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ABSTRACT

Basic information about the characteristics, uses, and implications of communication satellites is presented. Characteristics covered include the various types of systems--such as point-to-point, distribution, and broadcasting satellites--and the flexibility, capacity, geographical coverage, cost and disadvantages of satellites. The section on uses discusses existing and planned satellite communication systems, patterns and purposes of use, categories of services and users, remarks on costs, and alternatives. Implications for information, education, culture, the law, and institutional frameworks are noted. A selected bibliography is included. (JK)

No. 66

A guide to satellite communication

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Number

21 *Current Mass Communication Research I - Bibliography of Books and Articles on Mass Communication Published since 1 January 1955*, December 1956.
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47 *Books for the Developing Countries: Asia, Africa*, 1965.
48 *Radio Broadcasting serves rural development*, 1965.
49 *Radio and television in the service of education and development in Asia*, 1967.
50 *Television and the social education of women*, 1967.
51 *An African experiment in radio forums for rural development. Ghana, 1964/1965*, 1968.
52 *Book development in Asia. A report on the production and distribution of books in the region*, 1967.

Number

53 *Communication satellites for education, science and culture*, 1967.
54 *8mm film for adult audiences*, 1968.
55 *Television for higher technical education of the employed. A first report on a pilot project in Poland*, 1969.
56 *Book development in Africa. Problems and perspectives*, 1969.
57 *Script writing for short films*, 1969.
58 *Removing taxes on knowledge*, 1969.
59 *Mass media in society. The need of research*, 1970.
60 *Broadcasting from space*, 1970.
61 *Principles of cultural co-operation*, 1970.
62 *Radio and television in literacy*, 1971.
63 *The mass media in a violent world*, 1971.
64 *The rôle of film in development*. 1971.
65 *The practice of Mass Communication: Some lessons from research by Y.V. Lakshmana* (to be published).

A guide to satellite communication

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FOREWORD

This booklet is intended primarily to provide decision-makers concerned with planning and communication with basic information about the characteristics, uses and implications of communication satellites, in order to help them to assess their potentialities to contribute to development. Its publication forms part of Unesco's programme to promote the use of space communication for the free flow of information, the spread of education and greater cultural exchange. This programme is carried out in close co-operation with the United Nations and the International Telecommunication Union, and the booklet responds to a request from the United Nations Committee on the Peaceful Uses of Outer Space, for such a survey, in non-technical terms, as one of a number of documents reviewing the potential benefits of practical space applications.

The spectacular growth of space technology in the last decade has focused attention on the possibilities of using satellites to extend television services rapidly to communities outside the range of existing conventional transmitters. The technical possibilities certainly exist, but the economics, the cost benefits, the necessary organizational structures and legal arrangements are still under study.

While this survey confirms the expectations that space communication has high potential to extend the free flow of news and information, contribute to the renovation and spread of education and promote greater cultural exchange, it also cautions that the technology alone gives no easy answers to the world's problems of communication, education and development.

Communication satellites should be seen in perspective - as part of a complex and interconnected communication structure. The advent of satellites has occurred at a moment in time when communication and information technology generally is subject to far-reaching change. The use of such innovations as video-cassettes, cable distribution and computers, as well as communication satellites, must be blended with more traditional media into a comprehensive and coherent communication policy and plan.

The wide implications of the use of satellites for public service and educational broadcasting are also emphasized in the booklet. The satellite itself is only one component in a system, which includes earth stations, receiving sets, power and maintenance facilities and inter-connexion with terrestrial networks on the one hand, and on the other, the complex of activities relating to programme preparation, production, utilization and feedback, as well as organizational, management and legal aspects. The costs mentioned therefore, can only be indicative and sight should not be lost of the fact that in an operational system, the expenditure on "software" will be far higher than that on the "hardware".

Unesco's programme includes provision for assistance to Member States in studying the use of space communication for information, education, science, culture and development and a number of preliminary surveys have already been undertaken at the request of individual or regionally grouped countries. Some of the experience gained in these studies is incorporated in this booklet, which, it is hoped, will help a sound evaluation to be made of satellite potentialities.

The co-operation of the International Telecommunication Union is gratefully acknowledged in this publication, as in other aspects of Unesco's space communication programme. The author of the booklet is Mr. Edward Ploman, formerly Director of International Relations, Swedish Broadcasting Corporation, and presently Executive Director of the International Broadcasting Institute. He has also led a number of missions in space communication. Any opinions expressed are those of the author.

TABLE OF CONTENTS

I. DESCRIPTION OF COMMUNICATION SATELLITES

1. BACKGROUND

The first telecommunication service to be offered to the public was the telegraph which was followed by the telephone, by radio-communication, broadcasting and now remote access to electronic information and data systems. The earliest means of telecommunication transmission was the overland telegraph cable followed by submarine and overland telephone cables, high-frequency radiocommunication transmission, microwave radio relay links and co-axial cables for overland and undersea use. While each new transmission mode represented an improvement in terms of quality, reliability, capacity and costs, each was no more than an extension of a particular type of transmission capability, each with its own specific limitations. All of them could be described as single-route, fixed-capacity transmission links, capable of linking together only two points on the earth's surface, some directly between two points, some through complicated switching equipment.

Thanks to the ability of radio waves to traverse space without physical interconnexion, the introduction of radio communication technology also led to the broadcasting of messages to many receivers spread over sizable areas simultaneously. The use of radio waves, whether for radio communication or broadcasting, is conditioned by the limited, usable radio frequency spectrum and by the pressure from old and new communications services competing nationally and internationally for the available frequency bands. While sound broadcasting can be satisfactorily performed in a number of ways, the bandwidth required for television broadcasting makes necessary the use of higher radio frequencies whose propagation conditions are severely limited. Television services would therefore be local in character unless a chain of television transmitting stations is connected via co-axial cables or microwave, line-of-sight radio relay links. Apart from being expensive, this solution is also limited in application. Microwave relay towers cannot be used over the oceans and submarine cables of sufficient capacity are extremely costly.

The early development of telecommunication services was based on the characteristics of the transmission facilities. This led to national sovereignty in the provision of domestic facilities, bilateral arrangements for international services and multilateral agreements for a partial management, at least, of the radio frequency spectrum, through the allocation and registration of particular operating frequencies for particular radio services.

A number of these traditional concepts are being rendered obsolete through the introduction and development of satellite communication services.

Satellite communications are the outgrowth of developments in two main areas: space technology and communications technology.

The first requirement for any space activity has however nothing to do with the state of technology since it concerns the ability to compute the velocity needed to escape earth's gravity and, as a next step, to keep a satellite in orbit. This knowledge comes out of a very old branch of science, celestial mechanics which began when man first studied the motions of the stars. So old in fact that it has been said "it was a science which was almost in moth balls until the new-found rocket technology returned it to prominence".(1)

The key technology in space flight generally is propulsion since the problem of launching objects into space resolves itself into securing the initial thrust required to escape the gravitational attraction of the earth and to give the space object the velocity necessary to hold its course by the inertia of its motion.

The ability to provide transportation services for a wide variety of spacecraft has progressed rapidly. "The early efforts of the late 1950s involved modest mission and payload requirements and were generally concerned with the launching

(1) H. G. Stever and R. G. Schmitt: The technical prospects in outer space, prospects for man and society, ed. by L.P.Bloomfield, Frederick A. Praeger, New York, 1968.

of relatively simple space research experiments. The programmes of the early 1960s expanded into such areas as lunar and interplanetary probes. Today, a wide variety of spacecraft... are launched on a routine basis ... A family of proven launch vehicles exists which can be adapted to specific mission needs. "(1)

Rocket technology is now capable of accelerating useful payloads to the very high velocities required to orbit the earth, to escape the earth and go to the moon and the other planets and also of providing a high degree of precision when placing objects in orbit around the earth.

The cost of boosting a payload to the high speed required for its mission, including the development of boosters, the establishment and operation of complex launching bases, the manufacture of hardware and fuel represents a major share of space programme expenditure. Even if development costs are huge, in the long run operational costs are the most important - at least as long as the greatest expenses arise from the fact that the launch vehicle is used for only one flight. Despite considerable decreases in costs, present launch costs are still quoted as being between $12,000 and $15,000 per kg of useful load in synchronous orbit. Therefore, it is likely that one of the main objectives of space programmes during the next decade will be directed towards the development of manned space stations which can be served by reusable vehicles capable of transporting men to and from earth, and from point to point in space. These space stations will be manned not by astronauts but by communication engineers engaged in the installation, operation and maintenance of communication satellites.

Even if launch costs have been going down and even if a number of countries, individually or in groups, are building up a launching capability, it can be expected that, in the immediate future at least, only a few countries will have a major launch capability. Most countries or groups of countries wishing to establish satellite systems of their own would therefore have to negotiate provision of launch facilities with those who have already developed this technology. As in most other space activities, international co-operation is a key factor.

The existence of rocket power to place satellites in orbit would however be of no practical value in the absence of efficient communications with spacecraft. Not only are communications an integral part of space activities generally but also one of the most essential factors in space research and applied space technology, since without communications, no meaningful human activity in space would be possible.

Space communications and computer technology all depend on innovations and advances in electronics which started with the transistor invented in 1948. Since then the trend has been towards ever smaller, more reliable and versatile electronic devices which have become essential devices in aviation equipment, computers, space and communications industry.

2. DEVELOPMENT OF COMMUNICATION SATELLITE SYSTEMS

A. Short historical summary

While evidently the development of satellite communications draws upon centuries of scientific and technological advances, there seems to be general agreement to trace the history of communication satellites to a definite moment in time and to a definite individual: October 1945 when Arthur C. Clarke, a young British radio expert and science writer, published a prophetic article entitled, "Extraterrestrial relays".

