training for foreign surveyors and cartographers under the Colombo Plan. The actual condition of international mapping co-operation by GSI is reported in this paper.

### Background of international mapping co-operation and system of implementation

In response to many requests about technical co-operation with regard to preparing topographic maps by developing countries or reports of study missions dispatched from the Government of Japan through JICA concerning various development projects in developing countries, funds for mapping were appropriated in a budget of the Overseas Technical Co-operation Agency (the present JICA) in 1971.

International mapping co-operation has been carried out as preparation of the basic data for establishing the plan of expanding the productivity and the basis of industrial development in developing countries. At the beginning, the preparation of maps at 1 : 50,000 scale was necessary for planning the development of the Barito River basin in Kalimantan, Indonesia, in the same year. Thus far, this co-operation has been given in various countries in Africa, South-East Asia and South America.

The work is initiated by the Government of Japan by accepting the proposed request for mapping co-operation from a foreign country and is entrusted to JICA for execution of the mapping work. For the smooth execution of the work, JICA established an advisory committee composed of the Ministry of Foreign Affairs, Ministry of Construction, GSI and authorities in the same line of work.

The procedures for this work are as follows. The possibilities and importance of the work or the amount of work etc., are discussed between pre-study mission members and persons representing the requesting countries. In accordance with the results of this discussion, the Government of Japan forms a plan of execution and a schedule for co-operation. Then, if the requesting country agrees to the plan of execution, including the diplomatic procedures, the work will be done as a co-operative project of JICA. JICA supervises execution of the work which is to be done by a non-profit private association—the International Engineering Consultants Association (IECA). The work is done by a surveying group of IECA. The group consists of surveyors of leading surveying enterprises in Japan. Members of GSI supervise and direct the various types of mapping work and extensively co-operate in smoothly pushing this work forward. Because this work has been highly evaluated by foreign countries, the Government of Japan has been receiving many requests for this type of co-operation and aid.

### Activities of technical co-operation and aid

#### *Preparation of national fundamental maps*

Complying with the request for technical co-operation and aid in mapping from developing countries, the

* The original text of this paper, prepared by the Planning Department, Geographical Survey Institute, Ministry of Construction, Japan, appeared as document E/CONF.68/L.71.

Government of Japan gives aid for preparation of national fundamental topographic maps at 1 : 50,000 scale, which are mainly used as basic data for establishing an over-all development plan. It will also contribute to accelerate preparation of the national fundamental maps. This mapping work has been executed or is being continued in the following countries.

*Indonesia*

In Indonesia, mapping was carried out at the scale of 1 : 50,000 in the Barito River basin development planning area. The work was done with due regard to the location of ground control points and pass-point survey for aerial triangulation, before beginning the photography in this area. A tidal station to check the elevation already measured was built near the southern coast in this area, and precise levelling was executed to connect this station at the same time. Restitution was done in part by Indonesian aerial survey firms.

The project was begun in 1971 and the completed topographic maps were delivered to the Government of Indonesia in July 1974. The contents of the mapping by year are as follows:

(a) *Area*: 19,300 km$^2$;

(b) *Pass-point survey by astronomical survey*: 8 points;

(c) *Levelling*: second order, 360 km;

(d) *Topographic maps*: 34 sheets, 15′ × 15′;

(e) *Work schedule*: 1971, aerial photography; 1972, control-point survey, tidal observation and field reconnaissance; 1973, restitution, supplementary survey and drawing; 1974, printing.

*United Republic of Tanzania*

Aid in mapping the Musoma area located on the east coast of Lake Victoria has been given since 1973. This project consisted of topographic mapping on the scale 1 : 50,000, which should be useful for various kinds of development in this area. This work was conducted as a link in the chain of control point survey, aerial photography, field reconnaissance, restitution, supplementary survey, drawing and printing.

In addition, first-order levelling was carried out, and those results contributed to lower order levelling in this area as well as being used for water-use planning around the Lake Victoria area. Moreover, the first-order levelling route from the Mediterranean Sea and from the Indian Ocean were connected in the United Republic of Tanzania with excellent accuracy by this levelling.

The project was begun in 1973 and the completed topographic maps were delivered to the Government of the United Republic of Tanzania in July 1976. The work of the project by year is described below:

(a) *Area*: 12,730 km$^2$;

(b) *Traversing*: 25 points;

(c) *Levelling*: first order, 150 km; second order, 650 km;

(d) *Topographic maps*: 34 sheets, 15′ × 15′;

(e) *Work schedule*: 1973, aerial photography, control-point survey and levelling; 1974, control-point survey, levelling, field reconnaissance, aerial triangulation and restitution; 1975, restitution, supplementary survey, drawing and printing; 1976, printing.

*Bolivia*

In compliance with the request of the Government of Bolivia, topographic mapping on the scale 1 : 50,000 is being executed by JICA in the Chapare area in Bolivia, including the upper Amazon. This mapping aid constitutes a part of the national basic map preparation plan of the Government of Bolivia, and simultaneously is in reply to the request for establishment of an agricultural plan by the Public Development Corporation of Cochabamba Province.

Aerial photography was undertaken by one of the aerial survey firms in the United States of America, contracted with JICA. Field survey was done by a joint team with Japanese and Bolivian surveyors. The working area includes mountainous regions approximately 500–2,500 m in elevation from the Amazon basin. Because the latter area is covered with dense forest, it was determined that a control-point survey in this area could not be performed by the ordinary method. Also, in this working area there were no established control points and pass points should be established for aerial triangulation work in some way. Therefore, levelling with the vertical height values was executed along the river-bed or by using narrow paths etc. On the other hand, positioning for the horizontal values was adopted through satellite observations using the Doppler receiver after discussing various survey methods.

Experimental observation tests using this system were made in 1975; they obtained sufficiently good results for pass-point survey to the implementation of aerial triangulation. In 1976, practical survey work was carried out in the lowland using this system. Other field surveys will be finished in 1976. Restitution, supplementary work and printing will be scheduled in 1977; and the final results will be delivered to the Government of Bolivia early in 1978.

The mapping work already done and scheduled to be done in Bolivia is described below by year:

(a) *Area*: 25,000 km$^2$;

(b) *Triangulation*: 4 points;

(c) *Satellite observation*: 26 points;

(d) *Levelling*: indirect, 900 km; low order, 600 km;

(e) *Topographic maps*: 44 sheets, 15′ × 15′;

(f) *Work schedule*: 1974, control-point survey and aerial photography; 1975, aerial photography and control-point survey; 1976, control-point survey, satellite observation, and aerial triangulation; 1977 (scheduled), restitution, supplementary survey, drawing and printing.

*Kenya*

In Kenya, the topographic mapping project has been conducted on the scale 1 : 50,000 for the eastern area of Kenya. This work, which is scheduled to last five years, was begun at the end of 1975. The final results are to be submitted to the Government of Kenya early in 1979. Progress by year of the work done as of 1976 and the scheduled work are described below:

(a) *Area*: 27,000 km$^2$;

(b) *Traversing*: 16 points;
(c) *Levelling*: second order, 450 km; low order, 1,000 km;
(d) *Topographic maps*: 38 sheets, 15′ × 15′;
(e) *Work schedule*: 1975, establishment of aerial photo signal and reconnaissance for traversing; 1976, control-point survey and aerial photography; 1977 (scheduled), levelling, pass-point survey, field reconnaissance and aerial triangulation; 1978 (scheduled), restitution, drawing and printing.

*Other mapping co-operation*

Besides the above-mentioned projects, negotiation for mapping co-operation is in progress with other countries; among them are Guinea and Saudi Arabia.

