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ABSTRACT

The Commonwealth Secretariat commissioned Educational Technology Associates to conduct a study on the educational use of satellites for the Commonwealth Secretariat's Education Program. The study had the following aims: (1) to identify the policy issues that need to be addressed by ministries of education, universities, and other educational bodies in developing Commonwealth countries with respect to the educational use of satellites; (2) to describe the regulatory issues on which either individual or collective government action may be appropriate; (3) to review Commonwealth experience on educational applications of satellites, regulatory issues, costs, and technical issues; and (4) to examine the possibility of access to databanks from remote locations through satellite communications. The report includes a summary of case studies on Australia, Canada, India, the South Pacific, and the West Indies; discussions of the current status of satellite applications and of the potential of satellites in distance education; and considerations of equipment and costs, planning and management, institutional cooperation, and programming source (indigenous or imported). The report concludes with a set of 22 recommendations. Data on Commonwealth countries using satellites are displayed in five appended tables. (55 references) (GL)

Main report

Educational Information Technology Associates

SATELLITES FOR COMMONWEALTH EDUCATION:

SOME POLICY ISSUES

A study commissioned by the Commonwealth Secretariat

Main Report

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10 October, 1987.

CONTENTS

Page no.

A Setting up the study

1. The terms of reference

The Commonwealth Secretariat commissioned Educational Information Technology Associates to conduct a study on the educational use of satellites for the Commonwealth Secretariat's Education Programme.

The study had the following aims:

a. To identify the policy issues that need to be addressed by ministries of education, universities and other educational bodies in developing Commonwealth countries with respect to the educational use of satellites, taking into account the needs of small states.

b. To describe the regulatory issues on which either individual or collective government action may be appropriate.

c. To review Commonwealth experience, so that this can guide policy on, *inter alia*,

   i. the particular educational purposes for which satellite links have proved useful

   ii. regulatory issues

   iii. costs

   iv. technical issues

d. To examine the possibility of access to databanks from remote locations through satellite communication.

The study is part of a long-term strategy to help Commonwealth education systems to benefit from satellite technology. The study will provide background material for a meeting of specialists in 1987/88. We were asked to look at issues regarding the use of satellites for all forms of education in the Commonwealth, although we were aware also of the proposal for a University of the Commonwealth for Co-operation in Distance Education (Briggs et al., 1987).

The study was carried out by Tony Bates, Professor of Educational Media Research at the British Open University, working with Dr. Paul Bacsich, Senior Project Manager in Information Technology at the Open University. The study was conducted between June and September, 1987.

2. Method of working

Three sub-contracts were placed for case-studies of particular projects. Professor Gerald Lalor, Pro-Vice-Chancellor, University of the West Indies, provided details of the University of the West Indies Distance Teaching Experiment (UWIDITE). Marjorie Crocombe, Director of Extension Services, University of the South Pacific, provided information on the University of the South Pacific's satellite project (USPNET). Peter White, of Ross White Associates, Melbourne, provided a report on the current status of educational use of the Australian satellite system, AUSSAT.

Tony Bates had personally visited and written reports on both the Indian INSAT and the Canadian Knowledge Network satellite projects within the six months preceding the commissioning of this study. This study draws on both these studies.

Information and views about policy issues related to the use of satellites for Commonwealth education were also requested from and provided by Dr. Joseph Pelton of INTELSAT, Jon Chaplin of the European Space Agency, Birgitta Naesland of EUTELSAT, Dr. Jim Stevenson, Chairman of the Project SHARE International Advisory Council, and Barbara Helm, of the Department of Communications, Federal Government of Canada. (Several other agencies were approached, but were unable to respond in the tight time-scale of the project.)

Lastly, a large number of published reports were either purchased, provided as accompanying documents with the commissioned case-studies or sent in response to letters, or were accessed through the United Nations University International Documentation Centre on Distance Education based at the British Open University. Of particular value was the series of publications on Telecommunications and Rural Development produced by the United States Agency for International Development

Liaison was maintained throughout the study with the Dr. Hilary Perraton, of the Commonwealth Secretariat.

The study was carried out in a very short time period (four months). Obtaining accurate information from all parts of the world, especially with regard to often complex and inaccessble legal and regulatory issues, has been extremely difficult. The study was also carried out at a distance, without the benefit of personal contact and site visits. While every care then has been taken to check information, there will inevitably be errors of detail in this report. We believe that we have given an accurate general picture of the use of satellites in education, but we will be grateful to be informed of any errors or major omissions.

3. The report

The report of the study is in three separate parts:

1. An Executive Summary
2. This Main Report
3. The Case Studies

The Executive Summary concentrates on the main conclusions and specific recommendations arising from the study. This main report contains details and discussions, while the case-studies contain a good deal of the information on which this main report is based.

B. General information from the study

1. The case-studies: a brief summary

The five case-studies chosen were:

Australia:	a survey of educational projects using AUSSAT
Canada:	Knowledge Network (on ANIK-C)
India:	a survey of educational projects on INSAT
South Pacific:	University of the South Pacific's USPNET, using INTELSAT
West Indies:	The University of the West Indies Distance Teaching Experiment (UWIDITE), using INTELSAT

Quite apart from providing a world-wide geographical spread, the five case-studies were chosen to illustrate a wide range of examples of satellite use for education, while at the same time indicating the main ways in which satellites have been used in Commonwealth education. Table 1 (over) indicates the main differences and similarities. A very brief description of each case study is given below.

AUSSAT Educational services have only recently begun on AUSSAT, which provides continental-wide coverage of Australia, but is directed primarily at the more remote regions. A number of educational projects and services are already running on AUSSAT, although services have yet to be firmly established. Programming ranges from general ETV programming to specific teaching of school-age children in remote homesteads, using a mixture of television, radio and telephone. AUSSAT acts as a common carrier for educational services, with different agencies such as State Ministries of Education, commercial companies, and educational institutions being responsible for programming.

Table 1: Summary of case-studies

	Australia (AUSSAT)	Canada (Knowledge Network)	India (INSAT)	S.Pacific (USPNET)	West Indies (UWIDITE)
GNP per head	$11,140	$11,32C	$260	$740[1]	$1,330[2]
No. of systems	Several	One	Several	One	One
No. of countries	One	One	One	10	6
Teaching media	TV,voice,data	TV,voice	TV	Voice	Voice/graphics
Comms. tech.	Sat +radio + phone	Sat + phone + cable	Sat + TV	Sat + radio + phone	Sat + radio + microwave
Target groups	Children (home) vocational; prof. dev.; schools	Children (home); dist. ed; adult ed; prof,. dev.	Schools; farmers; rural women; univ.	Off-campus; adult ed.; prof. dev.	Off-campus; prof. dev.
No. of viewers/ listeners per week	100,000?	436,000	10,000,000	200	50
No. of (enrolled) students per year using sat.	10,000?	15,000	1,000,000	1,500	1,000

[1]Tonga [2]Jamaica

Knowledge Network. This is an educational television network funded by the Provincial Government of British Columbia in western Canada. Knowledge Network distributes its programmes on both the Anik-C satellite and local cable networks and stations, for use on domestically owned sets. It transmits bought-in programmes as either 'enrichment' teleseries or to support courses offered by provincial educational institutions. It also transmits programmes made by educational bodies within the province. It does not however produce its own programmes.

INSAT INSAT is an Indian designed and manufactured satellite which is used for a variety of purposes, one of which is to provide educational television programming for schools, rural development, and university-level education. National and State governments fund programming specially made for INSAT, and also provide re-broadcasting on low-powered terrestrial transmitters, as well as community VHF and direct reception equipment in at least six states.

USPNET The University of the South Pacific serves 11 different countries in the South Pacific. Its main campus is at Suva, Fiji, but it also has extension centres in the other islands. An INTELSAT satellite is used, in conjunction with radio and terrestrial telephone lines, to provide courses to students on each of the 10 islands currently included in the system, using inter-active audio (i.e. lectures, with the opportunity for students on remote sites to question and discuss with the tutor). Students need to attend local centres in order to participate.

UWIDITE. The University of the West Indies is supported by 14 different countries, and has three main campuses in Jamaica, Trinidad and Barbados. UWIDITE uses an INTELSAT satellite, combined with telephone, radio and microwave links, to deliver courses by inter-active audio to centres in six different countries.

A full project description is given in the case-studies, which are published in a separate document accompanying this report.

While these are not all the examples of the use of satellites in Commonwealth countries, nor can they be considered a scientifically representative sample, they do represent a wide variety of uses, and allow comparisons to be made and conclusions to be drawn.

2. Types of satellites and the need for regulation

It is important to understand the differences between various kinds of satellites, because these have implications particularly for the cost of earth stations for transmission and reception, and also for the way satellites can be used for education and development purposes.

A satellite is like a mirror in the sky, allowing telecommunications signals of various kinds (television, radio, voice, data) to be sent up from the ground (up-linked) then re-transmitted down again. The advantage of a satellite is that being high up, the signals are not hampered by mountains, faulty land lines, or other natural and man-made hazards, and the signals can also cover a very large area. The downward signal can either be spread over a very wide area indeed (up to a third of the world's surface), or concentrated into a narrower area, sufficient to cover a medium sized country. However, for the same amount of power, the wider a signal is scattered, the weaker it becomes at the point of reception, and the larger and more expensive the ground stations need to be to collect the signal.. Thus narrower beams (or footprints) require smaller ground stations. Alternatively, the power of the satellite can be increased, by making it bigger (satellites are powered by energy from the sun; the more power required, the more solar panels needed, the greater the weight, and hence the greater the cost of building and launching the satellite). More power is required to send the signal to the satellite than to receive a satellite signal, so up-links (which can also be used for reception) are considerably more expensive than just reception dishes. To avoid interference, up-link signals are in different frequencies from the down-link, the conversion being made on the satellite itself.

From the ground, communications satellites appear to be stationary. In fact, they move in orbit at the same speed as the earth spins on its axis, thus remaining at a fixed point at right angles from the equator. There is an optimum height (approximately 36,000 kms. from the ground) where the gravitational forces of the earth, moon and sun are optimally balanced, thus reducing the energy required to keep the satellite in space. These two factors mean that there is a specific orbit into which satellites must be placed.

A satellite is likely to carry several transmitters (called transponders). Each transponder can usually carry the equivalent of a television channel and several radio channels, or over a thousand voice channels, or very large quantities of digitised information, like words, computer programmes, or still pictures or any combination. Transponders can transmit in a range of frequencies. Because voice and data require much less of the radio spectrum than television, their signals can be transmitted and received by much smaller, and hence cheaper, earth stations than television.

Since the footprints of several satellites are likely to overlap, and since there are also terrestrial-based radio, television and micro-wave signals, it is important that satellites broadcast at frequencies which do not interfere with either those of other satellites or of other ground services. This means that there has to be international agreement about the power and the frequencies at which satellites will operate, and where they must be placed in the geo-stationary orbit. They need to be spaced apart (between 6^0 and 9^0) to avoid interference with one another. Because there is a limit to the number of satellites that can be placed in the geo-stationary orbit at any one time, there also has to be agreement on how many satellites (or rather satellite channels) each country can have. These agreements are made through a United Nations agency called the International Telecommunication Union (ITU), to which virtually all countries (160) are signatories. These agreements are binding on member states. Technically the government of each country is responsible for ensuring that operators keep within the agreed parameters, and therefore require agencies accessing satellites to be licenced. In practice, many have delegated responsibility to a national or single telecommunications organisation (PTT).

which means that the national PTT controls all access to satellites within that country, and also usually sets the tariffs for accessing satellites. However, the government of the USA has 'deregulated', allowing a large range of organisations to access satellites.

There are basically three kinds of satellites. First, there are low-powered satellites built primarily to facilitate world-wide communications. Since the aim is to cover large areas of the world, they tend to have a very wide footprint, and hence need large ground stations to pick up the signals. These earth stations tend to be used to collect signals, which are then relayed by terrestrial means (microwave or re-broadcast by terrestrial transmitter). The main operator of such satellites is INTELSAT. This is an international, non-profit-making co-operative of member states, to facilitate communications between countries. INTELSAT has 112 member nations, plus 56 more non-member nation users. It operates 15 satellites, giving global coverage. In order to cope with expanding demand, and variable levels of demand, there is a certain amount of spare capacity on the INTELSAT system. It is therefore possible for an individual country, or several countries within a region, to lease part of that capacity for the purposes of domestic communications (television or telephone). Nigeria already has such an arrangement. Because though the signals are widely scattered, large and expensive earth stations are still required. INTELSAT is in the process of launching a new series of satellites, with more transponders (i.e. greater capacity). The transmissions from this new series will be slightly more powerful, and will allow for some reduction in the size and hence the cost of earth stations. However, the signals will still tend to be widely scattered, and hence earth station costs are not likely to reduce dramatically in price.

