CENTRES FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION

Education Curricula

United Nations

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CONTENTS

Explanatory notes

The following abbreviations and acronyms appear in this publication:

AOCS	Altitude and orbit control subsystem
APT	Automatic picture transmission
ARABSAT	Arab Satellite Communication Organization
AVHRR	Advanced very high resolution radiometer
BW	Bandwidth
C/N	Carrier to noise ratio
C-band	5.725 – 7.075 GHz (high frequency end)
CAT	Computer aided teaching
CGCM	Coupled Global Atmosphere—Ocean Model
CHINASAT	Chinese Communication Satellite
CO	Carbon oxide
CO_2	Carbon dioxide
CS	Communication satellite
CZCS	Coastal zone colour scanner
DBS	Direct broadcasting satellite
DCP	Data collection platform
DCS	Data collection system
DIP	Digital image processing
DRS	Direct reception system
DWS	Drop-wind sonde
EIRP	Equivalent isotopically radiate power
EMI	Electromagnetic interference
ENSO	El nino southern oscillation
EPIRB	Emergency position indicating radio beacon
ERS-1	ESA remote sensing satellite
FM	Frequency modulation
G/T	Gain/temperature
Gb	Gigabyte
GCOS	Global climate observing system
GIS	Geographic information system
GMS	Geostationary meteorological satellite
GOES	Geostationary operational environmental satellite
GOOS	Global ocean observing system
GPS	Geo positioning system
GrADS	Graphical analysis and display system
GTOS	Global terrestrial observing system
H-F	High frequency
HDTV	High definition television
HIRS-2	High-resolution infra-red sounder
HPA	High power amplifier
HRPT	High-Resolution picture transmission
IF	Intermediate frequency
IGBP	International geosphere-biosphere programme
INMARSAT	International Mobile Satellite Organization
INSAT	Indian Satellite
INTELSAT	International Telecommunications Satellite Organization
IR	Infra red
ITU	International Telecommunication Union
LAN	Local Area Network
LANDSAT	Land remote sensing satellite

LEO	Low-Earth Orbit
LNA	Low noise amplifier
LNB	Low noise block converter
LUT	Local user terminal
MAC	Multiplexed analogue component
McIDAS	Man computer interactive data access systems
METEOR	Russian Remote Sensing and Meteo Satellite
METEOSAT	European Meteo Satellite
MSS	Multi spectral scanner
MSU	Microwave sounding unit
NOAA	National Oceanic and Atmospheric Administration
NTSC	National Television Standards Committee
OOSA	Office for Outer Space Affairs (of the United Nations)
PAL	Phase alternate line
PALAPA	Indonesian Communication Satellite
PLB	Personal locator beacon
RADARSAT	Canadian Remote Sensing Satellite
RS	Remote sensing
SAC	Science Advisory Committee
SAR	Synthetic aperture radar
SARSAT	Search and Rescue Satellite Tracking System
SECAM	Sequential Couleur A Memoire
SITE	Satellite Instructional Television Experiment
SNG	Satellite News Gathering
SPOT	Experimental Earth Observation System
SSU	Stratospheric Sounding Unit
TDMA	Time-division multiple access
TDRSS	Tracking Data Relay Satellite System
TIROS	Television and Infrared Observation Satellite
TM	Thematic mapper
TOVS	TIROS Operational Vertical Sounder
TTC	Telemetry, Tracking and Command
TV	Television
UHF	Ultra high frequency
UNCED	United Nations Conference on Environmental and Development
UV	Ultra violet
VISSR	Visible and infrared spin scan radiometer
VLF	Very low frequency
WARC	World Administrative Radio Conference
WEFAX	Weather facsimile

INTRODUCTION

In response to the General Assembly's endorsement of the recommendation of UNISPACE 82, that the United Nations Programme on Space Applications should assist member States in enhancing their indigenous capability at the local level, the Office for Outer Space Affairs developed a proposal for the establishment of Centres for Space Science and Technology Education in the developing countries. The objective of these Centres is to enhance the capabilities of member States, including those in Africa, in different areas of space science and technology that can advance their social and economic development. Thus, each of the Centres will provide in-depth education, research and application programmes with initial emphasis on remote sensing and GIS, satellite communications and global-positioning systems, satellite meteorology and atmospheric sciences, for university educators, research and application scientists. The concept of the Centre calls for it to offer the best possible education, research and applications experience to the participants in its programme. Permanent and visiting staff from countries both within and outside the region would contribute to the attainment of these elements of the Centre's programme. This proposal was presented to the Committee on the Peaceful Uses of Outer Space (COPUOS) through its Scientific and Technical Subcommittee at their 1990 session.

The General Assembly (GA), in its resolution 45/72 of 11 December 1990, endorsed the recommendation of its Committee on the Peaceful Uses of Outer Space, that "....the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort to establish regional centres for space science and technology education in existing national/regional educational institutions in the developing countries" (A/AC.105/456, annex II, para. 4(n)). This decision was taken in recognition that an essential pre-requisite for the successful implementation of space technology applications is the building of various essential indigenous capacities, particularly human resources, within each region. Specifically, if effective administrative and appropriate applications of space technology are to succeed in the developing countries, and particularly if such discipline as remote sensing is to transcend its current image of being a technology-driven tool into a user-driven one, efforts must be devoted, at the local level, to the development of necessary high-level knowledge and expertise in space technology fields.

The United Nations Office for Outer Space Affairs (OOSA) has taken a number of steps to translate the aforementioned GA resolution into an operational programme. A summary of the first steps taken by OOSA in connection with the establishment of the centres was prepared in early 1992 as United Nations document (A/AC.105/498). An updated project document (A/AC.105/534) on the same subject was issued in January 1993.

Goal of the Centre

The concept of each Centre dictates that such an institution shall offer the best possible education, research and applications experience to its participants in all its programmes. Thus the principal goal of each Centre is the development of skills and knowledge of university educators and research and applications scientists, through rigorous theory, research, applications, field exercises, and pilot projects in those aspects of space science and technology that can enhance social and economic development in each country.

Each Centre's initial programmes shall focus on (i) remote sensing and geographic information systems, (ii) meteorological satellite applications, (iii) satellite communications and global-positioning systems, and (iv) atmospheric sciences. Its Data Management Unit shall be linked to existing and future relevant global databases. Each Centre shall also foster continuing education programmes for its graduates, and awareness programmes for policy and decision-makers and the general public.

WORK PROGRAMME OF THE CENTRES

The activities at each Centre will be undertaken in two major phases. Phase 1 will emphasize the development and enhancement of the knowledge and skills of university educators and research and application scientists in both the physical and natural sciences as well as in the analytical disciplines. This will be accomplished through rigorous theory, research, applications and field exercises over a nine-month period as laid out in the curricula of the education programme of each Centre. Phase 2 will focus on ensuring that the participating scholars apply in their pilot projects the skills and knowledge gained in phase 1. The pilot project is to be conducted over a one-year period in the scholars own country. The activities and opportunities provided in the two phases should adequately equip these scholars (educators and research and applications scientists) to introduce relevant aspects of space science and technology into existing education curricula as well as to contribute significantly to development programmes in their countries. Each of the Centres for Space Science and Technology Education should also: contribute to sustainable development of natural resources (air, water, land); provide a crucial supplementary input for bio-diversity conservation and other related environmental programmes; and improve the overall development of the national technological base, including that of the telecommunications industry.

Each Centre's initial programmes shall focus on ***remote sensing and geographic information systems, meteorological satellite applications, satellite communications and global-positioning systems, and atmospheric sciences.*** Its Data Management Unit shall be linked to relevant global databases. Each Centre shall also foster continuing education programmes for its graduates, and awareness programmes for policy and decision-makers and the general public in each region. These Centres should result in the development and growth of capacities that will enable each of the participating developing countries to enhance its knowledge, understanding and experience in those aspects of space science and technology that could have a greater impact on the country's economic and social development including the preservation of its environment.

In phase 1, scholars participating in the programme will be at each Centre for a period of nine months. During this time, the Centre's academic programme will emphasize the development and enhancement of the knowledge and skills of the participating scholars in the physical sciences and analytical disciplines. This phase 1 academic programme, consists of both a common module (see page 5) as well as a specific area of the scholar's interest in one of the disciplines identified in the above paragraph of this work programme. The specific area of interest programme will include appropriate academic lectures, laboratory exercises, tutorials and field work. Thereafter, the scholars will proceed to their respective countries to carry out their field work for a period of one calendar year. This will constitute the second phase. Scholars are expected to make use of the knowledge and skills they have gained in phase one of their pilot projects. Subsequently, scholars will make a formal presentation of the results of their pilot projects at a special seminar organized for that purpose at the scholar's Centre.