*Mapping work related to construction projects*

As fundamental mapping co-operation, GSI (through JICA) has sent engineers to foreign countries in connexion with various types of construction projects. The engineers, as members of study missions for the projects, have made the necessary investigations, given advice, prepared mapping plans, executed and supervised the preparation of large-scale maps which were used for project planning. The projects listed below were done jointly with GSI engineers in the survey and mapping field:

(*a*) Bangladesh: Jamuna River bridge construction project;
(*b*) Indonesia: Lampung area irrigation project;
(*c*) Burma: Irrawaddy River bridge construction project;
(*d*) Indonesia: Solo River Wonogiri Dam construction project;
(*e*) Tanzania: South coast area road construction project;
(*f*) Indonesia: Mt. Merapi Sabo project;
(*g*) Indonesia: Wrar River basin development plan;
(*h*) Indonesia: South Sulawesi water resources development plan.

*Dispatch of experts*

Dispatch of experts on surveying and mapping has been done by GSI. In 1974, in response to the request of the Republic of Korea, geodesists were dispatched to discuss their geodetic work. In 1974, in response to the request of the Government of Indonesia, two experts were dispatched from GSI for a short term, in order to give technical advice in methods for large-scale mapping. Later, two engineers were sent on a long-term mission based on the Colombo Plan, for co-operation in executing in surveying and mapping of the Bengawan Solo project in 1975. That was the first time that GSI sent experts for a long period in the field, and this co-operation will be continued in the future.

## Training

As one of the international activities, technical training has been done by GSI. A group training course has been conducted on the basis of the Colombo Plan, under the sponsorship of JICA. The training covers geodesy, photogrammetry and cartography. Inviting participants from various countries, the course is given by GSI each year on one of the three subjects. The course began in 1963, covering a period of about six months, and up to now has trained more than 100 personnel from 25 different countries. The programmes of each course for the past three years are shown as follows:

I. *Course in geodesy (1976)*
- (*a*) General course (lecture);
- (*b*) Specialized course (lecture and practical training):
  - Introduction to higher geodesy
  - Triangulation, traverse and precise geodetic survey
  - Base-line measurement
  - Geodetic astronomy including satellite geodesy
  - Levelling and tide observation
  - Gravity survey
  - Geomagnetic survey
  - Data processing in geodetic work
  - Earthquake prediction by means of geodetic survey
- (*c*) Observation and others.

II. *Course in photogrammetry (1975)*
- (*a*) General course (lecture);
- (*b*) Specialized course (lecture and practical training):
  - Aerial photography
  - Aerial-photo signal
  - Field reconnaissance
  - Theory of orientation
  - Plotting
  - Cadastral survey
  - Application
- (*c*) Field survey;
- (*d*) Observation and others.

III. *Course in mapping and reproduction (1974)*
- (*a*) General course (lecture);
- (*b*) Specialized course (lecture and practical training):
  - (i) Mapping:
    - System of map project, cartographic performance and planning management
    - Map compilation
    - Map-drafting and map-model-making
    - Map source and map revision
    - Photo-interpretation and thematic mapping
  - (ii) Reproduction:
    - System of reproduction performance, planning and management
    - Photography
    - Plate-making
    - Printing
- (*c*) Subject study;
- (*d*) Observation and others.

Besides this type of group training, JICA also sponsors

on-the-job training in connexion with fundamental mapping co-operation. In this case, training is conducted while working on the projects, and about 40 persons have been trained in this manner.

## THE REGIONAL CARTOGRAPHIC INSTITUTE*

*Paper presented by Thailand*

The *objective* of the Regional Cartographic Institute is to collaborate in training of personnel in the fields of mapping and cartography. The emphasis is on practical, on-the-job training with appropriate theoretical supplements. The main purposes are:

(*a*) To arouse public interest in the mapping techniques and their applications to the regional development projects;

(*b*) To standardize and establish surveying and mapping as a profession;

(*c*) To promote regional surveying education, research, invention and evaluation of modern mapping techniques.

### Background information

Thailand has participated in international and regional mapping activities for some time, and quite a few engineers and technicians have achieved academic and technical status. Their experience and capability are, of course, up to a level at which productivity may be expected.

The survey schools were founded some 25 years ago, but as the scope of the training was limited to the particular needs of the military and the cadastral service, the needs of engineering projects were not fulfilled. In the past five years, the National Board of Mapping was assigned to cope with the production and the use of maps; the latter task was directly related to surveying education and the former was concentrated mainly on the security of the country. The concept needed a revision. Unfortunately, the Board was of an *ad hoc* nature which terminated according to the term of the government administration; therefore, the Board has been inactive since 1973.

Obtaining financial support was the main problem in setting up the survey or cartographic institute; the precise and highly technical equipments which were the essential counterpart to proper training could not be written into the fiscal budget. In fact, the organization of the institute calls for equipment and installation only at the beginning (the initial set-up costs over $1 million); the remaining expense will be the supply of materials and maintenance, approximately 15–20 per cent of the initial cost per annum.

### Organization

The Regional Cartographic Institute is operated on the larger scale, compared with the foregoing proposal; this scope is far beyond the responsibility of a single country. International co-operation is required for:

(*a*) The supply of equipment for geodetic surveying, photogrammetry, hydrography and cartography;

(*b*) The provision of experts and technicians for research and the application of modern technology;

(*c*) The provision of fellowships and expenses by the member countries participating in the academic or provisional conventions;

(*d*) The governmental counterpart for the recruiting and placement of personnel; the administration should be independent or under the patronage of the United Nations;

(*e*) The administration comprises the academic and technical teams, with 50 per cent or more of local personnel; the remaining staff may be representatives from the member countries, specialists and even the representatives of manufacturers.

### Curriculum

The training is conducted on two levels: (*a*) the ordinary and technical training, the ordinary level for those with moderate fundamentals in mathematics and science, and no background of mapping, in which the manual and visual exercises on the field and office practice take about 70 per cent of the course schedule; and (*b*) the theoretical and analytical problems with some standard university courses plus skills which are given for the technical level.

The duration of the course subjects range from 5 to 16 weeks according to the context by which some subjects are classified as electives or as special problems. The courses are given twice annually following the usual university semester, and students can register for up to three course subjects per semester. A period of one year is required for each training level. The trainings are arranged in three branches under the following headings:

(*a*) Topographic and engineering surveys; cadastral surveys; satellite geodesy; precise levelling; electronic distance measurement (EDM) traversing; nautical and aeronautical charting;

(*b*) Aerial photography; stereo-photogrammetry; analytical photogrammetry; advanced photogrammetry;

(*c*) Basic cartography; advanced cartography.

* The original text of this paper, prepared by Professor Somhvang Tandalak, Chulalongkorn University, Thailand, appeared as document E/CONF.68/L.75.

RECOMMENDATION

The proposal gives the general outline of what is expected and how to commence. Details of the course contents are to be negotiated by the committee; this process also involves the investment which calls for careful evaluation by the relevant authorities.

The mapping activities of Asia and the Far East are from 20 to 30 years behind those of the developed countries. The western world is coming to the age of fully automated processes of compilation, the orthophoto map and the picto map. Mapping may change drastically into a totally new format and it is not too late to prepare to conform to the changing concept.

The surveying profession is becoming increasingly specialized so that it cannot be classified as supplementary to the civil engineering curriculum. The analysis of mathematical models and modern computer techniques are major methods to maintain accuracy and save time. In the era of specialization, the tasks of the map-maker and the map-user should be clearly defined.

