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COMMITTEE FOR INFORMATION, COMPUTER AND COMMUNICATIONS POLICY

SATELLITE COMMUNICATION: STRUCTURAL CHANGE AND COMPETITION

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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EXECUTIVE SUMMARY

The aim of this report was to analyse the existing regulatory situation and policies regarding the provision of national and international satellite services in the OECD area and provide policy options. This document represents a review of the changes in the structure of the satellite industry. Information regarding the current state of this industry is set forth, and conclusions on regulatory reforms that may improve the efficiency of satellite communications are identified in an effort to stimulate discussion.

Two key factors driving the current changes in the provision of international telecommunication are increasingly competitive global markets and the rapid change to technological capabilities. In the past international telecommunication networks provided connectivity between national networks on an almost wholly co-operative basis. Whether by satellite or undersea cable the world (PTOs) co-operated in the provision of infrastructure and services. For many telecommunication systems co-operation still plays a central role. However with the increasing liberalisation of international telecommunication, competition is being introduced in network and services development. Increasingly PTOs are providing services at both ends of an international link and in some cases using independent satellite and cable transmission systems.

The second factor causing a fundamental shift in commercial strategies of PTOs is the dynamic nature of technological change, particularly in respect to the capabilities of satellites and undersea cables. Both International Satellite Organisations (ISOs) and separate satellite systems are driving satellite technology toward the provision of services to end users rather than the historical emphasis on network connectivity. Increasingly separate systems and ISOs are competing in the same markets. At the same time fibre optic submarine cables have radically altered the economics of providing connections for point to point traffic over the international routes with the largest traffic streams. Current growth in demand for international telephony traffic does not itself to appear to justify much increase in satellite capacity. Some growth in capacity may therefore be attributable primarily to the non-telephony services. Mobile satellite services also show strong growth.

PTOs that were formerly supply oriented are being transformed into demand led companies. ISOs essentially provide capacity and operate space segment on behalf of their owners. Yet at the same time that end users demand increasingly flexible service and tariff options, telecommunication carriers have a wider choice of technologies and systems to meet this demand. ISO capacity is only one medium to provide services. The ISOs recognise that their core markets face greater competition and that to sustain planned systems at an economically viable level they must expand new services. This involves an increased commercial outlook from ISOs and raises questions surrounding the current regulatory structure which limits their ability to deal directly with end users.

An efficient international telecommunication network infrastructure is vital to the efficiency and growth of national economies and global markets. OECD Member countries play a leading role in the provision of international networks and services. The balance between co-operation and competition in achieving the most efficient operation of international infrastructure is an increasing concern for Member countries. Regulation needs to be redefined to take account of the rapid change in telecommunication markets. In terms of satellite communication the most important issues facing policy makers surrounds market structure. The primary issue is the relationship between service providers and users. This has been recognised in policy development concerned with national systems in countries such as Australia and Canada. As international telecommunication markets become more liberal and the array of technological choice expands policy makers can expect calls for greater harmonisation of national and international regulation.

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SECTION I. INTRODUCTION

Policy-makers around the world are reviewing the application of satellite technology and service regulation. There is a widespread view that regulation and institutional arrangements that may once have been appropriate should be changed to reflect new circumstances. The available evidence indicates that some regulatory frameworks are restraining the efficient application of satellite technology.

These practices are sometimes a result of the separate regulatory treatment traditionally associated with the evolution of satellite communication. Yet regulation *per se* has not always had the effect of restricting application growth. At times regulation has been applied to ensure that satellites could co-exist with alternative transmission systems on equal terms. One such policy was that of `balanced loading' which until 1988 guaranteed that the bulk of the international traffic originating in the United States was divided equally between cable and satellite systems across the Atlantic.

The regulation responsible for restricting the development of satellite applications has been mostly the extension of more general communication policies to satellite services although other key impediments included the level of technological development and cost. Spectrum limitations may also be a key limiting factor, requiring on-going attention. Current best practice regulation is seen to be that which is technology neutral. This has the advantage of not placing policy-makers in the position of having to second guess markets on the efficient application of various technologies. While each country should determine where to apply co-operation and competition, some regulatory and institutional arrangements specific to satellite communication are acting as impediments to the application of that technology. This has a detrimental impact on the efficiency of their overall economy.

Similarly, some institutional arrangements based on geography appear to be less warranted as technologies converge and capabilities expand. Regulatory arrangements drawn on geographic lines may curtail satellite applications in an area where the technology has its greatest strengths. This is most evident in Europe where the full potential of satellites is not realised unless users are able to take maximum advantage of capabilities on a pan-European basis. To date the experience in OECD countries shows the spatial dimension of service areas to be the most fundamental criterion in the application of satellite technology.

Nevertheless, policy-makers should be cognisant of dynamics particular to the satellite communication industry. One fundamental difference that sets the satellite industry apart from the wider communication industry is the ratio between the supply of equipment and services. Whereas the telecommunication services market is around four to five times larger than the telecommunication equipment market in OECD countries, sales of satellite space and ground segment hardware still outweigh service revenues. Together with communication regulation this has produced certain industry structures and influenced the application of satellite technology. Apart from systems operated by governments and international organisations, most satellite capacity is owned by vertically integrated firms.

Satellites are often treated separately from the global communication system. Generally this is because satellite technology has been viewed as a means to provide communication networks where it was inefficient to use terrestrial alternatives. On a national basis satellites have frequently been regarded as an option of last resort rather than a major building block. To date, national applications are mainly limited to service extension (e.g. remote area communication) or niche markets where the technology has particular strengths (point to multi-point services).

Satellite applications still represent a relatively small segment of the overall communication market. Even where satellites form a fundamental link in communication capabilities, such as the carriage of trans-oceanic traffic, the vast majority of traffic emanates from and is distributed by terrestrial technologies. In addition terrestrial alternatives perform point to point transmission of international traffic which makes up the bulk of satellite telecommunication. In some areas satellites have vastly improved communication capabilities and are experiencing rapid growth (e.g. maritime communication) but in terms of revenue these markets are relatively small. More than thirty years after the launch of Sputnik in 1957, communication satellite revenue represents less than 0.5 per cent of telecommunication revenues in OECD countries.

The other main influence on the evolution of satellites has been the institutional actors it has brought to the forefront of developments. Historically the development of telecommunication was typified by public telecommunication operators (PTOs) with monopolies over service provision. Many of the larger PTOs in the OECD area had vertically integrated relationships with telecommunication equipment suppliers either through direct ownership (i.e. USA, Canada) or strategic national alliances (i.e. Japan, Germany, France and the UK).