The second type of satellite is also low-powered, but designed specifically for use within one country or a series of countries close together. These are called regional or domestic satellites. Because the signal is more concentrated, and because they are generally more modern in design, they tend to have stronger signals than existing global communications satellites, and hence can be used with substantially smaller and cheaper ground-stations (as small as 1.4 metres in diameter for a receive-only antenna for television). Examples of such satellites are EUTELSAT (Western Europe), INSAT (India) and PALAPA (Indonesia). Where transmissions are limited to voice and data only, even up-links can be very much cheaper using these satellites. The signals from low-powered domestic satellites, are, like INTELSAT's, usually relayed by terrestrial means, although television signals for instance may be received directly by hotels or apartment blocks, or by people living in remote areas. Similarly, businesses or local institutions may have their own voice/data up-link facilities on site for business purposes.

The third type of satellite is used for direct broadcasting services (DBS). They are much larger and more expensive to build and launch, but are much more powerful and operate at much higher frequencies (in the 12 GHz or

Ku-band range). Consequently, even television signals can be received on very small antennas (less than 1 metre in diameter). These satellites (such as ANIK-C in Canada and AUSSAT in Australia) can be used for direct transmission of television broadcasts to individual homes. They can also carry extremely large quantities of data and many voice channels on one transponder. These satellites are comparatively rare, but there will be a major expansion in their provision over the next five years, mainly but not exclusively in North America, Europe and Japan.

The regulations for lower-powered satellites, such as the INTELSAT series, were established in 1971, and up-dated in 1979. The ITU's 1977 World Administrative Radio Conference (WARC) allocated all countries outside the Americas either four or five high-powered (DBS) satellite broadcasting channels (in the 12 GHz band), to standards designed to cover each country's territory without interference to its neighbours. Countries in Australasia, the Pacific and Asia were in general each allocated four DBS satellite broadcasting channels, and those in Europe, Africa and the Soviet Union five. Thus Britain and Malawi can use up to five DBS channels each, and Singapore and Malaysia four each. There are some exceptions. For instance, Australia and India have been allocated up to 24 channels, reflecting the continental spread of their countries. Although the agreement is binding until at least 1994, the limits set by the 1977 WARC conference do not reflect technological advances since that date, and better reception and transmission equipment is likely to permit additional national direct broadcasting services beyond the number of channels allocated, in lower frequencies than those covered by the 1977 WARC agreement.

The situation in the Americas with regard to DBS is different. These countries did not agree to meeting in 1977, some arguing that it was premature to set standards when the technology was still developing. The countries in the Americas met in 1983 at the Regional Administrative Radio Conference (RARC), and signed an agreement which will also last until 1994 at the earliest. Here the allocation of channels was quite different. The majority of the DBS orbital positions in the Northern Americas that were allocated went to the United States, Canada and Mexico. Canada for instance is planning a satellite capacity of over 50 television channels. The situation regarding the Caribbean countries is more confused, and needs to be clarified.

The ITU established at its 1971 Space Conference 'the principle of equal rights for all countries in the frequency bands for space radiocommunication services, stating that the international registration of frequency assignments did not provide any permanent priority for any individual country' (Jipguep, 1987), and all Administrative Conference agreements must be in accordance with this principle. The next conference on the use of the geo-stationary orbit is in 1988.

3. Availability of satellites for Commonwealth education

Table 2 below summarises the number of Commonwealth countries currently using satellites for educational purposes.

Table 2: Commonwealth countries using satellites for education

	Member states		Associated states and dependencies		Total	
	No.	%	No.	%	No.	%
Using or linked to satellite for education	17	35	3	18	20	30
With satellite facilities, but not used for education	16	33	3	18	19	29
No up-link facilities	16	33	11	64	29	41
Total	49	100	17	100	66	100

See Appendix 2, Table 1 for details by country.

It will be seen that in 1987, 20 Commonwealth countries (about a third) are using or are linked to satellite communications for educational purposes; they range from continental-sized countries like Australia, Canada and India to tiny islands like Vanuatu and Grenada. Seven of these countries do not have their own satellite up-link and reception equipment, but are nevertheless linked in via radio, microwave or telephone. At least another 19 Commonwealth countries use satellite communications, but not for educational purposes. Every Commonwealth country is within the footprint of at least one satellite, but a maximum of 27 are currently without appropriate ground equipment for reception and transmission suitable for educational purposes (although some of these countries may well have INTELSAT facilities through British membership, or satellite facilities for military purposes).

Several Commonwealth countries (e.g. Sri Lanka, Papua New Guinea, Guyana) are within the footprint of a satellite carrying educational services for another Commonwealth country. It is possible, provided agreement can be reached between the different countries, for one country to run a service on another country's domestic satellite. For instance, the Indonesians have leased facilities on their PALAPA satellite for telecommunications traffic between West and East Malaysia, and for internal telecommunications use in the Philippines (Sommerlad, 1987). It would thus be possible, for example, for Malaysia to run an internal educational satellite project on the PALAPA project, if the authorities in both countries agreed. In practice, this means obtaining the agreement of the national PTT's and the agency responsible for operating the satellite.

However, if the countries are signatory members of INTELSAT, they are prevented from using a domestic satellite for communications between two or more countries by regulation. This is to protect the INTELSAT services, which have been established primarily for this purpose. For instance, the University of Papua New Guinea could not use AUSSAT for communicating with Australian institutions without a special agreement, even though it is covered by the AUSSAT footprint. It could use AUSSAT though for a domestic service in Papua New Guinea (if the Australian authorities agreed), or it could use INTELSAT for communicating with Australian institutions. It is possible under certain circumstances to make special agreements, but this requires the consent of all parties who might possibly be affected by such an agreement, and consequently could take a great deal of time to negotiate. In practice, this regulatory device limits the possibility of Commonwealth communication, because the costs of using INTELSAT are likely to be much higher than using domestic satellites for communication between countries. The reasons for this will become clearer when we examine the costs of satellite services.

Australia, Canada and India have their own domestic satellites (AUSSAT, ANIK and INSAT respectively) and each of these countries has several different educational systems or projects using the satellite. These three systems between them cover a large area of the earth's surface. The remaining 17 countries using or linked to satellites participate through the University of the South Pacific (10 countries) and the University of the West Indies (7), using INTELSAT-V and -IV respectively. Where satellites have been used for educational purposes, use has been heavy. Most of the projects studied used 50 hours a week of satellite time or more.

The other three main countries currently using satellites for education are the United States of America (several projects, including the National Technological University, and Learn Alaska, using domestic satellites), Indonesia (SISDIKSAT, using the domestic PALAPA satellite), and the People's Republic of China (Chinese Central Television University), currently using INTELSAT, but planning to launch its own domestic satellite soon.

INTELSAT also helped to arrange a number of education and development satellite demonstration projects through Project SHARE (Satellites for Health and Rural Education). This project, which ran between 1985 and 1987, aimed 'to foster the practical implementation of new satellite technology to elevate educational and health standards around the world, particularly for people living in rural or isolated areas' (Pelton, 1985). INTELSAT made its satellites available, free of charge, for tests and demonstrations under Project SHARE. In September, 1986, nine different projects had been completed or were in progress, and another 11 were in the active planning stage (IIC, 1986). Several projects involved Commonwealth countries, and these are discussed in more detail below (p. 41.).

There will be a spate of new satellites launched over the next five years, but few are designated for educational use. The two most likely are OLYMPUS (an experimental DBS satellite with a footprint over most of Western Europe, with time reserved for educational projects) and the use of a Japanese domestic satellite (again DBS) for educational use. It can be seen then that Commonwealth countries are already well to the fore in the educational application of satellites.

Only three Commonwealth countries to date have their own domestic satellite system, and a large number of satellites are scheduled for launch by non-Commonwealth countries over the next five years. There is nevertheless plenty of room in space to meet the requirement of most Commonwealth countries for at least the foreseeable future, with the possible exception of Caribbean countries. Availability of positions is not a limiting factor for using satellites in most Commonwealth countries; other factors - like the cost of building and launching a domestic satellite - are more important.

To summarise, a substantial number of Commonwealth countries are already using satellites for educational purposes; an equally large number have the potential to do so, using already existing facilities. Even the remaining quarter are within the footprint of at least one satellite, but would need to invest substantially in ground equipment to make any use for educational purposes a feasible proposition. Even some of these though could be linked into a satellite system through existing terrestrial telephone lines, microwave or radio links. In most cases, there is at least one satellite system (INTELSAT), often two (INTELSAT plus a domestic satellite) that could technically be used, although there are regulatory constraints on certain uses.

4. Communication within and between educational systems

It is important to distinguish between two rather different uses of satellites for Commonwealth education. The first is where satellites are used as part of a single educational system; the second is where satellites are used as one way of communicating between different systems. (An 'educational system' is defined in this report as a single system of education, with a single management structure and operational responsibilities for the system, on an ongoing basis, which may nevertheless include sites in several countries, such as the Universities of the West Indies and the South Pacific, or a number of different educational institutions (which would include systems such as the National Technological University in the USA, or the SISDIKSAT Distance Education Project of the Eastern Islands Universities' Association in Indonesia). It would not include though associations such as the International Council of Distance Education, or the Association of Commonwealth Universities, as these do not have management or operational responsibilities for educational provision. Nor does it include single demonstration projects, as found for instance under PROJECT SHARE.) Where satellites are used for communicating *within* a system, its primary role is likely to be for teaching, although it may also be used for administrative purposes. It is though also possible to use satellites to communicate *between* different Commonwealth institutions, primarily for administrative reasons, although this could be expanded into teaching as well. There are though different policy issues involved with these different uses, so it has been considered best to separate them in this report.

C. Use of satellites within systems

1. The educational rationales for using satellites

When and why are satellites appropriate for education in the Commonwealth?

a. *Unique satellite characteristics*

These are what really distinguish satellite from terrestrial services.

i. Distance: In all five case studies, educational programmes were delivered to students more than 1,000 miles away from the teaching centre (nearly 3,000 miles away in the case of USP). Terrestrial telephone and television services can of course cover long distances, but they tend to be concentrated on major areas of population, and their costs increase according to distance.

ii. Remoteness: Satellites allow for remote and isolated communities to be reached, where the provision of a ground service would not be feasible. Remoteness is not necessarily the same as distance. A community may be only 200 miles from a major urban centre, but be isolated by sea, desert or mountain ranges. The more a country's educational policy is geared to providing equal opportunities for all its citizens, no matter how geographically remote, the more important a satellite system becomes. Covering the last 5% of the population can cost as much as covering the first

95% for terrestrial transmission; whereas the cost of satellite transmission is the same for those in the most remote farmstead, village or island as for those living in the centre of a city.

iii. New services. This is not so much a technical as a political aspect of satellites. Terrestrial services, such as broadcast television, may have no space for or interest in providing an educational service. In some countries for instance, the national broadcasting organisations are strictly commercial, and have no interest in providing educational programming; in others, the broadcasting organisations have control over content and methods of production, concentrating on one-way, enrichment-type programming of a kind similar to that found in general programming. Where print-based distance education is already available, courses may be expensive and time-consuming to mount, and may not be able to meet immediate needs, like how to deal with an unexpected emergency, such as a cyclone or floods. Satellites offer the opportunity not only for more services, but *different* services. In particular, teachers often demand services that lead to *active* learning, and greater participation in the provision of services. Satellites allow for new organisational arrangements, for different kinds of programming, and above all for two-way communication. While it may be feasible technically to provide these new services terrestrially, it may not be feasible in practical terms, because of the power of existing organisations, or the particular regulatory and commercial conditions within a country.

