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International Communications Satellites: Global and European Regional Systems [and Discussion]

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International communications satellites: global and European regional systems

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The development of the Intelsat network has caused a revolution in international communications for most countries and particularly those in the developing world. The high growth rates in international communications have resulted in a new satellite generation every few years, which use progressively more advanced technology in both the space and Earth segment. However, Intelsat VI may be the end of the trend to ever larger, more complex satellites.

Satellites were unable to compete effectively with Europe's highly developed terrestrial network. However, European Governments took a view not only on the need for cheap communications but also the need to develop a capability in the field of satellite communications that would equip industry for the massive world markets foreseen for the future. The result was ECS, a regional communications Satellite system for Europe that will go into service within a few months and will be used well into the 1990s.

Introduction

Satellite communications must represent the most significant industrialization of space in the first 25 years of space exploration. This can be well illustrated by both the Intelsat global system and the European regional system, and these also serve as good examples of where satellite communications are likely to lead in the next decade or two.

Although prime interest is in the future we cannot predict this without reviewing what has happened in the past.

Intelsat

Intelsat started in 1964 with 11 members and one satellite. It now has 104 members and 17 operational satellites. The organization was formed by an agreement between Governments (the Parties) who meet every two years in the Assembly of Parties. There is also an operating agreement between the telecommunications authorities nominated by the Governments: the Signatories. They meet once a year in the Meeting of Signatories. The practical direction of the system is determined by the Board of Governors, which consists of the 13 largest Signatories plus certain other groups of smaller Signatories.

Signatories contribute to the capital requirements of the system in proportion to their use of it. They then pay for their use of the system on a per-circuit basis at a rate designed to give 14% per annum return on capital and to meet the operating expenses and depreciation. This has resulted in a charge that started at $32000 per annum for one half circuit in 1965 but now stands at approximately $4700 per annum.

To see what the industrial opportunities will be in the future a brief review will be given of the operational and technical development of the system since 1964.

There are three operational regions, each with at least one operational satellite and a spare one in orbit. The Atlantic Ocean Region covers much of North America, South America, Africa, Europe and the Middle East. The Indian Ocean Region covers Europe and Africa to Japan and Australia. The Pacific region covers the whole of the Far East and the west coast of North America. Two-satellite operation is introduced when the traffic in a region is too much for one satellite and also when the users feel that they are not prepared to put all of their circuits through a single satellite and a single Earth station aerial. One of the satellites is then designated the primary, to which practically all of the countries in the region operate and which therefore provides full connectivity in the region.

The second satellite is termed the major-path satellite and carries typically half of the mutual traffic of those countries possessing second Earth station aerials. These larger countries therefore split their traffic equally between two satellites and two Earth terminals. In the Atlantic Ocean region there is now also a second major-path satellite used by countries with three aerials, while the Indian Ocean region has a primary and one major-path and the Pacific region a primary satellite only. In addition to these operational satellites each region also has a spare satellite in orbit.

This configuration of the global system has led naturally to an evolution whereby a new generation of satellite is introduced every few years (typically five) and is put into service as the Atlantic Ocean primary and in the spare role. Since satellite lifetime is typically 6–8 years the replaced satellites can be moved to fulfil some of the less demanding roles. Gradually the new generation satellites are introduced into the successively less demanding locations and the predecessor satellites retired at the end of their lifetime. In practice some of them have also served for domestic leased services.

Intelsat services

The bulk of the Intelsat capacity is used for intercontinental telephone-type services, but there is significant use for television transmissions, a service that has now developed to include some full-time international television leases between certain countries in addition to the traditional service of transmissions booked on an hourly basis.

Much of Intelsat's spare capacity is used for domestic services, which are provided on a leased transponder basis. (A transponder is a radio transmission channel through a satellite; it is typically capable of carrying one or two television channels or from 500 to several thousand telephone channels.) Also, Intelsat has recently introduced international business services permitting access via small Earth stations, which may be at or close to the end-user premises where this is appropriate.

Evolution of Intelsat satellites

Since its first satellite, Early Bird, otherwise known as Intelsat I, Intelsat has used a further five generations of satellite design, the principal features of which serve to indicate the development.

Early Bird was a spinning satellite built by the Hughes Aircraft Company that provided about 240 telephone circuits through a partially directional aerial, which gave coverage of the North Atlantic. It could permit only two Earth stations to access it at a time and it used only about 50 MHz of the available 500 MHz of bandwidth. Its mass in orbit was 38.6 kg.