With the advent of satellites came a new mix of institutional actors. The two most important of these were broadcasters and aerospace companies. Broadcasting was already an established and mature industry by the arrival of operational communication satellites in the 1960s. Broadcasters were large customers of PTO services and major players in the overall communication industry in their own right. Broadcasting services were sometimes subject to the same regulatory bodies as PTOs. Yet for the most part broadcasting was regarded as being separate from telecommunication, a distinction based on technological differences which are rapidly disappearing.

Aerospace companies represented a completely new group of institutional actors entering the communication industry. Generally these companies were not the same firms supplying telecommunication equipment to PTOs. Both broadcasters, as sophisticated users, and aerospace companies, as potential equipment suppliers, recognised the existing institutional and industrial structures were unlikely to produce optimal outcomes from their perspective. Broadcasters were often tired of PTOs dictating their communication needs instead of being responsive to their expressed needs. In some countries PTOs placed priority on the extension of universal telephone service rather than supplying new and innovative services to major users. For broadcasters and other large communication users satellite technology promised greater flexibility in transmission and final delivery of services. For aerospace companies the existing telecommunication industry structures meant they were likely be excluded from a significant part of the market servicing PTOs. Moreover, as the PTOs existing suppliers developed capabilities (e.g. AT&T's pioneering efforts), they potentially faced greater competition in other evolving markets for satellite technology (e.g. military applications).

The common response from policy-makers around the world was to institutionally divide the satellite and overall communication industry along geographical and technological lines. New international satellite organisations (ISOs) were formed based on geographic criteria (INTELSAT -- international satellite services and INMARSAT -- maritime satellite services). The demarcation between ISOs and terrestrial service providers was drawn along technological lines. Much of the reasoning and the cause of the progressive development of the various ISOs, regional and national satellite carriers, was technology and risk driven. As such the ISOs became single technology companies providing links by satellite rather than a mix of technologies. On a regional basis some organisations were established to achieve the same goals as ISOs, such as EUTELSAT (the European satellite organisation). On a national basis new satellite carriers were created to provide services (e.g. Telesat, AUSSAT) and sometimes to act as a Signatories to ISOs (e.g. COMSAT, Telespazio). In all these instances satellite organisations were established by governments or international agreements between countries.

The institutional arrangements reflected geo-political concerns, the existing vertically integrated industry structure and the state of technological development. Most significantly they were made in reference to existing domestic and international communication regulation. International ISO monopolies were fashioned after national PTO monopolies. Co-operative international arrangements between PTOs provided the basis for the same structures to be applied to the development of satellite organisations. The primary role of INTELSAT, like terrestrial cable consortiums, was to provide infrastructure over which members could provide services. PTOs rather than ISOs provided services direct to users.

These institutional arrangements often produced innovative and pragmatic solutions to difficult problems. INTELSAT greatly enhanced and developed global connectivity between most national systems. This enabled international links irrespective of a nation's internal development and shared the cost of advanced communication infrastructure. Over 120 countries are members of INTELSAT and 64 members of INMARSAT. In 1992 EUTELSAT had 33 members.

On a national basis several OECD countries sought to take advantage of satellites to extend the capabilities of their existing communication networks. Canada and Australia created national satellite carriers and elected to extend the co-operative principles that featured in international service provision. A common feature of these systems was augmenting the capabilities of PTOs on a co-operative basis with competition limited to certain markets. This was reflected in policies that encouraged equity participation by existing carriers. While these satellite carriers were free to market services directly to some users, most areas remained the sole domain of the PTOs.

These national systems were also defined along geographical and technological lines and often referred to as domestic satellite systems or "Domsats". National systems in OECD countries, such as AUSSAT and Telesat, were permitted to provide capacity for neighbouring countries but not to compete with ISOs for services between countries. Like ISOs, Telesat and AUSSAT were single technology companies. Some countries preferred to utilise ISO capacity to meet their needs rather than acquire national satellite systems. By 1992, nearly 40 countries were using INTELSAT for their domestic requirements.[1] With few exceptions neither INTELSAT or national systems were permitted to offer services in each other's primary market. In the past, each would have suffered from cost disadvantages and technical limitations had competition been permitted since the systems had been designed for different applications.

In Europe, the creation of EUTELSAT was very much a product of the ISO formula. EUTELSAT was aimed at the provision of infrastructure to enhance regional network connectivity. Over time the balance of services offered came to reflect the mix found in national rather than international systems. Servicing the needs of broadcasters rather than the provision telecommunication services makes up of the bulk of EUTELSAT's market. However unlike counterparts with a predominantly domestic focus in Canada and Australia, EUTELSAT is not permitted to directly market services to customers.[2] Like INTELSAT and INMARSAT, prospective users of EUTELSAT's capacity must deal directly with Signatories.[3] Signatories to ISOs generally have the sole right to market satellite capacity, limiting the direct customer relationship between the space segment provider and the end user. The term "direct access" can be applied to mean direct commercial access and direct technical access. Unless otherwise specified, direct access applies to direct commercial access in this report. A possible definition of direct access is a process where the customer is given greater ability to go to an ISO directly and negotiate a commercial deal to use space segment in the same manner as most other telecommunications services.[4]

Other options available to improve access include multiple marketing and mixed access. Under a multiple marketing arrangement, more than one signatory, or parties considered to have the status of signatories, can market capacity direct to users. This arrangement is possible under existing agreements. Mixed access arrangements allow ISOs to market some services direct to users but reserve others for signatories. Such an arrangement exists between Eutelsat and the European Broadcasting Union.

Some liberalisation occurred in the late 1980s when two nationally licensed systems began to provide limited competition to ISOs. The US company PanAmSat offered international services in competition with INTELSAT, while Luxembourg's Astra system was permitted to offer pan-European broadcasting services. Nevertheless numerous restrictions on what came to be known as separate satellite systems were retained. PanAmSat was restricted to providing a limited number of circuits and Astra's licence confined it to the provision of broadcasting services.

By 1990 the three leading ISOs had well established satellite systems with INTELSAT accounting for 34 per cent of the world's available transponder capacity(Table 1). Satellite systems in OECD countries made up 52 per cent of available capacity, including domestic and regional capabilities. This capacity is expected to expand by 30 per cent during the first half the 1990s. While still providing a relatively small share of global capacity, private international systems have robust projected growth. Moreover the number of national systems in OECD countries offering regional competition with ISOs is steadily increasing. Examples include Optus Communications Ltd., utilising the AUSSAT system to provide international services between Australia and New Zealand; Hughes Communications Galaxy II for services between Barbados and other Caribbean Islands; Hispasat for services between Spain and the Dominican Republic; DFS for services between Germany and Luxembourg; and AsiaSat for use by Russia.[5]

Table 1. International Satellite Capacity

	Transponders 36 MHz equivalent						
	Number 1985	%	Number 1990	%	Number 1995	%	Increase 90-95 %
OECD Countries	933	52.1	1 210	52.4	1 537	50.1	30.0
INTELSAT	664	37.1	776	33.6	1 010	32.2	30.2
International Private Systems	0	0	36	1.6	156	4.9	333.3
Rest of World(1)	191	10.7	287	12.4	401	12.8	39.7
Total	1 788	100.0	2 307	100.0	3 140	100.0	35.9

1. Excludes Commonwealth of Independent States and China.

Source : Euroconsult, OECD.