The rationale then for using satellites *rather* than terrestrial services is that they can better overcome the limitations of distance and remoteness, and/or provide different kinds of services from those able to be offered terrestrially.

b. Distance teaching characteristics

These characteristics are a function of the ability to use telecommunications to teach students at a distance, and are common to *both* satellite and terrestrial communication services. It is nevertheless essential for satellite services that they exploit fully the opportunities provided by, and appropriate to, distance education.

i. Decentralisation of higher education. The more advanced the level of conventional education, the more centralised and urbanised it becomes. For people living in isolated areas, this means they have to move to where the campus is. Not only are there the costs of living away from home, there is also the cost of travel. The satellite service allows undergraduate students to continue to study on their own islands both in the University of the West Indies and in the University of the South Pacific; Knowledge Network supports distance education courses offered by the provincial universities, so that students can at least partly qualify without studying on campus. The Indira Gandhi National Open University is planning to use INSAT for supporting its distance education courses.

ii. Professional development. It is extremely difficult to provide training for professionals (doctors, teachers, engineers, managers, etc.) working in remote or distant areas. Not only are there the travel and accommodation costs, but also the loss of time away from their work. In most of the case-studies satellites were used for professional development and vocational training. Q-NET in Australia, Knowledge Network in Canada, UWIDITE, and USPNET are all used for delivering professional development programmes to remote students. Furthermore, the costs of conventional training for this group can be so high that even where satellite costs may be expensive, they can still be justified. The ability to continue to develop and qualify while working can help keep people in areas which otherwise they would feel forced to leave for professional reasons after a certain period.

iii. Continuing education. It is not only professionals that require up-dating or retraining. It is now accepted in many countries that people will need to change jobs, or be re-trained, several times during their working life. There is also a large demand in many countries for community and family-related courses, such as health education, nutrition and community action. As with professional development, satellites can help bring continuing education to the learner. Also, at this level (as with professional development), the learners themselves bring substantial experience and existing knowledge to the educational process, which is best exploited through two-way communication in the form of teleconferencing and discussion. It is not surprising then that one of the main educational applications of Q-NET is for technical and vocational education (TAFE); that UWIDITE has outreach courses aimed at technician up-grading and for day-care personnel; or that USP offers courses to encourage community development groups to exchange and share information.

iv. Rural development. By definition, remote students tend to be based in rural areas. There is a heavy emphasis in most of the case studies on the use of satellites for rural development. INSAT provides television programmes on agriculture, health, and rural development; Knowledge Network has transmitted programmes for voluntary fire-fighters in the forest areas of British Columbia; Q-NET has carried a course on horse care and management aimed at remote cattle stations. Two important lessons have been learned already regarding the use of satellites for rural development. The first is the importance of decentralised programming for satellite distribution. In India, it is clear that rural audiences prefer programmes in their own language, located in their own region, and using local dress and customs. The second is the importance of identifying local needs in remote areas, especially when the programmes are produced many hundreds of miles away. Q-NET has found that the regional co-ordinators at each TAFE site played an important role in keeping the production agency in Brisbane informed of specific community requirements.

v. Equalising educational opportunities. The ability of satellites to reach into remote or isolated areas makes them an ideal means for equalising educational opportunities for those living in such areas, who otherwise often suffer from a lack of teachers, equipment or even buildings. This is one of the main rationales for the Indian INSAT project, in that it enables school children in rural areas beyond the reach of urban transmitters to receive programmes directly in their villages. This is also the rationale behind the Queensland School of the Air in Australia. Similarly the ability of satellites to cover large areas allows for the networking of educational broadcasts, making them available across a whole country or continent. One of the major uses of INSAT is to provide a national network for otherwise local or regional television stations. This not only allows a wider spread of general and informational programming, but also enables high-cost television production to reach larger numbers.

vi. Administering distance education provision

A perhaps slightly unexpected role for satellites emerged in two of the case-studies, and is also a feature of the Indonesian distance education project. This is the use of a satellite facility for administration and planning within a distance education system distributed across different sites or even different countries. Thus in UWI and USP, audio-conferencing was used to facilitate course planning, technical arrangements and admissions policies.

This list of educational roles for satellites is not meant to be comprehensive. Probably other uses already exist, and new roles will soon be discovered. The important point though is that in the planning and use of any educational satellite system, the educationale rationale must be clearly identified and agreed, and should determine the system's priorities, if the investment in the system is to be justified. These educational rationales though, while necessary, are not sufficient to justify the use of satellites. These roles have been successfully met in other systems without using satellites. In the end, the justification must come back to the advantages of satellites for covering large distances, reaching into remote areas, or providing new services that could not be delivered as cheaply in other ways.

2. The mix of communication technologies in educational satellite systems

The study indicated the extent to which satellites are only one of several forms of telecommunications that can be used in educational projects. Indeed, each of the case studies demonstrated that satellites are always just one component of an educational communications system.

Knowledge Network in Canada for instance used both satellite and cable distribution for its television programmes. One of the major uses of

Knowledge Network is for inter-active television. Such programmes are transmitted by satellite or cable, but viewers from anywhere in the province can call in by (terrestrial) telephone, live during the programme, to ask questions or discuss points with the lecturer. Some of the Knowledge Network programmes designed by a local educational institution like a university will be linked to local ground support provided by community colleges throughout the province. Other programmes are linked to correspondence courses and telephone tutorials as part of distance education courses run by provincial universities or the Open Learning Institute. In these cases, there would be substantial print materials associated with the courses, and the television programmes may be subsidiary.

In Australia also, the main use of satellites is for transmitting television programmes, but an even wider range of other communications is being used in conjunction with satellite television. In Queensland, while the School of the Air is using two-way audio, via satellite, between children in remote farmsteads and their teacher, the more common use is to use satellite for the outward signal and the public terrestrial telephone system for the return audio signal, as with both the Queensland TAFE (Technical and Further Education) network, linking 26 sites around Queensland, and the Early Literacy In-Service Course for teachers (ELIC). The latter also uses group discussions and local tutors to back up the video transmissions. Also in Queensland, the Q-NET system has been used to transmit slow-scan television, X-rays and facsimile.

In India, as in parts of Australia, satellite television programmes are re-broadcast to surrounding areas by low-powered television transmitters on the ground, so that the signal is picked up by standard television receivers.

In the University of the South Pacific, only seven of the islands have satellite transmit and reception facilities for the lectures at the Extension Centres; the remaining three Extension Centres are linked by VHF radio.

The University of the West Indies has a satellite link between Jamaica and Trinidad, but the other sites and islands are linked in by microwave, radio and telephone lines.

Depending on the system, then, satellite transmissions may be combined with terrestrial re-broadcast low-powered television or radio transmitters, cable TV, microwave links or telephones. Each system studied had a unique telecommunications mix, determined by cost, existing services, geography, and educational purpose. This has implications for policy, since careful technical feasibility studies will be required in every case where a new satellite-based service is being planned. The important point though is that satellites are not an all-embracing technology. They may provide one useful means out of several, as part of an educational system, but other means of communication should also be considered and used in conjunction with satellites, where appropriate.

3. Mix of media for teaching purposes, and the need for a clear pedagogy of satellite use

The wide variety of technologies which go to make up a system of which satellite communication is a part has led to a wide variety of ways in which different media have been used for teaching purposes. It is important to distinguish between both the media used (TV, audio, data) and the configuration (broadcast or network).

a. *Broadcasting*: the dissemination from one point to many points, for teaching purposes, with no return communications (e.g. TV: INSAT, India).

b. *Video-conferencing*: Outside the free services provided by Project SHARE, there has been no major use yet in distance education of two-way full bandwidth television communications (video-conferencing), presumably because of the very high costs. There are technical developments leading to compressed digitised video (currently down to 2 megabits/sec., but still expensive) and slow-scan television (much less bandwidth and hence cheaper, but very slow), but these are still unlikely to be realistic or essential for satellite-based education within the next five years.

c. *Interactive broadcasting*: one-way satellite television, with terrestrial telephone used to allow students to call in (voice only) to the broadcast (e.g. Knowledge Network, Canada; GWN, Australia). Q-NET's SOTA is the only instance in the case studies of the voice being returned directly by satellite transmission.

d. *Audio-conferencing:* two-way audio communication between several points, for both teaching and administrative purposes (e.g. USP, UWI, and Indonesia).

e. *Enhanced audio-conferencing:* two-way audio communication between several points, for both teaching and administrative purposes, supplemented by low-band graphics such as slow-scan TV or electronic writing (e.g. USP, UWI, and Indonesia).

f. *Data transmission:* Q-NET's SOTA is the only example in the case studies of the use of satellites for two-way data communication. In this trial, the satellite was used for the transmission of computer programmes or data bases, but satellites can also be used for carrying electronic mail, computer conferencing, text transfer and accessing remote data-bases. This is probably the least developed and most exciting possibility for satellite use in education.

Within this variety of media configurations, there is a basic dichotomy between broadcast services and networks, and this has important educational implications.

Television and radio have traditionally been used in education as a broadcast service. Programmes are broadcast from one central point and received at many thousands or even millions of reception points - schools, homes or colleges. There are several reasons for the prevalence of this use of television and radio in education, at least within the Commonwealth. First of all, the cost of producing and transmitting a programme is the same, whether one or a million people hear or listen to the broadcast. Also, high quality television production that exploits the unique audio-visual characteristics of television (Bates, in press) is expensive to produce. Hence to justify the high costs, large audiences are needed. Secondly, educational broadcasting in Britain and several other Commonwealth countries (e.g. India, Australia) has been the responsibility primarily of national broadcasting organisations (commercial as well as public), which have been strongly influenced in the past by the standards and criteria of general broadcasting (Bates, 1984). Because of the need to reach, hold and be understood by a mass audience, educational broadcasts have rarely been used for direct teaching, but have deliberately been made as entertaining as possible, and as enrichment material. Thirdly, the only way in many countries to get television and radio programmes made and produced used to be through a broadcasting organisation. Despite a web of advisory committees, teachers, at least in Britain, have traditionally had little influence over the actual making of programmes produced by broadcasting organisations.

It is not surprising then that satellites, which are just another form of television and audio transmission, have been used as another means of providing an educational broadcasting service. This is the main way in which INSAT, the Learning Network and WA ED TV in Australia, and to some extent Knowledge Network in Canada, have been used. This is perfectly justifiable, when there are large audiences for the programmes.

Some of these factors governing the use of television and radio in education have changed, though. Many educational institutions now have their own facilities for producing programmes. The availability of low-cost video and audio replay equipment also means that broadcasting is not necessarily needed to distribute audio-visual material to students at local centres or even at home. Students often have access to audio and video replay facilities. Perhaps most significant of all, the audiences even for distance education courses are often small (less than 200), which hardly justifies the costs of high quality television production and national transmission. (It justifies even less the use of satellites for distribution). Lastly, research (Bates, 1984) has indicated that broadcast educational television is frequently used in a very passive manner by students, who often fail to make full use of the otherwise excellent teaching material contained in such programmes. When broadcast television and radio have been used in distance education they have usually played a subsidiary role to printed material.

It is therefore interesting to note that the introduction of satellites (and cable) has lead to three new developments. The first is the relatively low cost production of television programmes or audio presentations, making use primarily of studio presenters and/or panels of speakers, usually teachers or subject experts (as in Q-NET, and some of Knowledge Network's telecourses). The second is the introduction of interactive programming, where students call in live to on-air programmes. The third, and perhaps the most significant, is the development of networks, where all students and the teacher can participate, at least technically, on equal terms, and where each person can see or hear any other person in the network. Because of cost, this has tended to develop through *audio-conferencing*, as illustrated by UWI and USP. The next step would be to widen the development of networking to computer communications, allowing students and remote tutors to write to one another electronically and immediately, with nevertheless the messages being stored.

Interactive television and networking represent different pedagogical approaches to that of broadcasting. They can involve the students a great deal more, and permit greater student and teacher participation. Perhaps more significantly, they are much cheaper, and easier for teachers to do, than broadcast production, or the time-consuming and expensive production of print materials for distance education.

However, there are also dangers in over reliance on interactive television and audio-conferencing. Firstly, low-cost television or audio lectures can be desperately dull and far less involving than a high quality broadcast television programme. As with terrestrial systems, one must ask why full bandwidth television is needed on satellite, given the huge difference in cost, for merely relaying lectures or discussions; and if the television material does exploit some of the very many valuable and unique audio-visual characteristics of television, why one needs to transmit via satellite, rather than mail video-cassettes. Secondly, if either television or audio is being used primarily to deliver *information*, why are these very inefficient methods (in terms of student learning) being used, rather than print? The saving in cost may be illusory. The quality of distance teaching material rests not so much in the particular medium used, but in the thought and preparation, the contribution of different people, adding their own ideas and checking and cross-checking the teaching material. Audio conferencing, which involves students participating fully, does not solve the problem of delivering large quantities of information, which unfortunately is still a necessary pre-requisite of most teaching. So while interactive television and audio-conferencing, on their own, can reduce the costs of distance education, they may also reduce the quality, if used as a *substitute* for other media, such as print.

In practice, satellites are likely, in most instances, to be only one part of a teaching system. It is important to use the satellite for what it does best, in terms of reaching remote students, in terms of delivering material that could not be got to students in any other way, and in allowing as far as possible for two-way communication beween students and teachers. It is likely that there will still be heavy dependence on other media, including print and face-to-face tutors. It is essential then that there is a clear teaching rationale which determines the way satellites - and other media - should be used, if they are to be used effectively, and which ensures that more costly media are not used for what can be done better by cheaper media.

This problem of using media appropriately is not unique to satellite-based courses, but it still needs to be addressed. The pedagogical limits as well as the strengths of satellites need to be clearly recognised, and for most teachers, administrators and system planners, determining an appropriate and defensible teaching role for satellites is likely to be a more difficult exercise than resolving any of the technical or cost problems.

4. Indigenous or imported programming?

A major policy issue is whether or not to use material produced in other institutions. We have seen that the production of high quality television for instance is expensive. Could material produced elsewhere be used?