ESTABLISHMENT OF CENTRES FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION

The Governing Board

In the context of these Centres, a Governing Board is the overall policy making body of the Centre; it oversees every and all aspects of the Centre. It consists of member States (within the region where the Centre is located), that have agreed, through their endorsement of the Centre's agreement, to the goals and objectives of the Centre, and are fully committed to work, in cooperation with other member States of the region, for the well-being of the Centre.

A Governing Board, composed as described above, is necessary for each of these Centres because member States and their own citizens are more familiar with their own peculiar needs, aspirations, capabilities and resources, and are better equipped to find solutions to local problems that may surface. No part of the United Nations System, including the regional economic commissions, is equipped to address such an array of issues, particularly within the framework of these Centres.

Accordingly, once a host country is identified for the Centre in a given region, the process of establishing the Centre's Governing Board, spearheaded by the host country itself, is set in motion. It should be noted that resolution 45/72 specifically limits the role of the United Nations "to lead international efforts to establish these Centres", accordingly, once the location of the Centre is identified, its Governing Board will assume all decision-making and policy formulation responsibilities of the Centre. And because such a Centre has evolved through the efforts of the United Nations, the United Nations Office for Outer Space Affairs, including the concerned regional economic commission, shall serve the Centre and its Governing Board in an advisory capacity.

Curriculum development

The United Nations has developed model curricula for these Centres. The initial work on these curricula was accomplished at a Workshop that was organized and hosted by the Government of Spain in Granada in February/March 1995. In order to attain international recognition and certification, this finished model curricula will provide each Centre with a benchmark of the academic level necessary to maintain the international standard and character of the programme as well as the Centre.

In addition to providing opportunities for each scholar to gain the necessary knowledge, research experience and application skills in his/her chosen areas of space science and technology, the model curricula also requires that such individuals complete the obligatory common module at the beginning of their studies at the Centre. The successful completion of this initial obligatory module, which is the same for all participating scholars, is a pre-requisite to the enrolment of each scholar in his/her chosen field of study. This common module will provide all the scholars with an overview of the observation of the Earth and its environment from space and use of data collected in such a process through atmospheric and terrestrial analysis. The common module will also expose the scholars to the physical principles of remote sensing; satellite orbital characteristics; operational sensor systems; satellite and ground based communications; the impact of global positioning systems on the integration and construction of remote sensing and GIS databases and demonstration of selected environmental applications.

The participating scholars

Prerequisites

A sound academic background, experience and aptitude of each applicant in engaging in the different activities of the Centre cannot be over-stressed. The richness of these attributes will have a positive impact on the applicant's performance at the Centre. Towards this end, each applicant (university educator, research or application scientist) should have obtained, from an internationally recognized university/institution, a minimum of a master's degree, relevant to his/her chosen field of study, followed by a minimum of five years of relevant practical/working experience. An applicant with a Ph.D. degree, relevant to his/her chosen field of study, and from an internationally recognized university/institution should also have completed a minimum of three years of practical/working experience.

The academic qualifications, experience and other requirements of each applicant, depend upon the specific field of space science and technology to which the scholar is seeking admission. However, regardless of the field, the scholar should be in a position to comprehend promptly the programme he/she is applying for. Towards that end, it is highly desirable for the scholar to have practical experience in teaching (for educators) or in research (for research scientists) and applications (for application scientists) related to one or more of the major fields of space science and technology at the postgraduate level. The minimum entrance criteria is listed under each space science and technology discipline.

Post-centre activities

Of equal importance is the future of the participating scholars in their own countries on the completion of their studies at the Centres. It should be emphasized that the overall mission of the Centres is to assist participating countries to develop and enhance the knowledge and skills of their citizens in relevant aspects of space science and technology so that such individuals can effectively contribute to national development programmes. In order to ensure that appropriate and rewarding employment opportunities exist for these returning scholars, the sponsoring governments/institutions are obliged to sponsor development-oriented activities that will gainfully utilize the newly acquired knowledge and skills of the returning scholars.

Thus, the sponsoring government/institutions should provide appropriate infrastructure and undertake requisite preparations and plans for the careers of the returning scholars on a long-term basis. The sponsoring government is also obliged to guarantee that the returning scholar will remain in such a position with commensurate and progressive remuneration and other entitlement for a minimum period of 3-5 years.

Commitment by the Centres

The Centres are required to set up the necessary infrastructure, both in terms of the administrative arrangements, material facilities and academic and support staff that will enable the implementation of the curricula.

Centre personnel

The Director and Assistant Director shall have international reputations in space science and technology and proven administrative and leadership skills. The academic staff shall be of the highest calibre. The United Nations will work with the governing board to establish an academic peer review committee for the Centres to review their programmes on a regular basis.

Target audience

The programme of the Centre's will be directed towards the following categories of professionals:

- University educators and researchers
- Telecommunication professionals and specialists
- Systems managers, engineers and planners

Curriculum outcome

It is anticipated that at the end of the programme, participating scholars will be able to:

(a) Serve as focal points for furthering the skills and knowledge of other professionals in their countries;

(b) Contribute to policy-making, planning, development and management of operational satellite-based communications systems in their countries; and

(c) Enhance and increase the self-reliance of their countries so as to lessen dependence on external experts.

Assessment of scholars

The performance of the scholars in the Centre's programme shall be assessed through the following mechanism:

- Continuous assessment—this will take the form of bi-weekly assignments and monthly tests.
- Oral and written examinations at the end of the programme.
- Assessment of the pilot project—this will include an evaluation of reports and a presentation of the research project outline that is proposed to be executed during the next year.
- Assessment of the final project which will take place at the end of the one-year research project in the scholar's home country.

It is important to recognize that specialists participating in the programme carry a heavy responsibility to excite, inspire, motivate, and inform their countrymen about the unique opportunities that access to satellite observation data and services can provide. Along with this responsibility comes the recognition that these specialists can also make a personal and measurable contribution to the education and socio-economic development of an entire country. These responsibilities must therefore, be taken very seriously.

For the successful completion of the Centre's programme, each scholar will carry out an approved research project in his/her home country for a period of one-year. The ability to complete such research will depend on the available facilities at the scholar's home institution; the thorough preparation received at the Centre; and the support and encouragement given by senior personnel at the home institution. No scholar will have completed the Centre's programme until the research project has been completed and formally presented to and certified by the Centre.

The success of the programme will be measured by the impact the scholars will have upon their return to their home institutions and country. The relevance of the pilot project to be developed and the support the scholars will receive locally to accomplish the overall objectives of the proposal are the critical elements in this context. The project proposal will be jointly formulated by the scholars and their advisors at the Centre. The support for the development of the project and the continuity of the activity in the home country are the responsibilities of the scholar's home institution together with the advisor's guidance.

COMMON EDUCATION MODULE

This module will be completed by all participating scholars as the first phase of their work soon after their enrolment to the Centre's programme. The purpose of this module is to present an overview of how information is acquired through satellite technology for its use in atmospheric and terrestrial analysis. The common education module should include the following topics:

- Physical principles of the electromagnetic spectrum; reflectance, absorption and transmission of energy from Earth surface materials.
- Orbital characteristics, satellite systems, platform and sensor description.
- Acquisition, downloading, ground reception and transfer of satellite data; basic rectification, registration, calibration and atmospheric corrections.
- Classification, assessment and management of terrestrial surfaces; monitoring surface change; incorporation of remotely sensed data in model prediction of biophysical and geophysical surface parameters such as bio-mass, crop yield, soil moisture and mineralization.
- GIS data structures, output and display functions; development of global positioning survey techniques; coordinate systems; integration of remote sensing and GPS data.
- The contribution of satellite remote sensing and spatial information technologies to provide a quantitative understanding of the Earth's environment including global biosphere and climatic changes.
- Basic elements of satellite communications.
- Legal, political, and financial aspects of space science and technology; international and global scientific programmes.

REMOTE SENSING AND GIS CURRICULUM

Introduction

A remote sensing applications programme is a specific component of space science and technology education. It stresses the fact that remotely sensed data provides an ideal view of the Earth for many studies which require synoptic or periodic observations such as inventory, surveying and monitoring in agriculture, forestry, range management, geology, water resources and the urban environment.