Direct access to capacity by end users has become a critical issue as satellite technology evolved. Both ISOs and separate satellite systems are increasingly driving satellite technology toward the provision of services to end users rather than the historical emphasis on network connectivity. The traditional axiom of satellite communication has been that there is a trade-off between the amount of power radiated from a satellite and the size of the receiving equipment. To provide network connectivity to a relatively small number of sites, meant the most economical systems involved low powered satellites providing signals to large fixed earth stations. As the space and ground segment technology evolved it has become possible to place greater amounts of power reliably in the space segment and reduce the size and cost of receiving equipment. This capability was first utilised to provide television and radio broadcasting but also made possible private telecommunication networks. As the size of the receiving equipment was reduced, these became known as VSAT networks (Very Small Aperture Terminals).[6] Technological development also made greater flexibility possible through transportable and mobile terminals.

These technological trends were one element in regulatory change to domestic satellite systems in Canada and Australia. The ability of Telesat to provide space segment directly to end users started with the change in earth station licensing policy promulgated by the Canadian Department of Communications in 1984. In 1985 Telesat was given greater direct access to customers under a modification to the original connecting agreement with the then Telecom Canada. In 1987 the transfer payment between Telesat and Telecom Canada ended (the Telecom Canada Settlement). Under this arrangement Canadian PTOs marketed satellite capacity in certain areas for a guaranteed rate of return to the satellite carrier. In Australia, reforms introduced in 1989 enabled non-carriers to establish their own earth stations and to use these to access INTELSAT and separate satellite systems to provide international network services on an`own use' or `single-end interconnect' basis (Private Earth Station Policy). Further telecommunication reforms commenced in 1990 allow the two PTOs, Optus and Telstra, to market satellite capacity direct to users.

While co-operative arrangements have certain strengths the experience of many countries is that separating the provision of capacity from services has introduced a number of market distortions. In some cases this results from the incentives organisations have to market alternative systems, such as the PTOs own terrestrial communication networks that can supply substitutable services. Although it has a monopoly over satellite services in Canada it was estimated at the end of 1991 that more than 50 per cent of Telesat revenue came from customers with immediate supply alternatives.[7] Generally it is in a PTOs interest to market terrestrial capacity ahead of satellite systems. Some PTOs own satellites and therefore have an incentive to market these systems in preference to capacity available to them as ISO Signatories. Signatories may also have incentives to market the capacity of one ISO over another because of rate of return considerations.

These industry structures can also lead to price distortions. Not only can PTOs market one system more actively than another but they may price alternatives accordingly. Although ISO tariffs to Signatories are uniform there is little in the way of price transparency from the perspective of end users. This can result in arbitrary prices that bear little or no relation to cost causation. The price a user has to pay may vary by more than 35 per cent depending on through which PTO they access ISO capacity. In some cases users have to pay a Signatory for the provision of ground segment equipment even if they purchase and install their own equipment. Moreover in regions such as Europe users often have to deal with multiple PTOs and national regulatory environments to utilise satellite capabilities in those countries.

The United States avoided most of these problems at a domestic level by declaring an "open skies" policy in 1972. Subject to an applicant satisfying the FCC that it was financially, legally and technically qualified to launch and operate a satellite system, market entry was open. This policy permitted firms to offer competitive satellite services as markets were increasingly liberalised (including restrictions on the size of earth stations) leading up to the divestiture of AT&T. It also meant satellite carriers could deal directly with users. Yet while applying competition at a domestic level the US adhered to the principle of co-operation at an international level. PTOs and users wishing to access ISO capacity had to do so via the Communications Satellite Corporation (COMSAT). At the same time, unlike that of most other Signatories, COMSAT's rate of return was regulated by the FCC.

It is tempting to try to tackle the question "Are satellites competitive with terrestrial alternatives", based on the US experience. A generalised answer would be ambiguous at best. This is because judgements can only be made based on assessment of a particular application against the inherited communication network. Communication systems consist of a mix of different transmission technologies, e.g. cables, microwave, satellites. For some uses and locations the different technologies are competitive substitutes. For others, one technology will have distinct advantages over another when designing a total telecommunication system. An optimal system will usually involve more than one technology. By using more than one technology it is generally possible to achieve greater efficiency, diversity, flexibility and security than by using a single technology.

The historical record of satellite development in the US may not reflect the current capabilities of satellites and alternative technologies. Reports on this subject only several years old fail to mention the potential of small satellite systems operating in low earth orbit perhaps because of the classified nature of some military applications. Moreover, the trend toward vertical integration of the industry makes such assessments increasingly difficult. It is possible that vertically integrated firms price some market segments below cost in order to prime other spheres of activity. This is further complicated by developments in key related industries such as the satellite launch and insurance market; the civil earth observation market; and the military satellite market. The industrial and military policies of many governments also strongly influence the economics of the commercial space industry.

However, some trends can be identified based on the experience with satellite communication to date. The major growth areas for satellites are in the provision of services to end users rather than network connectivity. One reason for this is that the price of international circuits has declined to the point where it is no longer the sole criteria by which users select carriers. PTOs in competitive markets have to offer services to users based on a range of customer benefits. Uppermost in the considerations of major users are factors such as quality, reliability and whether PTOs can provide end to end services. Thus what may differentiate an ISO from a separate satellite system with direct access is that the latter can reduce the set up time necessary to make a circuit available. This can be critical in the provision of advanced satellite services, such as Satellite News Gathering (SNG) where media demand can be "crisis" driven.

The traditional role for international satellite systems in the carriage of international point to point traffic appears likely to yield ever greater market shares to fibre optic cable systems. One reason is price, because cost trends clearly favour fibre for point to point applications, but other factors include improved quality and reliability, especially for data communication. Even the important cable restoration role played by satellites may decline as several cables with abundant capacity operate along the same routes or in "self healing" loops where traffic is automatically re-routed in the event of a fault.[8] The reduction of time delay for interactive services is one advantage fibre optic cables have over satellites. It has also been suggested that greater control over cable based facilities has encouraged this shift. Cable systems are generally owned by PTOs and tend not to be subject to government involvement in the same way as international satellite facilities. Logically, the advantage of reduced set up times can be expected to favour cables owned by PTOs and separate satellite systems with direct access over even the most efficient ISOs without direct access.

By contrast, national and regional systems servicing broadcasters seem to be holding their own with modified DBS (Direct Broadcasting Satellites) being given a new lease of life by technological advances. Most satellite direct broadcasting channels are still not financially proven. The major growth areas will be in those applications that demand flexibility in areas of exacting spatial dimensions; maritime and aeronautical satellite mobile communication systems being prime examples.

