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COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

APPLICATIONS OF SPACE TECHNOLOGY FOR REMOTE AND RURAL COMMUNICATIONS AND BROADCASTING

Note by the Secretariat

1. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), in the report on the work of its sixth session, proposed that a few more specific space applications studies should be carried out to demonstrate the potentials of space technology. The Working Group identified a number of possible subjects for such studies, including the subject of remote and rural area communications and broadcasting (A/AC.105/513, annex II, para. 17).

2. The report of the Working Group was adopted by the Scientific and Technical Subcommittee in its report on the work of its twenty-ninth session (A/AC.105/513, para. 22), and the recommendations were endorsed by the Committee on the Peaceful Uses of Outer Space in its report on the work of its thirty-fifth session, 1/ and by the General Assembly in its resolution 47/67 of 14 December 1992.

3. The present study has been prepared by the Secretariat in response to the request of the Working Group of the Whole. Its purpose is to review the applications of space technology for remote and rural communications and broadcasting, and it is intended primarily for the benefit of countries that have not yet used space technology for this purpose but are interested in its potential benefits. The study was prepared using a variety of national and international sources, which are listed in the selected bibliography at the end of the study.

4. The following summary of the study appears in all the official languages of the United Nations. The full study, contained in the annex to the present document, is being distributed only in the language in which it was prepared (English) because of its technical character.

SUMMARY OF THE STUDY

5. Developing countries face major problems in ensuring their people adequate food, shelter, health, education, a clean environment and a better quality of life. Meeting those needs will depend in a variety of ways on improving communications. Currently, in many rural areas of developing countries, there is only one telephone for every 2,000 people, and many people live long distances from the nearest accessible telephone. Television, with its capacity for education and information, is commonly available only in the major cities.

6. Recent studies have demonstrated the important contributions that communications make to rural economic and social development through a variety of formal and informal functions: disseminating information on agricultural markets, production techniques and public health measures; facilitating trade, commerce and financial transactions; supporting education, social services and administration; and providing the extensive human contacts that people need, particularly as they become more mobile. However, developing countries face difficult decisions about how to invest their limited resources in communication systems and other basic infrastructure. Planners need information on the costs and benefits of a variety of options under a variety of conditions in order to decide on a development strategy. While some of the required information on costs and benefits exists, much additional research is needed, particularly on the long-term benefits of improved facilities for information exchange and education, the relative cost-effectiveness of various means of providing those facilities and the impact on such factors as population growth, urban migration and consumption patterns.

7. The development of communications services in rural areas faces a number of economic and logistical obstacles. Because of the distances involved and the low population densities, installation costs per person are much higher than in urban areas. Since rural incomes are generally low, the combination of high costs and the limited ability to pay for services means that investment in rural communications is not commercially attractive.

8. Since the 1960s, international, regional and national communication satellite systems have been established, making telephone, television, telex, data and other communication satellite services available to all countries. While early communication satellites were economically viable only for very long distances, the cost of satellite communications has decreased dramatically, making satellites increasingly attractive for domestic communications. And while early satellites required very large and expensive antennas and were therefore most economical for communication routes with heavy traffic, cost reductions in Earth station technology have made low-traffic routes more economical.

9. The flexibility of Earth station networks linked by satellite makes it feasible, in rural areas, to start with small terminals and then add more or different capacity as needs evolve. For example, an isolated village might start with equipment for just a few voice circuits and subsequently add

equipment for more voice, telex, data and television circuits as demand increased. Because a satellite transmission is not focused on a particular ground station, but is broadcast across a large service area, satellites are particularly economical for transmissions intended for multiple recipients, such as television or radio programming, news services, public service information, weather reports and storm warnings.

10. The biggest problem to be overcome in rural communications in developing countries is not one of long-distance communications but what is sometimes called the "last-mile problem", that of providing individuals in rural areas with access to the national, and then international, networks. In many countries it is not economically feasible to put a telephone or television in every house, much less a fax or telex terminal, and community facilities will need to be made available. As a result of the great reductions in the costs of satellite communications, it is the user facilities that will require the largest spending for national communications development.

11. While a rural communications network could be established using only satellite systems, in most cases a combination of satellite systems, land-lines and radio links will be most cost-effective and will integrate satellite systems into the existing terrestrial communications infrastructure. New and improved radio techniques, for example, offer great promise as an inexpensive means for the "last mile" communication link from a local satellite Earth station to individual residences, offices or public facilities.

12. As rural communications generally require a small capacity relative to that of urban communications and relative to the capacity of communication satellites, it will not generally be feasible to develop a satellite system specifically for rural development. Rather, rural communications will use a small part of the capacity of satellites established for other purposes. Countries that have domestic communication satellites, or that participate in regional satellite systems, will normally use part of those systems. For other countries, the alternatives are the use of international satellite systems such as Intelsat or the use of capacity on other domestic or regional systems that can reach the desired territory.

13. A growing number of countries, currently including 19 developing countries, not only use the global Intelsat system for international communications, but have also leased or purchased Intelsat capacity for domestic use, primarily to provide communications between cities. The use of Intelsat capacity allows a country to pay for only the capacity it immediately requires and to expand that capacity in response to demand. In addition to its standard services, Intelsat offers the Intelnet service, which can be used for domestic networks consisting of one or more large "hub" stations and a large number of small, low-capacity rural terminals each with a few circuits for voice, fax, telex or data. Such systems are being used for environmental monitoring networks, disaster relief and other rural and remote communication needs. To assist developing countries, there is the Intelsat Assistance and Development Program (IADP), the Intelsat Development Fund (IDF) and Project Access.

14. Inmarsat operates a system of satellites providing telephone, telex, fax and data services primarily for ships at sea, aircraft and land mobile users, but also for remote land uses. Inmarsat can be used through the larger Inmarsat-A terminals providing telephone, data, fax and telex links, through the briefcase-sized Inmarsat-C terminals which can send and receive electronic messages, or through the Inmarsat-M service now being introduced for telephone links through briefcase-sized terminals. Inmarsat is used for remote news-gathering, for disaster relief, on expeditions to remote areas and in other situations where conventional communication satellites or other communications services do not exist. The Inmarsat organization also cooperates in the Cospas-Sarsat satellite search and rescue programme. In general, Inmarsat terminals are cost-effective for mobile, emergency or short-term use in situations where larger terminals cannot be carried or set up, but are not economical for long-term rural development.

15. Among developing countries, communication satellites are owned and operated by Brazil, China, India, Indonesia and Mexico. Those systems primarily serve to link together the cities of those countries into a national communication network, but as those requirements are met, efforts are being made to extend services to smaller towns and rural areas. However, the lack of telephones and other user equipment in rural areas and the difficulties in paying for communications equipment and services are limiting the use of satellite services in rural areas. On the regional level, the Arab countries have established the Arabsat regional satellite system, the Andean countries have leased Intelsat capacity for a regional satellite communications network and studies are under way on the best way to develop a regional satellite system for Africa.