In this article Clarke introduced the idea of combining rocketry and microwave engineering to provide artificial satellites in stationary orbits around the earth serving as relays for transmissions from earth. He noted that "many may consider the solution proposed in this discussion too far-fetched to be taken very seriously. Such an attitude is unreasonable as everything envisaged here is a logical extension of developments in the last ten years - in particular the perfection of the long-range rocket of which V-2 was the prototype".(2)

It took some time before Clarke's idea was realized and then in a different way from what he had imagined. The first attempts at space communications were made not with man-made objects but with the moon as a reflector for radar and radio communication messages during the late forties and early fifties. Experiments using artificial satellites could not start until the beginning of the space era in the late 1950s.

Some of these experiments were an outgrowth of the use of the moon as a reflector. The orbit of the moon is anything but ideal for communications between various points on earth but with metallized balloons launched by rockets to sufficient altitude and placed in orbit around earth and adequate ground installations for tranmission and reception, a passive satellite communication system became possible. This concept was realized through the highly successful United States project Echo I, launched in August 1960, used for relay of telephony, facsimile and data.

This so-called passive satellite type had various disadvantages, above all the inefficient use of transmission power. Since new, miniaturized electronic equipment had made it possible to launch

(1) Joseph B. Mahon: Launch vehicles for space telecommunications applications, Telecommunications Journal, Vol. 38 - V/1971.

(2) Arthur C. Clarke: Extraterrestrial relays, Wireless World, October 1945, reprinted in Voices from the Sky, Harper and Row, New York, 1965.

automatic robots, experiments were undertaken with satellites that carried on board radiocommunication equipment for the reception, amplification and retransmission of messages received from earth. The advantages of such "active" satellites have proved so superior to the passive type that developments have concentrated almost exclusively on this kind of satellite.

These early experiments had to determine such factors as the optimum selection of spacecraft subsystems: repeaters, altitude control and station keeping, power supply, antenna design, telemetry, command and control for operational use in an earth/space environment. They did prove the feasibility of the idea. Already in June 1962, experiments started on a major scale with the Telstar and Relay satellites for intercontinental, wideband communications, including television transmissions. Within a few years, development had progressed from the use of the large balloon-type reflectors to sophisticated active repeaters. And already at this early stage, it became obvious that satellite systems could provide a capacity and flexibility which would make them a focal point for the development of international communications. Progress was rapid. Satellite communication may be said to have passed through an experimental period lasting about five years, followed by an initial utilization period which now has resulted in full operational status.

B. Different types of systems

A satellite communication system should be understood to comprise both the satellite itself with the necessary control and tracking facilities (space segment) and the associated earth stations (ground or earth segment).

Mention has already been made of the difference between passive and active satellites; in the following only the latter will be dealt with.

Satellite systems can also be defined in terms of the chosen orbit of the satellite. The first experimental active satellites (type Telstar, Relay) were launched into medium-high, random orbits around earth. Since the orbit of the satellite was relatively low and the period of revolution around earth short, the duration of time when the satellite was "visible" between two given points on earth varied considerably from one revolution to the other and was often limited to a few minutes only. Apart from the great number of satellites which would have been required to provide continuous, uninterrupted communications between points on earth, there was a further disadvantage in that the earth stations had to be provided with very advanced and expensive electronic equipment including computers in order to keep the antennas constantly pointed in the direction of the satellites despite their movements.

Clarke's original idea of placing satellites into orbit at an altitude of about 36,000 km in the equatorial plane offered much greater possibilities for communication purposes. A satellite in this orbit will revolve around the earth in about 24 hours, i. e. at the same speed as the earth itself and will therefore always keep the same position relative to the earth's surface. Unlike other heavenly bodies, including satellites in lower orbits, a satellite in this geosynchronous orbit will seem to have a fixed position in the sky. An observer from earth will always see such a stationary satellite in the same position and the satellite can provide constant "visibility" between any points in the area which can be reached or covered by the satellite. The major characteristic and advantage of the geosynchronous satellite lies in its fixed position and altitude which makes possible the coverage of about one-third of the earth with one satellite and of about 90% of the earth's surface with three equidistant satellites.

Other operational advantages have been realized over the past years. The fixed location and orientation of such satellites allow for the use of highly directive (focused) antennas capable of producing more powerful illumination over a selected area of the earth's surface. Frequency sharing between earth stations and terrestrial radio relay stations thus became much more feasible.

Another method for coverage of extremely northern (or southern) latitudes which cannot easily be reached from the synchronous, equatorial orbit, consists in launching satellites into orbits that are elliptical and very eccentric in the sense that the highest point of the orbit (apogeum) is above the area to be covered. These satellites are of the type used by the USSR to cover, for 10-12 hours continuously, the entire Soviet territory including the northernmost parts.

Another method now in use is the placing of satellites in medium-altitude, position-controlled orbits. In this case, it is possible to choose different solutions such as equatorial or polar subsynchronous orbits with periods of revolution in simple relation to earth's period of revolution (i. e. 12, 8 or 6 hours revolution). Such systems are mainly used for certain scientific and military communications applications.

As mentioned earlier, a satellite system includes the earth stations associated with the system. In some systems these earth stations are used for transmission and reception, in others there are special stations for transmission to the satellite and others for reception only. In general terms, there is a direct relation between the power which has to be provided in the satellite and the sensitivity of the receiving equipment: the more powerful, therefore, heavier and more expensive the satellite, the simpler, smaller and less expensive the receiving equipment on earth.

The type and kind of earth station utilized is one of the basic factors in differentiating between various satellite communication systems, seen in terms of patterns of use. From this point of view, it has become customary to distinguish between three main types of satellite systems: communication satellite systems for point-to-point communications, distribution satellite systems and broadcasting or direct broadcast satellite systems.

These types of systems can also be said to correspond roughly to the development of satellite communication technology. The development efforts have been directed towards providing more powerful, therefore heavier satellites, requiring more powerful boosters, better power sources in the satellite, extended life time, stabilized position control, greater antenna directivity, greater channel capacity, greater flexibility, possibilities for inter-satellite relay, etc.

C. Point-to-point communication satellites

As mentioned earlier, a synchronous satellite can cover approximately one-third of the surface of the earth and thus provide communications between any two points on earth, regardless of distance, within the area covered. Signals are transmitted via the satellite between earth stations connected to the existing terrestrial telecommunication networks. However, various technical constraints still limit the provision of electric energy on board the satellites, consequently the power of the satellite transmitter. Furthermore, strict international regulation prescribes well defined limitations to satellite transmissions so as to avoid interference with terrestrial and other space services. The result is that the signal arriving on earth is weak so that the earth station antenna must have high gain, capture a minimum of radioelectric noise and be precisely pointed in the direction of the satellite. These and certain other factors imply that, despite the development of technology and consequent cost reductions, earth stations for this kind of point-to-point communication satellite service intended for transmissions over great distances, still remain costly - in the order of $3-4 million.

Such point-to-point systems have been said to function as extensions of the terrestrial networks for the provision of long-distance, wideband telecommunication services. However, satellite systems have other characteristics, not shared by terrestrial systems. They have the capacity of serving not a single-route but multiple-routes through a single facility and of reallocating channel capacity among these routes. Also, their greater channel capacity compared with submarine cables has made it possible to provide new services such as transoceanic television transmissions.

D. Distribution satellites

By reducing the area to be covered to less than one-third of the earth surface, it is possible to provide a stronger signal to a smaller region of the earth than in the previous case. This, in turn, makes it possible to avoid certain constraints with regard to the earth stations (smaller antennas, no cooling-system, etc.) and consequently to reduce costs considerably. In certain projects for so-called distribution satellite systems, the costs of earth stations for both transmission and reception of telecommunications and television programmes have been evaluated at about $300,000-$500,000. Earth stations for reception only could be simplified so that they would cost no more than some $50,000-$75,000.

This would allow for other kinds of uses. Distribution systems would not function primarily for long-distance point-to-point transmissions but for providing connexions to and/or between a number of earth stations in a given area either for two-way communications (telephony, teleprinter, etc.) and/or for distribution of television programmes over a large area. In the latter case, the rôle of the earth station is to receive the transmission from the satellite and transform it for rebroadcast via a normal-type television transmitter. The distribution satellite does therefore replace the normally used microwave links for the transportation of television programmes to the transmitters, but in a more flexible and potentially cheaper way than terrestrial methods.

The range of utilization in the case of distribution systems is wide. They can provide services over a large country, as is now done in the USSR and foreseen in Canada, or over a region or group of countries, as discussed for Western Europe. The exact system configuration, type and cost of satellite and earth stations, and patterns of use would depend on the exact purposes the system is supposed to serve.

E. Broadcasting satellites

Quite a different pattern of use will be introduced with the broadcast satellite system. In this case, television (or sound radio) programmes transmitted from an earth station to a powerful satellite would be broadcast from the satellite for reception by individual receivers, without the need for intermediate earth stations.

If individual home-receivers are to be used without any modification, i.e. without the addition of any special equipment, the broadcasts would obviously have to be made according to the same principles as those used in terrestrial broadcasting (i.e. in amplitude modulation, AM). Such broadcasting would require a high on-board satellite power (in the order of 10 kilowatts) which poses certain technical difficulties and the satellites would be so heavy as to require powerful, expensive boosters. No plans for present development of such a satellite are known.

However, it is already technically possible to provide broadcasts in frequency modulation (FM) which require less power output for a given picture quality. A sufficiently strong signal can be provided over large but still limited areas to permit reception on simplified and cheap receiving installations. Such receiving installations may, in fact, consist of no more than a small specially designed antenna and simple conversion equipment (FM to video) to be attached to normal television receivers. Obviously, there also exists the possibility of manufacturing special sets mainly intended for reception of satellite broadcasts: such sets would then need special additional equipment for reception of terrestrial broadcasts.