ISOs will increasingly want to reach out to end users and directly market services. At the same time technological capabilities will converge exerting pressure for ISOs to offer the same services in competition with each other. It is not difficult to envisage a situation where three ISOs, with effectively shared ownership, may be offering services in competition with each other and separate commercial organisations. If this occurs there is likely to be pressure for institutional reform amongst ISOs and a progressive yielding of certain privileges, such as the tax free status, they currently enjoy over separate satellite systems. The increasing competition between ISOs and separate satellite organisations (and cable facilities), some of which are owned by the ISO Signatories, will increasingly lead to conflicts of interest in the commercial decision making procedures of the ISOs. If the future viability of the ISOs is to be ensured, then the decision making processes will need to take account these potential conflicts.

The aim of policy makers should be to enable the utilisation of the strengths and complementary nature of all communication technologies. An appropriate regulatory framework can allow the different technological capabilities to be efficiently applied. The boundary between the complementary and competitive use of alternative technologies should be drawn on efficiency rather than regulatory grounds. The aim of this report is to draw out the characteristics of the satellite technology and services market, together with potential hardware and application innovation, as a guide to policy-makers on the efficient application of satellite services.

The key findings of this report are:

- regulation once appropriate for the development of satellite technology is now restraining efficient application;
- satellite technology is evolving toward the provision of services to end users rather than merely connecting networks;
- international market structures still reflect the traditional role of ISOs while past technological, geographical and commercial distinctions are rapidly receding;
- the prevention of users from directly accessing capacity is producing a number of market distortions in terms of price and the efficient use of all available technologies.
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The key options available to policy-makers to increase efficiency are:

- allow ISOs, separate satellite systems and users full commercial freedom to develop, market and apply satellite capabilities as efficiently as possible;
- in examining full commercial freedom for the ISOs, consideration would also be given to examining the obligations and privileges that the ISOs currently have as treaty organisations;
- introduce measures, such as direct access or other improved access options that will stimulate new services, lower prices and encourage the use of available capacity;
- increase transparency in the pricing of international satellite services;

- liberalisation of resale of satellite communication;
- liberalisation of earth stations to allow non-signatories and non-PTOs to obtain licenses to own and operate earth stations;
- separate the regulation of international communication markets and commercial decision making.

SECTION II. SATELLITE COMMUNICATION

1. Introduction to satellite communication and applications

A lengthy review of the characteristics of satellite communication and use of the radio spectrum is beyond the scope of this report.[9] Essentially telecommunication satellites are radio relays operating in one of a number of orbits surrounding the earth. To date the most common location for communication satellites has been the geostationary orbit at a altitude of 36 000 Km. From this position satellites do not appear to move in relation to the earth and can be used as repeaters for radio transmission. A single satellite in geostationary orbit can cover 42 per cent of the earth's surface. In orbits closer to the earth a satellite's field of coverage is reduced. At an altitude of 500 Km the area covered is 4 per cent of the earth and a satellite only passes over a certain point for a short period of time.[10]

The major components of a satellite are:

- Payload -- antennas, receiver, transmitter;
- Stabilisation -- attitude sensors, thrusters, fuel;
- Power -- solar cells, batteries, regulators;
- Telemetry and Command -- encoders, decoders, control circuitry;
- Structure -- metal, plastics, nuts, bolts, glue, etc.

The satellite payload is sometimes called its *raison d'être*. It comprises one or more transponders, each with its own transmitter and able to provide a number of channels. Repeaters have an effective bandwidth of 500 MHz that is shared by transponders operating at unique frequencies. Two of the most common bands are C-band and Ku-band. The antennas associated with the repeater receive signals from earth and retransmit them after conversion in frequency and amplification by the transmitters in each transponder.[11] Solar cells provide the power source for satellites supplemented by batteries. While the satellite is held in geostationary orbit, the gravitational pull of other planets and irregularities in the earth's gravitational field causes satellites to drift from their assigned orbital slots. Sensors detect such movement and small liquid fuel rocket thrusters are used to maintain the satellite's position. The amount of station keeping fuel often ultimately determines the satellite's operating lifetime, sometimes limited by progressive degradation of the solar array output or random catastrophic failures of components particularly transmitters. The management of the satellite is performed through the Telemetry and Command system which provides the link to ground control centres. The spacecraft structure binds the satellite together and contains an apogee boost motor to circularise the elliptical transfer orbit so that the satellite becomes truly geostationary.

At the heart of satellite technology is the characteristic of point to multi-point communication. It is this capability that has made satellite technology a useful tool for communicating over large areas of the earth's surface. Technological advances such as directional antennas are increasing the flexibility of such applications and capabilities extended to include multi-point to multi-point applications. This can be taken advantage of where there is a need to cater for small or medium density scattered traffic, or where terrestrial networks are under-developed.

It is often noted that satellite communication costs are independent of distance. This does not mean that distance is not an element in the cost of a satellite. There is perhaps no other technology in daily use more reliant on distance as an element of cost than a geostationary satellite. Satellites have to be constructed to rigorous standards because in orbit maintenance is not practical. However the same distance enables provision of service to each location within a satellite's field of coverage at uniform cost in terms of the space segment.[12]

This is one characteristic of satellites that lends the technology to be used for telecommunication network extension. Satellites can extend service into areas of sparse population, harsh climatic conditions and rugged terrain where it is uneconomic or impractical to extend the terrestrial network. In those countries with a relatively high telephone penetration rate, but some having areas under-served for geographical reasons, satellites can be used for telecommunication network extension. For countries, wanting to quickly provide services where the terrestrial network is under-developed, such as Eastern Europe, satellites can also be a viable option.

The provision of services to widely dispersed areas is the primary advantage of satellite communication. While other factors play a part in the application of satellites, such as industry policy, there is a clear relationship between the size of OECD countries and whether they have acquired a domestic satellite system. Table 2 shows Member countries according to whether they have a national satellite prime contractor together with geographical, population and network characteristics. Most domestic satellites within the OECD area are found in those countries with prime contractors.

Greatest use of satellite technology for telephony in remote areas is to be found in the three largest OECD countries Canada, the US and Australia. These countries were among the first to acquire domestic satellite systems and have relatively low population densities. Yet even in countries of this size, the major application of national systems continues to be servicing the needs of broadcasters. This is even more evident in the other OECD countries with national systems. The overwhelming demand in these countries, such as Sweden and the UK, is direct to home broadcasting (DTH) and video distribution to cable-television systems. In these countries geography appears to be a constraining factor on the economic viability of dedicated domestic systems. In 1990 the French Government announced no further satellites of the TDF 1/2 design would be built.[13] In 1992 the UK's B-Sky-B sold one of its satellites to Norway and took a commercial decision to rely on the use of the pan-European Astra system. Similarly Sweden's Tele-X satellite is an experimental system with future plans again revolving around pan-European capacity. In addition European countries may be influenced by the increasing difficulty of obtaining or coordinating spectrum access for national systems in the European area and the policies of the EC.