16. Since satellites are particularly cost-effective for broadcasting information to many Earth stations, and since small Earth stations designed only for reception are substantially less expensive than Earth stations designed for transmission as well as reception, satellites are economical for extending television coverage from urban to rural areas. China and India use their domestic satellites to provide national coverage for educational television programming, including basic education, university-level education, teacher training, agricultural and health-care information, adult education and general information. In many areas, the most cost-effective technique has been to use satellites to distribute the programmes to local "hub" Earth stations linked to low-power transmitters, which rebroadcast the programmes for reception by ordinary television sets. In other cases, direct reception of satellite signals by specially equipped community television sets has proved the most economical means of reaching the desired audience.

17. Satellite communications have been used in the United States of America to extend modern medical services to remote and rural areas, either routinely or in emergencies. In addition to enabling local health-care personnel to have long-distance telephone consultations with specialists, techniques have been developed for transmitting X-rays, electrocardiograms and other medical data electronically for diagnosis by doctors in regional hospitals.

18. In Peru, Intelsat satellite channels were used for an innovative project for rural communications for development. The project provided villages with public telephone, telex and telegraph services as well as with teleconference facilities enabling groups to participate in education, public health and agricultural programmes. These village facilities were linked by radio to small local Earth stations, which connected them to the national and international communication networks. The system proved to be simple to operate and use and effectively made communication services accessible to previously isolated populations. In India and China, satellites have been used to provide data links for public services and industrial enterprises to collect and disseminate data for economic planning and development.

19. In areas struck by storms, floods or other natural disasters, which frequently knock out existing communication systems, the use of transportable satellite terminals is often the only way to quickly re-establish connections for relief planning and organization. Satellite communication systems can also offer an important means for the rapid dissemination of information concerning prospective disasters such as approaching hurricanes or predicted flooding.

20. Future developments in satellite and Earth-station technology are expected to further reduce the costs of satellite communications, making them financially more affordable for rural use. However, since most developing countries cannot afford to provide each home with an Earth station or even with a private telephone, further study and research will be necessary to find the most effective way to make public communication facilities available to everyone and to establish education and information services that promote rural development, which can in turn provide the financial resources for further improvements in the communication system.

Notes

1/ Official Records of the General Assembly, Forty-seventh Session, Supplement No. 20 (A/47/20), para. 29.

Annex

APPLICATIONS OF SPACE TECHNOLOGY FOR REMOTE AND RURAL COMMUNICATIONS AND BROADCASTING

Study by the Secretariat

CONTENTS

	Paragraphs	Page
INTRODUCTION	1 - 20	2
A. Rural communications and development	1 - 6	2
B. The development of satellite communications	7 - 20	3
I. SATELLITE SYSTEMS FOR DEVELOPING COUNTRIES	21 - 49	6
A. International systems	22 - 31	6
B. Asia	32 - 41	8
C. Latin America	42 - 45	10
D. Africa and West Asia	46 - 49	11
II. SATELLITE COMMUNICATIONS FOR RURAL DEVELOPMENT	50 - 82	12
A. Education	50 - 58	12
B. Health	59 - 71	14
C. Rural communications	72 - 78	16
D. Disaster relief	79 - 82	18
III. ECONOMIC AND PLANNING CONSIDERATIONS	83 - 92	19
IV. CONCLUSIONS	93 - 95	20
SELECTED BIBLIOGRAPHY		21

INTRODUCTION

A. Rural communications and development

1. Developing countries, which account for 75 per cent of the world's population, face major problems in ensuring their people adequate food, shelter, health, education, a clean environment and a better quality of life. Meeting those needs will depend in a variety of ways on improving communications.

2. Currently, in many developing countries, there is only one telephone for each 100 persons. In rural areas of developing countries, there are often 2000 people or more per telephone, and many of those people live a long distance from the nearest telephone. In 1987, the estimated telephone densities per 100 people were 80 in North America, 45 in Europe, 5.5 in Asia, 5.0 in Latin America, and 0.65 in Africa. Of the 3,500 million population of Asia, Africa and South and Central America, about 30 per cent live in cities with modern communications facilities, while the large majority live in the rural areas with little or no means of telecommunications. About 55 per cent of the world's population, generally the poorest people, can only use telecommunications facilities if they travel long distances.

3. This situation is a consequence of rural-urban and rural-rural "missing links," which have to be bridged if the economic, social and human development needs of remote and rural areas are to be met. In the majority of developing countries, efforts to meet those needs rely on imported communication equipment that has been designed to meet the needs of urban industrialized societies and is often not economic for rural areas in developing countries.

4. Until recently, the development of modern communication systems has been seen as a consequence of economic growth, sometimes even as a luxury that a country could afford once more important needs had been satisfied. The result of this has been a significant underinvestment in communications. Recent studies, however, have demonstrated the important contributions that communications make to rural economic and social development through a variety of formal and informal functions: disseminating information on agricultural markets, production techniques and public health measures; facilitating trade, commerce and financial transactions; supporting education, social services and administration; and providing the extensive human contacts that people need, particularly as they become more mobile. It is now increasingly recognized that while development of communications facilities is a result of economic growth, it is also a cause of that growth.

5. Even when communication systems are recognized as productive investments, developing countries face difficult decisions about how to divide their limited resources between communication systems and other basic infrastructure and services. Planners need information on the costs and benefits of a variety of options under a variety of conditions in order to decide on a development strategy. While some of the required information on costs and benefits exists, much additional research is needed, particularly on the long-term benefits of improved facilities for information exchange and education, the relative cost-effectiveness of various means of providing those facilities, and the impact on such factors as population growth, urban migration and consumption patterns.

6. The development of communications services in rural areas faces a number of economic and logistical obstacles. Because of the distances involved and the low population densities, installation costs per person are much higher than in urban areas. In the United States, it has been estimated that in areas where a telephone network exists, the cost of connecting a building to the network averages about $1800. Where a local network does not exist, the cost would be much higher. Since rural incomes are generally low, the combination of high costs and limited ability to pay for services means that investment in rural communications is not commercially attractive. Nonetheless, evidence from recent research indicates that rural communication systems can generate indirect benefits that substantially exceed the costs of providing the services. The problem of identifying and realizing the non-commercial benefits of rural communication systems poses a major problem for development planners.

B. The development of satellite communications

7. The use of satellites for communications began on an operational basis with the launch of the Intelsat-I Early Bird satellite in 1965. By 1969, with Intelsat satellites in geostationary orbit over the Atlantic, Pacific and Indian Oceans, every country in the world had access to satellites for international communications. The 1960s also saw the development of satellites for domestic communications by the United States and the Soviet Union. During the 1970s and 1980s, other international, regional and national communication satellite systems were created, making telephone, television, telex, data and other communication satellite services available to all countries. Virtually every country in the world now uses satellites for some telecommunications services.

8. Most communication satellites are located in the geostationary orbit, at an altitude of about 36,000 km above the equator. At that altitude, they orbit the Earth in synchrony with the Earth's rotation, thus remaining at a fixed point in the sky as seen from the ground. A geostationary satellite can see about one third of the Earth's surface and can provide continuous communication links between any earth stations within that area. The only parts of the world that cannot be served by geostationary satellites are polar areas beyond about 70° north and south latitude. For these areas and for certain special communications services, satellites in lower orbits are used, but such satellites will not be considered in the present study. A study is currently in preparation on the uses of communication satellites in low orbits.