There is a whole set of factors related to the use of materials prepared by other institutions that need to be considered. (Again, many of these issues will apply to the use of audio-visual material, whether or not a satellite is used for distribution, but still need to be addressed by satellite users.)

a *Cultural factors:* to what extent will the materials be suitable for the distance teaching system? While this may be less of a problem for scientific and mathematical subject areas, technology, vocational, management and agricultural programming may have transfer problems, surrounding both the use of language and the social context and assumptions that were made in the original production. At best, such programmes will need a revised sound-track and probably extensive support print materials; at worst, programme material may have to be severely edited and re-assembled, increasing costs substantially. We have already seen from the Indian experience that even within a single country, programme material originated in one part may not transfer too well to other parts. Importing materials from other countries is likely to be even more hazardous. For instance, even University-level students in India complained of language difficulties in programmes originated in Britain.

b. *Curriculum problems*: it may be difficult to find material that fits the curricular needs of a particular distance education system. It may be very difficult to find suitable material in the very areas which are of particular significance to the country or region in which the distance education system is located, because those problems may be unique to the region. The reverse of this is that the curriculum becomes defined by the availability of imported material around which courses can be designed, thus ignoring the indigenous needs of the distance education system. Also, the difficulty level of the programming may not match local needs. Finding suitable material is a major problem. Nevertheless there are extensive catalogues. For instance, the British Open University has a detailed shot list of most of the 3,000 television programmes it has produced, which would enable particular items to be extracted, reducing the problems of cultural transfer. What is required is a central data-bank of available audio-visual materials from different countries (which would include details of copyright, as well as content).

c. *Copyright problems:* international law relating to copyright and satellite transmission is very cloudy. (This is not just our view but one shared by specialist copyright lawyers - see Dietz, 1987). While broadcast rights may be cleared for terrestrial transmission, it is not clear whether this will also apply to satellite broadcasting, particularly if the signal spills over into other countries, or if the signal is likely to be relayed by cable. What is clear is that many programmes that could be used for distance education either need copyright clearance, which may be difficult to obtain and can be costly and extremely timeconsuming, or cannot be cleared for satellite transmission, because the rights are not held by the original broadcasting agency, but by 'third-party' agencies, like actors or picture libraries, who either are difficult to contact, or who may well refuse permission. Unfortunately, the areas covered by rights agreements which allow for secondary use are not usually consistent with Commonwealth needs. For instance, rights may have originally been cleared for national use only; or for national and North American use only, The Commonwealth Secretariat could help in a number of ways. One is to establish a clearing house or agency which could advise on and negotiate international rights clearance on behalf of Commonwealth countries. The second is to encourage distance teaching organisations that produce or commission audio-visual (and print) materials to obtain world-wide clearance at the point of production, which for A/V materials would include satellite (and cable) distribution. There are significant costs involved though in doing this, but these might be recuperated on sale of materials to other distance teaching institutions.

d. *Standardisation problems:* the two main television standards affecting Commonwealth countries are NTSC (North America and the Caribbean) and PAL. There may also be one or two Commonwealth countries on SECAM. However, because a satellite signal is usually on its own standard, there has to be a conversion in any case, both from the master tape to the up-link, then down from the received satellite signal to the standard of the television receiver (usually the same as the national terrestrial broadcast system). This latter conversion is built into the satellite receiving equipment Normally, programmes are converted to the required local broadcast television standard (NTSC or PAL), then converted to the local satellite standard before being fed into the up-link (conversion from PAL to NTSC is about £50 per hour at commercial rates). In terms of the total cost of television, standards conversion is a relatively minor problem, but does involve additional costs.

Therefore while the use of audio-visual material from other countries may appear attractive at first sight, there are significant obstacles to be overcome. For this reason, if television is to be extensively used as a broadcast service on satellite, it is strongly advisable to establish appropriate educational television production facilities, and adequate resources, on a recurrent annual basis, for indigenous programme production. This is what the Indian government has done for INSAT, establishing full production facilities first of all at the Central Institute for Educational Technology in Delhi, then devolving programme production to six State Institutes of Educational Technology. The Queensland Department of Education established a fully professional educational production studio at the South Brisbane TAFE College, to provide educational programming for Q-NET. However, there are substantial costs, both in capital and recurrent expenditure, in doing this. Nevertheless, to run a dedicated educational television channel requires a great deal of programming (approximately 5,000 hours a year). As Knowledge Network and Learning Network have found, there is a shortage of easily available, relevant, high-quality television material for broadcasting. The increase in satellite and cable services around the world needs to be accompanied by an increase in educational television production capacity. There is no point in establishing educational satellite services if there is no programming to run on them. There is an interesting proposal from Dr. Jim Stevenson, the Education Secretary of the BBC, for a world educational television satellite service based on the large stock of British educational television materials (Stevenson, 1987), but it will need something like £5 million a year to make it a viable proposition.

Consequently, Knowledge Network, WA ED TV, and to some extent Q-NET have also developed low-cost interactive programming, or devolved programme production to educational institutions. Thus for the North West Telemedicine Programme in Queensland, the hospitals themselves are responsible for the 'production' of the television programmes, although it is really misleading to suggest that these are like the programmes one might see on a public broadcasting channel. This is an excellent example of where satellites have led to the development of a new service, specifically geared to the needs of those with a need to communicate.

There is a very important regulatory issue here. There is a tendency for governments to see satellites primarily as a broadcast service, and therefore limit access to broadcasting organisations. Knowledge Network, though, and

Q-NET to a lesser extent, are 'open access' networks for educational institutions. If one of the rationales for introducing a satellite is to provide new services, and especially to encourage more interactive services, it is important that the regulations are drawn in such a way that they enable a wide range of potential production agencies, such as medical centres, educational institutions, and community groups, to access the satellite. Governments have to decide whether the satellite is to provide primarily a broadcast service, a common carrier network, or a mix of both. We would suggest for educational purposes it should be able to provide both broadcast services and act as a network for educational services. To some extent, this is what the Australian government has attempted to do with AUSSAT (and have it run as a commercial proposition), but not without some confusion and controversy.

Provided that the use of satellites can be justified in terms of educational cost-effectiveness, there is a great deal to be said for indigenously produced programmes. Where there is:

a. a good stock of indigenous or highly suitable television programming;

b. or already well-resourced good quality educational television production facilities;

c. or a commitment to meet the substantial capital and recurrent costs necessary to provide a regular and adequate supply of programming;

d. large numbers of the target population capable of receiving satellite television transmissions (even if re-broadcast);

e. and a suitable educational support system in place,

then educational television transmission can be an extremely valuable way to use satellites. However, these are demanding conditions to meet, and any agency considering using satellites for educational television services must be reasonably sure it *can* meet these conditions.

5. Data transmission

Satellites are capable of carrying huge quantities of data. It would be a mistake to think of data transmission as being primarily about sending computer programmes or large quantities of statistical information (like stock exchange prices) although that can be done as well. Because written or graphic information entered through a computer keyboard or even a television camera can be digitised, data transmission is also about the transfer of words and still pictures. In fact, data transmission works out much more cheaply per word than voice transmission, because being digitised it can be re-coded and packed tightly, then sent very quickly to the other end, where it is decoded and unpacked back into 'normal' text and pictures, thus occupying less capacity on the system than speech.

This has several major implications for distance education by satellite. It means that any student or tutor with access to a computer with word-processing software connected to a computer communications facility can communicate with any other similarly connected student or tutor, in the form of written messages, i.e. via 'electronic mail'. Consequently, tutors can communicate quickly with students and vice versa. An assignment can be sent to the tutor, marked and returned to the student as quickly as the tutor can get round to marking it. Alternatively, tutors and students can join computer 'conferences', where everyone who wishes can contribute comments or discuss a particular topic, and where the conference is available for reading whenever the student wishes, no matter how dispersed the students. Lastly, remote data-bases can be accessed, and information can be copied from the data-base and be down-loaded into the students' or tutors own computer and stored for later use.

Computerised communications need not be limited to mail and conferencing facilities, but can also be used for the transfer of large quantities of text, such as drafts of course units, provided that the material has been keyed in through a computer keyboard; similarly, it can be used for transferring large quantities of research data.

Such services require local micro-computers or terminals, a black-box or integrated chip called a modem which codes the computer information into a suitable form for transmission via the telephone system, a main frame computer on which resides the communications software which acts as the mail system, and good computer communications procedures. The British Open University is introducing a computer communication system for 1500 students and 80 tutors following a course on information technology in 1988, and is already using computer communications with the Universities of Guelph, Athabasca and British Columbia in Canada, and Deakin University in Australia.

Currently, electronic mail and conferencing systems have either been located within private internal data networks, or have been handled by the public telephone system, or a combination of both. However, there is no technical reason why satellites cannot handle this facility equally as well. Where students have to attend local centres, and where the number of sites is limited, (as at UWI and USP, for instance), or where students and tutors have access to computers which can be linked in to a satellite service, it would not be premature to explore the possibilities of using satellites for electronic communication.

The only example in the case studies of data transmission was the School of the Air in Queensland, and here the equipment and installation costs at each site were very expensive (£30,000 a site). There are though likely to be major technical advances in the next few years in the design of low-cost, voice/data transmit/receive ground stations, because of their value to the business community, and given the educational potential of electronic communication via satellite, this is an area of development that should be seriously considered by systems planners and teachers. While it is an area that would require substantial capital investment, the recurrent costs are likely to be low. We will return to the need for standardisation of equipment and software across Commonwealth countries when considering communication between systems.

6. Equipment and costs

'In the sky'

The total cost of putting a satellite in the sky, including launching and the construction or purchase of the satellite itself, varies according to the size and power of the satellite, and the extent of back-up for the satellite. Since the Shuttle launch disaster, and several launch failures by the European space rocket, Ariane, insurance costs are extremely difficult to estimate. Nevertheless, once launched and operational, satellites are not only reliable, but tend to remain operational considerably longer than their initial planned life, which is usually between seven to ten years. Unless otherwise indicated, the gross costs should be divided by the anticipated life of the satellite, to calculate the average capital costs per year. Because of the relatively high risk, and the need for money up-front, interest charges are usually substantial.

It should be noted that it is common to launch at least two satellites for a single project, one acting as a spare in case of malfunction by the 'main' satellite, with possibly a third in reserve on the ground. An extensive back-up system then could double or treble the cost of the 'in-the-sky' component.

Low-powered satellites

These are likely to cost between US$25 million and US$55 million for a single satellite carrying up to 30 transponders (i.e. 30 television channels, or any sub-division of that for telecommunications purposes).

India developed its own satellite technology. INSAT satellites are multi-purpose, providing television, telecommunications and scientific and meteorological data transmission. The cost of developing INSAT-1 was roughly US$226 million (£140 million) which covered the design, manufacture and launch of three satellites. This compares with about US$75

- US$150 million for the cost of a low-powered satellite bought from a Western manufacturer at equivalent 1981 prices, but the Western system is unlikely to include as high a cost for development as INSAT, which started from scratch.

High-powered DBS satellites

For a complete 'system' in the sky (satellite, launch and back-up) the cost, at 1986 prices, is likely to be between US$270 million (£170 million) to US$555 million (£350 million) (the latter being for the particularly large and powerful European satellite, Olympus, which becomes operational in 1989).

The advantage of a satellite like Olympus is that with a couple of high-powered transponders it can provide a DBS 'footprint' for a large part of continent, whereas the lower cost DBS satellites tend to provide good quality picture coverage for a single average-sized country, plus neighbouring countries, but not for a whole continent.

To cover a large continent completely, like Australia, is nevertheless expensive, as several satellites are required. Figures for the 'in-the-sky' component of Aussat, which is a medium powered satellite giving quasi-DBS, vary from around £73 million (for building three satellites, the launch of two, and ground control facilities) in 1982, to £210 million (covering the cost of building and launching all three satellites, costs of major earth stations, and ancillary broadcast-related costs).

Once a satellite is operational, the cost of using a television channel (i.e. the satellite transmission cost) will depend on a number of factors. A number of satellites have been launched as experimental projects, usually with State funding. In such cases, there may be no intention of recovering costs by charging commercial rates to cover the cost of development, launching and interest charges. However, as more and more experience has been gained, satellites tend to be run as a commercial operation. Satellite owners, whether governments or commercial companies, now have a much better idea of the tariffs needed to cover the costs of a satellite. The cost of renting a low-powered transponder (suitable for one TV channel) in Europe is US$1320 (£825) per hour for peak time, $560 (£350) per hour for day-time and $280 (£175) per hour for night-time, for occasional users (Eutelsat). This excludes the cost of the up-link, which will be considerable (see below).

Even when the capital and operational costs of a satellite are known, however, the cost of renting a transponder or TV channel will vary, depending on the economic approach of the satellite operator. For instance, the main purpose of the Indian INSAT project is to provide a number of public services: meteorological; telecommunications; and education and development. Since the satellite is government-owned, it does not charge transmission time to educational users, who are in any case government-funded organisations. Anik-C is operated by the Canadian Federal Government's Department of Communications. Knowledge Network, TVOntario and other provincial educational organisations do pay a rental for transmission to the Federal Governement, but at minimal, marginal cost rates. In the USA, however, a commercial company wanting access to a transponder for business purposes will be expected to pay what the market will bear. If demand is greater than supply, charges will go up; if supply exceeds demand, charges come down (in practice, competitive pricing due to a rapidly expanding supply situation has forced prices down, on balance). AUSSAT (which has a mandate to operate as a commercial venture) charges between £500 to £1,000 an hour for full broadcast quality TV services.