As if to disprove the relationship between size and satellite application Luxembourg, the OECD Member country with the least land mass, has a national satellite system. However the Astra satellite system is primarily used for pan-European broadcasting and programme distribution. This is one reason why it is more appropriate to compare satellite capabilities and applications on a regional basis. Table 2 includes a regional comparison using the same data for North America and Europe. Greater use of national systems is clearly evident in North America with larger service areas characterised by lower densities of population and main lines. Those countries without national satellite systems tend to use capacity from ISOs and suppliers from neighbouring countries. It has also been suggested that the costs or difficulties involved in using terrestrial systems in the US seem to be sufficiently great to make using domestic satellite systems economically viable, whereas in countries with integrated telecommunication systems for domestic communications, this is generally not worth considering.

2. Satellite service providers

Traditionally satellite systems have been categorised under four headings. International satellite organisations (ISOs) included INTELSAT, INMARSAT and INTERSPUTNIK. EUTELSAT is also an ISO and each year makes a report to the Secretary General of the United Nations. EUTELSAT can also be thought of as a regional satellite system along with ARABSAT in the Middle East. A third group was made up of national satellite systems such as Canada's Telesat and the former AUSSAT system (now Optus) in Australia. A number of countries which are not OECD Member countries also have national systems (e.g. Indonesia, Mexico, Brazil) or are moving to acquire systems (e.g. Korea, Malaysia, Thailand). The fourth group, sometimes called private separate satellite systems, is made up of corporations offering international telecommunication and broadcasting services (e.g. PanAmSat, Astra, AsiaSat and Optus).

The technological and geographical demarcations that separated these categories are breaking down. All four groups now either offer services in each others markets or are likely to do so in the future. Institutional structures are changing to reflect these new roles; gradually in the case of ISOs, but rapidly in some former national systems. Currently it is more appropriate to regard satellite service providers in two groups as converging on the same markets for OECD countries. International and regional ISOs are increasingly offering national services and "domsat organisations" are being integrated into PTOs capable of offering international services. Technological developments are even more radically redefining service capabilities in formerly distinct markets.

2.1 International satellite organisations

The International Telecommunications Satellite Organisation (INTELSAT) was formed in 1964 based on an offer from the United States to make satellite and launch technology available to improve global communication for all countries. By 1992 the organisation had grown to 124 members and provided international satellite infrastructure for more than 168 countries, territories and dependencies. INTELSAT's management structure operates at several levels. The INTELSAT agreement is between sovereign states (known as "Parties").[14] The operating agreement is between organisations designated by governments to act as their representatives in INTELSAT (known as "Signatories"). Certain decisions can be taken up by governments at the Assembly of Parties. Some decisions are taken at the Meeting of Signatories where all Signatories are represented. Most of the management, financial and operational decisions are taken by the Board of Governors in which representation is based on investment share. In 1992, the Board consisted of 28 Governors from the Signatories with the largest share-holding[15] and the geographical regions defined by the ITU. Together with INTELSAT management it is responsible for day-to-day operations.[16]

Table 2. Selected Factors in the Application of Satellite Technology in OECD Countries

Country	Total Area thousand Km^2	Main Lines per thousand Km^2 1990	Population per Km^2 1990	Mainlines per 100 inhabitants 1990	National Satellites 1992	Year of first Domsat
With Satellite Prime Contractor						
Canada	9 976.1	1.53	2.7	57.46	5	1972
United States	9 372.6	12.16	26.8	45.34	31	1972
France	549.0	51.15	102.8	49.78	4	1984
Japan	377.8	142.13	327.0	43.47	4	1983
Germany	356.9	89.38	217.45	38.83	3	1989
Italy	301.2		191.4		1	1990
UK	244.8		234.5		1	1989
Without Satellite Prime Contractor						
Australia	7 686.8	1.04	2.2	47.09	3	1985
Turkey	780.6	8.83	72.3	12.21	(2)	(1994/5)
Spain	504.8	24.96	77.2	32.35	(2)	(1992/3)
Sweden	450.0	12.99	19.0	68.28	1	1989
Norway	342.2	6.25	13.1	50.26	1	1992
Finland	338.0	7.89	14.8	53.55	-	-
NZ	268.7	5.48	12.6	43.60	-	-
Greece	132.0	29.91	76.8	38.94	-	-
Iceland	103.0	1.27	2.5	51.17	-	-
Austria	83.9	38.41	92.0	41.76	-	-
Portugal	92.4	25.74	106.7	22.94	-	-
Ireland	70.3	13.02	49.8	26.15	-	-
Denmark	43.1	67.54	119.3	56.63	-	-
Switzerland	41.3	95.47	164.6	58.02	-	-
Netherlands	40.8	170.09	366.4	46.42	-	-
Belgium	30.5	128.29	326.8	39.16	-	-
Luxembourg	2.6	70.76	146.9	48.29	2	1988
OECD Europe[1]	4 381.1	37.53	95.1	39.47	13	
North America	19 348.7	6.68	14.3	46.49	36	
OECD	32 063.1	11.13	26.16	42.54	56	

1. Excludes EUTELSAT.
2. Norway purchased one Marco Polo satellite from B-Sky-B in 1992. Norway and Finland were initially involved in Tele-X. With the exception of Tele-X, experimental satellites not included.

Source: OECD.

INTELSAT Signatories make capital contributions based on their investment (i.e. ownership) shares and pay space segment charges to finance operations.[17] Capital contributions and compensation are proportional to a Signatory's investment share. The investment share is equal to utilisation of the INTELSAT space segment (subject to a minimum share of 0.05 per cent). INTELSAT's space segment charges have the objective of covering: operating, maintenance and administrative costs, depreciation (mostly satellites in orbit) and compensation for use of capital. The target rate for compensation was raised from 14 per cent to 16 per cent, from 1 January 1993. Historically INTELSAT has generally exceeded the target rate of return. From 1973 to 1991 the organisation's cumulative rate of return was 15.9 per cent. Future charges are set to bring the cumulative value to the target level.[18] However, in using return on investment as an indicator to compare the performance of ISOs with other sectors it must be noted that the latter have a specific financing and accounting structure. For example, ISO capital structures may be adjusted in order that an agreed rate of return on investment is achieved. An additional measure of performance would be return on total financing (which would take into account direct capital invested and long term debt), however, insufficient data are available to undertake the required calculations.