9. The cost of communicating via satellite is independent of the distance between the earth stations, in contrast to ground communication lines, whose cost increases with distance. Early communication satellites were economically competitive with ground lines only for very long distances, particularly for inter-continental communications. As the capacity of satellites increased and the cost-per-circuit declined, satellites became economical for shorter and shorter distances, thus making domestic satellite communications increasingly attractive, particularly for the larger countries.

10. Early satellite communications required very large and expensive antennas and were therefore most economical for communication routes with heavy traffic, normally those between developed countries and between major cities. As satellite and earth-station technology improved, the size and cost of earth stations declined and new techniques were introduced to make low-traffic routes more economical. The cost of an earth station is largely independent of location, in contrast to land-lines whose cost depends on the distance from existing lines and the difficulty of the terrain to be crossed.

11. Because the cost-per-circuit for satellite communications declines as satellite capacity increases, satellites have steadily increased in capacity since their introduction. For example, the latest generation Intelsat-VII satellites can carry 18,000 telephone or data circuits and 3 television channels, and the Intelsat-K satellite can carry 32 television channels. Communication satellites are therefore designed to handle very large volumes of communications, and low-volume remote and rural communications are usually a secondary application of a system established for inter-urban services.

12. With the declining cost of satellite communications, a large or medium-sized country establishing a new national communications network would find a satellite network considerably less expensive and faster to build than a terrestrial network. However, every country has an existing terrestrial system, however limited it may be, and a gradual expansion of the terrestrial system may, at each step, cost less than the investment required to start a satellite system. There may also be the choice between building a domestic terrestrial system and leasing capacity on a foreign satellite system. The decision to invest in a communication satellite system, or in an earth station network that uses an international or foreign satellite system, may therefore be a difficult choice that involves political as well as financial considerations. It seems clear, however, that for most countries in the long run, satellite communications will provide less expensive and more reliable communications, with more flexibility for growth and adaptation to changing demand for services.

13. Because urban communications traffic is much more concentrated than rural traffic, is much larger in volume, and can be supported by greater economic activities, domestic satellite systems always begin as inter-urban systems. Once a system is operationally established between the major cities and financially sound, consideration can be given to expanding it to serve smaller cities, towns and ultimately rural areas. In most countries, most of the rural communications will be with the cities and will therefore connect into the existing urban network. Given the difficulty of financing rural communication systems, it may be reasonable, as part of a development strategy, to charge the large-volume urban and commercial users for the large fixed costs of a satellite communications system, and to charge rural users only the additional cost for their use, or to use charges on urban traffic as a subsidy to promote rural communications.

14. The flexibility of earth station networks makes it feasible to start a rural system with small terminals and then add more or different capacity as needs evolve. For example, an isolated village might start with equipment for just a few voice circuits and subsequently add equipment for more voice, telex, data and television circuits as demand increased. The capacity of land-lines by contrast cannot be readily increased without rebuilding the entire line. In areas with no electricity or unreliable supplies, small earth stations can be powered by solar cells.

15. Because a satellite transmission is not focused on a particular ground station, but is broadcast across a large service area, satellites are particularly economical for transmissions intended for multiple recipients, such as television or radio programming, news services, public service information, weather reports and storm warnings.

16. Satellite networks are extremely reliable. If a problem occurs in an earth station, only that site is affected, whereas in a terrestrial network if a line fails, in a storm for example, all sites beyond the failure point may be knocked out of service. Furthermore, since satellite earth stations are located near the people they service, they are readily accessible for maintenance and

repair. In contrast, microwave repeaters atop mountains and undersea cables can be very difficult and costly to repair. Once in orbit, satellites are generally highly reliable throughout their expected lifetimes and are generally backed up with spares.

17. Satellite communications technology, for the reasons outlined above, offers new and economical possibilities for linking remote and rural areas with the rest of a country and the rest of the world. Satellites have the potential to eliminate the barriers of distance and difficult terrain that have been an obstacle to economic growth, delivery of social services and public participation, especially in rural and remote areas of both industrialized and developing countries. Technological development will certainly continue to reduce the size and cost of earth stations and to make them more reliable, for example through the use of solar power, further increasing the contribution of satellite communications to rural development.

18. The biggest problem to be overcome in rural communications in developing countries is not one of long-distance communications but what is sometimes called the "last-mile problem," that of providing individuals in rural areas with access to the national, and then international, networks. In many countries it is not economically feasible to put a telephone or television in every house, much less a fax or telex terminal, and community facilities will need to be made available. Cost-effective arrangements suitable to each socio-economic system and geographic situation will need to be developed. It is that problem that will require the largest spending for national communications development.

19. While a rural communications system could be established using only satellite terminals, in most cases a combination of satellite and terrestrial links will be most cost-effective, particularly where some terrestrial communications infrastructure already exists. New and improved radio techniques, for example, offer great promise as a relatively inexpensive means for the "last mile" link from a local hub, which may be a satellite terminal, to individual residences, offices or public facilities.

20. As a result of the great reductions in the costs of satellite communications, satellites and earth stations represent a decreasing percentage of the cost of communication development. The major costs in rural communications systems will be for hardware in the home, school, business and village center, software and programming, and human resources to operate, maintain and develop those elements.

I. SATELLITE SYSTEMS FOR DEVELOPING COUNTRIES

21. As rural communications generally require a small capacity relative to that of urban communications and that of communication satellites, it will not generally be feasible to develop a satellite specifically for rural development. Rather, rural communications will use part of the capacity of satellites established for other purposes. Countries that have domestic communication satellites, or that participate in regional satellite systems, will normally use part of those systems. For other countries, the alternatives are the use of international satellite systems such as Intelsat and Inmarsat, or the use of capacity on other domestic or regional systems that can reach their territory.

A. International systems

22. The Intelsat satellite system is the most global communications satellite system, providing services to 124 member countries around the world, including 82 developing countries, and to a number of non-member countries. Some 34 developing countries that are not members make use of the system. In 1992, Intelsat owned and operated 19 geostationary satellites serving all areas of the world outside the polar regions. A growing number of countries, currently including nineteen developing countries, not only use Intelsat for international communications, but have leased or purchased Intelsat capacity for domestic use, primarily to provide communications between major cities. The use of Intelsat capacity allows a country to lease or buy only the capacity it immediately requires and to expand that capacity gradually in response to demand.

23. In addition to its standard services designed for heavy traffic routes, Intelsat offers the Intelnet service, which can be used for domestic networks consisting of one or more large "hub" stations and a large number of small, low-capacity rural terminals each with a few circuits for voice, fax, telex or data. Such systems are being used for environmental monitoring networks, disaster relief and other rural and remote communication needs. The European Space Agency is currently using such a network as part of its Direct Information Access Network for Africa (DIANA) to exchange information on droughts, crop failure, and desert locust movement between Ghana, Kenya, Zimbabwe and the headquarters of the Food and Agriculture Organization (FAO) in Rome. The United Nations also uses Intelsat voice links for communications between headquarters and peacekeeping forces in various trouble spots in the world. A remote terminal for use in an Intelnet system with, for example, a 2.4 m antenna with a capacity for a few voice and data channels would cost about $32,000.