Remote sensing observations make use not only of visible light, but also of several other portions of the electromagnetic spectrum such as infra-red, thermal and microwave regions. Different techniques may be required to handle and analyse these different types of data. Much of this data is in digital form and can be processed using computer techniques to improve the visual appearance or to extract the required information.

The programme covers the technology of image acquisition, digital image processing, geographical information systems, ground data collection and use, image interpretation, project planning and management. The programme includes practical work and offers participants the opportunity to acquire proficiency in the use of image processing and GIS software.

The first part of the course is broadly based in order to give students exposure to as different techniques, instrumentation, and types of data. Here, a thorough background of the physical principles involved is provided. In the second part of the programme, students explore different applications of remote sensing and specialize in a specific application to suit their own experience or needs.

A fundamental requirement of Agenda-21 of UNCED is to support sustainable development while safeguarding the Earth's environment. This will require optimal management of natural resources and it depends upon the availability of reliable and up-to-date information at national and regional levels. Remotely sensed data play an increasingly important role as a source of reliable and timely information needed for sustainable management of natural resources and for environmental protection. Through GIS, remote sensing data can be integrated with data from other sources and facilitate the efforts of resource managers, planners and decision-makers to obtain the relevant information they need.

Agenda-21 of UNCED emphasizes the urgent need for filling the geographic information gap in developing countries, and it recommended that advanced information technologies including remote sensing and GIS be used to achieve this goal.

Objectives

The main objective of the Centres is to strengthen the regional remote sensing/GIS capacities and to reflect upon the priorities and conditions of develpping countries in the postgraduate education and research work conducted at the Centres (A/AC.105/534, pages 16-17). Specifically, in remote sensing and GIS, the Centres should:

- Contribute to capacity building in the region;
- Contribute to breaking the current gridlock in the operational use of remote sensing and GIS;
- Promote the utilization of remote sensing satellite data and technology towards environmental applications;
- Prepare scientists and professionals from the region to take more active roles in developing equipment, software, and application techniques specifically adapted to the needs of the region; and
- Strengthen the capacity for South-South-cooper establishment of networks between institutions involved in remote sensing activities in the region.
- The curriculum aims to teach such principles that will enable each scholar to apply them with any type of system or software he/she has available.

In order to achieve these objectives, the following should be implemented:

- Finalization of the nine-months phase 1 curriculum.;
- Preparation, at the Centres, of short thematic programmes on remote sensing/GIS applications of special interest to the region;
- Establishment of cooperative agreements with accredited University for the joint execution of research in the remote sensing/GIS domain between University staff and scholars in the Centre;
- Provision of regional research facilities for remote sensing/GIS studies which cannot be undertaken by national institutions (e.g. for lack of equipment or capacity);
- Serve as a regional focal point for international programmes involving remote sensing, such as the Global Terrestrial Observing System (GTOS), the Global Ocean Observing System (GOOS), the Global Climate Observing System (GCOS), and the International Geosphere -Biosphere Programme (IGBP);
- Assurance of access to all data dissemination and management systems of relevance to the Centre´s curriculum.

Curriculum structure

The programme will consist of a nine month programme at each Centre, followed by the implementation and completion of a one-year research project in the scholar's home country.

At each Centre, scholars will participate in a programme of instruction designed to increase their scientific knowledge in the uses and applications of remotely sensed data and geographic information systems. The scholars shall also develop and extend their computational and analytical experience in order to allow them to initiate and implement the benefits of this science and technology in their home countries.

In order to achieve this, participating scholars will come to the Centre with a pilot project proposal which is significant to their home country and sponsoring agency. The design and methodology of their research will be refined and developed under the guidance and supervision of the Centre to enable the scholars to implement and sustain the research in their home country.

The programme at the Centre will include a common module in which an overview of the concepts of remote sensing and GIS are presented. This common module will be completed by all participating scholars.

Scholars in the second module will then be able to focus on the applications of remote sensing and digital image processing complemented by a series of practical exercise. Scholars will be able to master the computational and analytical skills necessary to process, interpret and apply these data.

The focus in the latter part of the programme is placed on the scholar becoming proficient in implementing selected applications of remotely sensed data, particularly those applications related to the chosen pilot project.

The programme will be for a nine-month period divided into three month modules of 12 weeks each, with one week break at the end of each module. The outline and specifications for each individual module is presented below:

- Module 1—Common module for all scholars.
- Module 2—Applications of remote sensing. Parallel courses may be considered by the Centre for these fields of applications.
- Module 3—Pilot project preparation and formulation. This initiates the one-year research project to follow after the programme.

Module 1. Common module: Lectures and exercises.

Second module. Lectures and exercises in: elements of photo-interpretation; digital image processing; remote sensing applications in natural resources, surveys and the environment,

Third module. Pilot study, planning and execution: planning and design of a pilot project; pilot project implementation—remote sensing data analysis check, data integration, report writing; planning and design of a one-year research project

General prerequisites

The general prerequisites include, but are not limited to the following:

(*a*) Data for the pilot project in module 3 must be available; when a scholar does not have it, it should be acquired at or before the beginning of the first module.

(*b*) Availability of image processing and GIS systems.

(*c*) Familiarity with computer operation/usage and file structures.

(*d*) The countries participating in the Centre's work programme are expected to make available for the scholars, required materials such as maps, air photos, radar and space data in digital and analog format, specifically in relation to the one-year research project to be carried out after the nine-months programme. The participating country should agree with the Centre, the specifics of the execution of the scholar's one-year research project in his/her home country.

Evaluation, assessment and programme requirements

Analytical skills. Scholars completing this programme, will have developed skills on the necessary computer interactive systems and will have mastered the appropriate mathematical, physical and statistical skills to enable them to carry out independent research work. They will be able to understand and extract information from satellite data using mathematical and basic knowledge they have acquired through formal education and through their work at the Centre.

Knowledge of remote sensing data application. Upon completion of the programme, scholars will have an understanding of a wide variety of practical remote sensing applications in natural resources and the environment. They will also use and apply this information to a range of environmental applications including monitoring, surveying, managing and inventory of the Earth's surface as well as their effect on the economic and social well being of the people on Earth.

Equipment

The United Nations document A/AC.105/534 specifies most of the equipment that will be needed at the regional Centres to enable staff members to effectively educate specialists in the use of remote sensing technologies. However, there are certain items of equipment that are not contained in these specifications, but are essential in conducting this programme. Also, there are certain specialized products that were not included.

In this section, we identify the equipment or products that are needed as part of this programme including those that are already specified in the United Nations document A/AC.105/534.

1. Automated AVHRR station
2. Microcomputers (20) (with modems and CD-ROM players)
3. INTERNET capability
4. Facsimile machine
5. Data analysis work stations
6. Image processing work stations

7. Geographic Information Systems terminals
8. Laser and colour printers
9. Scanners
10. Plotters
11. Digitizers
12. Tape drives
13. Data files
14. Graphical analysis and display system
15. Radiometers
16. 35 mm camera
17. GPS reciever (with notebook video camera)
18. Topographic maps
19. Textbooks and manuals
20. Mirror stereoscope with parallax bar

The minimum infrastructure required for the pilot project

Hardware

Separate systems should be available for text processing on the one hand, and DIP/GIS on the other hand. Each system must be available for each scholar, with sufficient processing capacity and memory (> 1 Gb) for the DIP/GIS system. For the teaching staff, similar equipment must be available. Additionally, digitizer and scanners, as well as printers and quality hard-copy output equipment are essential.

A local area network (LAN) will facilitate operations; a variety of software systems (DIP/GIS) must be available to meet the needs of the scholars.

Field equipment, including GPS and that of field surveying, must be available, as well as classroom equipment. Also, light tables and stereoscopes for analog image analysis are required, as well as sufficient quantities of analog and digital imagery for classroom use.

During the one-year research project, the scholar must be in touch with the Centre through an international network connection.

Software

Major internationally available image processing and GIS systems should also be made available to the scholars and Centres' staff. Teaching will concentrate on the principles that are applicable to a number of systems.

Computer-aided teaching material (CAT) may be considered for use in the Centres. Access to library materials (including books, journals etc.) through the Centres is essential.

Operation and management of the remote sensing satellite applications programme

The remote sensing applications programme of the Centre will require specific personnel, equipment and facilities in addition to those already available at the host institution. Specifically, it requires a full time dedicated person that will act as a facilitator or coordinator of the programme, laboratory instructors and a number of lecturers that may be invited from local institutions from the region as well as from abroad to review and advise on projects, serve as instructors, deliver special lectures and participate in seminars, as may be necessary.