Access to the space segment is made by a Signatory applying for capacity. This capacity is sold to end users or used to provide services by PTOs. Direct access to INTELSAT is available only to Signatories and Duly Authorised Telecommunications Entities (DATEs) in non-member countries. Other entities may be given direct access if authorised by a Signatory or DATE and several alternative arrangements have been adopted for this in a number of member countries. The Board of Governors set space segment charges on what is essentially an internal transaction. There is no requirement for these charges to be published and each Signatory is free to set their own tariffs for sale of services to end users.[19]

The International Maritime Satellite Organisation (INMARSAT) was established based on an Intergovernmental Convention which entered into force in 1979. The ISO became operational in 1982. Originally set up with a charter to provide satellite communication to maritime users, INMARSAT's mandate was revised to give it non-exclusive rights to provide aeronautical communications in 1985. In 1989 INMARSAT's convention was extended to include land based satellite communication and by 1992 around 20 per cent of all the ISO's mobile terminals were in this market. Signatories apply for access to INMARSAT capacity for each new terminal. INMARSAT capacity is allocated on demand.

INMARSAT's organisational arrangements are similar to INTELSAT. The governing body is the INMARSAT Council made up of the 18 Signatories with the largest investment share and four other Signatories elected by the Assembly of Parties. Each member has voting power equal to its investment shareholding. Capital contributions and compensation are proportional to a Signatory's investment share. Space segment charges are set by the Council and paid by Signatories. There is no requirement for the publication of space segment charges. While INMARSAT aims at a 14 per cent rate of return the ISO's simple average return on capital invested amounted to 20 per cent in 1992 and 31.5 per cent in 1991. On a cumulative annual basis the return on average capital invested in INMARSAT by Signatories amounted to 24.1 per cent in 1992 and 25.2 per cent by 1991.[20]

In 1977 the European Space Agency (ESA) adopted a resolution calling for the creation of a satellite organisation to manage its satellite communication system.[21] In response 17 European PTOs formed the European Telecommunications Satellite Organisation (EUTELSAT). EUTELSAT's organisational structure is similar to INTELSAT and INMARSAT. EUTELSAT's Convention is entered into by sovereign states (Parties) and its Operating Agreement by designated representatives (Signatories). Capacity is allotted according to applications made by Signatories. Capital contributions and compensation are proportional to a Signatory's investment share. Space segment charges are set by the Board of Signatories. Apart from the European Broadcasting Union, only Signatories have direct access and there is no requirement for charges to be published. EUTELSAT has an objective of a 14 per cent rate of return and in 1991 achieved 13.1 per cent.[22]

ISOs share a number of common features. For the most part they are owned by the same Signatories; they have similar financial and organisational structures; they have certain privileges arising from being founded by inter-governmental agreements, such as being exempt from taxation;[23] certain legal immunities; they are nominally non-profit making but two of the three annually return compensation to shareholders in excess of objectives. The final rate of return on all ISO investment by Signatories is superior to direct compensation for use of capital because it fails to include sales to end users. This differentiates ISOs from a national system such as Telesat. Whereas Telesat has a regulated rate of return on common equity of 13.5 per cent for the period 1991 to 2000, this allowance includes sales to end users.

Yet the most important attributes shared by ISOs relate to the current market structure. First is the requirement that Signatories, and other operators approved by Signatories, rather than ISOs market services directly to end users. Second has been the requirement for members to consult with INTELSAT (Article XIV (d)) before licensing separate satellite systems to prevent "significant economic harm". The market structure that results from these arrangements face mounting challenges as communication market liberalisation develops in OECD countries. For instance, under Australia's new telecommunication regulation there is a provision for foreign Signatories to market INTELSAT capacity for international services within that country.

This is recognised by policy-makers and some change is being introduced. EUTELSAT is moving to simplify and stream line economic harm procedures.[24] In 1992 EUTELSAT's Assembly of Parties agreed that access to satellite capacity could be improved by permitting multiple or controlled access arrangements. These arrangements mean that where reciprocal agreements exist between Signatories, each can supply capacity to end users in the other's country. In 1992 Signatories from the UK, France, Germany and the Netherlands concluded such an agreement for the marketing of EUTELSAT capacity. This measure still precludes direct access to EUTELSAT capacity. At the same time, INTELSAT's Assembly of parties has approved measures designed to relax Article XIV (d) which requires members to consult with INTELSAT prior to establishing separate satellite systems carrying international traffic on matters concerning technical capability, economic harm and prejudice to direct telecommunication links. Under the new rules, consultation concerning economic harm and direct telecommunication links will not be required for systems carrying traffic not interconnected to the public switched network[25] or for systems carrying no more than a specified number of circuits (1 250 64 kbit/s circuits per satellite) of traffic interconnected to the public switched network. Above this minimum level the Assembly of Parties must meet to evaluate if a proposal for a separate private system would lead to economic harm. Even if the Assembly concludes that there is likely to be economic harm, this would not impose an obligation on the originating Member state of the separate system to disallow operations by the applicant. The 1992 Assembly of Parties also decided to examine at its next meeting in 1994 whether the threshold established in 1992 should be further increased or eliminated during a four to six year transitional period (to 1996 or 1998). By 1997, the US Government plans to eliminate all restrictions on the interconnection of traffic carried by separate satellite systems to the public switched network.

All three ISOs in which representative Signatories of OECD countries have shareholdings are taking on a more commercial orientation. In 1990 EUTELSAT established a Commercial Department to deal with commercial and marketing activities. In September 1991, the INMARSAT Assembly established a working group to examine "...the objectives and processes of INMARSAT in view of the changing telecommunications environment and the challenges of competition".[26] The group is due to report to the INMARSAT Assembly in 1993, but the ISO has announced it "...is fully committed to a market driven approach to the way it does business".[27] At the same time INTELSAT made a number of changes to reflect "a new, more commercial orientation for the organisation". These involved raising the aimed at rate of return, entry to capital markets for the first time and signing PTOs to long term contracts.

The increased commercial orientation of ISOs to some extent reflects the changing mix of public and private ownership of Signatories (Table 3). Amongst OECD countries' shareholdings in ISOs the balance has swung in favour of private ownership for INTELSAT and INMARSAT over the last decade and significantly increased in the case of EUTELSAT. A number of factors impact on the level of investment share by Signatories in ISOs. These include the level of use over time, illustrated by the increase in Telefonica's shareholding in EUTELSAT. Company policy can also influence the level of shareholding. For instance an INTELSAT Signatory can invest a greater amount than its utilisation level. A third factor is changes in the number of member states (e.g. the break up of the USSR) and the admission of new members (e.g. Azerbaijan in 1992).[28]

While such factors influence the mix of public and private shareholdings in ISOs, there is a clear trend toward greater private investment shares amongst OECD country Signatories. Some of the impending or past privatisation of PTOs involves major shareholders. At the same time many other OECD countries have reformed their PTOs along commercial lines; a process sometimes referred to as corporatisation. These carriers have a mandate to act as if they were private companies. This impact on ISOs is pronounced because their organisation structure tends to focus commercial decision making at board level where the largest shareholders are represented.