24. The cost of a rural communication satellite system will include, in addition to the cost of the ground stations and user equipment, the charges for using the Intelsat satellites. Those charges depend in rather complex ways on the nature of the service and signals, the size of the earth stations, the capacity required and the length of the lease. In general, the smaller the earth station, the greater the satellite capacity required for a particular use, and hence the greater the satellite use charges. There is therefore a trade-off between equipment cost and usage charges. For rural communications with a low volume of traffic, the most cost-effective system will generally use low-cost terminals with higher prices for usage.

25. To assist developing countries in the use of the Intelsat system, Intelsat in 1978 introduced its Assistance and Development Program (IADP) to provide assistance in feasibility studies, planning of new services, system design, and training in the development, operation and maintenance of ground equipment. Some 61 developing countries, including both members and non-members, have received assistance under the IADP programme, and an additional 35 countries have attended IADP information seminars. In addition, the Intelsat Development Fund (IDF) can provide funding for the introduction and improvement of rural communications services.

26. In 1984, Intelsat introduced a project called Satellites for Health and Rural Education (SHARE), offering free satellite capacity for experimental uses of satellite communications for rural development. In 1987, as a follow-on to Project SHARE, Intelsat introduced Project Access, also for experimental use of the system for rural education, health and other social services, with an emphasis on voice, fax, data or narrow-band video rather than the more expensive television

links, and with a view to developing operational services. Examples of activities undertaken under the SHARE programme were the development of a national educational television network in China, which has since expanded and become operational, and the establishment of voice and data links allowing medical centres in Kenya and Uganda to consult with specialists at Memorial University in Canada.

27. Inmarsat is an international organization with 65 member countries that owns and operates a system of geostationary satellites to provide global communications for ships at sea, aircraft and land mobile users. The system is used for telephone, telex, fax and data services and currently serves some 25,000 terminals, including almost 5000 portable telephone systems for remote land use.

28. The primary Inmarsat service, Inmarsat-A, uses terminals with dish antennas housed in a 1.2 m radome and costing about $35,000. Those terminals provide telephone, high-speed data, fax and telex links. A transportable Inmarsat-A terminal can be carried in two suitcases and set up quickly where required. Inmarsat-C service, commercially inaugurated in 1991, uses the smallest and lightest type of terminal currently available, about the size of a briefcase, and is used to send and receive electronic messages. Terminals are available for about $4000 to $6000 and can be powered by batteries or solar panels.

29. The Inmarsat-M system, currently being introduced, will allow telephone communications through briefcase-sized terminals costing about $10,000. For the future, Inmarsat is planning a number of new services with smaller and more portable terminals, including a global paging service for alert signals or short electronic messages and, by the end of the 1990s, the Inmarsat-P service with hand-held telephones communicating directly via satellite, at an estimated cost of $1500 for the terminal and about $2 per minute of use.

30. On land, Inmarsat is used by trucks and other vehicles, for remote news-gathering, for disaster relief, on expeditions to remote areas, and in other situations where conventional communication satellite links or other communications facilities do not exist. The United Nations has a number of portable Inmarsat terminals for emergency use by peacekeeping forces. The Inmarsat organization also cooperates with the Cospas-Sarsat search and rescue system and is studying the possibility of offering navigation and search and rescue services in the future. Inmarsat has a programme for assisting developing countries in using the system, including free use of the system for experimental or emergency use, training of personnel and information workshops.

31. While Inmarsat terminals are less expensive than Intelsat terminals, the cost of using the system is substantially higher. In general, Inmarsat terminals are cost-effective for mobile, emergency or short-term use in situations where larger terminals for use with the Intelsat or other communication satellite system are not feasible. They are therefore not generally suitable for long-term rural development.

B. Asia

32. Indonesia was the first developing country to establish its own domestic communication satellite system, the Palapa system, which has been operating since 1976. The first of the second-generation Palapa-B satellites was launched in 1983, and the third-generation Palapa-C satellites

are now being planned. In addition to its use in Indonesia, the Palapa system is being used for domestic communications in Malaysia, the Philippines and Thailand.

33. For Indonesia, satellites offer a solution to the communication problems of a population of 180 million, largely rural and distributed over thousands of islands across an area of almost 2,000,000 sq. km. The introduction of the Palapa system made it possible to provide improved telephone and telex services among 40 earth-station locations which were integrated into the national communication network. Since its introduction, the Palapa network has increased from the initial 40 earth stations to more than 200. The communication services include telephone, television distribution, data and business services. The third-generation, Palapa-C satellites are expected to add other services, including maritime and land mobile services and services specifically designed for rural areas.

34. With satellite links established between cities, the priority for the further development of the Palapa network is bringing telephone service to remote and isolated communities on Indonesia's many islands, which have until now had to rely on high-frequency radio links that are often unreliable. Still, the economic problems of the "last mile" have limited the use of the earth stations for telephone service, since Indonesia's telephone density is only 0.4 per 100 inhabitants, and much lower in rural areas.

35. India, like many developing countries, faces great problems in providing communications services to its people. Some 90 per cent of the over 500,000 villages in India with populations between 500 and 2000 have no telephone facilities. Even where a village telephone exists, many people have to walk 5 km or more to get to it, and access may be available only during the working hours of the village post office. Hence, telephone usage for many rural people is limited to extreme emergencies. Almost all village telephones are on long open-wire lines which are difficult to maintain and often unreliable. Only 10,000 villages, mostly with populations above 5000, have telephone exchanges that can provide individual subscriber telephones. Where telephones and lines exist, maintenance and repair services are often poor due to non-availability of spare parts and skilled personnel. While the telephone provides a much cheaper mode of communication than the alternative of travel, the lack of access to reliable service results in a very low usage and hence the rural telephone services usually operate at a financial loss.

36. As communication satellite technology developed, it was recognized that satellite communications could offer a means of leap-frogging over conventional methods of gradually extending terrestrial communication facilities to remote areas. Satellite technology also offered an opportunity for improving the television broadcasting network. As a first step, under an agreement between India and the United States, the Satellite Instructional Television Experiment (SITE) was carried out for a year in 1975-1976, using the United States Applications Technology Satellite, ATS-6. Receivers consisting of antennas, electronics and television sets, all made in India, were installed in 2400 rural villages, including battery-powered systems in some 100 villages with no electricity. The educational television programmes were mostly aimed at children from 5 to 12 years old. During school vacations, teacher training programmes were shown to about 50,000 teachers, and general education programmes for adults were shown in the evening.