Naturally, the mapping industry requires appropriate equipment, skill, consistency, and efficient administration. In most of the countries of Asia, a certain number of personnel are available and productive for the profession. The demand for geographical and topographic data for various development projects is ever-increasing, but the economic situation of the country does not allow it to cope with the high cost of the technical organization. Thus, the aid of the United Nations remains the only means of organizing and establishing the institution to serve the region.

Public interest in mapping and its application is currently very low. The majority of local surveying enterprises are not competent in the areas of control survey and photogrammetric tasks. To eliminate the above-mentioned problems, encouragement can be given by the establishment of the proper survey or cartographic institute; the products would immediately reflect their own value to the industry. In addition to the principal duty of the institute—the professional training—consulting and production service may be offered to the general public, though it may sound unusual for an institute to take part in commercial activity in this country. In fact, the university research programmes exist because of commercial support, and the public demand supplies topics and fresh data for the research. In the final word, the organization of the Regional Cartographic Institute is a kind of leadership enabling the utilization of human resource to serve the public interest; to promote human co-existence, something must be done.

The principles and practice of the training institute are not new to mankind, a comprehensive study may be referred to the organization and success of several institutes as;

(*a*) The Swiss School for Photogrammetric Operators;

(*b*) The International Institute for Aerial Surveys and Earth Sciences (ITC) in the Netherlands.

(*c*) The Royal Institute of Chartered Surveyors of the United Kingdom of Great Britain and Northern Ireland;

(*d*) The Ordnance Survey and the Directorate of Overseas Survey of the United Kingdom;

(*e*) The surveying education programme of the American Congress on Surveying and Mapping and the American Society of Engineering Education in the United States of America;

(*f*) The Cartographic School by the Inter-American Geodetic Survey and the Defense Mapping Agency of Pan-America;

(*g*) The universities and technical colleges of Europe and the United States of America;

(*h*) The Royal Thai Army Survey School;

(*i*) Chulalongkorn University and the Institute of Technology of Thailand.

## REPORT ON FULL-TIME TRAINING FACILITIES IN THE UNITED KINGDOM IN LAND SURVEY, PHOTOGRAMMETRY AND PHOTO-INTERPRETATION, CARTOGRAPHY AND MAP REPRODUCTION WHICH ARE AVAILABLE TO OVERSEAS STUDENTS*

*Paper presented by the United Kingdom of Great Britain and Northern Ireland*

The training courses described in this paper are those which will be followed by persons wishing to make a career or profession in any of the subjects listed. The paper is not a comprehensive account of all teaching given in those subjects in the United Kingdom of Great Britain and Northern Ireland; and, in particular, it makes no mention of the many university geography and civil engineering departments which offer some specialization or option in those subjects during a first-degree course.

In general, all university and polytechnic courses are open to students from any country provided that the student has the necessary entry qualifications. Pressure on university places is, however, great; and a student may need more than the basic qualifications in order to stand a chance of being accepted.

Formal courses usually lead to professional, technician or academic qualifications: they are the standard courses offered to British students and they are not arranged especially for people from overseas. *Ad hoc* courses are normally directed to practical proficiency and do not award a recognized qualification.

All instruction is in English. Students must be able to

* The original text of this paper, prepared by M. B. McHugo, Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.68/L.14.

read and write English fluently and have a good comprehension of the language in order to be accepted. Most institutions require a candidate to pass an English test arranged by the British Council, which is taken in his own country. Some awards are conditional upon the student following an English course in the United Kingdom before commencing his technical training.

Students at universities, polytechnics and colleges may be either private or Government-sponsored: those at the other organizations listed must be Government-sponsored or be in receipt of a United Nations fellowship. Private students must apply in the first place through their own Embassy in the United Kingdom. Applications for sponsored students seeking United Kingdom Government awards must be made by their Government to the local British Council representative or, where there is no representative, to the British Embassy or High Commission. Details of awards are given in *Study Abroad* (No. XX, 1975-1977), a publication of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

United Kingdom Government awards will not be made for training in Great Britain if suitable facilities are available locally or regionally.

Inclusion of a course in this paper does not imply that it is necessarily eligible for a United Kingdom Government award.

## Information

The information in this paper is based on the answers to a questionnaire sent out in June 1976.

Information is provided by subject and institution, as follows:

*Land survey* (3.1)
- Courses at universities and polytechnics (3.1.1)
  - University of Newcastle-upon-Tyne
  - North-East London Polytechnic
  - University of Glasgow
  - University of London
  - University of Oxford
  - University of Nottingham
- Courses at other organizations: (3.1.2)
  - School of Military Survey
- Courses of allied interest (3.1.3)
  - University of Cambridge

*Photogrammetry and photo-interpretation* (3.2)
- Courses at universities and polytechnics (3.2.1)
  - University of Glasgow
  - University of London
  - National College of Agricultural Engineering
  - University of Reading
- Courses at other organizations (3.2.2)
  - Directorate of Overseas Surveys
- Courses arranged overseas by United Kingdom organizations (3.2.3)
  - Land Resources Division

*Cartography and map reproduction* (3.3)
- Courses at universities and polytechnics (3.3.1)
  - University of Glasgow
  - University of Wales
  - Oxford Polytechnic
  - Manchester Polytechnic
- Courses at colleges (3.3.2)
  - Luton College of Technology
  - London College of Printing
  - Watford College of Technology
- Courses at other organizations (3.3.3)
  - Directorate of Overseas Surveys

Under each institution information is listed under the following codes:

(*a*) Organization and department;

(*b*) Name of course and qualification to which it leads. The symbol † indicates that the qualification (at an appropriate level) gives exemption from the written final examination in land surveying of the Royal Institution of Chartered Surveyors (RICS);

(*c*) Length of course and month in which it begins;

(*d*) Entry requirements;

(*e*) Latest month for application;

(*f*) Number of years for which course has been offered;

(*g*) Average intake of students;

(*h*) Number and qualifications of full-time teaching staff;

(*j*) Summary of contents of course; practical work;

(*k*) Equipment available.

Shorter *ad hoc* courses and technical study visits arranged through the British Council or United Nations agencies to meet individual training requirements are not discussed here.

## Details by subject

### *Land survey*

There are no full-time courses for basic technician training in the United Kingdom[1] and there are no facilities for training in cadastral survey or in land registration practices.

After successful completion of professional courses marked a minimum of two years of probationary experience supervised by a chartered surveyor, followed by a practical examination; and a thesis is required for full professional recognition.

*Courses at universities and polytechnics*

(a) *University of Newcastle-upon-Tyne, Department of Surveying*

(b-i) B.Sc. in survey and mathematics/computing science/geography or physics †. (b-ii) B.Sc. in surveying science †.

(c-i) and (c-ii) Three academic years—October.

(d-i) and (d-ii) Two GCE "A" level passes including mathematics.

(e-i) and (e-ii) Before mid-December.

(f-i) 10 (f-ii) Starting 1976.

(g-i) Twenty.

[1] Apart from internal courses arranged by firms and organizations for their own staff.

(h) Four: two professional surveyors (one Ph.D.), one photogrammetrist (M.Sc.) and one technician.

(j-i) Field surveying, computations, field astronomy, geodesy, photogrammetry, land registration cartography. Six hours weekly, two weeks annually and estate survey. (j-ii) As for (j-i) plus hydrographic surveying, survey management. Three-week field course and survey project.

(k) Field instruments include geodetic theodolites and electronic distance-measuring (EDM) equipment: photogrammetric instruments include Wild A7, Multiplex and Kelsh plotter.