Intelsat II was also built by Hughes and was similar to Early Bird in capacity but it had a single multiple access transponder of about 120 MHz bandwidth.

Intelsat III, built by T.R.W., had two transponders filling the available 500 MHz bandwidth and providing some 1500 circuits by using an aerial fully directed at the Earth and giving global coverage.

Intelsat IV, built by Hughes, had 12 narrower bandwidth transponders filling the 500 MHz available bandwidth and provided some 4000 circuits plus a television channel.

Intelsat IVA was similar, but for the first time permitted re-use of the same frequencies on a given satellite to provide approximately 50 % more capacity. It used 20 transponders connected via aerials that gave beams shaped to the contours of the continents to permit frequency re-use between East and West. All the satellites up to this time were spinning to achieve stabilization relative to the Earth's axis.

Intelsat V, built by Ford Aerospace, is fully stabilized rather than spin-stabilized and further extends the capacity to some 12000 circuits plus two television channels by fourfold frequency re-use, introducing polarization separation for the first time. It also introduces the new frequency bands at 11 and 14 GHz and it has 27 transponders.

Intelsat VI, now being built by Hughes, has over 40 transponders with an even greater degree of frequency re-use than Intelsat V, but, more significantly, introduces for the first time on-board digital switching that, together with appropriate new techniques in the Earth stations, can raise its capacity to some 30000 circuits plus several television channels.

Over this period of some 20 years the design lifetime of the satellites has increased from 18 months for Early Bird to 10 years for Intelsat VI.

Future for intelsat

Technically the trend in Intelsat is likely to depart from its past pattern of a bigger and better satellite every few years because it is becoming progressively more difficult to obtain greater capacity from a single orbit location because of the constraint on the available frequency bands. Over the years Intelsat satellites have been one step ahead of other satellites used in domestic and regional systems, but there is now a risk of Intelsat getting too much out of step with most other applications.

Although there are further frequency bands at 20 and 30 GHz these are unlikely to be technically suitable for increasing capacity in Intelsat for at least a decade. Rather, increased capacity is likely to be achieved by new techniques in the Earth segment, particularly those associated with more efficient digital transmission systems.

Intelsat is likely to introduce more than one type of satellite in a given generation to meet the diverging requirements of the primary satellites in the Atlantic and Indian regions, and the various major-path, Pacific region and domestic needs. These other satellites are still likely to be relatively large, at least Intelsat V or Olympus class, and the satellites for the primary roles will need to continue to be at least of Intelsat VI class.

The principal development in satellite design is likely to be the introduction of a greater degree of on-board digital processing, while a significant improvement in system capacity will come from new digital techniques introduced in the Earth segment.

Industrially, these trends should give greater opportunity for industry outside the U.S.A. to participate in Intelsat programmes since the demands of the satellites will not be so far ahead of other systems that will be progressing in parallel.

Intelsat may also have to face changes in respect of competition going beyond the regional

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systems that are now permitted. In particular there is the threat of competition on transatlantic services, proposed by Orion, and from other systems. In principle, these proposals are contrary to the Intelsat agreements and it would seem unlikely that they will be authorized. If they are, however, they are likely to lead Intelsat changing its principle of uniform charging throughout its network, which will have an adverse economic impact on the many smaller routes that are currently provided. Such a change could also alter the types of satellite that Intelsat requires to provide its services.

Finally, politically there are moves by some third-world countries to change the procedures by which orbit locations are allocated for communication satellites. Any move towards detailed planning of orbit use would have a serious impact on Intelsat's ability to maintain and expand its global services.

The European system

The situation in Europe has in many respects paralleled that in Intelsat, but on a smaller scale. In 1970, E.S.R.O., the predecessor of the European Space Agency (E.S.A.), and the European Conference of Post and Telecommunications authorities (C.E.P.T.) conducted studies of possible operational systems for Europe, but the results showed that no economic case could be justified at the time. As a result, E.S.A. went ahead with the O.T.S. satellite, which was launched in 1978 and was a pre-cursor to a possible operational system.

In the mid-1970s further C.E.P.T. studies led to the conclusion that an operational system starting in the early 1980s would be justified if the Governments continued their funding to cover the provision of the initial satellites and the costs of their development. This they agreed to do to give European industry a foothold in expanding world markets. As a result, a decision was taken to proceed with the E.C.S. system consisting of four satellites plus a ground spare designed to provide two satellites in orbit throughout a 10 year mission.