Reception of satellite broadcasts on specially equipped or modified television sets is foreseen in two different ways: community reception and individual reception for domestic use. Community reception which might take place with more complex equipment than for individual reception and would be intended for viewing by a group of the general public, at one location, or possibly for redistribution (i.e. via cable) over a very limited area. The specially equipped sets would in this case be placed in schools, community centres, village squares etc. Such community reception has so far been foreseen mainly for use in developing areas. Satellite broadcasting has been studied within both the United Nations, specifically by the Working Group on Direct Broadcast Satellites set up by the Outer Space Committee and within ITU, as well as within Unesco's programme.

The United Nations Working Group in 1969 reached the following conclusions with regard to the feasibility of satellite broadcasting: "While it is considered that satellite technology has reached the stage at which it is possible to contemplate the future development of satellites capable of direct broadcasting to the public at large, direct broadcasting television signals into existing unaugmented home receivers on an operational basis is not foreseen for the period 1970-1985. This reflects the lack of technological means to transmit signals of sufficient strength from satellites.

Direct broadcast of television into augmented home receivers could become feasible technologically as soon as 1975. However, the cost factors for both the earth and space segments of such a system are inhibiting factors ... Therefore, it is most unlikely that this type of system will be ready for deployment on an operational basis until many years after the projected date of feasibility.

Direct broadcast into community receivers could be close at hand. Technology currently under development might allow this in the mid-1970s. Such a system is considered to be less expensive to launch than one intended for reception directly into people's homes ... "(1)

Within the International Telecommunication Union (ITU) and its competent bodies (particularly the International Radio Consultative Committee, CCIR), the technical aspects of satellite broadcasting services have been and still are the subject of intensive study. In 1970, the CCIR established an interim working party on possible broadcasting satellite systems, on comparisons between different systems intended either for community or individual reception, and on evaluation of possible uses of each system particularly for new and developing countries.

In 1959 and 1963, radio frequencies had, to a limited extent been allocated to various space services, including communication satellite systems. In 1971, through the World Administrative Radio Conference for Space Telecommunications, further allocations were made not only for existing services but also for satellite broadcasting. This conference also adopted special administrative rules for the notification and registration of frequencies used for space systems and recommended that special agreements and frequency plans be established for the satellite broadcasting service.

It might be noted that even if the estimates advanced by the United Nations and by ITU have been challenged as too conservative, in so far as the basic technology for broadcasts via satellites to community and augmented home receivers would be available today, there seems to be agreement that the timing for the establishment of such systems will depend on non-technical factors such as economic considerations and purposes of use. As for direct satellite broadcasting into unaugmented, existing receivers, some experts have advanced the view that it might never become a reality at all, not for technical or even political reasons but because a more cost efficient solution will be found. In many industrialized countries, already possessing television networks, the pressure is often not for more nation-wide dissemination but for more local outlets. In developing areas, the cost of providing a television receiver for each individual home will be so high that community type reception will be the most economic solution for some time to come.

The three categories of satellite communication systems should however not be used as more than convenient labels. In many cases, the most advantageous solution might in fact be found in a combination of various reception modes. One such combined or mixed system concept foresees enough power in the satellite to allow for reception on the special, low-cost installations for group viewing (or limited area redistribution). Since this requires the most simplified reception installations, any other reception mode using larger installations would evidently be possible, including medium-sized earth stations connected to normal television transmitters. The rebroadcast method might be the most economic and efficient in densely populated areas since there would be no need to provide individual sets with special equipment. Direct reception on community receivers might be best in rural, low-density, isolated or inaccessible areas where the installation of rebroadcast facilities is uneconomical or otherwise difficult.

(1) United Nations document A/AC.105/51 - 26 February 1969

3. CHARACTERISTICS OF SATELLITE COMMUNICATION SYSTEMS

Satellites have frequently been described as radio relay stations in the sky. While this description might be correct in certain respects, it is an oversimplification which tends to obscure some of the major characteristics of satellite systems and the main differences between satellite and terrestrial systems.

For a preliminary indication, some of the main characteristics might be summarized as follows:

A. Flexibility

For transoceanic telecommunication services, satellite systems have already proven more economical than the undersea cable. The advantage lies in the satellite system's multiple route capability as opposed to the single route capability of terrestrial systems. Through satellite communication facilities, it is possible to serve multiple routes through a single facility and of reallocating channel capacity among these routes. This cannot be done with terrestrial links which typically interconnect only two points. Thus, in addition to point-to-point communication between pairs of earth stations, it is possible to provide point-to-multiple-point transmissions from one earth station to a number of earth stations which can be activated and deactivated at will without affecting the overall system. Satellite circuits need then not be permanently assigned to a pair or several earth stations since the terminal points of a channel can be changed almost instantaneously and assigned on demand so that when no longer needed they can be released for use by others.

The flexibility provided by satellite systems also makes possible the use of small, transportable earth stations for service on an occasional or continuous basis to remote locations without physical connexions. Furthermore, mobile terminals on ships, aircraft or space vehicles may be used for aero-nautical, maritime-mobile or space services.

B. Capacity

Satellite systems cannot only provide capacity for the simultaneous use of many channels for such traditional services as telephony, telegraphy, teleprinter, facsimile, etc. They can also furnish previously impossible broadband services as proven by transoceanic television transmissions which could not be handled through terrestrial means. In principle, communication satellites may be used for any kind of electronic communication services. Satellite technology therefore shows great promise of possible future developments in terms both of communication services that can be provided (traditional telecommunications, television, videophone, facsimile, data transmissions etc.) and of patterns of use for these services (point-to-point communication, distribution, broadcasting and various combinations).

C. Geographical coverage and cost

Inherent in satellite communications is the capability to provide interconnexions over very large distances and to cover wide areas of the surface of the earth. This characteristic should however be seen in conjunction with the flexibility provided by the use of highly directive antennas to allow for coverage of only limited areas.

Satellite systems also introduce another relation between distance and cost of use compared with terrestrial systems. Since terrestrial systems must follow a specific, physical path along the surface of the earth, the cost of their use increases with the distance between the points they connect. The cost of a link between two earth stations via satellite is largely independent of the distance separating them, so that, at least in theory there need be no substantial difference between long-haul and short-haul traffic.

D. Disadvantages

Among the disadvantages of satellite communication systems have been specifically discussed:

- the further demands on the already heavily committed frequency spectrum and the risk of interference with terrestrial systems. On these points opinions seem to differ since a number of experts maintain that new technical methods (narrow beams, frequency reusage etc.) together with proper frequency management and planning would make it possible to overcome most of these problems. Similar arguments have been applied to the use of the geostationary orbit, which like the radio frequency spectrum, must be regarded as a limited natural resource;
- the hitherto limited operational life-time of satellites which goes from five to ten years. Satellites must therefore be replaced faster than equipment in terrestrial systems. In this respect, it should however be noted that the acual life-span of satellites in general has gone beyond that foreseen and can be expected to increase. In the future, the situation would change if possibilities of making repairs on satellites in orbit are realized. A weaker point seems to be the risk of launch failure which implies the need for spare satellites in reserve;
- greater vulnerability and sensitivity to interference than terrestrial systems. While this in certain respects is true it should also be pointed out that States have accepted much more stringent international rules concerning space systems than with regard to terrestrial systems.

In passing it should already be noted here that satellite systems cannot be dealt with in a vacuum as it were. They demand an integrated approach on the technical/economic level as well as in terms of planned uses involving both space and terrestrial systems. Furthermore, a decision to establishor use satellite facilities should be based on studies of alternative methods with regard to such factors as purposes of use and costs, general context, time-scale of introduction, etc.

II. APPLICATIONS OF COMMUNICATION SATELLITES

1. SATELLITE COMMUNICATION SYSTEMS, EXISTING AND PLANNED

Existing systems

The two existing satellite communication systems for telecommunication traffic are rather dissimilar in terms of technical solutions and objectives.

(a) The so-called Intelsat-system which has been established to provide international, mainly intercontinental, point-to-point communications links, uses geostationary satellites and large, elaborate earth stations connected to the national telecommunication networks. The system is used basically for telecommunications, mainly telephony but also to a limited degree for intercontinental television transmissions.

This system is based on a pattern of organization that presents some novel features in the field of international telecommunications. Intelsat (International Telecommunication Satellite Consortium) is a multinational body at present comprising about 80 countries with the United States Communications Satellite Corporation (Comsat) as manager. Of these, about 40 have established national earth stations with some further 25 countries having access through terrestrial links to stations in other countries. Each country owns its earth station (or stations) while the space segment is owned in common, through Intelsat. The organization of Intelsat is fairly complicated. Decision-making powers are to a certain extent vested in two assemblies and a board of governors whose membership and voting procedures are related to investment quotas, of which the United States of America and a number of the industrialized countries have contributed the larger share. While in the United States a special body - Comsat - has been set up for the purpose of international communications via satellites, in most other countries this activity is handled by those bodies traditionally in charge of telecommunications (telecommunication administrations, ministries of communication, recognized telecommunication carriers, etc.).

(b) The USSR has established a domestic satellite system called Orbita which uses larger satellites of the Molnya-type in elliptical, highly eccentric orbits around the earth, providing coverage of the whole national territory The Orbita system could best be described as a distribution-type system having as a main function the distribution of television programmes from Moscow to a great number of medium-sized earth stations located mainly in the Central Asian Republics and Siberia.

Previously, the terrestrial television network did not cover more than the European part of the USSR territory and an extension through terrestrial means for the entire country would have required some 7,000 km of microwave links and 120-160 relay stations just for the distance Moscow-Vladivostok. With the Orbita system television can now reach some 65% of the population and with the installation of further earth stations 82-85% should be reached by 1975.(1)

The Orbita system is also used for two-way communications and for a certain number of other purposes.