Specifications for the curriculum

First Module

Common Module (specified for the field of remote sensing) objective: The objective of this module is for the scholars to obtain a general knowledge of the basic tools and principles in remote sensing and GIS so that they can later, in module 2, be utilized for specific applications.

Physical principles of remote sensing

Electromagnetic Energy: electromagnetic spectrum, generation, wave model, Doppler effect, polarization

Propagation of electromagnetic energy: dispersion, scattering, absorption, refraction and reflection

Interactions between electromagnetic radiation and matter in the atmosphere and on the Earth's surface (emission of radiation): emissivity, black bodies, Stefan's Law, Kirchoff's Law, Wein's Law, Planck's Law

The nature of physical processes involved between radiation and matter: properties of the atmosphere, constituents, contaminants, lapse rate, clouds, atmospheric sounding, scattering mechanisms, temporal variations

Characterization of EM radiation through its frequency and intensity: thermal sensing, albedo, reflection, Snell's Law, absorption, spectral signatures, photo-electric effect

Platforms sensors and systems

Platforms

General overview of applicable technologies: aircraft, satellite: classification by orbit, applications, advantages and disadvantages, type of observation, orbital dynamics

Satellites found in each orbit and their specific purpose: geostationary: METEOSAT, GEOS, etc.; sun-synchronous: LANDSAT, TIROS/NOAA, NIMBOS, IRS, MOMS, SPOT, SEASAT, ERS-1, TOPEX-POSEIDON, etc.; polar platforms:

Future satellites

Ground configuration

Sensors

Wavelength classification

Fundamentals of sensor technology: imaging/non-imaging, active/passive, advantages and disadvantages

Overview of remote sensing instruments: non-imaging: infra-red radiometer, microwave radiometer, scatterometer, altimeter, etc.; imaging: photographic, historical, camera systems, film types, multispectral photography

Scanners/imagers: electro-optical, spin, scan, pushbroom, video, multispectral

Examples of satellite/aircraft imagers: satellite: AVHRR, CZCS, MSS, TM, ATM, HRV, spin scan radiometer, ATSR, Seawifs, etc.; aircraft: ATM, Moniteq, CASI, thermal linescan, GERS, video systems, imaging spectrometers.

Microwave sensors: SLAR, SAR, etc.

Programming

Programme writing in either C or Fortran is essential in order to be able to develop the necessary algorithms that manipulate images. Programming therefore, relates directly to the image processing part of this course.

Digital image interpretation

Statistical concepts: average, median, modal, standard deviation, covariance matrix, eigenvalues, eigenvectors, principal component analysis, etc.

Classification techniques: spectral distances, probabilities, error analysis, clusters, training areas, sampling methods, extrapolation

Modelling: forecasting

Elements of digital image processing and preprocessing: radiometric, geometric and atmospheric corrections

Image enhancement techniques

Overview of geo-informatics

Prerequisite: Physical fundamentals of remote sensing statistical concepts of remote sensing. Model objective: to provide scholars with a good understanding of those elements of geo-informatics which are needed for the planning and execution of remote sensing projects.

Geo-referencing of remotely sensed data: reference ellipsoids, cartographic projections, coordinate systems, Global Positioning Systems (GPS), types, scales and accuracies of maps

Introduction to Photogrammetry and Videography: aerial photography, photo-interpretation, analogue photogrammetry, digital photogrammetry, videography

Geographic information systems (GIS)

GIS principles concepts and principles of GIS, GIS components, data versus information, GIS data processing, methods of data representation, GIS data input, output and integration

Geographic Databases: assessment of data accuracy, editing of geographic data, database creation procedures, data integration and database management, data conversion (digitization, scanning), basic spacial data processing, query processing, maintenance analysis of spatial and attribute data, data sources, structure, characteristics and quality requirements

Cost benefit analysis

Concepts for estimation of costs and benefits during the formulation of projects as well as for the assessment after the completion of a project. These include the critical path analysis and quantitative analysis of economic, environmental and social impacts.

Second Module

Elements of photo-interpretation

Stereoscopy: theory and lens of stereoscopes

Parallax: measurements and height determination, parallax equation, accuracy, parallax bar, base/height ration

Recognition elements: image analysis; interpretation elements; metric correction and transfer of interpretation data; interpretation of scanned data

Digital image processing

Image enhancement: histograms, contrast stretching, transfer functions, histogram equalization, histogram specification

Image classification: supervised and unsupervised classification, density slicing, spectral signatures

Filtering: low and high pass filters, Ideal filter, Butterworth filter, exponential filter, trapezoidal filter, smoothing

Systems: display devices, interaction devices, hard copy devices, colour, selecting a system; geo-referencing; image registration; overlays; time series; radar processing; data fusion; digital elevation (terrain models); stereo image generation; integration of remote sensing data into GIS; further advanced techniques

Remote sensing applications in natural resources, surveys and the environment

Natural resources inventory and evaluation: resource utilization, information systems, monitoring, integrated approaches in eco-development, ecosystem concepts, bio-mass and productivity, landscape analysis, land-use systems, wasteland management, information management and planning tools

Non-renewable resources: building materials, mineral resources, environmental aspects of mineral resource extraction

Sustainable development: concepts and definitions, pollution of land, water, ocean and the environment, urban sustainability, Agenda 21 concepts

Environmental monitoring

Resource Management: integrated approach

Earth processes: climatic and bio-physical processes, atmospheric interaction

Survey and monitoring of natural hazards: disaster monitoring, mitigation and prediction, early warning systems

Geological and structural surveys:

Water resources surveys: groundwater detection

Processing requirements for specific job interpretation

Data requirement for specific jobs: resolution and system requirements

Stereo requirements: season, shadows, side-look effect

Multi-temporal data: crop calendar, season

Level of pre-processing required: geo-referencing

Multi-source data

Interpretation techniques applicable to the particular remote sensing technology and the job at hand

Use of data from meteorological satellites and similar sources: survey and monitoring of natural hazards, floods, drought, desertification, locusts, typhoons, and cyclones and other similar features

Practical exercises

Case studies in various fields will be discussed so that participants can integrate better remote sensing and GIS and apply them for decision making processes.

Third Module

Participants accepted into the programme are required to submit a preliminary project topic with their application. This preliminary topic should relate to specific in country needs and have the approval of the nominating agency.

The pilot project will be prepared and executed in consultation with the supervisor; alternatively, larger projects could be undertaken by a group of scholars. This will be the start-up of the one-year research project to follow after completing the programme which the scholar will undertake in cooperation with his/her home institution.

In addition to setting the aims and objectives of the project, this proposal will address research methodologies, resource requirements, costs and availability of funds, implementation and management of strategies, analysis and presentation of results, report writing and suggestion for further work.

Planning, design and cost of the project, including the preparation of a properly constructed and documented project proposal. Concepts such as critical path analysis, cost-benefit analysis and other management techniques will be applied; detailed coverage of the required use of satellite data, aerial photographs, maps, computer software and related equipment as appropriate should be included.

Projects may be executed in all relevant domains of remote sensing application. Most projects will go through phases of data acquisition—interpretation and field verification—integration and analysis. Often this will take place in a GIS environment. Output and visualization documents will supplement a written report. Evaluation of the results will be executed in consultation with the supervisor.

The pilot project will result in the design of a one-year research project which scholars will execute in their home institutions.

While course lecturers will provide supervision and expert guidance, participants will be expected to demonstrate independent thought and creative thinking in problem solving. One year after the completion of the formal course work, all specialists will return to the Centre to present the results of their research. Satisfactory completion of the programme requires the submission and presentation of the research project.

Home institution support

The institutional support required includes:

(*a*) The institutional recognition of the importance of the project in its overall aspects, the willingness to support a (small) group of scientists and technical personnel that might be needed for the project and future development of activities in the country;

(*b*) Basic data and reference materials on remote sensing applications;

(*c*) Satellite ground receiving stations and the required computational power and software adequate to the project, and line of activity the country/institution feels more suited to their needs and reality;

SATELLITE COMMUNICATIONS CURRICULUM

Introduction

Through specialized education and research, each Centre should assist its participating member States to acquire a higher capability in the development and transmission of knowledge related to satellite communications with a view to enhancing the indigenous national and regional capabilities in the utilization of satellite-based communications technology for sustainable development.