Despite these differing costing practices, the cost of renting transmission time for educational purposes is surprisingly consistent. Knowledge Network pays roughly US$300 (£187) per hour, for 98 hours a week, for a DBS service. In the USA, commercial companies may pay as little as US$500 (£312) per hour for transponders, with discounts for long-term leases. Similar figures are being quoted for European direct broadcast services. This compares with $US960 (£600) an hour paid by the Open University for *terrestrial* television transmission, giving full national coverage, but at marginal cost (i.e. the cost of running an already existing BBC transmission network for the extra time needed by the Open University). The figure of US$300-500 per hour is also a marginal cost, based on full or at least extensive use of a transponder, i.e. it assumes that the transponder is used most of the time, at least between 9.00 a.m and 11.00 pm.

The costs for audio on satellite are substantially lower. INTELSAT has a special service for rural communications, called Vista, and a single voice channel can be rented for US$3,180 (just under £2,000) a year. UWIDITE pays INTELSAT US$132,000 (£82,500) a year for a 24-hour per day lease, which works out at about £10 per hour. USP pays even less (US$17,000, or about £10,000, a year), for linking up six sites, but costs will rise as new sites are added. It must be remembered that both UWIDITE and USP are paying for conferencing calls (i.e. several points connected simultaneously). To give some form of comparison, a one hour point-to-point telephone call from the UK to France (less than 500 miles) at cheap rate costs about £20, while USP and UWIDITE are linking sites more than 1,000 miles apart.

'On-the-ground'

Although the 'big' costs, in terms of capital investment, appear to be in the sky, the major cost in fact tends to be on the ground.

There are several different kinds of 'on-the ground' costs: the up-link, costs of getting the signal to the up-link, the reception equipment, costs of return communications, costs of providing services (e.g. programmes), support services (e.g. maintenance), and administrative costs. Some of these vary considerably, dependent on whether a low-powered or high-powered DBS satellite is being used (e.g. reception equipment); other costs are independent of the power of the satellite (e.g. support services) except that high-powered satellites ultimately are likely to reach more people, thus requiring more ground support, for instance.

One other point to bear in mind is who is paying the costs. For instance. Knowledge Network in Canada pays for rental of satellite transmission time, and for buying in programmes already produced by other agencies, but is not responsible for purchase of reception equipment, nor pays for original production, nor for the support services. The Indian central and state governments though pay not only for the development of the satellite, but also for the reception costs, television programme production, and some of the support services (such as evaluation and curriculum development). The role of aid agencies is also crucial here, since historically they have been more prepared to finance hardware purchase and technical assistance rather than support services.

Up-links and return communication via satellite

A major capital investment is for the up-link - the transmitter that sends the signal from the ground up to the satellite. The cost of purchasing an up-link for full television transmission for a high-powered DBS satellite is just over US$1 million. It was predicted as long ago as 1981 that these costs will fall dramatically, to around US$50,000, but that has not happened yet. The cost for an up-link to a low-powered satellite is just over half that for a DBS satellite. Because of the high initial cost, up-links in the USA can often be rented for short periods of time, and may even be transportable. An estimated cost for renting a portable up-link in Europe is given as approximately DM1 million (£350,000 a year). This works out at about £1,000 a day.

As well as the capital cost of the up-link there is the tariff imposed by the PTT. The need to go through a PTT varies from country to country. In the UK, the only companies licensed for up-link communication are British Telecom and Mercury. British Telecom International are quoting a price of £30 per minute (£1,800 per hour) or £1 million per year for a complete TV channel on a satellite (including transponder time). It can be seen that with Eutelsat charging £825 for peak time, BTI's mark-up is over 100%. There is a tendency for PTTs to set up-link tariffs comparable to broadband international terrestrial communication tariffs. Deregulation in the USA however has led to far lower costs for up-linking DBS transmissions than in Europe. Knowledge Network pays £60,000 a year - or £12 an hour! - for up-link facilities for television.

Using spread spectrum transmission on a Ku-band transponder, a combined receive and transmit dish (1.8 metre) for data only is now available in the USA for US$5,500 (£3,500). A slightly more powerful system (2.8 metre) to include voice costs around US$11,000 (under £7,000). The low cost of deregulated, spread spectrum satellite technology in the USA is encouraging companies with multiple sites to use satellites to by-pass the terrestrial telephone system. The catch is that these operate on the higher-powered satellites in the Ku-band frequency (14/12 MHz), which are not generally available over developing countries.

It can be seen that the up-link costs, even on an hourly basis, can exceed the transponder costs, due to the high capital cost of the equipment, and even more so to the tariffs imposed by PTTs.

Particularly for television, but also for two-way audio, the up-link is unlikely to be close to the origination of the communication. This means getting the signal from a campus, or school, for instance to the nearest (or only) national up-link. There can be substantial charges in doing this, particularly for television. For audio, there is often a loss of quality in the land-lines, and this can be disastrous if data is being sent, since it is not as resilient as voice communication to distortion and loss of signal. In some developing countries, the whole rationale for using satellite will be to avoid the poor or even non-existent terrestrial telephone service. There are both cost and technical advantages then of an educational institution having low-cost transmit and receive audio earth stations on campus, where this is technically feasible.

Reception equipment

Reception costs consist of a number of elements: the dish aerial; any retransmission costs (e.g. through a land-line to a cable TV station or a terrestrial broadcast station); the 'black box' of electronics which converts a satellite signal into a form that is compatible with a 'normal' television receiver, allows the television receiver to tune to an appropriate satellite channel, and perhaps unscrambles an encrypted or coded signal; the television receiver; and the cost of installation.

Reception costs also depend on the power of the satellite signal, and on whether just one satellite is to be used, or whether the reception equipment has to be capable of receiving signals from several satellites. The lower the power of the signal, the larger the reception aerial, and hence the cost; similarly, the more satellites from which signals are required, the more antennae that are required, or the greater the need to 'steer' the receiver to the right point in the sky.

Perhaps the most significant advance in satellite technology in recent years has been in reception equipment. Costs and size of aerials required to receive even low-powered signals have dropped dramatically, and are likely to continue to drop over the next few years. Similarly, as more people acquire satellite dishes, so the economies of mass production begin to be achieved.

It is now possible to purchase in the United Kingdom a 1.4 metre steerable satellite dish capable of receiving all television transmissions from satellites within the Western/Northern hemisphere (high and low-powered) for £1,200 (under US$2,000). (This includes the electronics and installation). There are 21 satellite channels that can now be picked up in this way in the United Kingdom. However, if one wants a system that allows simultaneous reception of transmissions from more than one satellite, a separate dish is really needed for each satellite. A non-steerable 2 metre dish suitable for a low-powered domestic satellite such as Indonesia's PALAPA costs about US$1,000 (£625). However, to receive a TV signal of the same quality from an INTELSAT satellite, one would need an 8 metre dish, costing US$33,000 (£20,000).

Because of the higher power, a dish of 90 cm (one yard in diameter) is at the moment more than adequate to receive a DBS service, if properly installed. The cost of such a dish, including installation and the electronics for converting the satellite signal for use on a standard TV set, is approximately US$2,000, (£1250) in the United Kingdom. However, since there is no current DBS service in the UK, there is little demand to date for such aerials, so it is a slightly misleading cost.

Television set manufacturers are now beginning to make receivers which include the electronics necessary to convert satellite signals, as a standard component. When these receivers reach the market (in Europe by about 1988), satellite manufacturers expect these prices to drop to £400 by 1990 and £200 by 1995 for a 40 cm antenna, since the cost of the aerials will also fall with mass manufacture and improved technology. However, skilled installation may still be necessary for some time, which will add to that cost.

Table 3 over summarises earth station costs:

Table 3 is perhaps the most significant in this report. It shows the dramatic reduction in earth station costs (except for TV up-linking) that results from the increasing power of satellites. While INTELSAT satellites give global coverage, and hence can provide a service to many countries which otherwise would be impossible, they are not designed for internal, domestic traffic. The large cost of a single earth station is acceptable, if this provides international communication, which can then be relayed internally by terrestrial means. It is not feasible though to use an INTELSAT satellite for direct reception of television signals, or direct internal point-to-point telecommunications, because of the high earth station costs.

Table 3: Earth Station Costs

	INTELSAT	Domestic (C - band)	DBS (Ku-band)
TV up-link		£325,000	£625,000
Two-way voice/data	£125,000		< £20,000 (£7,000 USA)
Two-way voice	£70,000	£56,000	
Two-way data			£3,500
TV Receive Only	£20,000	£1,000	£400

These costs exclude delivery, tax and installation, and are meant for broad comparative purposes only.

However, improvements in reception equipment means that low-powered domestic satellites, like PALAPA and INSAT, can deliver directly TV signals to institutions like universities or even schools at a reasonable cost. even though direct inter-institutional voice and data communication via satellite is still not feasible. However, the high-powered satellites. although more expensive to build and launch, provide dramatic savings on the ground. making domestic TV reception feasible, and even direct point-to-point voice and data communication reasonable for institutional use. Thus while many Commonwealth countries are covered by INTELSAT, they would be able to provide a much more flexible and extensive educational service if they had access preferably to a DBS service, or at least a low-powered domestic or regional satellite.

However, access to DBS in particular for two-way communication needs to be combined with an element of de-regulation. The advantages come from having the satellite voice and data up-link on campus, and not having to pay high PTT tariffs or land-line costs for the right to access the satellite.

In developing countries in particular, the cost of television reception equipment would normally have to be included as an essential part of any satellite project, since educational establishments would not normally be able to find this cost from their own budgets, even for low-cost DBS reception.

The cost of reception equipment is significant:

> 'The constraining factor in large-scale growth of the INSAT-I utilisation is essentially the investment involved in provision of community TV receivers, direct satellite reception of VHF type, and rebroadcast transmitters.'
>
> Govt. of India, Dept. of Space (1984)

INSAT is basically a low-powered domestic satellite. If it had been a high-powered satellite, the cost of reception equipment would have dropped by at least half. Why then did it not put more cost into the satellite in order to save ground costs? A common feature of many satellite projects is the re-transmission of material originated through the satellite. Thus in the INSAT, AUSSAT, and Knowledge Network projects, programmes are taken down from the satellite, and rebroadcast via low-powered terrestrial ground stations or by cable TV stations, in addition to areas where the satellite transmission is received directly. Thus both DBS and low-powered satellites can be used to build up national networks of programming. Especially for large countries, or countries with difficult terrain, satellite networking is much more economical than building a network of terrestrial transmitters.

However, the technical infrastructure chosen for satellite delivery can seriously affect the suitability of a system intended for educational or development purposes. In India, the original intention was to spend money primarily on direct reception equipment. However, engineers calculated that for the same amount of money, more people could be reached if low-powered receive and re-broadcast transmitters were built, allowing programmes to be received on standard VHF aerials. Local state governments were given the responsibility for installing community VHF sets within the re-broadcast transmission areas, and direct reception equipment in the areas outside. The consequences of this were profound. Instead of the main viewers being rural people watching on the 8,000 community sets, the main viewers in India are now urban, more wealthy Indians, watching on 6 million private sets, and not surprisingly demanding more entertainment and less development programming.

It can be seen then that the choice of satellite, and assumptions about the availability and location of ground stations, are crucial decisions. Education is likely to be considered in most cases a minor influence on the design of satellite systems, but nevertheless educators should try to influence systems designers, to ensure the most flexible and cost-effective educational use of the systems. Once the satellite is in position, it is too late to do much about it. In the meantime, developing countries should perhaps consider the advantage of regional DBS services over low-powered options, if they believe that satellites could provide a solution to some of their pressing educational problems.

Programming and production costs

It is no good having a sophisticated satellite communication system if there is nothing running on it. It would be a mistake to think of satellite *only* for television transmission, since a single satellite transponder can handle very many telecommunications and data channels, as well as, or instead of, a single television channel. It is worth spending some time though looking at television production costs, because they can form a very significant recurrent cost in a satellite project, and it would require an enormous amount of voice and data to fill one transponder with educational material.

It is necessary to say something about the nature of communication through television. Television is unique when it breaks away from the classroom lecture, and brings in material from the real world, backed up by dynamic televisual techniques. However, this type of production is much more expensive than relaying classroom lectures.

The Open University spends nearly £8 million a year on television production, or about £50,000 a programme. TVOntario spends US$18.5 million (£11 million) on production. The general figure given for broadcast production is around £1,000 a minute in the United Kingdom. However, despite the very high sums spent on production, the Open University fills less than one-quarter of a channel (25 hours a week), even though it repeats each programme every year for eight years. Both the Open University and TVOntario produce educational programmes of the highest production quality. Nevertheless, if one wants to use television for other than relaying classroom lectures, production on a regular basis becomes very expensive.

Knowledge Network has avoided this problem in two ways. It buys in educational programmes from other producers (such as TVOntario and the BBC). It also encourages educational institutions within the province to produce their own programmes, for transmission on Knowledge Network. Nevertheless, it still has to find around US$250,000 (£150,000) per year for programming costs to fill half of one channel of 100 hours per week with bought-in programming.