37. Since 1983, domestic satellite communications and broadcasting have become operational using the Insat satellites. The Insat satellite system has made possible a massive expansion of television coverage through a nation-wide system including both direct reception systems and

community receivers connected to low-power broadcasting stations. By the end of 1988, television broadcasting covered most of the country, even very remote areas and the island territories. The ground system included over 250 community receivers and rebroadcasting systems, about 2,000 government-funded direct receiving systems, and many thousand of privately-owned receivers, as well as fixed and transportable stations for remote transmission of programmes to the satellite.

38. China, with its huge population and vast territory, 80 per cent of which is mountainous or desert, has been using satellites to improve communications throughout the country. China began by leasing Intelsat capacity for domestic use, then launched its own experimental communications satellite, STW-1, in 1984. In 1988, China launched the first Chinasat operational communications satellite to supplement the capacity leased from Intelsat, and additional Chinasats have been launched and are being planned. The primary functions of those satellites has been to link together the capitals of the provinces of China and to extend television coverage to the whole country. In addition, the satellite network has been used to provide data networks for economic enterprises, and a small-earth-station telephone network is now being developed in the vast thinly-populated areas of western China.

39. Before the introduction of domestic satellite communications in 1985 there was only one nationwide television channel, which was transmitted through multistage microwave links and videotape. Reception quality was uneven and 38 per cent of the population lived in areas with no television service. In 1985, a pilot project was established to provide nationwide television coverage through a transponder provided without charge by Intelsat for six months as part of Project SHARE. 53 small earth stations were installed in remote and rural areas to receive the satellite transmissions and rebroadcast the programmes for local reception by ordinary television sets.

40. The pilot project showed that 6 m antennas could be used with the Intelsat transponder and indicated that 3 or 4 m antennas could be used with a transponder focused on China. Financial analysis indicated that the most cost-efficient way to distribute television was through a large number of local earth station linked to low-power rebroadcasting stations, with direct-reception systems connected directly to community television sets for isolated small villages, organizations and schools. By 1987, the satellite television network had become operational, and more than 2000 television receivers and retransmitters had been set up as part of the national television broadcasting system, providing television coverage to an additional 60 million people.

41. The second phase of this programme, using the Chinasat satellites and leased Intelsat capacity, is expanding the network of receiving stations, and introducing a second nationwide television channel for educational programmes. In the third phase, now being planned, a more advanced Chinasat with twenty-four transponders will be launched with additional channels devoted to educational television for remote and rural areas.

C. Latin America

42. Mexico has a population of more than 77 million, of whom 20 million live in villages without telephone, telegraph or television services. This rural population is spread throughout the country in more than 100,000 villages. Mexico first introduced satellite services for communications and broadcasting by leasing capacity on both Intelsat and the United States

domestic Westar system. Mexico's domestic Morales satellite system was launched in 1985, with one operational satellite and an in-orbit spare, and is used for long-distance communications between major Mexican cities, national television distribution, and radio and data communications through 272 earth stations.

43. Plans are underway to add up to 250 new earth stations to serve smaller towns and make the system available to more people. However, while the Morales satellites have substantially expanded television distribution in rural Mexico, the extension of other communications services has remained limited due to the "last mile" problem. There are still only 4.6 telephone lines per 100 people nationwide, and far fewer in rural areas.

44. Brazil is one of the largest countries in the world, with vast, sparsely populated areas in and around the Amazon basin, with very limited communications and transportation services. The population is largely concentrated in the southeastern part of the country around Rio de Janeiro and São Paulo. Brazil began its domestic satellite communications programme in 1976 with the lease of Intelsat capacity for distributing television programmes to cities in the Amazon region and other areas in northern and western Brazil that had previously been served by radio links that were not always reliable. Telephone service was soon added, and the system grew to the point where a domestic satellite system became more cost-effective than Intelsat leases. The first two Brasilsat satellites were launched in 1985 and 1986. In 1991, the ground network consisted of 35 earth stations for general communications purposes, 40 for data networks, about 800 official earth stations for television reception and rebroadcast, and an estimated 15,000 unofficial television reception systems.

45. To overcome the difficulties in developing communications networks in the mountainous areas of South America, the Association of State Communication Enterprises of the Andean region (ASETA) decided in 1991 to use satellite capacity leased from Intelsat for the development of a regional Andean satellite communications system. The five countries involved in the project, Bolivia, Colombia, Ecuador, Peru and Venezuela, are already leasing 11 transponders and have recently decided to lease eight more to meet the growing demand for telephone, data, television and business services. Through the use of Intelsat leased capacity, ASETA members have established their system quickly while minimizing financial investments and allowing for flexible and incremental growth as the earth station network is established and traffic increases. In planning the system, ASETA received assistance from Intelsat in the financial analysis and in estimating demand for communications services. The consolidation of the requirements of a number of countries has made possible more efficient use of transponders and hence lower cost.

D. Africa and West Asia

46. For the Arab Peninsula and North Africa, satellites offer an ideal means to deliver communications and broadcasting services, including services to the villages scattered across the vast deserts of the region. Algeria was the first of the Arab nations to use satellites for domestic use through the lease of an Intelsat transponder, and Libya, Morocco, Oman, Saudi Arabia and Sudan have also leased Intelsat capacity for domestic communications. With this experience, the Arab nations went on to develop their own Arabsat satellite for regional and domestic communications.

47. The Arabsat system evolved from a 1953 Arab League Agreement to develop regional telephone, telex and telegraph communications. In 1976 the twenty-two members of the Arab League established the Arab Space Communication Organization (Arabsat) to own and operate a regional satellite system for domestic and regional use by its members. Two satellites were launched in 1985, with a third serving as an unlaunched spare. Each spacecraft has a capacity of 9,000 telephone circuits and seven channels for television distribution as well as a channel for high-power television broadcasting for direct community reception. The television receivers, estimated to cost about $3,000, are designed to operate on regular power, by battery or by solar power. The construction and operation of the earth stations is the responsibility of the individual countries.

48. The population of Africa is about 72 per cent rural and often living in rugged or inhospitable terrain with limited facilities for transportation and communication. Development of communications is also limited by limited incomes and a lack of power supplies, especially in rural areas. Many African countries face critical problems of food supply, health care and illiteracy, making it very difficult to find resources for communication services to rural areas, even recognizing the contributions that improved communications could make to addressing those problems.

49. About twelve African countries are now using transponders leased or purchased from Intelsat for domestic services, generally for linking major cities into national networks. While some consideration has gone into the possibility of domestic satellite systems, the large capital outlays required are beyond the capability of most if not all African countries. A number of studies have been undertaken to determine the feasibility of a regional African satellite communication system (RASCOM) and have indicated that satellites can play a major role in meeting the communication needs of African countries, including radio and television broadcasting. Studies are continuing in order to identify the most cost-effective means of meeting those needs through the use of satellites together with other communication technologies. Consideration is being given, for example, to consolidating the leased transponders and enabling them to be used for regional as well as domestic communications. For rural development, the economics of providing telephones or other communication media to villages with extremely limited financial means remain a major obstacle.