In 1977 Eutelsat was formed, mirroring Intelsat in many respects, to run the E.C.S. system in return for annual payments to E.S.A. The E.C.S. satellite has 12 transponders of which 9 can be operated simultaneously, the other three serving as spares. From the second flight model onwards there are two further transponders provided for business services. The satellites have three spot beams in addition to European coverage and operate entirely in the 11 and 14GHz frequency bands.

There will be typically one Earth station per country for the main mission, which will use digital transmission for telephony and frequency modulation for the television. Business services Earth terminals will use small aerials of 3.5 or 5 m diameter. Eutelsat will also be using one transponder in the Telecom 1 satellite for a certain category of business applications. A new dimension, not originally foreseen for Eutelsat's activities, is the leasing of transponders for television distribution to cable television networks for which otherwise spare transponders will be used.

Future of European system

By the end of 1985 the European system may need a third satellite in orbit to cater for the increased demand for leased television transponders. Launching the third satellite will bring forward the date when the next generation will be required.

One possibility for the next generation is the so-called E.C.S.-A, which would be a modest

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development of the initial E.C.S. satellites sufficient to carry the main mission telephony an television transmissions until the mid-1990s. The carriage of the increased level of traffic will be greatly helped if a technique to reduce the transmission rate for digital telephony is introduced into the Earth stations. This should be possible by 1990 and will avoid undue complexity in the satellites. The satellites will also have to carry the business services provided on the first generation, preferably including the component that is initially being carried on the Telecom 1 satellite. Provision for television leases, both fully spared and preemptible, is likely to require the continuation of a configuration with three satellites in orbit.

In the longer term, additional capacity could be provided by the introduction of 20 and 30 GHz frequency bands, frequency re-use other than by means of polarization, i.e. by multiple small spot beams, and may possibly involve the use of on-board digital switching and processing.

Since the economics of satellite communications in Europe other than for television distribution are not sufficiently favourable compared with terrestrial systems, it seems unlikely that Eutelsat will face competition from other satellites within the next decade, except for competition for its leased transponders from Intelsat or national systems. This economic picture is likely to force Eutelsat to follow a relatively modest development of its services, concentrating on well tried techniques and operating its satellites as close to saturation as possible.

Politically, there may be some complications introduced into the way Eutelsat operates if more countries follow the U.K. lead of introducing competition nationally. Also, procurement policy will not necessarily reserve this market for the European space industry alone.

As a general conclusion, therefore, there will continue to be opportunities for the European space industry in maintaining and expanding the European regional system, but the development is not likely to be as dramatic as it has been in Intelsat.

Discussion

F. Miles (*Independent Television News, London, U.K.*). Mr Jefferis has referred to the remarkable lowering of the cost of a 'half circuit' when using communications satellites, in comparing 1964 charges with those of today. But why is it that when using satellites for television transmissions across the Atlantic, British Telecom charge around twice as much for their 'half circuit', that is, bringing the signal *down*, as an American company will charge to put it *up* to the satellite?

A. K. Jefferis. The basis of charging for television transmissions frequently differs from one operator to another. For example, in the U.K. the cost covers the transmission from the international Earth station to the customer's premises within the U.K., but this is not always so in the U.S.A. Also, Comsat frequently make charges without taking account of the proper full allocation of the costs of their Earth station, i.e. they charge the fully allocated costs to the main telephony services but carry television on a marginal basis. I am not able to comment on whether your claim that the B.T. charge is around twice as much as that charged by an American company. I will be happy to look into this and give Mr Miles appropriate information after the meeting.

(After the meeting, Mr Jefferis established that in fact the B.T. charges are substantially *below* those charged by the American companies that offer equivalent service.)

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D. O. Fraser (*British Aerospace p.l.c., Dynamics Group, Space and Communications Division, Bristol, U.K.*). In addition to the return on capital from Intelsat, has Intelsat use been profitable to the member countries?

A. K. Jefferis. Intelsat itself does not make profit for its members. As I explained, the Intelsat charges cover operating costs, capital depreciation and enough to pay 14 % per annum return on the capital invested by the members. However, in using the facilities provided by Intelsat as part of their international networks, most of the members do of course make substantial profit from their international telecommunications activities. For British Telecom, this can be seen quite readily from the published Report and Accounts.

I. Nicolson (*Hatfield Polytechnic Observatory, Bayfordbury, Hertfordshire, U.K.*). Could Mr Jefferis indicate the approximate annual turnover in terms of revenue and capital of Intelsat at present?

A. K. Jefferis. The 1983 figure for revenue, which covers operating costs, return on capital and an allowance for depreciation, is about $400 million.

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