On the basis of the Orbita system, a further international system is being established under the name of Intersputnik. This system is intended to provide for telecommunication and television services between participating countries. So far nine countries, mainly in Eastern Europe, have agreed to participate in this system.

Intersputnik shows certain similarities with the Intelsat arrangements in so far that the space segment will be jointly owned by the Member States while the earth stations are owned by each country Otherwise, the structure is based on somewhat different principles with regard to organizational features.

Future planned systems

In a number of industrialized countries, various kinds of distribution type systems are under

(1) See "Sputnik", October 1970.

construction, planning or discussion. The first of these will be established in Canada, in 1972, for telecommunication and for distribution of television programmes. Domestic satellite systems of a similar and, in certain cases, more advanced kind are being proposed in other countries (United States of America, Australia).

On a regional level, discussions have been going on for a number of years concerning the establishment of a satellite system to serve Western Europe, including Iceland and a number of countries around the Mediterranean belonging to the European Broadcasting Zone. This system would have two main functions to provide telecommunication facilities and to serve as an extension of and a complement to the present terrestrial regional television network being used for Eurovision. According to present plans, each participating country would have an earth station for transmission and reception, connected to the national terrestrial networks. The Franco-German satellite project known as Symphonie would have similar functions, the intention being to serve a number of countries with cultural and other affinities.

A number of studies have been undertaken in developing countries for the use of satellite communication, particularly with regard to educational programmes through television. These studies have mostly been based on the concept of providing a national or regional service through broadcast type satellites with reception by community receivers in rural areas and distribution for rebroadcast in urban areas.

A pilot project on an experimental basis will be undertaken in India, in 1974 in accordance with an agreement between the concerned United States and Indian authorities. This agreement provides for the use of an experimental American satellite (ATS-F) for a year with the Indian authorities being responsible for all programming and for the ground installations. It is foreseen that the experiment will be carried out in 5,000 villages, 3,000 of which will be reached through rebroadcasts and 2,000 through direct reception on village community receivers. According to the Indian plans, this experiment will be followed by an operational system, one of the ultimate objectives being to provide each of the 560,000 villages with a receiving set. The United States proposes to use the same ATS satellite possibly in 1973, for experimental broadcasts to community receivers in Alaska.

Preliminary studies undertaken in a number of Spanish-speaking countries in South America have led to a United Nations Development Programme supported project for a feasibility planning and pre-investment study of a South American regional system for education, culture and development, using advanced communication technology, including satellites. Unesco has been appointed executive agency for this study in association with ITU. The countries participating in the study are Argentina, Bolivia, Colombia, Chile, Ecuador, Paraguay, Peru, Uruguay and Venezuela.

Studies by national bodies or made with the assistance of such international organizations as Unesco and ITU concerning the use of satellites for education and national development have also been undertaken in Brazil, Indonesia and Pakistan. On a regional level, a similar Unesco assisted study has recently been undertaken in a number of Arab countries and a preliminary survey is under way in sub-Sahara Africa. A proposal for interlinking national television services and providing national educational television services in South East Asia is also under consideration.

2. PATTERNS AND PURPOSES OF USE

The probable patterns and purposes of use have been discussed in terms of two main, interlocking aspects:

- should satellite systems be multipurpose or single-purpose, i.e. should they serve a number of purposes at the same time (telecommunications, television broadcasting, meteorology, etc.) or only one purpose (viz. educational television);
- should satellite systems be organized and operated according to the concept of overall single, global system(s) or should there be multiple systems.

In the present situation, the development of satellite communications tends towards not a single, global concept but towards a plurality of systems intended for different purposes, on different geographical levels, with different communication patterns and categories of users.

On the basis of present and planned system concepts, it is possible to advance some preliminary observations on the overall patterns of use. In a very simplified form, these patterns seem to develop as follows (see table on p. 16).

Even if this model provides no more than a rough idea, there seems to be a certain logic to these patterns with regard to requirements, services provided and present communication patterns.

The first application of satellite communication was for transoceanic transmissions through point-to-point facilities and it seems probable that this will continue. Even with increased ability to focus satellite energy in increasingly smaller areas, a number of factors militate against the concept of large satellites providing both international and domestic or regional services. In many cases, the location of the satellite would not be suitable for all these services. There is little likelihood that a single satellite could provide both the channel capacity and the reduction in earth station cost required while the possibility of inter-satellite relay and interconnexion between systems can provide the extensions required.

Kind of system	Purposes of use	Geographical coverage	Operational agencies
Communication satellite systems: point-to-point, point-to-multiple point	Interconnexion of networks for telecommunications (telephony, teleprinter, facsimile, data, television transmissions, etc.)	Intercontinental intracontinental	Multinational organizations: Intelsat, Intersputnik
Distribution-type satellite systems	Interconnecting or supplementing networks, establishment of networks for telecommunications, television distribution	Regional national	Regional bodies (European space organizations) national bodies (Telesat Canada)
Satellite broadcasting systems and mixed systems	Establishment of networks for television broadcasting and possibly two-way communications	Regional national	Regional and national bodies

A fair assumption therefore seems to be that international point-to-point communication satellite systems will increase their importance as one of the main means for the intercontinental traffic. However, the importance of intracontinental traffic should not be overlooked. For economic and technological reasons, the traditional international communication systems mainly connected the principal communication centres (such as London, Paris, Moscow, New York) with various parts of the world, with little provision for interconnecting even neighbouring countries in Africa or Latin America for instance. A case in point concerns the interconnexion between such countries as Argentina and Chile where the Andes acted as an almost insuperable barrier for surface communication using conventional technology.

One of the main advantages of the distribution type systems is to provide a new method for establishing or supplementing national or regional networks intended to cover large areas. In the case of Canada, the following statements are revealing:

"The capacity of the communication satellite for carrying high-quality telephone, television and data-transfer signals between widely separated points is particularly relevant to the geography and demography of Canada, both in supplementing terrestrial connexions between urban centres and even more importantly, by bringing telecommunications services to scattered and otherwise inaccessible communities, particularly in the North."(1) "A domestic satellite system would make television service in both English and French available to any point in Canada. It would do it sooner and at a lower cost than would any other known system of communication. In particular, it would facilitate the extension of television network service into many areas previously unserved because of the prohibitive cost of a terrestrial microwave feed."(2)

There are other cases where the establishment of earth-bound facilities could be too costly and time-consuming to consider. Indonesia has a land-area fragmented into about 3,000 islands spread over hundreds of thousands of square miles of the south-west Pacific. Only a satellite system can efficiently link these islands. In Brazil, the coverage of the Amazon basin with its almost impenetrable forests would, if technically possible, be economically ruinous with other means than satellite facilities.

Whether in such cases, a distribution type system, a broadcasting satellite system or a mixed system would be the most appropriate can only be ascertained after a thorough study of requirements, purposes of use, geographical and demographic conditions in each given country or group of countries. In developing areas, the interest in satellite systems for domestic purposes has above all concerned the possibility of providing nation-wide television services for education and national development. Therefore, the preferred system concept should have the capacity to allow for direct reception through village community receivers as well as rebroadcast facilities in densely populated areas. In the case of India, the option chosen for the experiment in 1974 represents such a mixed system with broadcast capability, according to the following objectives:

(1) Instant World, A report on telecommunications in Canada, Telecommission, Ottawa, 1971.
(2) Government White Paper: A Domestic Satellite Communication System for Canada, Ottawa, 1968.

technical objectives include a system test of broadcast satellite television for national development; enhancement of capability in the design, manufacture, development, installation, operation, movement and maintenance of village television receivers and of broadcast and/or distribution facilities to the extent that these are used in the experiment; determination of optimum receiver density; distribution and scheduling techniques of audience attraction; organization and solution to problems involved in development, preparing, presenting and transmitting television programme material;

the primary instructional objectives comprise contribution to family planning; improvement of agricultural practices; contribution to national integration. The secondary objectives are contribution to general school and adult education, to teacher training and improvement of health and hygiene.

Even if such systems are neither planned nor contemplated, there has been considerable speculation as to the consequences of world-wide television broadcasting via satellites. Apart from political and economic obstacles, differences in programming policies and needs, and programme acceptability in different areas and countries, there are some even more immediate, practical reasons why this concept seems improbable.

At present, twelve different standards for monochrome television and three different methods for producing colour television pictures are used in the world. Even if in the future some simplification may be achieved, expensive standard conversion equipment would still be necessary between the major standards. Satellite broadcasting over large areas will be possible only in zones with the same standards.

The language problem has been mentioned as another obstacle. It might partly be alleviated through the use of a mutliple-sound channel system for different language-sound components with the same image. More serious seems the time variation since there is a relatively limited range of time in which a given type of programme can be usefully presented. One possible approach to the problem is to use movable or multiple antennas on the satellite with the coverage being changed as the programming is changed.

These and other reasons of a technical, economic and political nature have led to a situation where there are no plans for a world-wide broadcasting satellite service. Planning or studies have exclusively concerned national use, (e.g. Brazil, India) or regional use (e.g. Spanish-speaking countries in South America, Arab States).

Not only compatible time-zones but also cultural similarities and common levels of development argue in favour of the national or regional approach. A further reason is the greater opportunities on a regional level for all concerned countries to participate in the operational and programming policies of satellite broadcasting services. It is significant that this concept has retained the attention of the United Nations General Assembly in the resolution on satellite communication adopted in December 1970 (resolution 2133 (XXV)).

3. CATEGORIES OF SERVICES AND USERS

The purposes of a satellite system can also be described in terms of the communication services the system is designed to provide.

In principle, satellite communications can be used for any kind of information that may be transformed into electronic signals. In the first place, this means that satellite systems can be used for all kinds of telecommunication services, which include not only the classical categories: telephony, telegraphy, teleprinter, facsimile broadcasting, etc., but also new services now becoming available such as: videophone, data transmissions including remote access to data centres, closed-circuit television. However, there are further possible uses of satellite communication which to many may seem still in the realm of science fiction.