A very rough estimate of the Indian INSAT programmes is that they cost about $US1,500 (or about £1,000) per hour for production, or a total of US$125,000 (£78,000) for the schools programmes. The higher education programmes (covering one third of the educational output) cost US$2 million (£1.25 million). These figures are particularly interesting, because there is strong evidence that in the earlier Indian satellite project in 1976 (SITE), the television production costs were seriously under-estimated, with less than 10% of the total budget for the project allocated to programming, although the total project cost US$9 million.

To set up an educational television production centre is also expensive. The BBC/Open University Production Centre cost £5.5 million in 1979. The Queensland Government spent A$4 million (£1.76 million) on equipping a studio for TAFE production. It is not necessary though to build or provide one's own facilities. Despite (or perhaps because of) its high budget, TVOntario does not have its own studios, but uses the facilities of other broadcasting organisations. In many countries, there is plenty of spare production capacity; what is often lacking are the funds for making programmes.

There are also costs involved in setting up facilities for audio-conferencing. The University of the West Indies spent almost US$30,000 a site (nearly £20,000) on equipping each teleconferencing room, plus another US$10,000 for room adaptation, totalling over US$240,000 (£150,000). USP received a grant of US$705,000 from USAID for equipment (£440,000).

A major short-coming of audio-conferencing is the lack of a suitable way to provide reliable, easy to use, low-cost graphics, i.e. a means of sending still pictures, diagrams, and hand-written notes in the bandwidth of a single audio channel. A number of different devices have been tried, including electronic pens, computer-generated graphics, and slow-scan television, but none has proved reliable or cost-effective. While most systems seem to manage adequately without the graphic support, there is evidence (McConnell and Sharples, 1983) that a flexible and reliable way of generating graphics can considerable enhance audio-conferencing. Manufacturers though have not been able yet to produce the goods at a price and reliability that suits the educational market.

Local support costs.

It is essential to ensure that once installed, the satellite equipment is properly maintained and made available when necessary. The Indian INSAT project learned a great deal from the earlier SITE project. Efficient local maintenance of sets is essential, as is the provision of a reliable electricity power supply. This meant in India that each of the participating States had to set up a maintenance team capable of reaching even remote areas, training them in the necessary maintenance skills, and providing them with suitable transport and running costs. Despite this there were reports that in one of the poorer States, only 25% of the community sets were operational. India also pays 'set custodians' to look after the community sets, and to make sure they ware available when required. In Queensland, local ground stations had to be properly installed and secured, not only against damage from children, but also from cyclonic weather conditions. The more widespread the system, the more important these factors become, and the more expensive they become to maintain.

Costs of total systems

What is the total cost of an educational satellite system? This figure is difficult to calculate, if not meaningless, because it does depend on so many assumptions which will vary from project to project. Knowledge Network, which does not produce its own programmes, costs around C$4 million (£2 million) to run per year, at 1985 prices. Adding together all the programmes run on INSAT, television production alone costs around £2 -£3 million per year, without any costs for capital investment in ground equipment or the satellite itself being taken into consideration. The direct costs of UWIDITE in 1987/88 were approximately US$350,000 (£220,000). I articularly though where teaching is done primarily by central staff, and full standard television is not used, there are many hidden costs, such as staff time. These may well exceed the actual satellite and other telecommunications costs.

Table 4: Summary of available costs in case study

	Programming		Transmission	
	Total	Per hour	Total	Per hour
AUSSAT - TV	Not known			£750
Knowledge Network - TV	£175,000	£70	£500,000	£180
INSAT (schools) - TV	£70,000	£1,000	Not charged	
UWIDITE - audio	Hidden		£138,000	£10
USPNET - audio	Hidden		£10,000	£0.22

Table 4 indicates how difficult it is to get proper cost comparisons. Q-NET projects have relatively low-cost television production on AUSSAT, but reception equipment costs seem to be high, as are television transmission costs. Knowledge Network spends a quarter of its budget on television transmission, despite a very low hourly transmission cost, but does not produce original television programming itself. The schools sector of INSAT, despite production costs one sixtieth that of broadcasting organisations in Britain, still spends £70,000 a year on direct costs of television production. The UWIDITE and USPNET audio costs look extremely good value, until one considers the numbers covered. Theirs are closed networks, using a small number of sites, and reaching relatively small numbers of students (2,000 - 3,000 a year, compared with 600,000 to 1,200,000 million Indian school children by INSAT, and 400,000 adults by Knowledge Network.) Some institutions have to pay full costs, others are highly subsidised, while others have hidden or base-line costs which are not included.

What would be extremely valuable for planners would be a set of comparative cost studies, using agreed methods of costing which are applied to all projects compared, and which take into account subsidies, hidden costs, student contact hours, and differences in local costs.

Perhaps the most valid method of costing though is not to compare totally different systems, with different objectives, target groups, financial structures, and mix of media, but to compare, within a country, the cost of a satellite based system with that of conventional educational provision. This is what Lalor and Marrett (1986) did in their study of UWIDITE. They found that on one programme alone (the Certificate of Education), the cost for full-time, on-campus education for one year in 1986 would have been US$1.3 million (£800,000). However, this programme has been delivered by UWIDITE since 1983. Since the total cost of UWIDITE over an 18 month period covering 1986 was US$545,000 (£340,000), for all courses delivered, it can be seen that the programme has been able to bring substantial savings. Average unit costs per student work out at around US$1,500 (about £1,000). Tietjen (1987) claimed savings of between 35% and 90% on satellite delivered teleconferencing projects over face-to-face teaching.

Conclusions

With DBS satellites costing over £250 million, it is natural that governments look very cautiously at the cost of providing a national or even regional satellite service, especially since nearly all countries are already covered by INTELSAT services. From an educational point of view though, there are two key issues, the first concerned with the provision of a broadcast service, the second with interactive or network services. The only way to justify the high cost of indigenously produced educational television is to ensure that it reaches large numbers of the target group. This may mean providing reception equipment in a large number of schools, colleges or villages, or ensuring that the cost of reception equipment is so low that large numbers of the target group can afford to buy reception equipment. With regard to low cost audio services, if they are to be interactive, each site needs to be able to communicate with every other site. This means installing ground equipment at many sites, and either paying landline costs, or accessing satellites. In either case, it is essential to reduce not only the transmission costs, but also the costs of equipment at local sites.

The satellite costs will be spread over a large number of services: weather forecasting, general television networking, telecommunications, even military uses. Regional arrangements (a group of countries sharing the same regional satellite) can help to reduce the satellite costs for a single nation. The reception costs for education though will fall directly on the national education budget. If the use of satellites can be justified for education, the cost-benefits are more likely to come from the use of high-powered, direct broadcast satellites, which spread the teaching to far greater numbers, and/or keep down the costs of ground equipment.

Secondly, educators and planners should worry less about the transmission costs of using satellites, and more about the ground costs, and the effectiveness of the teaching that is carried by satellites. Reception costs will be substantial; so will the provision of production or teaching facilities for use on the satellite, as well as the cost of providing essential local ground support, in the form of maintenance. Also, the high costs of broadcast services have to be set against the large numbers they can reach. Low-cost interactive audio may appear attractive, but if it is limited to a small number of sites, the cost per student may not compare favourably with a broadcast service, and it may be difficult to justify using a satellite for small numbers.

The use of satellites is not going to be a cheap option. It may however open up new target groups and new areas for education, and may force a fundamental re-thinking of the teaching process.

7. The planning and management of educational satellite systems

Most satellite projects seemed to have gone through a number of similar stages: the first is a relatively short demonstration project, often supported by external technical assistance. Then follows a longer period of political negotiation, planning and technical feasibility studies. This period may last from three to even 10 years. There then follows the initial operation of the system, usually beset by technical problems which are quickly resolved, and more serious management and educational problems, some of which may never get resolved. It is at this stage that it may become clear that a number of programmes or goals within the project are not viable. During this period, external technical assistance and consultancies are particularly helpful. The last stage sees the project settling down to a fully operational and effective system, financed and run locally.

To establish a fully cost-effective system, it appears important then to have:

a. some external technical assistance, at least in the early stages;

b. a lengthy period of planning;

c. a commitment to (eventual) full funding and operational responsibility by the particular educational authority or authorities for whom the system has been established.

There is probably enough experience now to avoid the need for a demonstration or pilot stage, although this may still be necessary to convince teachers and administrators within the planned system. However, such a pilot phase could delay a fully operational system by several years, and will not necessarily answer crucial questions such as the appropriateness of the goals or the cost-effectiveness of the system.

The importance of effective planning and management came through repeatedly from the various case-studies. Mechanisms need to be established to bring together government departments (perhaps from several different countries), PTTs, international carriers, and educators. Both USP and UWIDITE benefited from an international telecommunications development group working in each region. For a successful project, engineers, administrators and teachers have to work together, perhaps for the first time for all parties. Within the satellite-based education system, there is a need for clear management structures which facilitate communication on a regular basis between key decision-makers located on different sites. Fortunately, the technology itself can be used to facilitate inter-site communication, but this must be linked to a management structure which has clear lines of responsibility while at the same time encouraging participation in decision-making. Budgetary arrangements must match with management responsibilities - in other words, resources for operation of the system must be under the control of those who operate the system.

8. The scale of satellite projects

While satellite-based educational systems can significantly increase the numbers able to benefit from educational provision, this expansion is unlikely to be massive. The largest system studied, INSAT, reaches no more than 1.2 million viewers on community sets. While Knowledge Network has 300,000 general viewers a week, only 15,000 students enrolled in associated courses in 1985. Under 2,000 students a year follow USP courses, and under 1,000 UWIDITE courses. This in no way disparages the achievements of these systems, but it does provide a sense of realism about what satellites can achieve. What limits greater expansion are the costs of reception in developing countries, and the cost of local educational support in all countries.

Communications between systems

1. Commonwealth inter-institutional communication by satellite

So far, we have concentrated on the use of satellites for providing education within a particular country or teaching system. However, perhaps of more significance to Commonwealth co-operation is the potential of satellites to allow direct, world-wide communication between different Commonwealth institutions.

The main initiative to date that has used satellites in this way has been Project SHARE, and Table 5 lists the Commonwealth countries that took part:

Table 5: Commonwealth Countries in Project SHARE demonstrations

Project	Commonwealth Countries	Other countries	Technology
Completed			
Women's Institute for Freedom of the Press	Kenya, Tanzania (audio)	USA	2 videoconferences
American Society of Microbiology in Africa	Ghana, Kenya, Nigeria, Tanzania	USA, Ethiopia	
In progress (1986)			
Telemedicine	Kenya, Uganda, Canada, Univ. of West Indies		Audio-conferences, EEG &ECG transmission, via satellite, phone, and microwave
Use of teleconferencing for business	Canada	Colombia	Videoconference

A number of other projects have been implemented, but information on their progress is not yet available. Nevertheless, a number of useful pointers have emerged from Project SHARE.

First of all, the two telemedicine projects have indicated the potential of satellite communications for sharing problems and knowledge between different institutions continents apart. The telemedicine project between the Kenyatta Medical School in Nairobi, the Makerere Medical School in Kampala, Uganda, and the Health Sciences Centre in St. Johns, Newfoundland - later extended to the University of the West Indies - enabled electroencephalographs (EEGs) measuring brain activity, and electrocardiographs (ECGs) measuring heart activity, to be taken in hospitals in Africa and sent to Canada for analysis, using just an audio (telephone) circuit. It also enabled audio-conferences to take place between students and staff in the three sites, using an inexpensive form of communication (Bouk, 1987).

The American Society of Microbiology in Africa demonstration also provided an interesting example of how useful satellites could be for professional development in Commonwealth countries. This project arose from a request from African doctors for video teleconferences on fungal infections, infant diarrhea, vaccine development and parasitology. The London School of Hygiene and Tropical Medicine is looking for ways of delivering courses to students in overseas countries. This particular demonstration illustrates that the technology is in place to support this kind of activity.

Project SHARE however also demonstrated the need to use simple and low-cost technology. The projects requiring video conferencing all disappeared as soon as the free transmission facilities were withdrawn. The Canadian telemedicine project, which used audio only, demonstrated the need to adapt equipment (in this case battery-operated audio-conferencing equipment) to local needs. A number of potential projects did not materialise when participants realised that they could already achieve their goals more cheaply using existing terrestrial services. The projects also demonstrated that the cost of getting the signals between the sites and the nearest national earth station could be substantial.

The Project SHARE interim report (IIC, 1987) suggests that the following principles have emerged already:

a. Satellites now enable people in educational and development institutions to communicate with one another in ways that were previously available only to more powerful groups (like the military, and multi-national companies).

b. Two-way communication is a characteristic to be fostered and developed on satellites.

c. Satellites need to be used appropriately; what they do well is to facilitate communication over vast distances with an immediate and live quality that terrestrial broadcasting lacks.

The project has now come to an end, but it is possible to see ways in which satellites could provide a more permanent communications infra-structure for Commonwealth co-operation.