Specific objectives:

(*a*) Development of the skills of university educators, researchers, telecommunication professionals, government personnel, and others in the field of satellite communication and its applications to broadcasting, telecommunications, health-care, education, disaster, positioning, search and rescue etc;

(*b*) Assistance in preparing satellite-based communications projects, policy-definition and the establishment of communications systems;

(*c*) Provision of expertise in the use of operational systems and integration of advances in communications technology in day-to-day activities;

(*d*) Assistance in promoting intra- and inter-regional cooperation in utilizing and expanding the scope of communications technology; and

(*e*) Development and enhancement of public awareness on the benefits of satellite-based communication technologies in the improvement of the quality-of-life.

Curriculum structure

Satellite-based communications is the most effective medium for reaching out to the world and in bringing nations closer together into what is described as a "Global Village". It is against this background that the programme must provide scholars from developing countries with skills to appreciate the fullest potential of the technology. Consequently, this programme must cover the basics of communications systems and provide an in-depth orientation to the undertaking of projects in this field.

The programme will consist of nine modules—each covering specific areas of satellite-based communications technology. The broad structure of these modules is given below:

	Lecture	Laboratory	Total
Communications systems—an overview	75	–	75
Communications satellite systems	200	100	300
Earth station technology	75	75	150
Broadcasting using communications satellites	60	90	150
Development of education and training applications	60	90	150
Specialized applications and future trends	60	90	150
Operational communications satellite systems	50	25	75
Network planning, management and operational issues of communications systems	75	75	150
Pilot project	–	150	150
TOTAL	655	695	1350

The details of the modules contents are given below.

Minimum required equipment

To ensure that the programme is effectively implemented, the following equipment should be available at the Centre:

Basic laboratory equipment: power supplies, oscilloscopes, signal generators, power meters, attenuators, co-axial cables, frequency synthesizers, spectrum analyzers, personal computers, network analyzers, demodulators, modulators, wave guides, high power amplifiers, etc.

Subsystems (bus): power, attitude control, telemetry tracking and command (TTC), structure and thermal control.

Payload (transponders): solid state amplifiers, travelling wave tube amplifiers, multiplexer, diplexer, on board antenna, low noise amplifier, modulators, demodulator, local oscillators, IF amplifiers, etc.

Assembly, test and integration facilities: vibration table, shock table, thermal vacuum chambers, EMI test chamber, anechoic chamber, clean room, etc.

An experimental Earth station.

Specifications for the curriculum

Communications systems: common module for all scholars

Duration: 0.5 month/75 hours;

This module addresses the fundamentals and basics of communication technology and provides an overview of circuit and systems theory, microwave theory, communications theory, computers, space environment and a refreshment course in relevant areas of mathematics.

Communications satellite systems

Duration: 2 months/300 hours. 200 hours lectures and 100 hours exercises/lab

This module will encompass the technology of satellite systems and include the space segment with details of sub-systems, satellite communication services and techniques, frequency bands, orbit selection—LEO and GEO, transponders and sub-systems, integration and testing, satellite operational issues etc.

Elements of satellite communications system: space segment with details of bus subsystems, communications subsystems and satellite control centre and ground segment with details of communications Earth station and communications network control system. Power system, AOCS system and details, mission analysis, structure design, payloads, radiation effect on satellite.

Satellite orbits: Kepler's laws; types of orbits; ranging and satellite positioning; launching of satellites.

Geo-synchronous satellite communication system: Earth coverage and antenna beams; eclipse due to the Earth and Moon; solar interference.

Satellite communications services: fixed satellite services; broadcast satellite services; mobile satellite services; data collection services; search and rescue services; radio navigational services; VSAT networks; personal communications.

Frequency bands for satellite communications: satellite communications links with details of basic propagation theory, system noise temperature and G/T, C/N of up and down links, link calculations for analog and digital systems.

Satellite communication techniques: multiplexing techniques for analog and digital signals, analog and digital modulation and demodulation, multiple access techniques, encoding and error correction techniques.

Communication transponder: frequency conversion; characterization; beam inter connectivity; bent-pipe or regenerative type of transponder.

Communication transponder subsystems: antenna and feed systems; receiver; power amplifiers (TWTA and solid state); multiplexer; switch matrix; demodulator and modulator.

Satellite bus subsystems: attitude and orbit control; propulsion; TTC; thermal; electrical power structure.

Integration and testing: payload; satellite platform (bus); reliability and space qualifications.

Experiments/demonstration (spread over total duration): familiarization with payload subsystems; testing of communication payload subsystems - antenna radiation, pattern, coverage, receiver, power amplifier, multiplexer; integrated testing of communication transponder.

Lab/test facility: Earth station ground hardware labs; antenna test facility; spacecraft payload facility labs; communications systems lab; microwave integrated circuits labs; payload fabrication facility; environmental test facility; electronics fabrication facility.

Earth station technology

Duration: 1 month/150 hours. 75 hours lectures and 75 hours exercise/lab

The thrust of this module is on Earth station sub-systems, Earth station design considerations, system fabrication techniques, operations and maintenance of Earth stations, commercial aspects of Earth stations, planning for Earth stations, etc.

Planning for setting up an Earth station

Technology of Earth station subsystems: antenna and feed systems for large, medium and small Earth stations; antenna reflector and mount for large, medium and small Earth stations; tracking systems; low noise amplifier; solid state power amplifier; high power amplifier; frequency converter; modulator and demodulator; encoder and decoder; test loop translator; electrical power supply system.

Earth station design considerations: EIRP and G/T; antenna size and gain; radiation pattern and antenna coverage; redundancy and reliability.

Earth station subsystems: antenna measurements; LNA and G/T; HPA and EIRP; frequency converters; test loop translator; check-out of Earth station; reliability; frequency coordination.

Operations and maintenance of Earth station: deployment and operations of transportable Earth station; example of Earth station standards: INTELSAT, INMARSAT and INSAT.

Fabrication techniques: mechanical and electronics fabrication.

Commercial issues: Earth station technology and related industries; communication gateways; satellite communication Earth station operations with INTELSAT and INMARSAT.

Experiments/demonstration (spread over total duration): testing of Earth station sub-systems; antenna radiation pattern (at test range); feed of LNA, HPA, frequency converter, modem, tracking system, servo system.

Broadcasting using communication satellites

Duration: 1 month/150 hours. 60 hours lectures and 90 hours exercise/lab

This module is oriented towards broadcasting applications. It includes broadcasting techniques, frequency modulation, access, DBS, scrambling, satellite TV networking, radio networking, tele-text, video-conference, interactive TV, TV standards etc.

Colour television system standards: NTSC; PAL; SECAM; MAC; MPEG; HDTV; Digital TV; regulations and administration of technical standards.

Satellite broadcasting: analog and digital TV system; frequency bands for satellite broadcasting; modulation system; satellite access methods; direct broadcasting system; video on demand; scrambling and encryption of TV.

Satellite television network distribution: Earth station for TV broadcasting, TV receive only terminal, direct reception system with details of antenna and feed, LNB and receiver.

Radio networking: digital audio broadcasting; SNG.

Other applications: teletext; video conference; interactive television.

Experiments/demonstrations (spread over total duration): familiarization of video baseband system; measurement of S/N versus C/N and video threshold; measurement of S/N versus FM deviation; measurement of TV signal parameters using waveform monitor vectorscope and automated test equipment; determination of transponder operating point for a single carrier per transponder and two carriers per transponder; familiarization of radio networking terminal; demonstration of operation of satellite news gathering terminal; two-way video conferencing.

Development, education and training, using communication satellites

Duration: 1 month/150 hours. 60 hours lectures and 90 hours lab

This module covers another application area of satellite communications and deals more with delivery services. It includes applications like rural telegraphy, disaster management, emergency communications, telemedicine and health-care, talk-back DRS and programming for people etc.

Satellite communications for development: role of communications in development; reach versus access to communication in a developing country with details of community viewing situation and related issues; overview of satellite applications for development, education and training; thin route telephony; video conferencing; business data network; emergency communication; mobile satellite communications; disaster warning system; telemedicine and tele-health care.

Interactive television for training, education and development: talk back DRS system; different alternatives for managing interaction in talk back systems; experiments in interactive television with different users; requirements of operating a talk back system.

Case-study and project experiences: examples such as the Chinese and Indian experiments on satellite instructional television experiment with details of hardware; software; social research issues. Other case studies can also be included.

Programming for people: local audience specifics; irrelevance of imported programmes; an approach to programme planning; role of the user/development agencies. Need to coordinate for better planning and utilization; peoples' participation in a communications system; evaluation of a communication system; transnational broadcasting—impact.