The techniques of electronic distribution of mail, photographs and newspapers have been known for some time. Experiments are under way to develop a viable system for reception of printed or graphic material transmitted in conjunction with television broadcasts for reception on a television set or reproduction, through a facsimile method, via a special attachment to the television receiver. This is only one indication that many forms of information dissemination which now fall outside television as traditionally defined may be channelled through the television set.

The various uses of satellite communication have been conditioned also by the institutions and organizations that act as users of terrestrial systems. These users should be seen on two levels. The actual operation of satellite communication facilities has in most countries come to be entrusted to existing agencies involved not in space but in telecommunication activities, i.e. telecommunication administrations, ministries of communication or post and telegraph or private, authorized communication carriers. In some countries special bodies have been created, the most notable being Comsat (Communication Satellite Corporation) in the United States and Telesat Canada. Comsat was created by act of Congress as a private, commercial company, under government supervision, its shares being divided between telecommunication carriers and the public. According to present rules, Comsat has the mandate to provide satellite communication facilities for international communications and to act as the United States representative (and concurrently manager), in the Intelsat organization. Telesat Canada is incorporated by statute to provide domestic satellite communications with provision for share-ownership between the Federal Government, the Canadian telecommunication carriers and private investors.

On the other level are the users for whom these facilities are operated. They include all the present institutions using terrestrial communication facilities including the broadcasters and other mass media as well as the general public. These users require different patterns of communication:

point-to-point, two-way or conference facilities basically providing communication between users of the same kind: between individuals, governments, international organizations, business enterprises, information and data centres, mass media institutions, universities and research institutions etc. The services required include communication by voice and image, teleprinter, facsimile, data transmission with visual display, closed circuit television etc.; these services are provided by communication and certain distribution satellite systems;

one-way or two-way communication between one user and other specified multiple users. In this category fall communications between headquarters and branch or field offices within international organizations, foreign ministries, business enterprises, etc.; communication between such mass media institutions as news agencies, newspapers and broadcasters for both collection and in certain cases distribution of news, instructional television, intended only for schools etc. Such services are provided by communication and distribution type satellite systems;

one-way service from one point to an indefinite number of other points which function for reception only; this corresponds to the broadcasting pattern in which one user transmits messages to the general public; at present broadcasting is in all countries entrusted only to authorized institutions functioning on the national level.

There are indications that these traditional categories and institutional patterns might change in the future. Certain trends point to difficulties in maintaining the strict distinction between telecommunications and broadcasting which now is basically intended for the public at large, but which may develop in the direction of providing more transmissions to specialized groups in society. The distinction between printed media and electronic media might be narrowed with widespread electronic distribution of printed or graphic material. A more generalized use of on-demand, two-way facilities to request educational, information and entertainment material would not fit any existing category. Furthermore, television programme material does not have to be broadcast at all but can be distributed via cable or through cassettes to the public. It would seem, therefore, that our present categories and attendant organizational structures may need modification.

4. REMARKS ON COSTS

The question of how much a satellite system would cost is often put in such a way that a straightforward, simple answer is impossible in the absence of an exact technical definition of a specific system configuration. Furthermore, in order to compare various alternatives and evaluations it would be necessary to agree on which costs should be included, whether only the costs for satellites, launching facilities, control stations and earth stations and receivers or also costs for research and development, various overhead costs in terms of the technical, programming and administrative organization needed.

In this context, it would be impossible to consider these latter aspects and the following remarks will therefore concentrate on some salient facts and figures referring to the actual, out-of-pocket costs for a satellite system, as far as they can be ascertained. It should be emphasized, however, that the "hardware" component of a satellite system for education cannot be considered in isolation, and the "software" costs for programme production and utilization would represent the major part of the operational expenses of the system.

The main factor with regard to launching costs is - apart from the orbit which here is taken to mean the synchronous stationary orbit - the weight of the satellite which in turn depends on such factors as technical configuration, power requirements, type of frequency and modulation used, channel capacity, etc.

The figures available for the commercially operated communication satellite system operated by the Intelsat-organization refer to a high-capacity system for international communications on a global basis with high investment costs both in satellites and earth stations (though costs for both have been going down).

Satellite	Year	Capacity	Weight (approx.)	Cost million US $	Launch cost million US $
Intelsat I (Early Bird)	1965	240 voice or 1 TV channel	42 kg	4	3.7-4
Intelsat II	1966-67	240 voice or 1 TV channel	95 kg	4-4.5	3.7-4
Intelsat III	1968-69	1,200 voice or 4 TV channels	160 kg	$ 6	$ 5
Intelsat IV	1971-73	3,000-10,000 average 6,000 voice or 12 TV channels	600 kg	$ 13.5	$ 16

The trend of costs of the communication, point-to-point satellites used in the Intelsat system can be seen from the following table which provides economic comparisons of the four generations of commercial communications satellites:(1)

Satellite	Circuits	Design lifetime (years)	Circuit years of capacity	Investment per circuit year of capacity
Intelsat I	240	1.5	360	$ 15,300
Intelsat II	240	3	720	8,400
Intelsat III	1,200	5	6,000	1,450
Intelsat IV	6,000	7	42,000	500

Earth stations costs vary with complexity and capacity but for systems such as Intelsat would seem not be much lower than $3-4 million. This figure should be compared to the three to four times higher costs for the earlier earth stations.

The figures for distribution type systems vary considerably depending on satellite capacity, area to be covered, the number of earth stations and whether they are to be used for transmission and reception of both telecommunications and television, for telecommunications only, for television reception only, etc.

Generally speaking, the minimum costs of a satellite telephone system are reached with a comparatively high earth station cost. The situation is different in the case of a network containing a large number of stations for receiving radio and television programmes. With an increased number of stations, it is advisable to use smaller and cheaper installations. In a specialized satellite distribution network designed for television reception, the economic efficiency of the system rises very rapidly in proportion to the number of stations in the network. (2)

In principle, the type of satellite that will be used for the domestic Canadian system with a capacity of 12 repeaters each providing 960 voice channels or one television channel would cost about $7.5 million. With this type of system can be used main earth stations for about $2.5-3 million, while an earth station for reception only of 12 television channels would be no more than about $130,000. In the case of the Canadian system the total costs have been estimated at about $90 million for one prototype satellite, and three flight models, launch facilities, two major earth stations, five regional stations and twenty-five stations for reception of television programmes and telephony.

Proposals for a domestic satellite system in the United States range from about $70 million to well over $200 million depending on capacity (in some cases up to 48 television channels or some 34,000 telephone channels), type and number of earth stations (up to 400 in certain projects).

In a broadcasting satellite system, capital investment and operating costs for the space and the earth sector depend on the configuration required to meet the objectives of the system, for example, frequency and modulation, sound transmission mode, size of area to be covered, number of programmes to be broadcast simultaneously, etc.

In general terms, the choice is between a powerful, hence expensive satellite and launch with simple, inexpensive receiving installations or a less powerful, smaller satellite with more sensitive, costly receiving installations. The first solution would be more advantageous when receiving points are numerous and scattered over wide areas, the second might be more suitable when there is a relatively limited number of receiving points. It should be pointed out that these factors are relatively more or less important depending on the existing state of television coverage. Since, in most cases, satellite broadcasting systems are discussed primarily for use in developing countries for educational purposes, large areas and numerous receiving points would be involved so that the greater part of the cost would fall on the receiving installations on the ground.

The total costs quoted for various systems vary considerably depending on whether or not ancillary costs are included. Amongst these ancillary costs should be mentioned spare satellites, in orbit or on the ground; launch failure insurance; telemetry, tracking and command facilities; civil works for earth stations and staff training costs. The research and development costs would depend on whether a satellite system should be specially designed for particular purposes or an existing design could be used with minor changes. Also, most estimates have been made prior to the World Administrative Radio Conference for Space Telecommunications, held in Geneva in June-July 1971; certain decisions concerning technical constraints may affect further costs.

A number of studies have been made concerning the costs of broadcasting satellite systems both within such international organizations as the United Nations and ITU and by various national bodies and private firms. In this context, no more than an indication of the results of some of these studies can be given; further information is to be found in some of the documents listed in the bibliography (Annex I).

Various prototypes of the special receiving equipment (antenna, converter, etc.) have in fact been developed and tested and costs evaluated with regard to mass production. While some results fall within the $150 range as given by the United Nations Working Group on Direct Broadcast Satellites, other

(1) W. L. Pritchard: Communications satellites, presented at the Chania International Conference on Space Research and Applications, 1970.

(2) M. V. Talyzin, L. Y. Kantor and Y. M. Payansky: Optimum power parameters and economic efficiency of a communication satellite system, Telecommunications Journal, Vol. 38-V/1971.

results point to lower figures and still others to higher. Of particular interest are figures provided by Indian authorities to the effect that the additional receiving equipment could be fabricated in India for a sum corresponding to about $100. Evidently, if this equipment is manufactured in small quantities the cost will be much higher than some of the estimates made for mass production.