II. SATELLITE COMMUNICATIONS FOR RURAL DEVELOPMENT

A. Education

50. The global population today is over 5 billion, and it is projected to reach nearly 10 billion by the middle of the 21st century. Over the next 30 years, more people will need to be educated than in all of history up to this point, and a large proportion of the children needing education will live in rural areas of developing countries where existing educational systems are not equal to the challenge. In developing countries, the median age of populations is typically 17 to 19 years with limited numbers of adults qualified to teach the huge school-age populations. The use of electronic media and of satellites can make an important contribution to meeting those needs.

51. Communication satellites can be used to give additional people access to basic education, to improve the quality of education in rural areas, and to bring specialized courses to small

schools in order to promote economic, social and cultural development. Students will need programmes covering not just basic literacy, numeracy and the traditional academic subjects, but also skills, knowledge and practice in such fields as agriculture, public health, hygiene and family planning, and general knowledge of science, history, the arts and current events. Continuing education will be required for teachers, health care and social workers, farmers, technicians and other skilled workers to enable them to keep up-to-date with rapidly changing technologies.

52. A satellite-based system for programme distribution is one means among many that can be used, either separately or in combination, for educational purposes. Receiving systems can be located in schools for use as a resource by teachers, in the workplace for training or upgrading professionals, or in the home for correspondence courses or general education. Programmes can be watched as they are broadcast or recorded for later viewing. Broadcast programmes can complement closed-circuit television, radio, other audio-visual means, written materials and interaction via telephone for conveying information. Response to student questions and comments can be provided by teachers in the schools using the broadcast programmes or by the distant instructors through voice links for correspondence. A detailed study of the use of satellite broadcasting or educational purposes is contained in document A/AC.105/341/Rev.1.

53. A number of educational broadcasting programmes in the United States have created new opportunities for students in rural or small town schools that did not have teachers qualified to teach courses such as foreign languages, advanced physics and calculus. In the 1970s, the experimental Applications Technology Satellite ATS-6 was used to provide educational programming to small towns in the Appalachia Mountain region, in the Rocky Mountain region and in Alaska. In the 1980s, based on its experience with ATS-6, the state of Alaska, with a large area and a low population density, established a state educational satellite network. In 1985, Oklahoma State University established the Arts and Sciences Teleconferencing Service for providing educational programmes for small schools, with a satellite audio-return channel, as well as telephone and electronic mail enabling students and instructors to interact. The cost of equipping a school to participate in these programmes, including the cost of the receiving equipment and related video, communications and computer systems, is about $10,000. Similar programmes were subsequently established in other states with extensive rural areas including Kentucky, Missouri and Washington State.

54. An effort is being made in the United States to facilitate access by schools to existing educational television broadcasts. The Public Broadcasting Service (PBS), as part of a pilot programme named Project VSAT (Very Small Aperture Antenna), is promoting the use of a single communications satellite dedicated entirely to educational broadcasts as a carrier for educational programmes that are now carried by a variety of satellites. This would mean that schools could receive a variety of different programmes through a single small antenna without having to repoint the antenna from one satellite to another, thus improving access, simplifying equipment and reducing costs. As a second objective, Project VSAT will promote the use of advanced video-compression technology to increase the effective capacity of the satellite, making it possible to transmit 20 to 40 programmes using 5 transponders. The increased capacity will also enable the schools to interact with the studio instructors and perhaps with each other.

55. China began using satellites for rural education in 1985 through Intelsat's Project SHARE and has since developed the system to provide national coverage. The programme is carried out under the direction of the State Educational Commission, which established China Educational

Television (CETV) to prepare and broadcast educational programmes for distribution via satellite. Cooperating with the Post and Telecommunications Ministry, CETV operates an earth station to broadcast programmes through Intelsat and Chinasat, with thirty-one hours of educational programming broadcast every day via two channels. The remaining time is used by provincial education stations that prepare and broadcast their own programmes.

56. A priority for rural education in China is teacher training. There are 8 million teachers in elementary and middle schools in China, of which 3 million require further training in order to be able to teach all levels in China's nine-year basic education programme. There are also 2.6 million people needing further on-the-job-education and training in technical and professional work required for national technological and economic development. In addition, tens of thousands of students are studying for regular university degrees through the Central Broadcasting and Television University. In order to promote market development and improve the rural economy, adult educational programmes emphasizing economic and technical information have also been broadcast. The organization and management of television education is based on more than 10,000 study centres, including existing teaching centres and newly created television university centres across the country.

57. By the end of 1990, some 36,000 hours of educational programmes had been broadcast over the two channels devoted to educational television. More than 600 receiving and rebroadcasting stations and 4,000 direct-reception systems have been set up in 29 provinces. About 20 million people view educational programmes or take courses either at home or in learning centres throughout the country.

58. Satellite broadcasting projects have demonstrated the immense potential of the technology for education. The successful projects have also demonstrated, however, the importance of organizational and institutional factors. While hardware can be imported, the organization of an educational broadcasting programme must be adapted to the existing educational structure, institutions and personnel. The educational material must be indigenously produced so as to correspond to the needs of the target population and to the country's priorities for economic and social development. To the extent that hardware can also be produced indigenously, it can be adapted to local needs and can more easily be maintained and improved. Finally, the hardware, software and human resources of the system must be integrated so as to be able to respond to the evolving needs of the society in a cost-effective manner.

B. Health

59. In virtually every country, people in remote and rural areas have not received the same level of health care as those living in more populated and urban regions. While it may never be possible to distribute health services equally throughout a country, the gap between urban and rural areas can be narrowed. Attempts to provide human and material resources in rural areas have often encountered recruitment difficulties and high costs. Experiments during the last two decades, however, have shown that telecommunications can contribute to the effective and affordable delivery of health services to remote and rural areas.

60. The use of telecommunications for medical services is not entirely new. Since the development of the telephone, telegraph and radio, doctors and other medical workers have

used these means to consult with each other. The extensive use of electronic communications for medicine, however, required a further step, namely the development in the 1960s and 1970s of techniques for converting medical observations into signals that could be transmitted over ordinary telephone lines or other telecommunication links.

61. Major advances included the development of modems for converting data and information into audio-frequency signals that could be carried by telephone lines and then back into data and information at the receiving end. Another advance was the development of scanning systems for converting images into electronic signals, a technique now widely used in the form of fax transmission. These techniques allowed the transmission of x-ray images, electro-cardiogram traces, medical records and other data without retyping or other special preparation. Also developed were electronic and programmable medical instruments such as cardiac pacemakers and temperature probes that could be implanted in the body to generate medical data in a form that could easily be transmitted by telephone for diagnosis at a distant site.

62. Those techniques, combining medical measurements and telecommunications, are referred to as telemedicine. Some of the techniques were developed for monitoring the condition of astronauts during spaceflight and subsequently developed into ground-based telemedicine applications. A detailed study of the applications of biomedical technology resulting from space life-science research is contained in document A/AC.105/500.

63. Telemedicine has been used to improve medical care in a number of ways: to make specialized expertise more widely available; to provide routine medical care to areas without local services; to provide rapid response in emergencies; to provide medical students with access to medical knowledge and experience not otherwise available; and to improve the sharing of information and experience between medical practitioners and promote a sense of professional community, particularly for practitioners working outside of medical centres. All of these elements are particularly important for rural areas in developing countries.