Planning of satellite communications system for development: and economics of satellite communication system.

Experiments/demonstration (spread over total duration): familiarization of talk back system (interactive TV) with details of teaching and studio; hub station and remote class room; setting up a talk back class room terminal; video conferencing; demonstration of interactive TV systems.

Specialized applications of communication satellites

Duration: 1 month/150 hours. 60 hours lectures and 90 hours lab

This module will include special and newer innovative applications of communications satellite and include VSAT networks, search and rescue, DWS, meteorological data collection, news-gathering, computer networks, information superhighways, mobile communications and personalized applications, etc.

Rural telegraphy and telephony

VSAT networks: for voice, data and fax (including images): remote terminals and hub station.

Search and rescue system: PLB; EPIRB; LUT.

Disaster warning system

Meteorological data collection system: UHF random access system; C-band TDMA system along with rural telegraphy; Ext. C-band response on interrogation system; emergency communication system; data collection platforms; reception of INSAT VHRR imageries and data dissemination; reception of NOAA AVHRR imageries.

Other applications: news dissemination system; mobile communication system; personal communication system; standard time/frequency transmission; global positioning system; computer network.

Experiments/demonstration (spread over total duration): radio networking terminal; NOAA/AVHRR data reception; meteorological data collection; news dissemination; meteorological data dissemination; satellite based rural telegraphy network; emergency communication terminal; operation of GPS.

Operational communication satellite systems and future trends

Duration: 0.5 month/75 hours, 50 hours lectures and 25 hours exercise/lab

This module will provide the system details of international, regional and domestic satellite systems that are in operation. Future trends of communication satellites—information superhighways, HDTV, frequency compression, lasers, optical fibre and other needs to be also covered.

Future trends in satellite communications: HDTV; frequency compression techniques; TDRSS; optical fibre technology; lasers; information super-highways etc.

Regional and Global systems (invited talks): examples such as Palapa; Chinasat Solidaridad and its applications; SASAT of South Africa; Koreasat; INSAT etc.; International Telecommunications Union (ITU) and International regulations.

Networking planning/management/ operational issues of communication systems

Duration: 1 month or 150 hours. 75 hours lectures and 75 hours exercise/lab

This module will be oriented towards the provision of an in-depth account of issues associated with the communication network planning and project management including communication satellites—satellite design, frequency management, interaction with ITU/ WARC, orbit and coverage design etc; management of communication satellites-tracking and ranging, eclipse operations, black-out, life and thermal management etc.

Planning for space segment: traffic requirements; options for satellite transponder (coverage, power, BW); trade off of space segment and ground segment; launch vehicle.

Operations of satellite: launch of satellite; tracking and ranging; orbit determination and station keeping; eclipse operations; thermal control; life of a satellite; space environment and its effects.

Pilot project

Duration: 1 month/150 hours. All 150 hours lab

A pilot project could be conducted on one or more topics of interest for the scholar and must be oriented towards the one-year research project that the scholar is supposed to undertake in his/her home-country. The project definition must be based on the needs of the scholar's country. Some of the project topics could be oriented towards Earth station sub-systems, systems analysis for communication satellites—spacecraft design, footprint design, orbit selection, mission design, communication system design, network planning and relevant software development, application of TV, radio, etc,.

METEOROLOGICAL SATELLITE APPLICATIONS CURRICULUM

Introduction

A meteorological satellite application programme is a specific component of space science and technology education. It stresses the fact that, while meteorological satellites have operated in space for over three decades, the majority of the world's scientific, professional, and educational communities are unaware that observations from these satellites are freely accessible and that they can be applied directly or combined with other information, to benefit large segments of a country's population or to help resolve specific problems affecting those populations, especially where the savings of lives, the protection of property, or the responsible management of natural resources may be involved.

Meteorological satellites have been operating almost continuously since the beginning of the space age. Their continuing presence in space for decades to come is virtually assured, because of the importance that society at large places on the observation and forecasting of weather phenomena. These spacecraft have been launched by various nations specifically to meet the needs of professional government meteorologists (in those nations) who are responsible for providing weather forecasts for civil and military interests. However, most weather satellite launching nations have designed their satellites to operate in such a manner that anyone, anywhere on Earth that is within radio receiving range of these satellites, can acquire the data free, and use the data for any purpose. Thus, real time, direct readout observations from these satellites being used as an educational resource within schools is feasible; such observations can also be used as a tool for weather management levels; for fine weather forecasting and forest fire detection, to support air, sea, and land transportation; to support agricultural and fishing interests; and for wide range of other "non-meteorological" purposes.

The global access to meteorological satellite data as we know it today was an initiative of the World Health Organization; it was conceived to help ensure that knowledge of aerospace sciences and technologies that have evolved as a result of the free access to meteorological satellite observations can and will be utilized by many more individuals, organizations, and nations, specially the developing countries. It does this by endowing a core group of specialists in different countries with the analytical skills and technical knowledge that will enable them to instigate and sustain a wide variety of indigenous programmes in which technology supports scientific, economic, educational and humanitarian programmes that will enhance the quality of life for broad segments of the population.

Objectives

The objectives of the programme on satellite meteorology include the following:

(a) To educate specialists from developing countries in meteorological satellite applications in support of their development and socio-economic well-being; and

(b) To promote the utilization of meteorological satellite data and techniques for the monitoring and assessment of the environment, and severe meteorological phenomena.

Curriculum structure

The programme will consist of a nine-month programme at each Centre, followed by the implementation and completion of a one-year research project in the scholar's home country.

At each Centre, scholars will participate in a programme of instruction designed to increase their scientific knowledge in the application of meteorological satellite-derived data and shall develop and extend their computational and analytical experience in order to allow them to initiate and implement the benefits of this science and technology in their home countries.

In order to achieve this, participating scholars will come to the Centre with a pilot project proposal which is significant to their home country and sponsoring agency. The design and methodology of their research will be refined and developed under the guidance and supervision of the Centre to enable the scholars to implement and sustain the research in their home country.

The programme at the Centre will include a common module in which an overview of the nature and use of space technology in resource and environmental analysis is presented. This common module will be completed by all the participating scholars.

Scholars in the meteorological applications of satellite data programme will then be involved in a rigorous examination of relevant aspects of the fundamental sciences behind the collection of meteorological data from satellites. This is followed by modules dealing with the platforms and sensors currently in operation, including the acquisition, processing and derivation of significant meteorological data and standard products. Scholars will master the computational and analytical skills necessary to process, interpret and apply these data.

The focus in the latter part of the programme is placed on the scholar becoming proficient in implementing selected applications of both polar and geostationary satellite data, particularly those applications related to the chosen pilot project. The programme will be for a nine-month period and will consist of: a six-week common education module; an eighteen-week component consisting of, examination of the science behind data interpretation; development of interpretation and application skills; and twelve weeks devoted to project development and proposal.

Evaluation, assessment and programme requirements

Analytical skills: Scholars completing this programme, would have developed skills in the necessary computer interactive systems and should have mastered the appropriate mathematical and statistical skills to enable them to carry out independent research work.

For example, they should be able to compute vegetation indices, estimate cloud motion winds, estimate sea surface temperatures, recognize and describe cloud patterns and their movements, etc. They should be able to understand and extract information from satellite data using mathematical and basic knowledge they have acquired through formal education and through their work at the Centre.

Knowledge of meteorological satellite data application: Upon completion of this programme, scholars will have an understanding of a wide variety of practical meteorological applications. They should be able to specify the type of infrastructure required to support the routine acquisition and operation of satellite information for national and regional weather observation and forecasting. They will also use and apply this information to a range of environmental applications including the monitoring of changes that occur on the Earth's surface as well as in the atmosphere and their effect on the economic and social well-being of the people on Earth.

Equipment

The United Nations document A/AC.105/534 specifies much of the equipment that will be needed at the regional Centres to enable staff members to effectively educate specialists in the use of remote sensing technologies, including meteorological satellite applications. However, there are certain items of equipment that are not contained in these specifications, but are essential for the conduct of this programme. Also, there are certain specialized products, particularly related to meteorology, that were not included.

In this section, we identify the equipment or products that are needed as part of this programme including those already specified in the United Nations document A/AC.105/534.