A study made in India(1) concerning four possible alternatives of providing nation-wide television coverage, reached the following summarized results:

System	Initial cost million US $	Annual maintenance million US $
Conventional broadcast stations with terrestrial microwave inter-connexion (150 TV transmitters and 24,000 km microwave links)	393.60	26.28
Satellite broadcasting exclusively (one or two transmitting earth stations direct reception by 560,000 village community receivers at a cost of $ 345 each)	225.05	9.50
Conventional rebroadcast stations with satellite inter-connexion (150 rebroadcast stations with additional reception facility)	325.15	21.78
Hybrid system combining rebroadcast and direct broadcast (five rebroadcast stations)	224.04	9.78

A similar study made in Brazil(2) shows the following comparative figures for a nation-wide communications network for telecommunications and television:

	Cost (million US $)	Maintenance over five years 10% for cable 20% for microwave (million US $)
Cable system consisting of 6,000 km main cable, 100,000 km connecting cable, 23,000 km feeder cable	400	200
Microwave system of 129,000 km with 3,375 relay stations and 1,420 terminal stations	170	170
Satellite system including two satellites, 1,000 communication stations, 12 receive/transmit stations and 152,000 sets for direct reception	116.1	19.0

These and other estimates show that the major capital item is for the television receivers. In ground-based television the costs of stations are large items, while the satellite in a space-link system is often no more than 10% of capital investment. Therefore, it has been stressed that whatever could be done to reduce the cost of receivers or to make them last longer or any investment in the satellite that would reduce the cost of augmenting the ground receivers, would make a substantial difference in the total.

As to the cost of a satellite and launch, the best available information is the offer made by Hughes Aircraft Company for a satellite similar to that being used in the Canadian domestic system (HS 333) capable of transmitting two concurrent television programmes to community receivers. This satellite can be launched by the Thor Delta rocket. Estimated cost of one satellite and launch (with some provision for insurance in case of failure) is about $15 million.

The same company has quoted a price of about $29 million for a space segment consisting of:

(a) Two synchronous television satellites.
(b) Booster rockets and launch capability.
(c) Reserve satellite (on the ground) or insurance provisions.

Since the use of satellite broadcasting systems is primarily foreseen for educational purposes, calculations have also been made as to what a total system would represent in terms of costs per student/year. Naturally these figures vary substantially, depending upon the type of costs included and the assumptions as to the costs of the various elements.

5. ALTERNATIVES

Technological advances have made available a number of alternative methods for communicating and distributing all kinds of electronic messages. An example can be given based on present day "television programme" material. Such material can at present be distributed through:

satellites;
terrestrial, conventional microwave and transmitter networks with the possibility of adding more channels in higher frequency ranges (i.e. the 12 GHz band);
cable systems of various kinds;
videotapes, video-cassettes, video-discs;
combinations of two or more of these methods, viz. satellites and cable and/or transmitter systems;

(1) B.S. Rao, P.L. Vepa, M.S. Nagarajan, H. Sitaram and B.Y. Nerurkar: Satellite Television: A system proposal for India, Space Exploration and Applications, Papers presented at the United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna 1968; United Nations, New York, 1969.
(2) Comissão Nacional de Atividades Espaciais, São José dos Campos, Brazil, Maio 1968.

Even if it is possible to define the technical advantages and disadvantages for each of these alternatives, it is obvious that a decision cannot be based on technological aspects only. On the contrary, technical characteristics and economic considerations are of prime importance but they must be put in a wider perspective. The kind of issues involved range from the need to establish social priorities for the use of radio frequencies to the relative importance which educational television could or should be accorded in a given context. Such issues in turn make necessary consideration of the possible implications of satellite technology.

21

III. IMPLICATIONS OF COMMUNICATION SATELLITES

1. GENERAL

Interpretations as to the significance of satellite communication will show as many facets as there are theories about the rôle, function and effect of communication upon individuals and society. Many times it seems that attitudes towards satellite communication have crystallized to an unusual degree around opposite poles in the controversy about media and messages. Those for whom the medium is the message, for whom the channels of communication in themselves have a decisive importance, often describe communication satellites as the climax of the revolution in communication and information which is to change our world into a global village. On the contrary, those for whom the medium, the communication channel is secondary to the content, to what is communicated, seem more hesitant. Some regard satellite communication as a further step towards still more powerful and all pervasive mass media whose content binds individuals to a technocratic order. Others foresee, if not a global prison, at least a global mass of individuals more or less helplessly reeling under the impact of constant floods of incoherent information.

Without taking sides - except perhaps to see these views more as complementary than mutually exclusive - there are some general, though more modest, observations that seem relevant in this context.

Changes in communication systems which make it possible for more people to get access to more and a greater selection of information, education or entertainment might in themselves have far-reaching consequences, regardless of the content at any one given moment. It is the sheer presence of television which is expected to break the feeling of isolation in remote communities. The impact of introducing a medium such as television will evidently be the greater, the less other information media are present in a given environment.

The anxieties and fears that have been expressed with regard to the possibility of unwanted television broadcasts via satellites, do in fact recognize the importance of both the medium and the message, whatever the theorectical position taken. On the one hand, there is a recognition of the much greater impact of television as compared to such a medium as short-wave radio, on the other hand, there is the concept of certain kinds of content being more acceptable - or unacceptable - than others.

It is often said that one of the main consequences of modern communications technology, as specifically represented by satellite communication, would be instantaneously and universally available information. The problem would then be one, not of availability, but of selectivity. This would imply the recognition of the need for new kinds of education so that "people can cope efficiently, imaginatively and perceptively with information overload"(1) or of the important place held by the mass media, the significance of their goals, principles and practices.

However, these issues cannot be dealt with without some indications of trends and possibilities and implications of satellite communication in the light of more clearly defined aspects. The implications may be seen from various points of view. In response to such questions as to what kind of information can be or need be transmitted over satellites, according to what patterns, by whom, for whom and for what purpose, in which context.

The introduction of satellite communication occurs in widely different socio-economic, political and cultural contexts. The implications will therefore vary from country to country and region to region. One of the basic differences will be between those countries already possessing a well developed telecommunication and broadcasting network and nations with only limited, inadequate facilities where geographical, and other factors add to the difficulties in establishing nation-wide networks. These two categories would generally

(1) Michael N. Donald: The Unprepared Society.

but not completely correspond to the industrialized and developing areas of the world.

It has been said that satellite technology would be particularly unsuited to developing countries because it is expensive, technologically sophisticated and presents new problems when the present ones have not been solved.

While admittedly the cost factor is an essential consideration, the scale of expenditure should not distract from an evaluation in terms of the development goals that can be served in this way and in some cases in no other way, it should also be realized that financial estimates point to the fact that satellite system costs have fallen low enough to be possibly within reach of developing countries and to represent, at least, an option seriously to be taken into account.

It has been recognized in various international bodies, primarily in the United Nations, that all efforts should be made to assist developing nations to benefit from space technology. It has been emphasized that if the developing countries continue to rely upon traditional, conventional techniques without taking the plunge into new technology, the gap between them and the technologically advanced countries will not close but continue to widen. "Several peaceful applications of outer space can be applied now in developing countries to provide for them a new stimulus for progress. Above all, it is necessary to ensure that they are not compelled to follow through the same steps as were taken during the past century by those countries which are today technologically advanced. Many traditional technologies become much more cost effective if combined with space applications. The population explosion and the rapidly shrinking world do not permit delaying the benefits arising from space until the older methods have been deployed. The question is not whether developing countries can afford the peaceful uses of outer space. Rather, it is whether they can afford to ignore them." (1)

Another great inequality in today's world that must be overcome lies in the disparity between the urban centres and the rural areas, which is particularly evident in the case of information and communication media. Traditionally, they are first established in the cities from where they slowly, if at all, penetrate the countryside. Terrestrial telecommunication and television networks almost never achieve full coverage. Therefore, "until the advent of space technology, many benefits of a modern society were available only to communities residing in large metropolitan areas or to those linearly connected to such areas. Through communication satellites, it is now possible to reach isolated communities dispersed over a large region without suffering economic penalty....... This aspect of space technology is of particular significance to developing countries where agriculture plays a preponderant rôle, and substantial sections of the population are non-urban with a low level of literacy. Education as well as information inputs which might contribute to motivation for modernization, the use of new techniques in the production of food, for improved health and sanitation, can all be provided much more readily if a reliable audio-visual communication link can be established nation wide. Moreover, many developing countries face an acute problem arising from social forces of disintegration. Their continued viability is dependant on the integration of many tribal/religious and regional groups which have distinct cultural and political traditions. A single system of mass communications providing a common-shared experience to the entire population can perform an important rôle in making credible the oneness of the territory". (1)

2. IMPLICATIONS FOR INFORMATION, EDUCATION AND CULTURE

One of the more obvious potential benefits of satellite communication would be to make available cheap and reliable connexions for telephone, teleprinter and similar communication services, all over the world. There is however no agreement as to what the consequences might be. Would people write more or less letters, travel more or less, change their habits in other ways? Nor is there agreement as to the effects of satellite communication in more complex areas such as increased and changing flows of information or satellite-borne educational television.

Pollution has become a key concept which can usefully be applied to areas other than our physical environment. Communication engineers more and more speak of radio pollution referring both to an indiscriminate use of radio frequencies and to interference and disturbances from an ever-growing number of electric and other appliances, both of which might necessitate drastic measures for any rational use of radio communications.

The results of serious investigations into the future of the postal services which have been undertaken in some countries (France, United States) point to a "mail pollution" which might not leave us any other choice but to use electronic post services with the satellite as an "orbital post office". (2)

Other areas in the information field seem similarly affected. We have alreadv reached a stage when the concept of data and publication pollution

(1) From The Application of Space Technology to Development. Report prepared by Vikram Sarabhai, P.D. Bhavsar, E.V. Chitnis and P.R. Pisharoty, for United Nations Advisory Committee on the Application of Science and Technology to Development (United Nations document E/AC.52/XV/CRP.1, 9 June 1971).

(2) This expression has been used by Arthur C. Clarke in many articles and speeches.

is taken seriously. One field has attracted particular attention: scientific information. Today, some 35,000 scientific journals publish about 2,000,000 articles each year, written by some 75,000 scientists in about 50 languages.(1) The combination of computers and satellites might offer an opportunity to make a real attack on the increase in scientific data that is rapidly becoming too great for many fields to handle. Libraries are already becoming information centres for storage and retrieval of data by electronic means. These centres will have to be interconnected so that they can share resources, many considering the communication satellite as the ideal link between information centres. Satellites can handle great amounts of information, transmit it quickly to processing centres all over the world and circulate details wherever needed.