64. In the United States, the first experiment in satellite telemedicine was undertaken in Alaska beginning in 1971 under the auspices of the United States Public Health Service, using the ATS-6 satellite. Faced with the problem of servicing scattered small villages in remote regions with limited access to transportation and communications, the agency turned to satellites and consultation by telecommunications in order to improve health services.

65. In one application, 14 villages without telephone service were provided with satellite telephone links to a regional hospital. The experiment involved daily consultations between local village health aides and doctors at the hospital. In addition to consultations, the voice link was used for communications between patients at the hospital and their families in the villages, providing the patients with valuable psychological support. The satellite system was also used to enable doctors in Alaska to consult via computer the National Library of Medicine on-line information system in Bethesda, Maryland, and to enable nurses to take a University of Alaska continuing education course on coronary care.

66. As a result of the satellite link, the number of contacts between doctors and village health aides increased by 400 percent during the first year of the experiment. The State of Alaska and the United States Public Health Service subsequently converted the experimental projects into operational programmes using commercial communication satellites.

67. In 1972, a demonstration project entitled Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) was undertaken jointly by the United States National Aeronautics and Space Administration (NASA) and the Department of Health, Education and Welfare. The project goal was to develop a system for delivering quality health care to people located in remote areas, initially working with the people on the Papago Indian Reservation in Arizona. A combined system of voice, video and data satellite links, together with computerized patient data banks was developed for this purpose.

68. The STARPAHC system serves over 10,000 people in 75 villages scattered over 70,000 sq. km. on the reservation, as well as an additional 4000 people who live outside the reservation but return for health care. The system is staffed by government medical personnel and includes a control center located in a hospital in Sells, Arizona, a clinic on the reservation, a mobile health unit, and a referral center in the Indian Health Hospital in Phoenix. The computer center in Albuquerque, New Mexico, provides access to a central health information database. A portable electronic vital-signs monitor (Telecare Unit) is used for house calls and emergency treatment. A doctor at the hospital can visually examine patients in the mobile unit or clinic by means of remote controlled television cameras, display patient medical data, conduct private interviews, and read X-rays or microscope slides on a video screen.

69. The mobile unit is a fully-equipped clinical van that visits settlements on a regular schedule, establishing communications with a doctor at the hospital at each stop. Staffed by physician's assistants and laboratory technicians, the unit gives the doctor an efficient and flexible outreach capability. The doctor can see and talk with patients and medical personnel, order diagnostic tests, make a diagnosis and specify treatment to be performed in the mobile unit or clinic.

70. Following the 1988 earthquake in Yerevan, Armenia, the United States and the USSR established a Telemedicine Spacebridge to provide expert medical advice from several university hospitals in the United States to doctors in Yerevan. The satellite links, donated by Intelsat, included a video channel from Yerevan to the United States and two-way voice and fax circuits. The project was subsequently extended to provide assistance in the treatment of burn victims from a train wreck at Ufa, Russia.

71. A low-cost, not-for-profit, international medical communications satellite system called SatelLife is now under development under the sponsorship of the International Physicians for the Prevention of Nuclear War and in cooperation with the Red Cross, UNICEF and the World Health Organization (WHO). Doctors or clinics in developing countries will use a microcomputer and a radio transmitter with a simple whip antenna to send a message to a small, low-orbiting micro-satellite, which will relay the message to doctors, hospitals or medical libraries. A reply can be returned in a few hours, depending on the number of satellites in operation. One of the planned projects will connect a hospital in rural Nigeria with a university hospital in Canada to try to reduce complications in childbirth.

C. Rural communications

72. The predominant use of satellites for telephone and electronic message service in both developed and developing countries is for urban and commercial communications. Such services are generally offered on a commercial basis, with the users paying for the system through usage charges. As the cost of satellites and earth stations has decreased, such commercial satellite

communications have become viable for smaller cities and, in some countries, for smaller towns. At the village level, however, in most developing countries, modern communications media, whether via satellite or by other means, are not financially self-supporting. An extension of modern communications to rural villages will require new low-cost communications techniques, organizational approaches and financial arrangements. The development of commercial or administrative networks that could be used by rural populations as a secondary service at marginal costs would be one way to promote rural use. A small surcharge on commercial and urban users could also be used to promote development of rural communications as an investment in national development.

73. The design of a cost-effective rural communication system will depend on the type and volume of communication traffic, the number of earth stations, and the pattern of communications between the earth stations. In general, the least expensive system for rural communications is a "star" network, consisting of a large number of small earth stations communicating through one or more larger "hub" stations. The larger the number of small terminals served by a hub station, the more cost-effective the network, and a number of small networks can reduce costs by sharing a hub station. Such star systems of small terminals have been established in a number of countries in Latin America and Asia, but mostly for urban uses such as banking, tourism or government administration. That experience, however, and the financial base, can be useful for the subsequent development of rural networks.

74. In northeastern Peru, a pilot project known as the Rural Communications Services (RCS) project was carried out between 1978 and 1986. A transponder leased from Intelsat was used to link three small (6 m diameter) earth stations in a rural area of the country to a central earth station and the national network. The small earth stations were linked to village facilities through VHF radio-relay stations.

75. The project provided the villages with telephone, telex and telegraph facilities for public use, and installed in each village a teleconference room to enable groups to participate in education, public health and agricultural programmes. The purpose of the pilot project was to develop, evaluate and promote ways to use telephone and audio-teleconference services in support of rural development. Information was collected on telephone usage and revenue generated from the public telephone booth and from private subscribers in order to assess the economics of the telephone service.

76. The assessment indicated that the project was technically, economically and socially successful, although it required a greater investment than originally planned. The project personnel received valuable training and acquired technical and operational experience, and the social evaluation of the rural localities provided information for development planning. From the technical and operational point of view, the project demonstrated the cost-effectiveness of combining satellite links and VHF radio-relay links, and the audio-teleconference services proved to be an effective means for supporting development programmes in the fields of education, public health and agriculture in rural areas. The system was simple to operate and use and effectively made communications services accessible to previously isolated populations.

77. In 1987, India began installing a national information network to connect local government service facilities throughout the country by satellite as part of an effort to improve social services and economic planning. The system uses PC-type computers at the local level communicating via satellite with larger computers at the state and national level. Among the applications of the

system are the collection of data on food and fertilizer supplies to ensure that distribution corresponds to requirements.

78. There are a number of proposals for low-orbit communication satellites which could provide voice, data, electronic messaging or paging services to very small and inexpensive personal terminals. Those terminals would communicate to large central international facilities which would transmit the messages through national or international communication networks or retransmit it to another personal terminal. The use of low orbits reduces the power requirements for the terminals, but requires multiple satellites for continuous communications, thus shifting costs from the ground to the space segment. The systems are intended largely for business people or other travellers in areas without adequate communications facilities, but, depending on the financial arrangements, may be useful for some rural development applications. If the necessary investment funding is found, such systems could be operational within a few years.