The utilisation of satellites for domestic applications was pioneered in North America in 1972. Canada was the first OECD country to acquire a domestic satellite system and was closely followed by the United States. Canadian policy-makers chose to apply the co-operative principles underpinning international systems. The US opted for competition as a tool to increase efficiency and licensed a number of operators. These models were progressively applied in other OECD countries that acquired domestic satellite systems. In countries where co-operation was favoured separate operating entities were often formed with equity participation from existing telecommunication carriers. The exception to this rule were separate direct broadcasting satellite systems that often brought new institutional actors to the industry. The largest application of virtually all national satellite systems has proven to be servicing the needs of broadcasters.

The first two OECD countries to vary the co-operative model for national systems have been Canada and Australia. In 1987 arrangements whereby Telesat had a negotiated settlement with terrestrial carriers in return for their marketing some satellite capacity were ended.[29] Telesat always marketed directly to all potential users of its services. Until 1988, Canada's "terrestrial carriers" had first option on the required earth stations and right to provide the backhaul between the earth station and customer. The carriers could also market satellite capacity, but Telesat was not excluded from this function. In 1991 the Australian Government-owned AUSSAT system was sold to Optus Communications as the basis for a second telecommunication carrier. The new arrangements allow Optus direct access to all markets. Previously, AUSSAT was precluded from directly marketing switched telecommunication services. These services were reserved for the PTO which had a 25 per cent shareholding in AUSSAT. Under the new Australian arrangements both Optus and Telstra are able to utilise all available technologies to provide services. A duopoly for satellite services connected to the public network will exist until 1997 in line with that country's overall communication policy, although such services may be resold by other market participants and use of non-carrier satellite provided services is permitted in some instances.

Table 3. Shareholdings in International Satellite Organisations

Country OECD	Signatory 1992	INTELSAT		INMARSAT		EUTELSAT	
		1983%	1992%	1981%	1992%	1986%	1991%
Australia	Telstra (State)	3.45	2.79	1.68	1.21	-	-
Austria	Austrian PTT (State)	0.28	0.49	-	-	1.96	0.45
Belgium	RTT (State)	0.71	0.78	0.60	0.87	4.90	2.95
Canada	Teleglobe (Private)	2.96	2.25	2.62	2.19	-	-
Denmark	Tele Denmark (51% State)	0.43	0.54	1.68	2.00	3.27	1.47
Finland	Telecom Finland (State)	0.08	0.18	0.60	0.25	2.72	0.42
France	France Télécom (State)	5.45	4.24	2.89	5.41	16.35	18.81
Germany	DBT (State)	3.29	4.19	2.89	2.77	10.79	15.05
Greece	OTE (State)	0.29	0.49	2.89	2.49	3.18	0.05
Iceland	Iceland PTT (State)	0.14	0.17	-	0.05	0.05	0.05
Ireland	Telecom Éireann (State)	0.13	0.19	-	-	0.22	0.05
Italy	Telespazio (State)	2.29	2.47	3.36	2.75	11.45	7.26
Japan	KDD (66% Private)	3.14	4.50	6.99	9.08	-	-
Luxembourg	Admin Des P&T (State)	0.05	0.05	-	-	0.22	0.08
Netherlands	PTT Netherlands (State)	1.04	1.22	2.88	2.51	5.45	3.89
New Zealand	Telecom NZ (Private)	0.44	0.66	0.36	0.17	-	-
Norway	Norwegian Telecom (State)	0.42	0.69	7.88	10.66	2.50	0.69
Portugal	CPRM (80% State)	0.63	0.62	0.21	0.26	3.05	1.12
Spain	Telefonica (65% Private)	1.99	2.44	2.01	1.84	4.63	18.47
Sweden	Swedish Telecom (State)	0.51	0.64	1.88	0.78	5.45	3.35
Switzerland	Swiss PTT (State)	1.32	1.09	-	0.54	4.35	2.08
Turkey	Turkish PTT (State)	0.23	0.39	-	0.12	0.93	2.87
UK	BT (78% State)	12.99	12.05	9.89	11.75	16.35	18.49
USA	COSMAT (Private)	24.36	21.86	23.36	24.64	-	-
OECD Signatories[1]	Public	41.52	25.88	50.56	37.97	83.92	70.20
	Private	25.78	39.11	24.71	44.39	11.94	27.40
OECD[2]		67.30	64.99	75.27	82.36	95.96	97.60

1. Shareholding allocated according to amount of state & private investment in Signatory. Allocation made according to 1992 status for all Signatories, except BT for 1986. Telespazio has some private equity but its ISO share-holdings are here allocated entirely to the public share of ISO investment. Numbers may not add due to rounding.
2. Excludes Signatories incorporated in non-OECD countries owned by companies incorporated in OECD countries.

Source: EUTELSAT, INMARSAT and INTELSAT.

National and separate satellite systems

In 1992 the Canadian government's 53 per cent share of Telesat was sold to Alouette Telecommunications Inc., an alliance of Canada's major telecommunication carriers (BC Tel, AGT Limited, Bell Canada, Quebec Telephone, Maritime Telephone and Telegraph, Newfoundland Telephone, Saskatel, Island Tel, the Manitoba Telephone System and New Brunswick Tel) and Spa Aerospace. At that time the Canadian Government announced that Telesat would be given the sole rights to operate a satellite to provide fixed-satellite facilities for ten years following the completion of the sale. This monopoly does not extend to mobile satellites, direct broadcast satellites or earth resources satellites.

Canada's approach brings that country into line with a number of other OECD countries where national systems are owned by telecommunication carriers (e.g. France, Germany) with reserved facilities or services. Australia's policy is a step toward the more competition oriented policy existing in the US. Private users in Australia do not have to use PTO facilities, but must acquire space segment for domestic services from Telstra or Optus. In Australia, satellite capacity may be acquired from a non-carrier for international services which meet the requirements of the international service providers' class license. Both Canadian and Australian policies share a shift away from single technology companies in favour of operators able to offer end to end services utilising all available technologies.