(a) *North-East London Polytechnic, Department of Land Surveying*

(b-i) B.Sc. in land surveying sciences †. (b-ii) Higher Diploma (TEC) in land surveying. (b-iii) RICS final examination †.

(c-i) Three academic years—October. (c-ii) Two years and two terms sandwich—October. (c-iii) Twelve months—April.

(d-i) Two GCE "A" level passes including mathematics. "O" level in English language and physics. Individual cases considered on merit. (d-ii) One GCE "A" level and study of mathematics to "A" level, "O" levels as for (d-i) desirable. Individual cases considered on merit. At end of first year suitable candidates can transfer to (b-i). (d-iii) RICS part I/part II or (b-ii) above at appropriate level.

(e-i) August. (e-ii) September. (e-iii) March.

(f-i) Nine. (f-ii) and (f-iii) Three years (replaces an RICS course which had run for 25 years).

(g-i) Forty. (g-ii) Forty.

(h) Twenty-seven mainly graduate and chartered surveyors, six with higher degrees, 25 with over three years' experience.

(j-i) Geodetic surveying, photogrammetry, cartography, cadastre, geodesy (+off shore), hydrographic surveying, mathematics, physics, law, geology and geomorphology, construction and planning. Nine weeks of field courses. (j-ii) Land surveying, cartography, photogrammetry, mathematics, physics, law, geography. One term practical plus one term in industry.

(k) Geodetic and lower order theodolites, EDM equipment; Wild A9 with EK8, Thompson Watts, PG2, Multiplex and Kelsh plotter; process camera and automatic proofing press.

(a) *University of Glasgow, Department of Geography*

(b-i) M.App.Sci. in topographic science. (b-ii) Diploma in surveying. (b-iii) B.Sc. in topographic science †.

(c-i) Two academic years—October. (c-ii) One academic year—October. (c-iii) Three academic years for ordinary degree, four for honours—October.

(d-i) First degree from an approved university, or other qualification recognized by the university: pass in mathematics in Higher Grade of Scottish Universities Preliminary Examination or equivalent. (d-ii) As for (d-i). (d-iii) University entrance.

(e-i) and (e-ii) June. (e-iii) December.

(f-i) and (f-ii) Starting 1976. (f-iii) Ten.

(g-iii) Twenty-five ordinary, nine honours.

(h) Two senior lecturers and three lecturers with higher degrees, ITC qualifications and commercial experience.

(j-i) As for (j-ii) in either 3.1, 3.2 or 3.3 plus two courses from one of the alternative diploma programmes and a dissertation. (j-ii) Land surveying techniques including EDM, and positional astronomy, mathematics, survey computations, hydrographic surveying, geodesy (including satellite geodesy), computer programming and computer graphics. (j-iii) Land surveying including field and satellite geodesy, engineering and hydrographic surveys, physical and legal boundaries, basic electronics and optics, geography, cartography, photogrammetry and computing science; 420 lectures (hons.), practical and tutorial field courses.

(k) Theodolites, Hewlett-Packard EDM equipment: Wild B8 and A6, Zeiss C6 and Multiplex, Kern PG 2L, Galileo Stereo Simplex 11C with Whitwell digitizer attached, Wang 2200 calculator, two stereocomparators (Cambridge and Zeiss Jena): rectifier, process camera, vacuum frames, photo-typesetting machine, co-ordinatographs etc.

(a) *University College London, Department of Photogrammetry and Surveying*

(b-i) M.Sc. in surveying. (b-ii) Diploma in surveying († with cognate degree or RE qualification).

(c-i) Twelve months—October. (c-ii) Nine months—October. Students who achieve a sufficiently high standard in the Diploma examinations are invited to stay on to attempt the M.Sc, which requires a dissertation on an appropriate piece of research.

(d) An approved degree in engineering, physics, mathematics or geography at an appropriate standard. Alternative qualification may be considered. English standard at least British Council "A" grading.

(e) May.

(f) Twenty-four.

(g) From eight to ten.

(h) One professor, one reader and five lecturers, including two chartered surveyors, plus technical staff and visiting lecturers.

(j) Topographic, engineering, cadastral and geodetic surveying, including astronomical observations and elementary gravity survey. Land registration, aerial survey, cartography, statistics, optical and electronic engineering, electronic computer appreciation and simple programming. Fifty per cent practical, including five weeks of field courses.

(k) Theodolites, EDM equipment, tacheometers, levels etc.; IBM 360/65 computer; photogrammetric equipment (see photogrammetry below).

(a) *University of Oxford, Department of Surveying and Geodesy*

(b) M.Sc. in geodesy († for those holding, or exempted from RICS Part I/II).

(c) Twelve months—October.

(d) Upper second-class honours degree in appropriate subject from an approved university. Sound knowledge of written and spoken English.

(e) January.

(f) Five.

(g) From three to six.

(h) Two chartered surveyors, one with a higher degree.

(j) Computation and mathematics, geodetic astronomy, artificial satellites, the earth's gravity field, refraction, field-work (including instruments, specifications, methods and accuracies). Some practical field-work during first six months.

(k) Wild T4 and Kern DKM 3-A universal theodolites and chronocord plus ancillary equipment and usual survey instruments.

(a) *University of Nottingham, Department of Civil Engineering*

(b) B.Sc. Honours in civil engineering († for those who include two surveying options and computer methods in their final year, plus a surveying project, and obtain at least an upper second degree).

(c) Three years—October.

(d) GCE 'A' in pure mathematics, applied mathematics and physics (with 'O' in chemistry) or in mathematics, physics and chemistry.

(e) January.

(f) Three.

(g) From 10 to 12 take options for †.

(h) Three with Ph.D in surveying.

(j) Surveying options only include photogrammetry, map projections, site investigation, field astronomy and figure of the earth in final year; and previously distance plus angular measurement, levelling, errors plus adjustment of instruments, control surveys, theory of errors, EDM, hydrographic surveying. Computer methods and techniques including least-squares adjustment of geodetic networks.

(k) Wide range of surveying instruments, including EDM, photogrammetric stereo-plotters, a satellite Doppler receiver and wide variety of research equipment.

*Courses at other organizations*

(a) *School of Military Survey, Ministry of Defence*

(b) Army Survey Course (ASC) †.

(c) Fourteen months. Starting February and August each year. Overseas students must attend a three-and-one-half-month ASC induction course before the ASC.

(d) Degree in or cognate to land surveying, with mathematics at GCE 'A' level or equivalent. Must be fully conversant with technical English. A diagnostic test in mathematics is sent to each applicant. Overseas applicants may be given a preliminary technical interview in their own country by a chartered surveyor. All applications are considered by a Selection Board in the United Kingdom.

(e) Approximately two months before start of course.

(f) Twenty-two.

(g) Twelve.

(h) Nine professionally qualified officers and 30 soldiers with appropriate military technician/tradesmen qualifications.

(j) Land survey including field astronomy, large-scale survey and land registration, air survey, map production.

(k) Up-to-date equipment in field survey, aerial survey and map production for both instructional and practical use. This equipment includes terrestrial and astronomical theodolites, tacheometers, EDM equipment, crystal chronometers, tilting and automatic levels, gravity meters; Wild A8 with EK8, B8 and B8S with tri-axis locator and EK22, C5, Thompson Watts Mk I, and Zeiss 03P orthophotoscope, stereotope, Zeiss DP1 Plotters, SMG4, Zeiss Stecometer, Coradi co-ordinatographs, Diatype Phototypesetter, process cameras; one- and two-colour printing-machines; Hewlett-Packard desk calculators (9810A) and peripheral equipment.