Another aspect of the information field relates to the collection, transmission and distribution of news in the world. Here again, improved means of communication such as satellite systems can make a great difference, particularly with regard to visual news. Not only can they make possible a more reliable and increased flow of news between the main news centres but even more importantly, can contribute to an increase in a two-way flow between these main centres and the developing areas as well as in and between the developing countries themselves.

The following objectives for the use of satellite communication for the possible world-wide distribution of information material were regarded as of prime importance, at a Unesco meeting in 1969:

"making the flow of visual news in the world more balanced, particularly with regard to providing news coverage to and from, as well as between developing areas;

ensuring that satellite communication is made available to all countries, with special regard to smaller and developing countries;

providing broadcasters all over the world with the opportunities and conditions enabling them to use communication satellite systems for the coverage, collection, transmission and dissemination of news;

providing conditions enabling mass media institutions all over the world to co-operate for the exchange of news and coverage of current events".(2)

Questions of tariffs, access, technical facilities and trained staff must therefore be seen in the perspective of how the world gets or wants to get informed about itself. The improved facilities for transmission of news which can now be made available through satellite systems must also be examined qualitatively as well as quantitatively. The concern must not only be with the volume or speed of transmission. There is a need to consider the decisions that may be necessary to ensure that this flow is channelled in such a way as to reach the ultimate consumer - the ordinary newspaper reader, radio listener, television viewer - in a form that will be comprehensible and give him some sensible understanding of the significance of all the mass of instant news that technological advance might bring to him.(3) The editorial process becomes not less but more important with the advance of space communication.

With regard to education, it is generally assumed that the chief contribution of satellite technology will be to deliver educational television. This new combination of satellites, television and education presents challenging problems - and considerable controversy.

The particular contribution of satellite technology for distributing educational television is seen as a key for solving a number of problems of human resources development. "Not only can it overcome terrain and distance, it may also be able to reform and modernize educational systems more rapidly than would otherwise be possible, give more people access to education and training, place the best teachers within reach of large audiences, help to integrate large sectors of the population into the social, economic and cultural life of the nation or region, and contribute to international understanding."(4)

A second assumption is that television can be an effective instrument of education - if rightly used. It is becoming clear that the use of television challenges the traditional concepts of education and educational methodology. "It is not a situation in which any educator can be satisfied with routine teaching, undistinguished content, outmoded method. If ever in the history of a school system, a thorough curriculum review is called for, this is the time."(5)

Media of mass communication such as television, reaching the entire population, have certain characteristics which explain their importance for education and national development. They are able to communicate regularly with large audiences whether in formal educational situations or beyond. They are modern and flexible and thus able to link education with events of the day as well as with the emergence of new subject-matters and new methods in education.

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(1) See Harrison Brown: Toward an Effective World Science Information System. ICSU General Assembly, Madrid, Spain, 1970.

(2) See Broadcasting from Space, Reports and Papers on Mass Communication, No. 60, Unesco, Paris, 1970.

(3) See Francis-Williams, Lord. Responsible presentation of the news in the space era, Communication in the Space Age, p.44, Paris, Unesco, 1968.

(4) W.Schramm and W.J.Platt: Satellite-distributed educational television for developing countries, Washington D.C. 1968.

(5) Wilbur Schramm: Satellites for Education: Lessons from a Decade of Experience with Educational Television, U.N. Conference on the Exploration and Peaceful Uses of Outer Space, 1968.

Moreover, as reported by a number of Unesco missions which have studied, in various countries, the use of satellite communication for education and national development, the demands that are and will be made on the educational systems cannot possibly be met through traditional methods. As in the case of South America, "quantitatively the demands due to population growth, national programmes to achieve universal primary education of up to 5-6 years of schooling, to extend and redirect secondary education, to increase and reorient higher education, to expand vocational training in all fields, can only be met by a massive use of modern technology as provided particularly by television. If to these quantitative demands are added the qualitative demands in terms of a higher level of capacity amongst the teachers, the introduction of new methodology and teaching methods, the insistance on a massive extension of technical and scientific training, and the initiation of new programmes intended to contribute to the modification of attitudes, the conclusion seems inevitable that the methods to be used must be as massive as the changes required.

As far as all the aspects of 'adult education' that never have been part of the traditional educational systems are concerned, it is a foregone conclusion that only modern technology provides the means of reaching numerous populations dispersed over vast regions". (1)

Obviously, education as used in the expression educational television must be used in the largest possible sense. And the concept of life-long education must be linked to the development of information media. "This is why, recourse to the most advanced technologies appears as the only adequate solution to allow for an organic linkage between education and information, an integrated co-ordination of the different degrees and categories of education for development purposes, and to open up the school and provide for intercommunication with the social and cultural environment. "(2)

These views do not imply that satellite-borne educational televison will solve all problems. "There must be an objective assessment of the limitations and capabilities of the new communication satellite technology in meeting our expectations... There are many components of any major technological system and usually the least complex of these is the technical one. Perhaps most often overlooked is the question of social feasibility, and particularly of users' needs. Assuming that the system can be built, will it be accepted and used as anticipated by the people for whom it is intended? "(3)

The use of satellite-borne educational television should also be seen in the context of the balance to be struck between mass distributed educational programmes and the need for education geared to local and individual requirements.

One overall conclusion seems warranted. When dealing with satellite technology, neither analysis of use nor evaluation of possible impact can be done on the basis of traditional watertight compartmentalization. The need is for an integrated approach to the cluster of activities contained in education, information, culture and communication - to which should be added such aspects as access and transfer of technology in this vital and expanding field.

3. LEGAL IMPLICATIONS AND APPLICABLE INTERNATIONAL LAW

As in the case of many other activities made possible by recent and far-reaching technical developments, satellite communication and in particular satellite broadcasting presents complex legal problems. International legal and other rules must take into account various spheres of activity and will therefore have to be based on a cross-disciplinary approach.

Satellite communication in its various aspects represents a new activity combining features from at least four different areas: applied space technology, radio-communication services, broadcasting and information activity. Hitherto these four areas have been governed by concepts and rules created independently and not necessarily in concordance with each other. Applicable laws and principles therefore relate to such areas as general international law; space law; international telecommunications law; principles concerning human rights and freedom of information; legality of transmitted or broadcast programme content with regard to copyright and neighbouring rights, right of privacy, slander etc.

Of specific interest in this context are the principles of space law and of international telecommunications law.

Space law

Space law is that body of international legal norms which has been developed since the beginning of the 1960's, primarily under the auspices of the United Nations General Assembly and its Committee on the Peaceful Uses of Outer Space. Following various basic resolutions (in particular 1972 (XVI) and 1802 (XVII)), the General Assembly, in 1963,

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(1) Preparatory Study of the Use of Satellite Communication for Education and National Development in South America, Unesco, Paris, May 1970.

(2) Arab States, The Use of Satellite Communication for Education and National Development, Unesco, Paris, March 1971.

(3) Delbert D. Smith: Educational Satellite Telecommunication: The Challenge of a New Technology, Bulletin of the Atomic Scientists, April 1971.

adopted a "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space". Most of these principles were thereafter incorporated in the Outer Space Treaty of 1967(1) which is being complemented with special instruments on particular subjects (rescue of astronauts, liability etc.). The principles embodied in the Declaration and the Treaty constitute a framework for the international regulation of all space activities and are therefore valid also for satellite communications.

The formulation of legislative provisions for space has been approached intellectually in a fashion very different from traditional notions of international law.

The basic approach as expressed in the Preamble and Article 1 of the Treaty is the common interest of mankind in outer space. This principle is explicitly and implicitly brought to the fore in a number of its provisions such as, that the exploration and use of outer space shall be carried out for the benefit of all peoples, that astronauts shall be regarded as the envoys of mankind etc. The internationalization of outer space is also expressed in the general principle that international law, including the Charter of the United Nations, applies to space activities. Both in the Declaration and the Treaty this principle is complemented by a number of provisions which are particular to space law:

the principle of free use of outer space by all States, without discrimination which should be seen in conjunction with the principle that outer space is not subject to national appropriation in any form;

particular stress is also laid on the principles of co-operation, mutual assistance and mutuality of interests as applicable to all space activities.

The principle of State sovereignty and equality of States is complemented by the notion that States bear the international responsibility for space activities whether they are carried out by the States themselves, by international organizations or by non-governmental entities. This implies that no outer space activity can be carried out without the consent of the responsible government.

The subject of space communication has been specifically mentioned in a number of resolutions adopted by the General Assembly. All stress the principle of international co-operation, particularly with regard to making satellite communications available on a world-wide and non-discriminatory basis.

Satellite broadcasting has attracted particular attention. Following the work of the Working Group on Direct Broadcast Satellites set up in 1969, the 25th General Assembly unanimously adopted a resolution (2733 (XXV)) on this subject-matter. Apart from recognizing the potential benefits of satellite-borne television particularly for developing countries and the importance of large-scale international co-operation, the Assembly recommends "that Member States, regional and international organizations, including broadcasting associations, should promote and encourage international co-operation on regional and other levels in order, inter alia, to allow all participating States to share in the establishment and operation of regional satellite broadcasting services and/or in programme planning and production".

It is obvious that in such a new, constantly evolving field as space law, there would be differences of opinion as regards the interpretation and application of the principles adopted, particularly since these principles represent a new dimension in international law.

While there is general agreement on the applicability of the United Nations Charter, the Outer Space Treaty and relevant provisions of the International Telecommunication Convention and the Radio Regulations (see below) to satellite communication and broadcasting, opinions differ as to whether and to what extent the content of satellite broadcasts should be regulated by further legal rules. Some countries favour new sets of general principles or even detailed rules while others consider such efforts premature and still others would prefer regional and international co-operative arrangements. The difficulties are obvious in view of the differences in rôle, status and structure of broadcasting in the world and in the interpretation given such concepts as freedom of speech, censorship and control of media.