D. Disaster relief

79. Between 1967 and 1987, natural disasters disrupted the lives of more than 800 million people, caused nearly 3 million deaths, and resulted in property damage on the order of $50 billion. Disasters caused particular hardship in developing countries, which often did not have the resources to cope with them. Effective responses to disaster require good communications between those responsible for planning the rescue and relief efforts and those in the affected area who are the best able to describe the extent of the damage and the type of help most urgently required. However, even in developed areas, communications lines are often disrupted by the disaster and can take weeks or months to repair, leaving disaster response organizations with little information on conditions in the affected area.

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80. The development of mobile or transportable satellite terminals allows rapid deployment of emergency communications systems in disaster-affected areas. Transportable or "flyaway" earth stations as small as 1.8 m can be carried in 2 to 4 suitcases and can be used to communicate via conventional communication satellites. Very small antennas use more satellite capacity than larger antennas and are charged higher usage fees, so the optimum size for a given mission depends on the transportation logistics and the volume of communications expected. In some cases the very small systems that can be carried on an airplane are used for immediate communications, then replaced by larger but still temporary satellite earth stations delivered by truck, and finally by the re-establishment of the permanent system, whether satellite or terrestrial. Such systems have been used recently to re-establish communications following earthquakes in Mexico and Armenia, a volcanic eruption in Colombia, and hurricanes in the United States. They have also been used to manage operations in non-natural disasters such as large off-shore oil spills or other environmental accidents where communication facilities are inadequate.

81. Satellite communication systems can also offer an important means for rapid dissemination of warning information concerning prospective or potential disasters such as approaching hurricanes or predicted flooding in remote and rural areas through small warning terminals.

82. The Cospas/Sarsat satellite search and rescue system was established in 1982 as a cooperative programme between Canada, France, the USSR and the United States to locate aircraft and ships in distress in remote locations anywhere in the world without charge. The

Sarsat payload developed by Canada and France is carried on United States NOAA meteorological satellites, and the Russian Cospas payload is carried on Russian Nadezhda (Hope) satellites. The satellites relay distress signals from ship or aircraft emergency radio beacons, which are activated under accident situations, to terminals in the four operating countries and in ten other countries around the world. With four satellites in operation, it takes an average of about one hour for the distress signal to be picked up and analyzed to determine the location of the accident. The system has been used in nearly 1000 accidents and has resulted in the rescue of about 3000 people. In addition to ships and aircraft, the system has been used by a number of land expeditions operating in remote areas, including the Arctic, the Antarctic and the Sahara Desert.

III. ECONOMIC AND PLANNING CONSIDERATIONS

83. Compared to terrestrial communication networks, a satellite network can provide rapid and total coverage of a large territory, including coverage of mountainous or isolated regions with the same reliability, capacity and quality as for highly-populated areas. For large areas, satellite networks generally cost less to install and operate and offer increased security and reliability since they can avoid unpopulated stretches of land where land-line maintenance is difficult. Satellite networks also offer greater flexibility in responding to changing requirements and growth.

84. While a satellite network could, in principle, provide for the full communications needs of a country, in practice some sort of hybrid system, using a combination of satellites, land-lines, microwave links and radio, will be most cost-effective. Satellite networks must be designed to supplement existing systems by upgrading inadequate elements in the system and linking previously unserved areas into the national network.

85. The choice of technologies for telecommunications, the integration of different technologies and the services to be provided will be an economic and technical policy decision specific to each country. The considerations that need to be taken into account include the size of the country, the geographical constraints on communications and transportation, the existing communications system, and the economic and social needs of the people and institutions.

86. While the need to communicate is common to people everywhere, the characteristics of communication systems are different because of the socio-economic, geographic and climatic environments. Systems designed for cities are generally not suitable for rural use because of their size, complexity, cost and maintenance requirements. A rural communications system needs to be easy to transport and install, low-cost, low-maintenance, and adaptable to changing needs.

87. Low-cost VHF or UHF radio systems can be effectively combined with satellite networks for thin-route rural applications. Individual telephones or other communication devices can be connected by radio to a small local earth station, which provides satellite links to the national and international networks.

88. In many developing countries, it may not be possible in the near term to provide every household with a telephone, both because of the public investment required and because of the cost to the household. A feasible goal might be ensure that everyone at least has access to a public telephone within a five minute walk.

89. In the field of television broadcasting, satellites can be much less expensive than terrestrial microwave networks for distributing and broadcasting programmes to large areas. Where the population is not too thinly scattered, a combination of satellite distribution with local retransmission by conventional broadcasting is often the most cost-effective method.

90. Much of the communication equipment that has been designed in advanced countries for temperate climates is not suitable for rural areas of tropical developing countries because of high temperature and humidity, dust, salinity, heavy rainfall and severe storms. Equipment requiring an air-conditioned environment may be unusable due to lack of stable and reliable electrical power.

91. In areas of unreliable electrical power supply, a back-up power supply in the form of batteries or a generator may be required to maintain continuous service. New technologies with lower power consumption will reduce the battery or generator capacity required. Developments in reliable and low-cost solar cells and wind generators will also help to address the power-supply problem in rural areas.

92. It should be noted, however, that the newest technologies are undergoing rapid changes, and support services for spare parts, software, maintenance and training can be expensive and difficult to obtain. With digital technology, it should be possible to develop a family of systems or modules for a variety of uses in different situations with common elements of hardware, software, documentation and training. This should reduce the cost of digital exchanges for small-scale rural use because the developmental costs could be shared with the large urban exchanges.

IV. CONCLUSIONS

93. In spite of major developments in communications technology, there is, on average, only one telephone for every 100 persons in developing countries, compared with about one telephone for every two in developed countries. In rural areas of developing countries, the situation is even worse, with the large majority having no convenient access to telephone service. Satellite-based communications, with its inherent flexibility, offer new opportunities for cost-effective rural communications, information gathering and dissemination, data networks, mobile communications and disaster warning and relief management. While domestic, regional and international satellite systems have already initiated a new communications revolution, the share of developing countries in these systems is less than 10 per cent.

94. While the role of education in the liberation of humanity from poverty is well recognized, over 30 per cent of the population in developing countries — some 2 billion people — will still be illiterate in the year 2000. The fact that most illiterate people in developing countries live in rural and remote areas makes the eradication of illiteracy a major challenge for humankind. A major role in meeting that challenge can be played by the use of satellites for distributing audio-visual programmes for basic education, public education for rural development, social and cultural education, continuing education for public service personnel, and for university-level and other advanced education and training.

95. The applications of space communications for rural communications, education, health, disaster warning and relief, and other aspects of social development are still largely in an

experimental phase, particularly in developing countries. The examples discussed in the present study illustrate the value of such space applications for social and economic development in remote and rural areas, but do not by any means exhaust the ways in which space technology can be used for such development. Rather, the examples are intended to illustrate ways in which institutions working with space technology have worked with economic development institutions to develop imaginative new approaches to meeting the particular needs of particular areas or groups of people.

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