*Courses of allied interest*

(a) *University of Cambridge, Wolfson College*

(b) Cambridge University course on development (with option in land policy and the environment). Diploma (or Certificate) in Development Studies.

(c) One academic year—October, with preliminary language course if required.

(d) Good degree in a related subject in student's own country. Sound knowledge of written and spoken English. Under 40 years of age.

(e) Normally March.

(f) Nine.

(g) For all options, 45; for land policy and the environment, 15.

(h) Several, all with higher degrees and considerable experience in developing countries.

(j) There is an obligatory examination paper, common to all options, on theories of development. In addition there are four papers on different aspects of land policy and the environment, two of these papers being alternative choices. Fields of study include: the natural and cultural environments; natural resource endowment; urbanization phenomena; regional and urban perspectives in national planning; proprietary patterns and social structure; the ideology and rationale of reform policies; resource management strategies; energy accounting and environmental co-ordination.

*Photogrammetry and photo-interpretation*

There are no full-time first degree or technical college courses in photogrammetry and photo-interpretation.

Successful completion of post-graduate courses marked † exempt from the written RICS finals candidates who have already reached RICS part I/II standard.

*Courses at universities and polytechnics*

(a) *University of Glasgow, Department of Geography*

(b-i) M. App. Sci. in topographic science. (b-ii) Diploma in Photogrammetry.

(c-i) Two academic years—October. (c-ii) One academic year—October.

(d-i) First degree from an approved university: pass in mathematics in Higher Grade of Scottish Universities Preliminary Examination or equivalent. (d-ii) as for (d-i).

(e) June.

(f-i) Starting 1976. (f-ii) 10.

(g-ii) Two.

(h) (j-i) and (k) See University of Glasgow entry under "Land survey".

(j-ii) Aerial photography, stereoscopy, stereoplotting instruments, aerotriangulation, orthophotography, automation, testing/accuracy, mathematics, computer programming and computer graphics.

(a) *University College London, Department of Photogrammetry and Surveying*

(b-i) M.Sc in Photogrammetry. (b-ii) Diploma in Photogrammetry († with cignate degree or RE qualification).

(c-i) 12 months—October. (c-ii) Nine months–October. Students who achieve a sufficiently high standard in the Diploma examinations are invited to stay on to attempt the M.Sc., which requires a dissertation on an appropriate piece of research.

(d) An approved degree in engineering, physics, mathematics, geography, land surveying or topographic science of an appropriate standard. Alternative qualifications may be considered. Sound knowledge of English.

(e) May.

(f) Twenty-four.

(g) Eight to ten.

(h) See University College, London, entry under "Land survey".

(j) Aerial photography, photogrammetric theory, plotting instruments (theory, development and operation), aerial triangulation, cartography, mathematics, statistics, EDM measurements, optical and electronic engineering, computer appreciation and simple programming; 50 per cent practical.

(k) Thompson-Watts Mk 2, Wild A8 + A5, Zeiss C5, Kern PG2, CP1, Hilger and Watts, Cambridge, and Zeiss Jena Stereocomparators, SMG4, Stereosimplex IIB, Multiplex, Wild P.30 photo-theodolite, Santoni stereometric cameras, ancillary equipment. (For survey equipment, see entry under "Land survey".)

(a) *National College of Agricultural Engineering, Silsoe, Bedford, Department of Field Engineering (Land Resource Planning)*

(b-i) M.Sc agricultural engineering (land resource management option). (b-ii) Post-graduate diploma in agricultural engineering (LRM option).

(c-i) Twelve months—October. (c-ii) Nine months—October.

(d-i) Good honours degree in agriculture, agricultural engineering, geography, environmental science, agricultural economics or a similar discipline. Sound knowledge of written and spoken English. (d-ii) Normally a degree, higher national diploma or equivalent professional qualification. English as for (d-i).

(e-i) and (e-ii) June.

(f-i) Starting 1976. (f-ii) Eight.

(g-ii) From five to seven.

(h) Thirty-five full-time teaching staff in the college with academic and professional qualifications. Director of Studies in Land Resource Planning.

(j-i) Studies in resource survey and analysis (including the use of remote sensing) and the economics of resource management, supplemented by subjects selected according to qualifications and experience. These include: land, soil and water management; photogrammetry and Land surveying; statistical and mathematical programming techniques; field-work. (j-ii) Theoretical and practical training in the application of remote sensing (including aerial photography) to all aspects of land resources planning. Programme supplemented by subjects selected according to previous qualifications and experience. These subjects include soil and water engineering, tropical crop and range ecology and managerial economics. Substantial practical work is included in all subjects.

(k) Wild B9; interpretoscope; colour-additive viewer; Sketchmaster; stereoscopes.

(a) *University of Reading, Faculty of Science*

(b) M. Phil. in integrated land resources survey.

(c) Two years—September.

(d) A first degree in science, agriculture, geography or related disciplines or such other qualification as approved by the University.

(e) June.

(f) Two.

(g) —.

(h) —.

(j) Aspects of earth and physical sciences, techniques of land resource survey, land use planning and plan implementation. Two of the 15 units of the course cover cartography, field survey and elementary photogrammetry and also aerial photo-interpretation, the use of remote sensing and associated semi-automatic analyses and display techniques; also the co-ordination of the acquisition, storage, retrieval and evaluation of natural resources information from aircraft, balloon, rocket and satellite platforms as well as from field-work.

*Courses at other organizations*

(a) *Directorate of Overseas Surveys, Ministry of Overseas Development*

(b) *Ad hoc* courses in practical air survey and photogrammetry are arranged to meet the requirements of overseas technical departments. No academic qualification.

(c) Three to eight months as required. Variable.

(d) No answer.

(e) No answer.

(f) Twenty-six.

(g) Three at a time on photogrammetry.

(h) Experienced technical staff engaged in map production.

(j) Basic aerial survey using simple instruments, graphic and mechanical methods, interpretation, parallax bar heighting. Preparation and operation of modern stereoplotters as listed under (*k*). Control planning, aerotriangulation. 90 per cent practical.

(*k*) Wild A8s with EK5 and EK8, A10 with EK22, B8s with EK8. Thompson Watts Mk 1a and 2; Kern PG2s; Multiplex; PUG4, Z240 Zoom stereoscope; E4 rectifier; Coradi co-ordinatograph with visual read-out; variety of minor instruments.

*Courses arranged overseas by United Kingdom organizations*

(*a*) *Land Resources Division, Ministry of Overseas Development*

(*b*) Intensive training courses in land-use capability classification and conservation layout planning are given in applicant countries by members of the Division. No academic qualification.

(*c*) Three weeks. As arranged.

(*d*) For Government agricultural officers normally.

(*e*) No answer.

(*f*) No answer.

(*g*) No answer.

(*h*) Two qualified scientists experienced in soil conservation and land-use planning.

(*j*) Aerial photo-interpretation and soil studies; land capability classification; conservation layout planning. Total of 105–125 working hours. One member of the Division remains attached to the local Ministry of Agriculture for from six to eight weeks to assist by guiding field-work and initial planning operations.

(*k*) No answer.

*Cartography and map reproduction*

There are no full-time first degree courses in cartography and map reproduction. The photolithography courses listed do not relate specifically to map printing.

*University and polytechnic courses*

(a) *University of Glasgow, Department of Geography*

(b-i) M. App. Sci. in topographic science. (b-ii) Diploma in cartography.

(c-i) Two academic years—October. (c-ii) One academic year—October.