International telecommunication law

International telecommunication law as it has developed over the last 100 years has a number of special features and presents a number of special problems.

As a starting point, the applicable legal instruments are the International Telecommunication Convention and the Radio Regulations which both have treaty force. These instruments differ from most other international treaties in the way they are prepared and adopted (by the Plenipotentiary and Administrative Conferences), in their contents and in the manner they are applied and administered.

At the basis of international telecommunication law lies the principle of State sovereignty expressed in terms of a fully recognized sovereign right for each State to regulate its own telecommunications, including broadcasting. However, international co-operation is necessary to establish telecommunication links between countries and for the use of radiowaves the behaviour of which varies with frequency and which are propagated without regard for man-made frontiers.

(1) The full title is: Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and on Other Celestial Bodies (1967).

The main principles of international telecommunication law concern, inter alia, the international allocation of frequencies, government licensing of all kinds of radio stations, international notification and registration of frequency use, prohibition against harmful interference and to some degree the principle of effective national broadcasting coverage.

As in other contexts, a significant problem on the international level posed by the transmission or broadcast of programmes via satellites lies with the need to strike a balance between two legitimate and sometimes contradictory considerations: on the one hand the desire and need to increase the free flow and wide dissemination of information, of educational and cultural materials and, on the other, the desire to protect the holders of rights covered by the various international conventions. In these respects, the need is for reaching globally acceptable international arrangements taking into account the interests of all countries, particularly the needs of developing countries.

Attention has also been drawn to the need for a readily and globally acceptable international instrument protecting television programmes transmitted or broadcast via satellites against unauthorized use.

These questions are now under study both within Unesco and WIPO (World Intellectual Property Organization).

Discussions have also taken place concerning the cultural and social standards embodied in national legislations affecting such matters as libel, slander, right to privacy as well as the different rules applying to right of reply and rectification. Since no globally accepted rules exist, it has been suggested that solutions might be sought through bilateral and multilateral agreements both on the governmental and non-governmental level.

4. INSTITUTIONAL FRAMEWORK, ORGANIZATION AND PLANNING

As has previously been mentioned on a number of occasions, communications via satellites represent an activity that depends on and interlocks with activities in a great number of areas. The necessity for an integrated, multidisciplinary approach is obvious if such seemingly disparate fields as space technology, telecommunications, broadcasting, information and education, economic and social development, sports and art, public and private, national and international law are to be brought together. All these activities have developed independently, based on concepts and institutions peculiar to each which now must form a functional whole. Many traditional concepts and social arrangements are clearly inadequate to deal with such a new, interdisciplinary, inter-institutional activity. One of the main problems therefore concerns the creation of adequate social structures, on the national and international level.

Institutional inertia and resistance to new approaches will require time for this process to take place. In the meantime, the two key concepts for dealing with satellite communication are co-ordination and co-operation.

Some specific problem areas might be mentioned as examples. The allocation of radio frequencies to different, competing services and the management of the radio spectrum represent a highly specialized, technically and administratively sophisticated activity. The implications go far beyond the technical aspects. The frequency spectrum is a limited natural resource to be managed in the best interests of all countries and therefore requires a highly developed form of international negotiation. The uses to be made of radio frequencies involve not only traditional telecommunications but a number of activities in society among them science, information and education. The relative priorities can only be established through high-level policy considerations. Action therefore requires international co-operation on the basis of nationally co-ordinated planning.

This co-ordination however encounters difficulties since national institutions more often than not are badly equipped to deal with new, multidisciplinary problems. It seems symptomatic that in such formalized policy statements as national plans for economic and social development, education, information and communication are treated separately. National plans and programmes in the field of education and information are often established without regard to the new mass communication media or recognition of their potential.

This aspect should also be seen in the perspective adopted by the Unesco General Conference with regard to a long-term plan for the work of the Organization. In this plan it is pointed out that "the accelerated progress of communication techniques and the increasing diversification of information media have opened up new prospects especially for education at all levels and for all age-groups". This development necessitates accurate analysis both of the impact of communication media and of the services they can render. Communications planning should be integrated into the general development planning. "But, communications planning cannot be approached realistically without first defining a communications policy."(1) The challenge of defining a communications policy has been well formulated in the following statement:

"If our policies are to fulfil the promise of technology, the promise of a better and more equitable distribution of information power, public policies must look beyond artificial boundaries, vested interests and specialized knowledge. If our policies are to succeed, if they are to correspond to the needs of the people ... we must have the courage

(1) Long-Term Outline Plan for 1971-1976 presented by the Director-General to the sixteenth session of the General Conference. Unesco document 16 C/4, Paris 1970.

to accept new facts, and to bring these facts together in a coherent and flexible policy."(1)

The planning for satellite communication, in particular with regard to the use of satellite broadcasting for education and national development requires, on the national level, the participation of a great number of institutions, ranging from all the concerned ministries to groups of the public for whom this activity is after all undertaken. The necessity for this national co-ordination corresponds, on the international level, to the need for co-operation between nations and the co-ordination between international agencies.

On the international, intergovernmental level, the organizations most immediately and generally concerned are the United Nations and its Committee on the Peaceful Uses of Outer Space as well as the United Nations Development Programme, the International Telecommunication Union (ITU) and Unesco. Furthermore, such organizations as FAO, WMO, WHO and others have a more specialized interest in the use of satellite communication for specific purposes. Multinational or regional intergovernmental organizations with specific tasks in the communication satellite field have also been established, i.e. Intelsat, Intersputnik, European Space Research Organization etc.

With respect to the use of satellite communication for information, specifically for broadcasting purposes, international co-operation not only takes place on the intergovernmental level but is effective also on the non-governmental, professional level between broadcasting organizations and their regional and international associations. Both within Unesco and the United Nations it has been recognized that "the use of satellite systems for television has already made possible new patterns of co-operation between broadcasting organizations in widely separated areas of the world and provides opportunities for extending regionally evolved co-operation to a broader international level"; recognition has also been given to "the rôle that broadcasting organizations are playing and can continue to play in the co-ordinated development of broadcasting via satellites".(2)

(1) Statement by Mr. Kierans, Minister of Communications, Canada, quoted in Instant World, op. cit.

(2) See Report of the Second Session of the Working Group on Direct Broadcast Satellites, United Nations document A/AC.105/66 of 12 August 1969.

IV. CONCLUDING REMARKS

Much has been said and written about the potentials of satellite communication systems, less about the work needed to prepare for their use. It seems appropriate, as a conclusion, to summarize thoughts on what steps a country would have to take with regard to the introduction of satellite communication. The concepts selected here have been formulated particularly with the developing countries in mind but would in many respects be valid also in other cases.

With regard to space technology generally, a plan of action might involve the following stages, according to the earlier mentioned United Nations study on the applications of such technology to development:

(a) a promotional phase which involves exposure of the nationals of developing countries to the wide scope of practical applications of outer space;

(b) the articulation of particular needs of individual developing nations by nationals of the countries concerned, with the necessary assistance from international survey teams;

(c) the transfer of knowledge and information through training of selected nationals of the country in those applications which seem of primary importance;

(d) trials and demonstrations of the space application in the local context;

(e) cost benefit evaluation of various alternative technologies that are available;

(f) political decisions on the basis of the demonstration and the analysis of various alternatives; this should lead to a commitment for action on an ongoing basis;

(g) the planning and execution of an operating system which might require a variety of inputs from outside such as international financing, know-how, hardware and training facilities.(1)

In the various studies made on the use of satellite communication for education and national development, the action recommended comprises a number of basic elements that seem applicable generally.

From the outset, there must be a recognition that, in order to attain the objectives stated or implied in their development plans, the countries concerned require the use of advanced methods and technology, particularly with regard to the systems of communication, education, information and culture, as an integral part of general development.

In this perspective, a satellite system for education would imply a commitment to television as an instrument for achieving the adopted goals. This approach involves the organization and use of television as a national public service available to the entire population of the country.

In choosing between alternative methods to achieve these objectives, careful consideration should be given to all available technical options, including such advanced options as the use of applied space technology. This choice between conventional and advanced technology should be considered in the general context of the transfer of technology and know-how as a means of bridging the technological gap.

The necessary studies must therefore be directed towards two main objectives simultaneously: prepare for a decision to use television on a massive scale for education and national development and prepare for a decision whether to use satellite communication for this purpose. Such studies would then need to cover definition of requirements according to development needs: software aspects including programme requirements in all relevant fields, staff recruitment and training, reorientation of education programmes, organization and management requirements, costs; hardware aspects with regard to the satellite system, space and earth sectors, additional production facilities required, costs, technical staff requirements; organizational aspects with regard to coordinated management and operation of system, particularly when several countries are concerned,

(1) The application of space technology to development, op. cit.

participation in programme planning, co-ordination and production.

Satellite communication particularly when used for education and information, cuts across traditional intellectual and social categories. In all case studies, the emphasis is on a co-ordinated, integrated, interdisciplinary approach.

This approach must be applied on the highest policy level to ensure the co-operation and involvement of all ministries and institutions concerned and equally for the training of the different categories of professionals required to participate in programme production who must learn how to work in teams. This same basic approach is needed for the programming and programme content which not only should strike a balance between motivation, intellectual education and training but also take into account the context of the educational situation. Production, distribution and reception should be so organized that the programmes, the "mediator" in the field, the receiving groups, the evaluation and follow-up form an interactive whole. Evidently, this approach is a prerequisite for the formulation of action plans, be it on the national or regional or international level.

ANNEX I

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B. Satellite systems, technology, costs, etc.

C. Educational uses

D. Legal aspects

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