Indeed, we would argue that the time is now right to develop a special communications network linking Commonwealth educational institutions. The technology is available, the need is there, where pilot schemes for inter-institutional communication have been established, they are working well, and a specialised network could lead to substantially increased educational communication within the Commonwealth at much lower cost than conventional services.

2. The need for inter-institutional communication

While the advantage of modern communications within a distance teaching system is perhaps self-evident, the need for communication between Commonwealth education institutions in different countries needs to be more carefully elaborated, to ascertain what kinds of communication are necessary, and whether these needs can best be met by satellite communication or through other methods. (This section draws heavily on Briggs et al., 1987)

a *National networks*: There is a need to exchange information within a country regarding the different forms of distance and open learning available: this suggests the creation of national data-bases, and easy access to the information contained in that data-base; in Canada, the Canadian Association of Distance Education (CADE) links together over 30 different institutions engaged in distance education, across a huge distance. The 1987 Annual General Meeting of CADE was held by audio teleconference and was preceded by a lecture delivered by telephone from the United Kingdom, relayed by conference bridge to all 32 sites. This was done using the existing PTT telecommunications systems.

There is a rapid expansion currently in India of distance teaching institutions and a large number of conventional universities scattered over a whole sub-continent, with relatively poor telecommunications. In the United Kingdom, all universities are already connected to a private data network (JANET), which is used not only for the sharing of research data, but also for electronic mail and access to data-bases. JANET in turn is now connected to EARN, a data network for all European universities. Australia is developing a network (AOLIN) for computer communications between universities, based at Deakin University. These networks are currently terrestrially based, but in large countries like Canada, Australia and India there may be technical and cost advantages in having two-way ground stations at each campus for data and voice communication, within a private network.

b. *Regional networks*: The University of the West Indies and the University of the South Pacific are regionally based institutions using satellite-based technology to provide *within*-system communication. Organisations like the

Australia and South Pacific External Studies Association provide professional links *between* systems, to share experiences, for professional development, and to promote joint activities between different systems. Professional development and the exchange of experience between academics is becoming increasingly important, but very expensive to provide by traditional means that involve travel to and subsistence within another country.

c. *International networks*: the International Council for Distance Education (ICDE) has 82 institutional and 301 individual members in 49 different countries, of which 19 are Commonwealth countries. (Of the nine Executive Committee members, seven are from Commonwealth countries.) The ICDE organises a world conference every three years, but not all those who would like to attend can find the funds, and communication at other times is difficult. Other professional associations, such as medical teachers, microbiologists, physicists, etc. could make use of an international network for computer conferences, and administrative functions.

d. *International access*: Students in one country may wish to enrol in a institution located in another country. There are already some schemes where this is possible: UK citizens resident in Brussels and certain areas of West Germany can enrol with the British Open University; Massey University in New Zealand enrols students from the South Pacific; the Open Learning Institute in Canada enrols students in Malaysia, with local tutorial provision being provided in Malaysia. It is planned in 1988 to deliver part of a course on distance education to students in Canada from the Open University in England. However, by and large distance teaching institutions have been cautious in expanding beyond their national boundaries, because of the difficulties of providing local tutorial support. Increased international communications facilities would not only make it possible to provide tutorial support at a distance, but also to negotiate and administer such cross-national initiatives. Some institutions not currently engaged in distance education may nevertheless want to take advantage of what such a network would provide. For instance, Universities or Schools in the United Kingdom with specialist interests in Commonwealth countries, such as the Schools of Tropical Medicine, or the London School of Oriental Studies, may wish not only to use the network for communication between academics, but also to hold audio- or computer-conferences on special topics.

e. *Shared use of materials*: Several institutions (The Open College of Hong Kong, OLI and Athabasca University in Canada, Deakin in Australia, for example) use distance learning materials developed in other distance teaching institutions. This can mean many months of searching for appropriate material, negotiating charges, clearing rights, and agreeing examination procedures between different institutions.

f. *Joint production of materials*: The high cost of producing good quality distance learning materials, and problems of adapting existing materials to suit local conditions, have combined to encourage a number of institutions to produce joint course materials. However, to date this has usually required extensive exchange of staff between the institutions, and delays due to communication problems between different institutions, so the cost benefits have not always been as great as had been expected.

g. *Joint research activities between Commonwealth institutions*: The ability to exchange large quantities of data, to hold extensive individual or group discussions, and the opportunity to send mail and draft papers quickly, without being dependent on other people being physically present at the same time, may encourage greater research co-operation between different institutions within the Commonwealth.

3. What media are needed for a communications network?

Two points emerge from this analysis of needs for inter-system communication. The demand so far has been in two main areas. The first is for *person-to-person communication*, at two levels: communication at a professional level between academics in different institutions, often extremely far apart in distance; and for limited communication between students in one country, and tutors or administrators in another. At both levels, communication is time-critical, in that a quick response is often needed.

The second demand is for the exchange of large quantities of *text or research data*, in the form of course units or drafts of articles for joint discussion and approval. This is less time-critical, but nevertheless delays due to international mail and customs clearance can be most frustrating. Most of these needs could be met by

a. *voice communication*

b. *electronic mail*

c. *high-speed data transmission* for texts in draft form.

PROJECT SHARE has shown the value of television communication between developed and developing countries, but this was provided as a free service. Whether the 'true' cost would make the provision of such a service viable remains to be seen. Apart from PROJECT SHARE, there has been little demand to date for the exchange of broad-band television material, and where this has been done, it has not been so time-critical; in other words, programmes can be sent on tape through the normal postal communication systems, or by courier service. However, one feature of new communications systems, whether they are motorways or telecommunications systems, is that they generate new traffic. The provision of broad-band links could generate new demands for inter-change or joint development of television material, but it has to be recognised that no pressing need for this has yet been identified, at least in terms of justifying the much greater costs involved for international broad-band transmission.

4. A dedicated system - or use existing international systems?

There already exists of course world-wide electronic communications networks provided by national PTTs linked into international carriers, including satellite systems such as INTELSAT. So it is necessary first to determine the reasons for not making greater use of existing services. To do that, it is necessary to distinguish between data, voice and television communication.

a *Voice*: PTT networks currently provide good international voice links between major cities, but at a relatively high cost, and links in many countries between main cities and more local centres may be poor or unreliable. Using PTTs for phone calls on an international basis is feasible only for relatively short communications on grounds of cost. For instance, it costs £1.23 per minute for a call from the United Kingdom to Malaysia, and over £10 for a 20 minute call to Canada at cheap rate, i.e. outside office hours for both parties (see Appendix 2, Table 2 for some examples of international phone charges). There are obvious major problems with time differences. These are currently major inhibitors to using the public telephone system for greater co-operation between Commonwealth distance teaching institutions.

b. *Telex and facsimile*: Most Commonwealth universities have telex and/or facsimile links, which in general provide fast, reliable and relatively inexpensive transfer of short documents, letters, etc., and avoid problems of time differences. Telex services could probably be used more than they are for inter-institutional communication, but they are still too expensive for longer documents or regular communication, and could not handle the transfer of draft texts. For instance, from the UK to Kenya, a single sheet of A4 of 30 lines would cost £2.34, and take a minute to send. International computer communication, even through PTT systems, is generally much cheaper than telex. Similarly, facsimile uses the telephone network and is subject to the same limitations as outlined above.

c. *Data*. There is now a large number of large-scale computer networks in place throughout the world, country-wide, continent-wide, or world-wide. These networks typically offer electronic mail and file transfer facilities; in some cases, users can also connect into services such as data-bases and computer conferencing systems. The computers which make up such a data network are linked together by a 'mesh' (a sort of spider's web) of data network connections. These are normally supplied by the relevant PTT. There are four main types of network:

i. Research/academic/military networks: the best known of these is the US ARPANET network; other examples are JANET in the UK and the European EARN network sponsored by IBM. Most advanced tertiary education institutions and government research labs in the UK are connected to JANET (say 60 main nodes) but each of these may have up to 50 sub-nodes each (departmental computers).

ii. Corporate networks, run typically by large multi-nationals (often in the computer industry) for their own staff. The main examples are Digital Equipment Corporation (DEC), Xerox, IBM and AT&T. DEC's EASYNET system is one of the largest corporate networks, with over 10,000 nodes.

iii. public electronic mail networks, often run by a PTT. They are open to any paying customer. Access to the network is often via the local PTT's public data network. One of the main examples is the Dialcom network, which links 18 national public electronic mail networks (e.g. in UK, Australia, US, Hong Kong, etc.)

These different networks are not usually linked to one another. However, the emergence of a common standard for linking electronic mail systems (X.400) is beginning to produce links. A number of educational users (for instance the British Open University and several institutions in Canada) run their own internal electronic mail services. Unfortunately, these do not link to each other or to anything else. However, this is a temporary problem, and pressure from users is bound to bring about these links. The most common way for users to access public electronic mail networks is through public data networks, which are almost without exception built on the basis of the X.25 data network standard. There are some 96 X25 networks in 66 countries, all inter-connected. Surprisingly (given GNP and industrial capacity), there is a large number of Commonwealth countries without a public X.25 network, especially in Africa (see Appendix for list). A major benefit that could be provided by a Commonwealth initiative is to ensure that all Commonwealth distance learning institutions are able to communicate directly through the same electronic mail/conferencing system. Electronic mail offers considerable advantages for inter-Commonwealth communication.

iii. *broadband television:* broadband television requires roughly 1000 times the bandwidth of a single voice channel, so costs increase proportionately, although there may be reductions available if there are large quantities of appropriate bandwidth unused on a satellite. At strictly commercial rates, then, the international transfer of broadband television for conferencing purposes is always going to be expensive, and it would be hard to justify using PTT services for international television communication.

While then there are already several services in place that can facilitate or improve current communication between Commonwealth institutions, there are still serious limitations in the current services being provided. We believe though that it is a false dichotomy to have to either use existing services entirely, or build a completely separate and dedicated service. We believe it is perfectly feasible, using a mixture of existing and new services, and a mixture of satellite and terrestrial telecommunications, to put into place a Commonwealth Education Communications Network, which will overcome or by-pass many of the current limitations.

5. A proposal for a Commonwealth educational communication network

It is proposed that the Commonwealth provides the means to plan for a private telecommunications network, linking individual institutions in Commonwealth countries all round the world, via a combination of satellite and other telecommunications technologies, based on systems already in place. The network would be a hybrid system for both voice and data, using a mix of private and public, satellite and terrestrial systems, for inter-institutional communication, providing audio communication, electronic mail, computer conferencing, text transfer and access to remote data-bases, and allowing high-speed (up to 64 mgb/sec) data transfer.

We are unable in the timescale of this study to draw up detailed plans for this network, but we can give some indication of how we would see it developing. The network design though would require a full technical feasibility study.

The basic system configuration is likely to be a 'cascade' model, at two levels. At the first level, there would be nine regional 'hub' transmit and receive stations located at or near a Commonwealth educational institution (e.g. Western Canada; Eastern or Central Canada; Caribbean; South Pacific; Australia; India; Britain; West Africa; East or Southern Africa). These 'hub' stations would be linked together via satellite (probably through a leased service from INTELSAT). At the second level, each hub station would also be linked into a private regional network. Each regional network will vary, but is likely to be a mix of domestic or INTELSAT satellites and terrestrial telephone. Thus each Commonwealth education institution in a particular region could be linked through the regional hub station to any other institution in that region. In addition, links could be made with any other Commonwealth education institution in any other region through 'hub-to-hub' communication, then onward relay.

It will be necessary to obtain the agreement and co-operation of the PTT in each Commonwealth country that wishes to join the network. It is suggested that the Commonwealth seeks to contract a major 'lead' PTT to liaise with all the other PTTs. It will also be necessary to work very closely with INTELSAT. It is suggested that a representative from both organisations should be invited to join the technical feasibility study.

It is proposed that a Commonwealth Educational Communications Network Company should be established as a single organisation to obtain single user status in negotiations with INTELSAT and PTTs. This would be a small organisation, but with full-time staff, and it would be responsible primarily for the management and long-term planning of the network, but would not be directly responsible for its technical maintenance. The Network team would draw up recommendations for minimum educational network standards for homes, schools, tertiary institutions, and company training. The Network Company would be funded by contributions from member countries or organisations. It is assumed that each country will be responsible for deciding whether to join the network, for finding the capital and recurrent costs of doing so, and for maintaining its part of the network.

The voice and data networks are likely to be designed differently and separately, for technical reasons, but would result in the same inter-institutional communication facility. If the Network Company was recognised as a single user organisation, it would request the establishment of a private voice network for the connections between the main hubs, and for the regional connections into the main hub. This would allow individual institutions to have their own two-way voice (and data) stations, and exchanges to handle switching of calls.

The priority for the data network will be the establishment of an electonic mail service based on national X.25 data networks. There will be a need to standardise on text and X.400 protocols; some countries will need to up-grade PTT voice and data links to those main educational centres to be included in the network; the Network team would liaise with relevant PTTs to draw up a phased plan to meet the necessary specifications for a network in that country. Computer conferencing would operate as a series of semi-independent regional services, linked into their regional nodes; inter-regional connections would up-date neighbouring conferences at regular intervals.