(d-i) First degree from an approved university: pass in mathematics in Higher Grade of Scottish Universities Preliminary Examination or equivalent. (d-ii) as for (d-i).

(e) June.

(f-i) Starting 1976.

(f-ii) Thirteen.

(g-ii) Seven.

(h) (k) and (j-i) see University of Glasgow entry under "Land survey".

(j-ii) Metrics, graphics, map reproduction, history of cartography, boundaries, cadastre, automation, orthophotos/photo mapping, map production, atlases, thematic mapping, computer programming, data processing, computer graphics.

(a) *University College of Swansea, Department of Geography*

(b) Diploma in cartography.

(c) One academic year—October.

(d) An approved degree in geography, or another degree with mathematics, statistics or physics at subsidiary level.

(e) Normally June.

(f) Seventeen.

(g) Two.

(h) Two graduates, one with higher degree.

(j) Techniques of map and chart compilation. Cartographic processes involved in the production of topographic and thematic maps and nautical charts. Map design and reproduction. Additional courses in computer programming and languages. Nine hours of practical work per week.

(k) Wide range of cartographic, photogrammetric and surveying instruments.

(a) *Oxford Polytechnic, Department of Construction*

(b) Diploma in cartography.

(c) Two academic years, including six weeks in industry—September.

(d) GCE 'A' level pass in geography and one other subject plus a minimum of five 'O' level passes including English, mathematics and one science subject.

(e) June.

(f) Twelve.

(g) From 15 to 20.

(h) Senior lecturer and two lecturers plus specialist teaching assistance.

(j) Map compilation, including history of mapmaking, photogrammetry, field studies and source material; statistical mapping costing and publication problems. Mathematics and measurement including geometry, projections, survey methods, statistics; an introduction to computers, information storage and automation in cartography. Practical cartography, photography and introduction to lithography. Field trips and cartographic visits.

(k) Cartographic and reproduction equipment; some land survey and photogrammetric instrumentation. CADMAC computer graphics work station.

*Note*: The course provides a background suitable for those who may wish to become cartographic editors or university cartographers.

(a) *Manchester Polytechnic, Department of Printing Technology*

(b-i) Diploma in printing. (b-ii) Certificate in graphic and photographic technology.

(c-i) Three academic years. (c-ii) Two academic years.

(d-i) One GCE 'A' level pass plus five 'O' level passes, including English and mathematics. (d-ii) Five GCE 'O' level passes.

(e) Normally June.

(f) Twenty-three.

(g-i) Twenty. (g-ii) Sixteen.

(h) Thirty (plus part-time).

(j-i) Technology, 40 per cent; management, 40 per cent; production design, 20 per cent. Adequate practical work. (j-ii) Technology, 80 per cent; management, 10 per cent; design, 10 per cent.

(k) Extensive laboratories and printing workshops.

*College courses*

(a) *Luton College of Technology, Department of Science*

(b) Diploma in geographical techniques (TEC Higher Diploma).

(c) Three-year sandwich (second year in industry)—September.

(d) GCE 'A' level pass in geography (or an approved alternative subject) plus three 'O' level passes, including English and mathematics.

(e) —.

(f) Nine.

(g) Thirty.

(h) —.

(j) Foundation year in practical work with emphasis on construction and design of maps, acquisition of source material for thematic and statistical maps, compilation, computers, photography, mapping skills. Second year in practical experience in industry, planning or university cartography department. Third year in more advanced technology and individual projects, a planning study and group projects. The course also includes geography, planning and development, field studies and a number of related studies.

(k) Minor cartographic equipment. Rost co-ordinatograph, vacuum contact with u/v plus point source light, radial line-plotter, Sketchmaster, mirror stereoscopes, Lithotex vertical camera, Asahi Pentax Fl.4 Spotmatic camera with accessories and other photographic equipment.

*Note*: The course provides a background suitable for those who wish to become cartographers in university geography departments, planning departments, map and atlas publishing firms.

(a) *London College of Printing, Department of Graphic Reproduction*

(b) Certificate in photolithography (suitable students may sit for the City and Guilds examinations).

(c) Two academic years—September.

(d) Three GCE 'O' level passes (or equivalent). Industrial experience is an advantage.

(e) April.

(f) Twenty-three plus.

(g) Twenty-five.

(h) Qualified staff, 250 with industrial experience as appropriate (plus part-time staff).

(j) Composition. Design. Graphic reproduction. Camera operation. Colour correction. Lithographic plate-making and printing. Science. Management principles, estimating and costing; 80 per cent technical work.

(k) Moden shops and laboratories with major graphic reproduction equipment of all types for teaching and for student use.

*Note*: The College also arranges special training programmes to meet the specific needs of overseas Governments. Advice on these programmes can be obtained from the Co-ordinator of Full-time Printing Courses.

(a) *Watford College of Technology, Department of Printing and Packaging*

(b-i) B.Sc. Honours in printing technology. (b-ii) Higher National Diploma in Printing. (b-iii) Diploma in printing administration.

(c-i) Four-year sandwich (three six-month periods in industry)—September. (c-ii) Three-year sandwich (three six-month periods in industry)—September. (c-iii) Two years full-time study—September.

(d-i) Minimum five GCE passes (including mathematics with two at 'A' level, including either physics, chemistry, physical sciences, engineering sciences or mathematics; or four GCE passes with three at 'A' level, including one of those listed above. (d-ii) Four GCE 'O' level, including mathematics and either physics, or physics with chemistry, or general science, and two 'A' level including a mathematical or science subject. (d-iii) Five GCE 'O' level or City and Guilds Advanced Craft or Technicians Certificate. Equivalent qualifications should be discussed with the College. Good English is required for all courses.

(e) March.

(f-i) Eleven. (f-ii) Fourteen. (f-iii) Eight.

(g-i) Up to 10. (g-ii) From 15 to 21. (g-iii) From 30 to 40.

(h) Head of Department, two principal, 14 senior and 14 other qualified lecturers with professional and industrial experience as relevant.

(j-i) Physics, chemistry, engineering, mathematics, printing materials, printing technology, printing surfaces, humanities, industrial administration, project work. Industrial training. (j-ii) Technology of printing materials, general printing technology, design and production plus two specialized options and a project. Industrial training. (j-iii) Printing administration, design and technology, printing management, production and organization, business administration. Practical work where relevant.

(k) Modern specialist laboratories, workshops and

studios with a wide selection of printing and scientific equipment. Extensive computer facilities.

*Courses at other organizations*

(a) *Directorate of Overseas Surveys, Ministry of Overseas Development*

(b-i) *Ad hoc* courses in practical cartography are arranged to meet the particular requirements of individual overseas technical departments. (b-ii) During training, students with the right entry qualifications can follow the part-time course at Kingston College of Further Education leading to the Ordinary National Certificate (ONC) in surveying, cartography and planning.[1]

(c-i) From three months to two years as required. Variable. (c-ii) Two academic years—September.

(d-i) No answer. English standards acceptable to the British Council. (d-ii) Four GCE 'O' level passes, including English and mathematics.

(e-i) No answer. (e-ii) June.

(f-i) Twenty-six.

(g) Up to 20.

(h) Experienced technical staff engaged in map production.

(j) All aspects of practical cartography using modern techniques and materials: multicolour work; revision techniques; map construction; photographic and photomechanical processes; mosaics; hill shading; thematic mapping; photo mapping. Individual subjects are included as required; 90 per cent practical. Short management courses for senior trainees with management experience.

(k) All the cartographic and photographic equipment used in a modern map production organization.