1. HRPT ground station
2. Microcomputers (20) (with modems, CD-ROM players, etc.)
3. Printers
4. INTERNET capability
5. Facsimile machine
6. High resolution Geostationary Satellite Ground Stations
7. Data files
8. Graphical Analysis and Display System
9. Access to Radar and National Weather Prediction Products
10. Work station (10)
11. APT/WEFAX station (10)
12. ADDIT Geographic Information System
13. Landsat Imagery
14. Aerial Photography
15. Atlases (one per person)
16. Topographic maps
17. Textbooks and manuals

Operation and management of the meteorological satellite applications programme

The meteorological satellite application programme of the Centre will require specific personnel, equipment and facilities in addition to those already available at the host institution. Specifically, it requires a full time dedicated person that will act as a facilitator or coordinator of the programme, five laboratory instructors, and a number of lecturers that may be invited from local institutions in the region as well as from abroad to review and advise on projects, serve as instructors, deliver special lectures and participate in seminars, as may be necessary.

Specifications for the curriculum

Common module for all scholars.

The science behind meteorological satellite data applications

A series of lectures will cover relevant aspects of the Earth's atmosphere, planetary circulation and the fundamental physical laws governing atmospheric and oceanic motions on those scales that meteorological satellites are important sources of observation for their monitoring and predictions. Basic radiometry and thermodynamics will also be covered in the context of radiation matter, interaction, electromagnetic spectra, thermal and microwave radiation, absorption/emission and transmission. Tropical convection and mesoscale and synoptic scale motions, heat sources, tropical and extra-tropical cyclones, ITCZ, easterly waves are important topics in the application. Merging of satellite and conventional in-situ data will be discussed in conjunction with techniques for numerical weather predictions. Coupled global atmosphere-ocean models (CGCM) will be stressed as important tools for ENSO, monsoons, and drought predictions.

The following topics summarize the contents of the lectures:

- Radiation laws: radiative transfer and radiation balance; atmospheric composition.

- General circulation of the atmosphere and the oceans; water cycle; seasonal and inter-annual climate variability; ENSO; monsoons, droughts.

- Basic Radiometry: photometric and radiometric units, electromagnetic radiation sources, radiometry and radiometric method; reflectance, absorption and transmittance; interaction of radiation and matter; introduction to thermal and microwave radiation, transmission, absorption/emission, scattering.

- Thermodynamics: laws, heat sources and sinks, hydrostatic stability.

- Dynamics: forces and fundamental laws; scales of motion in the atmosphere and oceans; tropical and extra-tropical motion systems.

- Meso-scale and synoptic scales systems; convective systems; tropical and extratropical cyclones; easterly waves; tropical depressions; hurricanes; ITCZ, SPCZ, SACZ.

- Weather forecasting: combined use of satellite, radar and vertical profiles. Numerical weather prediction.

Meteorological satellite data acquisition and management

This module of the curriculum treats the essentials of satellite types, orbits, and sensors, vertical sounding systems on board satellites, as well as in-situ data collection platforms. It also discusses direct access stations for both polar and geostationary orbiting satellites. It focuses attention on antennas, receivers, recorders, etc., and discusses data management, archival, processing and distribution. Scholars will be exposed to software, such as McIDAS and GrADS.

(a) *Platforms, systems and sensors*
Satellite Trajectories
Polar: NOAA, METEOR
Geostationary: GOES, GMS, METEOSAT

Satellite Sensors
AVHRR (NEAR-IR, THERMAL IR, VISIBLE)
VISSR
Comparison with LANDSAT MSS, TM, and SPOT
SAR (ERS-1, RADARSAT, SIR-C), CZCS, SeaWifs

Vertical Sounding
NOAA TOVS (HIRS-2, SSU, MSU)
GOES GVAR

In-situ Data Collection
DCS,
Platform Location (ARGOS)

(b) *Direct access stations*
Geostationary and Polar Orbiting Satellites
Antennas, Receivers, Bit-synchs, Recorders,
Moving Window Displays
Tracking data
Timing
Unmanned Direct Access Stations

(c) *Data management*
Data Formats (APT, WEFAX, HRPT, HiResGSO)
Data Archives
Data Distribution
Catalogs, Browsers

(d) *Retrieving meteorological parameters*
Development of proficiency in processing and data display; use of dedicated software including Man Computer Interactive Data Access Systems (McIDAS), and Graphical Analysis and Display System (GrADS).

The products

Lectures and practical laboratory work will cover the broad range of meteorological satellite applications of data gathered via geostationary as well as polar orbiting spacecraft (GOES, METEOSAT, GMS, TIROS/AVHRR, etc). The remote sensing of the gaseous envelope of Earth (atmosphere) will provide the meteorological products such as cloud tracking and derived winds, precipitation, vertical profiles of temperature and water vapour, etc. The surface properties can be derived to describe the spatial distribution of sea surface temperature, soil moisture, ice and snow cover, etc. Laboratory lectures will be a major activity so that specialists will get a good and broad knowledge of data processing techniques, and the software and hardware involved. Certainly one or a class of products will best suit the scholar's pilot project. In this case the participant should acquire an in-depth knowledge of that class of products and master the techniques to obtain them.

The following are the different types of products that scholars will be exposed to:

(a) Meteorological-clouds, winds, water vapor, storms, vertical sounding.

(b) Hydrology-snow cover, rainfall, storage, runoff.

(c) Climate-integrated data over time.

(d) Vegetation indices.

(e) Sea surface temperature.

(f) Atmospheric composition.

Specialized applications

This module of the curriculum focuses on specialized treatment and application of satellite data, acquired by polar orbiting and geostationary satellites, in several areas of human endeavours, e.g. agriculture, determination of shelter temperature, estimation of soil skin temperature; estimation of amount and distribution of precipitation, crop inventory, livestock management, fisheries, etc.; TV-weather forecasting; energy management. This module also treats the use of data from both polar or biting and geostationary satellites in disaster mitigation, e.g. flood forecasting and control; mitigation of effects of droughts, locust control, control of atmospheric and ocean pollution, etc.

This approach should equip participants in the programme to contribute to the enhancement of knowledge and experience in their respective countries in those application areas that have great impact on their country's economic and social development including the country's environment.

Polar	*Geostationary*
Livestock management	TV weather and forecasting
Optimum ship track routing	Storm tracking
Fisheries	Disaster mitigation
Flooding	Flood forecasting and control
Drought	Locust control
Geothermal activity	Frost forecasting
Pollution-atmosphere/ocean	
Weather modification	
Buoy tracking DCP	Data collection platforms
Crop inventory	
Energy management	Energy management
Ecosystem	

Pilot projects

Research methodology and design: Participants accepted into the programme are required to submit a preliminary project topic with their application. This preliminary topic should relate to specific in-country needs and have the approval of the nominating agency.

Implementation: In addition to the lectures, participants will be expected to modify and refine the aims and objectives of the pilot project to reflect the scientific knowledge and technical information presented in their course work. At the end of their stay at the Centre, participants will have completed a fully developed research project proposal for implementation in their home country.

In addition to setting the aims and objectives of the project, this proposal will address research methodologies, resource requirements, costs and availability of funds, implementation and management of strategies, analysis and presentation of results, report writing and suggestion for further work.

Evaluation: While course lecturers will provide supervision and expert guidance, participants will be expected to demonstrate independent thought and creative thinking in problem solving. Approximately one year after the completion of the formal course work, all specialists will return to the Centre to present the results of their research. Satisfactory completion of the programme requires the submission and presentation of the research project.

Home institution support

The institutional support required includes:

(a) The institutional recognition of the importance of the project in its overall aspects, the willingness to support a (small) group of scientists and technical personnel that might be needed for the project and future development of activities in the country;

(b) A basic data and reference materials on meteorological satellite applications;

(c) Satellite ground receiving stations and the required computational power and software adequate to the project, and line of activity the country/institution feels more suited to their needs and reality.

On the satellite receiving, processing, and display of imagery and data, two families of satellites are contemplated. For some applications, as for example, cloud displacement, flood warning, weather forecasting in general, the geostationary satellites (METEOSAT, GOES, GMS, etc.) are most appropriate. Other applications, such as fire detection, vegetation, information, etc. could be achieved with AVHRR data available through the polar orbiting satellites. Not having any of these facilities, and/or data in real or near-real time will certainly be an impediment for the development of meteorological satellite data application and education in the scholar's country.

SPACE AND ATMOSPHERIC SCIENCES CURRICULUM

Introduction

With the rapid degradation of the environment, it has become extremely vital for all countries of the world to concentrate on a better understanding of atmospheric dynamics, including its interaction with landmass and oceans. Realizing the gravity of the situation, the United Nations Conference on Environment and Development proposed in its Agenda 21, a series of measures for addressing environmental conservation. The developing countries, as it is, have very limited capacity, if any, to undertake research and development in the field of atmospheric sciences. As such, they are not even in a position to benefit from the international programmes in the field. Nor do they have the desired level of minimum infrastructure to provide in-situ data and information to the international programmes for global studies.