The feasibility study will need to look at the possibility of the following domestic satellites providing a major component of regional networks:

a. ANIK: Canada/Caribbean

b. INSAT: Indian sub-continent; Malaysia; Sri Lanka; Singapore

c. AUSSAT: Australia, New Zealand, Papua New Guinea, South Pacific

The region where we believe there is the greatest potential for a regional communication system is Africa. However, because of the need to reduce the cost and maintenance of ground stations, we believe it is important that the area is served by a high-powered satellite. The case for a Commonwealth African satellite, perhaps using capacity on either Olympus or Telecom 2, needs careful consideration; it is to be hoped that the proposed AFROSAT project (Riverson, 1987) is funded by the European Development Fund, and in time for inclusion in a Commonwealth Network.

The network will require several different types of earth station within the following general design:

a. speech and data up-link and down-link

b. less than 1 mbps. throughput rates (except for regional nodes)

c. preferably Ku-band; if not, C-band

d. optional TVRO equipment

The aim would be for a station costing below £10,000. The regional node station would be in the range of £200,000.

We are aware of the regulatory problems this proposal may run into. INTELSAT signatories are prevented from using domestic satellites for international communications. However, we are proposing that INTELSAT is used for inter-regional communications, and for some links within regions. By establishing a private network limited to particular institutions for a particular purpose, it is hoped that this will enable a domestic satellite to be used for inter-institutional communication between different countries within the same region. Even if this is not possible, it would still be possible to use INTELSAT and/or the terrestrial telephone system for communications within a region, although the costs are likely to be greater.

The technical feasibility study is likely to require at least six months preparation, and will cost approximately £200,000, although this cost will be reduced if free technical assistance is offered by agencies most likely to benefit. We recommend the appointment of a part-time steering group for the study, and a full-time study manager, who should be a high-level satellite/telecommunications engineer. Part-time consultants would also be required. The feasibility study would need to carry out the following:

a. design of satellite transmission networks

b. design of terrestrial transmission networks

c. detailed design of electronic mail network

d. co-ordination of national PTT plans for voice and data

e. survey of institutions' perceived requirements

f. traffic forecasts

g. communications protocols

h. define satellite systems to be used

i. define terrestrial systems to be used

j. decide on appropriate earth stations

k. decide on common applications and system software for the computers linked to the network

l. prepare a full implementation plan, in phases, with priorities

m. prepare a financial plan

The task of the study manager is to synthesise at a high level the various inputs so as to produce an overall plan. Detailed discussions will need to take place with:

i. the major relevant providers of satellite services (e.g. INTELSAT; TELESAT, Canada; AUSSAT; INSAT)

ii. the major providers of earth station technology

iii. organisations providing the regional hub sites

iv. the main PTTs involved.

In addition site visits will probably be necessary. We are convinced that £200,000 is the minimum required to do the job properly, but not all the cost need fall on Commonwealth funds. There is a good record of certain computer companies supporting international academic networks. A Commonwealth country's own PTT or satellite operator may be willing to undertake an appropriate consultancy free of charge. This may enable the core funding to be reduced nearer to £80,000.

If the full feasibility study is not considered appropriate, we would still strongly urge the establishment of a Commonwealth educational communications steering group, to draw up recommended standards and approaches in this area.

Our aim has been to indicate that it should be possible to set up such a network, in a phased manner, that there is likely to be considerable demand for use of such a network, and that such a network could provide an invaluable infra-structure for Commonwealth co-operation in education.

E. Recommendations

1. Satellites should be considered as one means of widening educational access, particularly to remote or isolated regions within a country.

2. The educational reasons for using satellites should be clearly defined before any commitment is made to use a satellite, and the costs (and benefits) of alternative media/distribution systems should also be investigated. A full feasibility study should be commissioned before commitment.

3. Satellites should be considered as part of a total educational provision; as much attention needs to be paid to the other components of the project.

4. The main use of satellites in developing countries should be for audio conferencing; the time though is now appropriate for testing the use of satellite-based systems for electronic mail and text transfer as well; television should only be used when adequate production resources and reception facilities are available.

5. Where television is to be used, priority should be given to indigenous programming, or to adapting or integrating externally produced material into indigenous programming.

6. There should be a central Commonwealth data-bank of audio-visual materials, their copyright status, and their content. A clearing house or agency should be established to help with copyright issues; Commonwealth production centres should try to obtain rights clearance for Commonwealth use at the origin of production.

7. Where there is higher-powered satellite transmission, or where appropriate earth stations can be provided, it is better to locate narrow-band (voice/data) earth-stations at the educational sites, and allow direct access to the satellite. This may mean some form of deregulation, if the PTT has sole right to access the satellite.

8. There is an urgent need for good quality, reliable, easy to use narrow-band graphics equipment.

9. The provision of a basic technological infra-structure should take precedence over satellite developments in national planning. Satellite projects therefore are unlikely to be practical in very poor countries, without

a great deal of external assistance.

10. Where possible, Commonwealth countries should work together to develop *regional* satellite projects, to reduce costs and to get better co-operation from PTTs.

11. A special study needs to be done to see what arrangements could and should be made for African countries. This study should take into consideration the French government's plans to make the Telecom-2 satellite available for Francophone Africa.

12. The establishment of a fully cost-effective system is likely to require some external technical assistance, at least in the early stages; a lengthy period of planning; and a commitment to (eventual) full funding and operational responsibility by the particular educational authority or authorities for whom the system has been established. If planning is done properly, a pilot demonstration should not be necessary, and a pilot could delay a fully operational system by several years.

13. Good planning and management arrangements are essential. Team working, involving educators, engineers and administrators, is necessary, as are clear management structures. Educators should be involved in the planning of a satellite system from the beginning. Support at a high political level is likely to be essential.

14. Governments can help to keep down satellite transmission costs for an educational system. They can put pressure on PTTs to charge special tariffs for educational purposes which take into account the use of spare capacity and off-peak traffic; or they can give the educational institutions a licence to up-link directly with their own or rented equipment. Without government support for educational services there is a risk that some PTTs will exploit their monopoly position regarding satellite tariffs at the expense of worthwhile educational development.

15. Great care is needed in choosing a satellite system, because relatively small savings on satellite costs can have major consequences for earth station costs, and these in turn influence the effectiveness and scope of the education provided. The greater the number of students in the target group, the more important it is to reduce reception costs by using more powerful satellites. Developing countries might do better to wait until higher-powered satellites ('genuine' DBS) are available for their use, before investing heavily in a satellite system for educational reasons.

16. Adequate annual resources for course production and local ground support is essential; these will be substantially higher than satellite technical costs, but must be found if the system is to be effective.

17. The Commonwealth Secretariat should instigate a feasibility study. at a cost of approximately £200,000, to draw up a specification for a Commonwealth inter-institutional communication network.

18. Access to satellite transmission should not be restricted by government regulation to broadcasting organisations alone; educational institutions should have access as well, and be encouraged to develop new services and types of programming. Satellites should not be restricted by government to one-way boadcasting services or to the private use of PTTs; educational institutions should be allowed to use satellites for two-way communication; where appropriate.

19. The study team should include representatives from INTELSAT and a lead PTT, as well as representatives from Commonwealth satellite projects. A satellite/telecommunications engineering consultant will need to be appointed to the feasibility study.

20. The aim should be to establish a Commonwealth Education Network Company as a single organisation, to plan and manage the Network, funded by member countries.

21. The Network should be based on voice and data communication, using regional nodes as the connecting points between international and regional sub-networks, combining satellite and other telecommunications systems, as appropriate.

22. Individual countries should be responsible for equipment installation, and for communications cost incurred in running the network, but should follow common technical standards laid down by the Commonwealth Education Network Company.

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G. Appendices

Table 1: Commonwealth countries using satellites in education in 1987

	Using or linked to satellite for education	With satellite facilities, but not used for education	No up-link facilities
A. Commonwealth countries (*associated states and dependencies)			
Antigua & Barbuda	x (relay)		
Australia	x (AUSSAT)		
Barbados	x (relay)		
Canada	x (ANIK-C)		
Cook Islands*	x (INTELSAT-V)		
Dominica	x (relay)		
Fiji	x (INTELSAT-V)		
Grenada	x (relay)		
India	x (INSAT)		
Jamaica	x (INTELSAT-IV)		
Kiribati	x (INTELSAT-V)		
Nauru	x (INTELSAT-V)		
Niue*	x (relay)		
St. Lucia	x (relay)		
Solomon Islands	x (INTELSAT-V)		
Tokelau*	x (relay)		
Tonga	x (INTELSAT-V)		
Trinidad & Tobago	x (INTELSAT-IV)		
Tuvalu	x (relay)		
Vanuatu	x (INTELSAT-V)		
Total	20		
Bangladesh		x (INTELSAT)	
Britain		x (INTELSAT)	
Cyprus		x (INTELSAT)	
Falkland Islands*		x (INTELSAT)	
Ghana		x (INTELSAT)	
Gibralta*		x (EUTELSAT)	
Hong Kong*		x (INTELSAT)	
Kenya		x (INTELSAT)	
Malawi		x (INTELSAT)	
Malaysia		x (INTELSAT)	
Malta		x (EUTELSAT)	
New Zealand		x (INTELSAT)	
Nigeria		x (INTELSAT)	

Table 1: (cont.)

	Using or linked to satellite for education	With satellite facilities, but not used for education	No up-link facilities
Papua New Guinea		x (INTELSAT)	
Singapore		x (INTELSAT)	
Sri Lanka		x (INTELSAT)	
Tanzania		x (INTELSAT)	
Uganda		x (INTELSAT)	
Zambia		x (INTELSAT)	
Total		19	
Anguilla*			x
Bahamas			x
Belize			x
Bermuda*			x
Botswana			x
British Virgin Islands*			x
Brunei			x
Cayman Islands*			x
Christmas Island*			x
Cocos Islands*			x
The Gambia			x
Guyana			x
Lesotho			x
Maldives			x
Mauritius			x
Montserrat*			x
Norfolk Islands*			x
Pitcairn Islands*			x
St. Helena*			x
St. Kitts-Nevis			x
St. Vincent & Grenadines			x
Seychelles			x
Sierra Leone			x
Swaziland			x
Turks and Caicos Islands*			x
Western Samoa			x (1988)
Zimbabwe			x
Total			27

(excludes private and military installations; also possible that some of these territories have INTELSAT facilities through British membership)

Table 2: Countries with a X.25 public data network

Commonwealth

Antigua	
Australia	AUSTPAC, OTC
Bahamas	
Barbados	
Bermuda	BERMUDANET
Canada	DATAPAC, GLOBEDAT INFOSWITCH
Cayman Islands (soon)	
Channel Islands	
Great Britain	PSS
Hong Kong	DATAPAK, IDAS
Jamaica (soon)	
Malaysia	MAYPAK
New Zealand	PACNET
Singapore	TELEPAC
Trinidad	DATANETT, TEXDAT
Zimbabwe	ZIMNET (soon)

Other

Europe
Austria, Belgium, Bulgaria(soon), Denmark, Eire, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Netherlands, Norway, Portugal, San Marino(soon), Spain, Sweden, Switzerland,

North and Central America
Costa Rica, Cuba, Dominica, French Antilles (Guadeloupe and Martinique), Guatemala, Honduras, Luxembourg, Mexico, Netherlands Antilles(soon), Panama, USA

South America
Argentina(soon), Brazil, Chile, Colombia, French Guiana, Peru,

Asia
Bahrain, China, Indonesia, Israel, Japan, Kuwait, South Korea, Taiwan, Thailand, Turkey(soon), United Arab Emirates,

Africa
Cameroon(soon), Egypt, Gabon, Ivory Coast, South Africa,

Australasia and Pacifica
Guam, New Caledonia, Philippines, Puerto Rico, Reunion, Virgin Islands

Table 3: Dialcom Public Franchises Worldwide

Commonwealth
Australia, Canada, Great Britain, Hong Kong, New Zealand, Singapore.

Other
Denmark, Eire, Finland, Italy, Netherlands, West Germany;
Japan, South Korea, Taiwan; Mexico, Porto Rico.

Table 4 International Public Data Charges for the UK

	Duration	*Volume (1K= 8 segments)*
Australia		
	9p/min	4.32p/K
Brazil		
	9p/min	4.32p/K
Canada		
	7.5p/min	3.6p/K
France		
	3.0p/min	1.44p/K
Gabon		
	9p/min	4.32p/K
Malaysia		
	9p/min	4.32p/K
Oman		
	9p/min	4.32p/K

Table 5 International Phone Charges From UK

Band	*Rate*	*Cheap rate*
Australia (61)		
E	88p/min	70p/min
Brazil (55)		
F	119p/min	97p/min
Canada(1)		
C	66p/min	53p/min
France (33)		
A	40p/min	31p/min
Gabon (241)		
F	119p/min	97p/min
Malaysia (60)		
G	123p/min	123p/min
Oman (968)		
D	88p/min	70p/min