[1] Technician education in the United Kingdom is currently in course of reorganization and ONC courses/qualifications are being transformed into Technician Education Council (TEC) courses/qualifications in England, Wales and Northern Ireland and SCOTEC courses/qualifications in Scotland.

## THE DIRECTORATE OF OVERSEAS SURVEYS: TECHNICAL CO-OPERATION IN SURVEYING AND MAPPING*

*Paper presented by the United Kingdom of Great Britain and Northern Ireland*

The Directorate of Overseas Surveys (DOS) is a technical unit within the Ministry of Overseas Development of the United Kingdom of Great Britain and Northern Ireland. It carries out land surveying and mapping projects for developing countries as part of the United Kingdom over-all aid programme and it provides technical advice, information and guidance on request. To do this work, the DOS is staffed by professional land surveyors and technician cartographers, photogrammetrists and photographers. During the past 30 years, this multidiscipline team has built up a considerable body of skill and knowledge of working with and in the developing world. Today this expertise can be made available to all Governments seeking assistance and co-operation from the United Kingdom in these fields.

The Directorate participates actively in projects by carrying out field survey operations overseas and map production at its headquarters in the United Kingdom. Joint projects are also undertaken in which DOS and an overseas survey department work together on all stages of a project, thus providing training as the work progresses. DOS manages all land survey and mapping contracts financed by British Technical Co-operation funds. On request, it can also manage survey and mapping contracts financed from capital aid and arranged directly between overseas Governments and commercial mapping firms in the United Kingdom.

### SERVICES PROVIDED

#### *Advice*

DOS provides technical advice on all aspects of land survey, aerial photography and mapping, including project feasibility, techniques, equipment, materials, books, training needs and facilities, and qualifications.

Many inquiries are handled by discussion and correspondence with DOS headquarters in the United Kingdom or with the DOS senior regional survey officers, who are stationed overseas both to supervise DOS field survey teams and to provide advice on the spot. Currently, there is a senior regional survey officer in the Caribbean (based in Barbados), one in East Africa (based in Kenya) and one in Central Africa (based in Malawi).

Other matters and, in particular, detailed project proposals are often best discussed in the country concerned. This can easily be arranged, since DOS directing staff travel widely overseas specifically to visit, on request, survey and mapping departments and organizations, to attend international symposia and technical conferences, and to visit the DOS field parties working on technical co-operation assignments. Each senior regional survey officer also visits the countries within his region and is available for consultation when required. Such preliminary visits and discussions may give rise to an official request for a specific investigation, for a longer

* The original text of this paper, prepared by M. D. McHugo, Directorate of Overseas Surveys, United Kingdom of Great Britain and Northern Ireland, appeared as document E/CONF.68/L.15.

"advisory visit" by an expert in a particular field, or for a full-scale project appraisal. Requests for preliminary visits can be made direct to DOS, or to the Ministry of Overseas Development, or through diplomatic channels.

*Aerial photography*

DOS examines the photographic requirements of particular projects and, on request, draws up detailed flight plans and makes arrangements for the photography to be flown. DOS itself has no flying unit and so the tasks are undertaken by British firms of proven competence, working under contract to the United Kingdom Government, usually as part of a technical co-operation scheme. DOS draws up the technical specifications, monitors and checks the progress of the work and ultimately assesses the quality of the photography. It can also undertake these services for overseas Governments, which themselves wish to enter into aerial photography contracts directly with British commercial firms.

The copyright of all photography achieved under contract is vested in the country for which it is flown; and, on completion of the whole project, the original negatives are held by that country.

Aerial photography of survey standard flown by other countries and agencies is also often used in mapping projects undertaken by DOS and can be part of the overseas contribution or input to a joint project.

*Field survey and mapping*

The production capacity of DOS has been developed to enable it to participate in all types of land survey and mapping projects requested by developing countries. It may, at any one time, be working for 40 or more countries and on projects involving the establishment of a national survey framework, the observation of mapping control; the production of topographic maps on large, medium and small scales; the preparation of rectified mosaics and the compilation of thematic maps. Each such project must be "aidworthy" to be acceptable, i.e., the country requesting it must be able to show that the project is justifiable on economic grounds, that it will make a positive contribution to development and that there are no local facilities for carrying out the work within the necessary time scale. This means that DOS is normally asked to assist in initial basic national and project mapping and it encourages overseas countries to develop the skills and facilities to carry out revisions and to produce derived mapping themselves.

When a project has been officially accepted by the Ministry of Overseas Development as part of its technical co-operation programme and all the technical requirements have been worked out, a self-contained fully equipped team of professional surveyors can be sent to any part of the world. The team works in close collaboration with the local survey authorities, carrying out the programme of work planned by headquarters; it recruits labourers and assistants locally and gives local qualified land surveyors an opportunity to participate in the fieldwork, if this is requested. The mapping operations are carried out in the DOS photogrammetric laboratories and drawing offices in the United Kingdom. The overseas country is normally expected to participate actively in the project by carrying out field completion of the photogrammetric plots before the maps are finalized and published.

In recent years joint survey and mapping projects have been undertaken with a number of countries. A detailed technical programme, including estimates of time, cost and technical input, is worked out between DOS and the overseas survey authorities; and the programme itself forms the basis of a memorandum of understanding or of an official agreement that is signed jointly by the United Kingdom and by the overseas Government concerned. Joint projects have the advantage of building up and developing the local department and of providing training in modern production techniques for staff at all levels during the course of the work. Such projects are normally managed by sending a DOS project manager and senior technical staff to work alongside counterpart officers in the local department, while selected senior staff from overseas and trainees come to DOS headquarters for short liaison visits and practical attachments.

*Secondment of staff*

It is an important part of the United Kingdom aid programme to second professional and technical staff to overseas countries to help build up new departments, introduce new techniques and equipment, and launch and supervise specific projects.

To assist in this scheme, DOS has an additional complement of 20 posts (14 surveyor and six cartographer) classified as the Expanded Home Base. These additional posts enable the Directorate to provide staff at all levels for secondment for limited periods to the service of overseas governments. In the past they have worked in local departments as chief surveyors, training officers, assistant directors, chief draftsmen and reproduction officers; and they have acted as district surveyors and supervised individual tasks such as precise levelling schemes.

*Training*

The Directorate provides some training facilities for overseas personnel at its headquarters; and it also advises the Ministry of Overseas Development and the British Council on the most suitable courses for applicants for technical co-operation training awards in land surveying, cartography, photogrammetry, photography, computing, printing and allied subjects.

Training at DOS headquarters is at technician level. *Ad hoc* courses, mainly in cartography, photography and photogrammetry, are arranged to meet the requirements of individual departments and individual trainees. Training is primarily practical and it does not lead to an academic qualification; it is given at all levels from new entrant to deputy director. All trainees must be sponsored by their own Government; they must be able to speak, write and understand English and they must be financed either by a United Kingdom technical co-operation scheme, by a United Nations award or by their own Government. In the last two cases charges are raised

for the training courses. Arrangements can also be made for suitably qualified trainees to attend a part-time college course leading to the Ordinary National Certificate (ONC) in surveying, cartography and planning while they are doing their concentrated specialist training at DOS. (With the current reorganization of technician training in the United Kingdom, the ONC will in due course be superseded by a similar new Technician Education Council certificate.)

### *Information*

Technical data and information are disseminated widely and made available to inquirers. In particular, information on new techniques and production procedures and the results of tests and experiments carried out at DOS on materials and equipment are made available to overseas survey departments; information of wider scientific interest is written up in the appropriate technical journals, in contributions to international conferences and in the publications mentioned in a later section of this paper.