Yet on an another plane, space technology has made tremendous strides and its impact has been felt in a broad variety of sectors, especially those relating to natural resources and environment, meteorology, and communications. On account of the fact that spacecraft operate in space and receive as well as transmit electromagnetic radiation signals through space and the atmosphere, the development of space technology and consequently its applications can be greatly enhanced through a deeper understanding of the atmospheric and space sciences.

Objectives

The objectives of the programme in space and atmospheric science include the following:

(*a*) To enable the scientists of the developing countries to efficiently interact with their counterparts in the developed countries in the pursuit of international programmes of atmospheric, environment, and space science related studies.

(*b*) To develop the capacity within the developing countries to educate scientists in numbers which are required to attain the minimum level of critical mass in each country.

(*c*) To enable the establishment of laboratory and field facilities in the developing countries for research and development in selected fields of atmospheric and space sciences.

(*d*) To assist the developing countries in the implementation of Agenda 21 of the United Nations Conference on the Environment and Development.

(*e*) To promote the development of new technologies and enhance the applications of space technology especially for meeting the needs of the developing countries.

Curriculum

The following research-oriented curriculum consists of two modules (A1 and A2) on atmospheric science, two modules (B1 and B2) on space science, and two modules (C1 and C2) on data analysis and data modelling. Depending on the research interest of the scholar, he/she can focus on atmospheric science, i.e. modules A1 and A2 or space science, i.e. modules B1 and B2. It should be noted that modules C1 and C2 are a pre-requisite and mandatory for the scholar's programme at the Centre.

Module A1: The atmosphere

Duration: 2 months

Atmosphere-space transition; introduction to the structure and composition of the atmosphere, thermodynamics; solar radiation and its transfer through the atmosphere; atmospheric circulation; large-scale motions and observed circulation; water in the atmosphere; atmospheric electricity; turbulence; positional determination.

Module A2: Atmospheric changes

Duration: 3 months

Atmosphere-ocean and atmosphere-land interactions; ozone: its formation in the stratosphere and distribution as a function of altitude and latitude; methods of its measurements; formation of ozone at ground level and the basic processes; observation of ozone concentrations from space leading to discovery of ozone holes above the poles; interaction of ozone with solar radiation and the attenuation of UV; importance of the ozone's protective role; concentration of CO_2 in the atmosphere; principle sources of CO_2 and how it is leading to the increase in the surface temperature of the planet; other greenhouse gases and their sources and effects; other effects of the increase in the concentration of CO_2 and nitrogen and sulfur oxides; acid rain and its damaging effects to the environment;

Module B1: The ionosphere

Duration: 2 months

Ionospheric physics; various layers; dynamics; columnar electron density; geo-electric and geo-magnetic fields and their relationship with the ionosphere; geo-magnetic field and its coupling with the ionosphere; relevance of geo-magnetic and geo-electric fields to space technology and its applications; Faraday rotation; calculation of phase changes in the plane of polarization of electromagnetic radiation in the ionosphere; ionospheric sounding: space based and ground based; anomalous conditions in the ionosphere; ionospheric studies through vertical and oblique ionsondes; calculation of optimum radio-frequencies in the H-F band for pre-defined circuits as a function of time; solar flares and their interaction with the ionosphere leading to proper understanding of the radio-wave propagation.

Module B2: Solar-terrestrial interaction

Duration: 3 months

Production of charged particles; solar radiation-induced reactions in the atmosphere; photosynthesis; solar radiation budget at different altitudes above the mean sea level; sunspot activity especially solar flares and solar wind and their influence on the ionosphere and neutral atmosphere; past history of solar activity using C^{14}, Be^{10}, and tree rings; solar disturbance measurements through VLF radio transmission and reception on a long distance circuit; solar activity and its coupling with the Earth's magnetic and electric fields; the influence of solar activity changes on the spacecraft.

Module C1: Instrumentation and data management

Duration: 2 months

Techniques and instrumentation; data collection; processing; archiving.

Module C2: Modelling studies

Duration: 2 months

Ocean-atmosphere interactions; land-atmosphere interactions; ionospheric; geo-magnetic and geo-electric fields; contributions of vegetation, hydrocarbons, CO, CFCS, sulphur and nitrogen oxides to the atmospheric changes and their composite effect; diffusion coefficients (for various contaminants) as a function of altitude and meteorological conditions; linkages with regional/international programmes for input and output of data and/or information in support of various studies or otherwise.

Hardware and software requirements

DGS-256 Vertical Ionosonde or equivalent

Oblique Ionosondes

Automatic Magnetic Observatory System comprising a fluxgate magnetometer, a proton precession magnetometer, a system controller (central processing unit), temperature sensor, a 9-track magnetic tape recorder and an analog chart recorder.

VLF Receiver, WWV Receiver, GPS Time Signal Receiver, Rubidium/Cesium time standards

LIDAR equipment, Radiometers, Synthetic Aperture Radar
(Availability of a suitable aircraft on which such sensor equipment could be mounted would be a plus point for atmospheric and surface features monitoring purposes).

Ozone monitoring equipment for monitoring at ground level, Troposphere and Stratosphere

UV Flux meters

Atmospheric composition, including the presence of particulate matter, analyzers and monitoring equipment fixed and mobile. It would also include Atomic Absorption Spectrophotometer.

Appropriate number of computer hardware that should include micro-computers, mid-range computer and access to a supercomputer especially for the purpose of modelling studies. The hardware has to be backed up with requisite software packages.

Experimental workshop having facilities for mechanical fabrication, electrical and electronic design especially for the purpose of fabricating payloads to be flown on board aircraft/sounding rockets/satellites.

Down linking facilities for NOAA and other scientific satellites data

Telemetry ground receiving stations for reception of data from special payloads

Spacecraft derived datasets and archiving systems

Mechanisms for electronic access: Internet, and other networks for maintaining close liaison with the three remaining sections namely Remote Sensing and GIS, Satellite Communications, and Satellite Meteorology, as also with centres like International Centre for Theoretical Physics (ICTP) and IGBP.

Annex. Equipment for centre

CENTRE

VSAT Very Small Aperture Terminal

ASG *Administrative Fac*	*LIBRARY & DOC.* *CEII*	*TFG* *Tech. Fac*	*NREMG* *Natural Resources and Environment*
PC FAX TELEX E-MAIL JEEP 2 CAR 1 COOKING OVEN GAS BANK REFRIGERATED WATER COOLERS FOR CANTEEN AND INTERNAL HOSTEL	TV 2 VCR 2 NC SCRIB 1 *DRAFTING EQUIPMENT* XEROX M/C 1 *ADDITIONAL* DTP UNIT 1 S/W COLOUR XEROX 1 DISPLAY BOARDS PC 1	DATA RECEPTION AVHRR STN. ONE UNIT COMPLETE AUTOMATED DATA ARCHIVE MAP CABINETS CCT RACKS. *DATA ANALYSIS* FILE SERVER 3 WORK STN. 3 IMAGE PROC 14 WORK STN. GIS TERMINALS 6 LASER PRINTER COLOUR PRINTER SCANNER PEN PLOTTER DIGITIZER TAPE DR. DAT/CCT CD ROM IMAGE PROC. S/W GIS S/W *ADDITIONAL* ADV. S/W TOOLS ARTIFICIAL NEURAL NETWORKS ARTIFICIAL INTEL. EXPERT SYSTEMS FRACTALS SOFT COPY STEREO WORK STATION MULTIMEDIA W/S *PHOTO PROCESSING* DARK ROOM EQUIP. FILM PROCESSOR CONTACT PRINTER ENLAGER FILM & PAPER CUTTER	GROUND DATA COLLECTION LABORATORY RADIOMETERS 2 35 MM CAMERA 2 *ADDITIONAL* GPS RECEIVER WITH NOTE BOOK VIDEO CAMERA 2 SOLAR SENSOR 1 QUANTUM SENSOR 1 (APAR, IPAR) AUTOMATIC WEATHER STATION 1 LAI MEASUREMENT INSTRUMENT 1 LEAF CHAMBER ANALYSER 1 THERMAL SENSOR 1 MOISTURE METER 1 *INTERPRETATION LAB.* MIRROR STEREOSCOPE WITH PARALLAX BAR 17

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