The resources of the Directorate's libraries, which contain unique collections of maps, aerial photographs and survey records, are normally available for consultation by public, private and international organizations working in the developing countries. The library holdings relate to the countries for which DOS has worked; and copies of the photographs, maps and records are only released with the permission of the country concerned.

## United Kingdom technical co-operation

### *Technical co-operation schemes*

The Directorate's services are provided as part of the over-all aid programme of the United Kingdom to help the economic and social development of developing countries. Most of the survey and mapping projects on which it works are financed under United Kingdom technical co-operation arrangements. These require that the overseas country shall contribute towards the cost of the project: the contribution is normally of the order of 15 per cent and is paid sometimes in cash but preferably in services to the project, e.g., field completion of mapping.

### *How to request DOS assistance in land surveys and mapping*

The technical details of proposals can be discussed with the Director of Overseas Surveys or his representatives as described above. Requests for assistance and official projects must be submitted on a Government-to-Government basis through the appropriate British Embassy or High Commission; these diplomatic missions are each responsible for the administration of the British aid programme overseas and they will forward requests to the Ministry of Overseas Development. The Ministry itself maintains five regional Development Divisions overseas primarily to advise and assist British missions within their region.

Requests for training must be channelled through the local British Council representative, or in countries where there is no representative, through the British Embassy or High Commission.

## Publications and addresses

### *DOS publications*

Topographic maps produced by DOS are available from the survey authorities in the country concerned. Most of those printed in the United Kingdom are also available from the DOS sales agent, and copies of dye line series can be purchased from DOS headquarters.

The *Annual Report* of the DOS is obtainable from the agents of HM Stationery Office and the *Proceedings of the Commonwealth Survey Officers' Conference*, which are published every four years, are obtainable from DOS.

## ANNEX

### Useful addresses

The Directorate of Overseas Surveys
Kingston Road
Tolworth, Surbiton, Surrey, United Kingdom, KT5 9NS

The Ministry of Overseas Development
Eland House, Stag Place, London, United Kingdom, SW1E 5DH

British Development Division in the Caribbean
Carlisle House
Hincks Street (P.O. Box 167)
Bridgetown, Barbados, West Indies

East Africa Development Division
c/o British High Commission
Nairobi, Kenya

Middle East Development Division
c/o British Embassy
Amman, Jordan

British Development Division in Southern Africa
P.O.Box 30059
Lilongwe 3, Malawi

South East Asia Development Division
c/o British Embassy
Bangkok, Thailand

DOS Sales Agent:

Edward Stanford Ltd.
12/14 Long Acre, London, United Kingdom, WC2E 9LP

# INTERNATIONAL TRAINING IN REMOTE SENSING*

*Paper presented by the United States of America*

The training and assistance programme at the Earth Resources Observation Systems (EROS) Data Center, Sioux Falls, South Dakota (United States of America), is designed to provide for the transfer of remote-sensing technology to land managers and resource specialists, both domestic and foreign. The programme does not emphasize research and development (i.e., sensor development, feasibility analysis, applications research etc.) nor does it provide services to operational remote-sensing applications projects. Instead, the objectives of the programme are to comprehend, interpret, assess and translate state-of-the-art remote-sensing techniques and transfer to users those techniques in such a manner that they can be easily understood. The purpose of this paper is to describe briefly the user assistance programmes available at the EROS Data Center, with emphasis on the international activities.

## TRAINING

Formal training on the applications of remote-sensing techniques is offered at the EROS Data Center. In general, three types of training programmes are given: orientation sessions; discipline or technique workshops; and complete organized courses. The orientation sessions are introductory short courses (from one to three days). The discipline or technique workshops usually last from three to five days and concern specific, basic or advanced subjects. The complete organized courses concern specific, basic or advanced subjects and vary in length from a week to several weeks. During the past year, more than 700 persons have participated in 30 training sessions given by the Data Center staff.

In response to increasing interest by foreign countries in the uses of remote-sensing technology for earth resources inventory and assessment, an international remote-sensing workshop series has been developed, consisting of two four-week sessions held at Sioux Falls each year. The international workshops are introductory and are designed to give participants some familiarity with various remote-sensing systems—i.e., their characteristics, limitations, advantages and applications—as well as some experience in analysing several forms of imagery to produce an environmental data base or other useful product. Emphasis is placed on the analysis of LANDSAT (formerly called ERTS, or Earth Resources Technology Satellite) imagery. Attention is also given to other imaging forms, such as aerial photography, thermal infra-red imagery and radar imagery.

In addition to discipline-oriented studies, the international workshops provide instruction in multidisciplinary and interdisciplinary uses of remote-sensing data. Candidates for the workshops generally have backgrounds or assignments in one or more of the following disciplines: agriculture; engineering site selection and evaluation; forestry; geography (including land-use planning and demography); geology; hydrology; range management; soil science. The international workshops are designed to present the basic principles of optical image analysis. They do not include advanced theoretical work or computer-aided image analysis and thus are not appropriate for those seeking training in computer-assisted applications.

The four-week international workshop programme consists of class-room lectures, demonstrations, workshop exercises, homework and field-work in the analysis of LANDSAT images and other image forms. Workshop exercises include the study of imagery and its applications to North American environments as a basis for studying LANDSAT imagery of the participants' countries. A field trip to the Black Hills of western South Dakota provides the means for gaining experience in field data collection and to verify many of the interpretations made during the workshop exercises. Lastly, an important part of the international workshop is interpretation of LANDSAT imagery of areas selected by the participants, preferably an area where the participant is working or has worked.

Thus far, seven international workshops have been given, in which 185 scientists from 55 countries have participated; and two more are scheduled for the calendar year 1977, in May and September.

## EDUCATIONAL AIDS

Another element of technology transfer at the Data Center is preparing complete and concise training aids commensurate with the training programme. Workshop exercises are prepared to give each student hands-on experience with data obtained by remote sensing. Each exercise poses a problem to be solved with well-chosen images, and 25 exercises are used during each international workshop. For example, an exercise on "Application of PPS sampling to estimate acreage of forest land with satellite and aircraft data" gives the student a basic understanding of probability notation; simple random sampling and sampling based on probability proportional to size (PPS). The exercise also demonstrates the theory and application of PPS sampling for estimating the acreage of forest land. Copies of all workshop exercises, including images and overlays, can be ordered from the EROS Data Center; however, these items are not stand-alone documents but supplement class-room discussions.

## CO-OPERATIVE DEMONSTRATION PROJECTS

Another component of the EROS Data Center training and assistance programme is a series of demonstration

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projects in co-operation with federal and state and other governmental user agencies. These projects help transfer remote-sensing technology to users interested in mineral resources, civil works, land use, forestry, range management, agriculture and soils, and water resources.

The primary criterion for a demonstration project is for a user agency to actually perform the work, with the Data Center providing technical assistance and equipment. Each project demonstrates the utility of remote-sensing technology for solving a resource inventory or monitoring problem, and the procedures are documented and published.

Among current demonstration projects is a co-operative effort under the Environmental Impact Assessment Program. The primary objective is to document remote-sensing techniques for monitoring changes in phosphate strip-mining.

## Data analysis laboratory

A key element in the Data Center training and assistance programme is an advanced digital image-analysis system within which earth scientists can be trained effectively. Software is continuously being improved to aid resource managers.

The laboratory serves as a focal point for leading earth scientists and representatives of user organizations to apply current techniques to a variety of earth resources problems.

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