The other common feature of events in Australia and Canada is the convergence of capabilities offered amongst national systems and ISOs. A prime example is the mobile satellite market where both Optus and Telesat are developing capabilities that can offer alternative services to INMARSAT. This exemplifies the decreasing distinctions between the capabilities of national and international systems. Former national systems are evolving along the same lines as PanAmSat in offering competition with ISOs. The major difference between former national systems and companies such as PanAmSat is that, outside of the US and Japan, they are generally owned by shareholders of ISOs (Table 4). This means that some separate satellite systems have a voice within ISOs in relation to a range of competitive issues. For instance the approval to increase in the number of circuits able to be interconnected to the public switched telecommunication network can be expected to benefit the systems shown in Table 4. Separate satellite systems owned by non-Signatories appear to have greater difficulties with the co-ordination process than Signatories have had for their own systems involving carriage of international traffic.[30] In the past the carriage of international traffic by non-Signatories, both by terrestrial and satellite technology, has involved ISO objections even when they were not in a position to offer services themselves.[31] Nevertheless it is true to say that in only one case has a separate satellite system (Orion) been found to have had the potential to cause economic harm to INTELSAT. In the past the major problem seems to have been with the delay caused by the co-ordination process rather than findings adverse to separate satellite systems. Signatories with alternative satellite and terrestrial systems may use their position within ISOs in anti-competitive ways, both against non-Signatory satellite systems and the ISOs themselves. This problem has long been recognised by policy-makers. In 1978 a report to Office of Telecommunications Policy pointed out:

> *"...there will be competition to INTELSAT by several mini-global systems, and due to its constitution, INTELSAT may be unable to compete effectively. We must remember that INTELSAT's business decisions are made by its Board of Governors, and that these same individuals also represent their own regional and national satellite systems. In a competitive environment it is clear that in the long run the national interests of each Governor and Signatory will have priority over the INTELSAT System. Eventually the INTELSAT system will be managed by its competitors and will therefore be unable to compete."*[32]

More recently this concern was raised by EUTELSAT's Director:

> *"In the longer term, EUTELSAT may become subjected to strong competition from such national systems, which represent different financial and industrial interests and a greater political interest for their owners than does the collective system."*[33]

Table 4. Common Shareholdings amongst ISOs and Separate Satellite Systems

PTO(s)	Related Separate System[1]	INTELSAT Shareholding	INMARSAT Shareholding	EUTELSAT Shareholding
Admin Des P&T	Astra	Yes	-	Yes
Bell Canada[3]	Telesat	Yes	Yes	-
Cable & Wireless	AsiaSat/Optus	Yes	Yes	-
DBT	Kopernikus	Yes	Yes	Yes
France Télécom	TDF	Yes	Yes	Yes
Telefonica	Hispasat	Yes	Yes	Yes
IRI (Telespazio/STET)	Italsat/Orion	Yes	Yes	Yes
Swedish Telecom[4]	Tele-X	Yes	Yes	Yes
Turkish PTT	Turksat	Yes	Yes	Yes
European PTOs[5]	EUTELSAT	Yes	Yes	Yes

1. Via direct ownership or by shareholding of related company.
2. The Government of Luxembourg holds a 20 per cent stake in SES through two public financial institutions
3. Bell Canada has a share in Memotec, owners of Teleglobe.
4. Swedish Telecom and the Swedish Space Corporation are government owned.
5. As per Table 3.

Source: OECD.

3. Satellite capacity

Regional comparisons of satellite capacity are more appropriate than national ones because countries without national systems use regional and international satellite systems. All the European OECD countries shown in Table 2 without a national system are members of EUTELSAT. New Zealand does not have a national system but uses Australia's AUSSAT system in addition to capacity provided by ISOs. Table 5 compares available transponder capacity for selected countries and regions with the exclusion of INTELSAT and INMARSAT and private international systems.

In 1990 Canada and Australia had the greatest amount of satellite capacity per capita, for both more than twice the OECD average. However these countries had a lower capacity based on land mass of much less than half the OECD average. The main reason for such relationships is the large size of these countries and their low population densities. Another significant factor is that both countries can provide capacity too others, Canada into the US and Australia for New Zealand. As at March 1993, Optus provided capacity for New Zealand users but Telesat did not provide capacity to the US, although both Telesat and U.S. domestic satellite operators can carry certain transborder traffic.

Based on regional comparisons, North America and Australia and New Zealand had roughly equivalent amounts of transponder capacity in 1990. Europe had less regional capacity on a per capita and geographical basis. However, by 1995 Europe is expected to have twice the projected OECD average on a geographic basis. EUTELSAT increased its fleet of satellites from four to seven between 1990 and 1992.

Table 5. Satellite Capacity in OECD Countries[1]

Country/Region	Transponders 36MHz equivalent Number			Transponders per million people		Transponders per 10,000 Km[2]	
	1985	1990	1995	1990	1995[2]	1990	1995
US	624	706	720	2.80	2.71	0.75	0.77
Canada	144	120	134	4.50	4.69	0.12	0.13
Japan	64	171	218	1.38	1.73	4.53	5.77
Australia	37	56	65	3.27	3.53	0.07	0.08
North America	768	826	854	2.96	2.90	0.43	0.44
Europe[3]	64	157	436	0.37	0.96	0.36	0.97
Japan	64	171	218	1.38	1.73	4.53	5.77
Australia & NZ	37	56	65	2.73	2.95	0.07	0.08
OECD	933	1 210	1 573	1.44	1.75	0.38	0.49

1. Excludes INTELSAT, INMARSAT and Private International Systems.
2. Based on 1989/90 population growth rates.
3. OECD Europe (1990 includes Western Germany before unification only; 1995 is unified Germany).

Source : OECD, Euroconsult.

The 30 per cent increase in capacity for OECD countries between 1990-95, as measured by transponders, does not capture the full expansion of capabilities. A number of technologies are enabling existing capacity to be more efficiently utilised. Between 1985 - 1990 the number of INTELSAT circuits increased by around 30 per cent. Between 1990 and 1995 the number of circuits potentially available through the application of digital multiplexing could increase by well over 550 per cent. Digital circuit multiplication equipment technology (DCME) concentrates the number of input digital lines (trunks) onto a smaller number of output channels (bearers) required to service them.[34] The technology can increase the number of telephone channels carried by a transponder by a factor of up to five. A transponder with a nominal capacity of 1 200 channels (at 64 kbit/s) can carry up to 6 000 telephone channels (half circuits) by using improved digital signal processing techniques and technologies.

Current growth in demand for international telephony traffic does not itself to appear to justify much increase in capacity. In 1991 global traffic rates, as measured by Minutes of Telephone Traffic (MiTT), grew by 13 per cent[35] whereas INTELSAT's full-time telephone channel use expanded by 2 per cent. This was primarily due to users converting to digital transmission and implementing DCME techniques as well as exploitation of rapidly expanding fibre optic capacity. INTELSAT expect this near standstill of capacity required for international telephony will continue until the mid 1990s while the conversion continues, despite a strong underlying growth in global traffic. The reason for the current shortages, and for the growth in capacity INTELSAT says it needs, may therefore be attributable primarily to the non-telephony services such as occasional-use television, full-time television leases, business services and domestic or regional leases. The proportion of INTELSAT's capacity in use for these services grew from about 25 per cent to more than 50 per cent between 1985 and 1991 and is projected by INTELSAT to reach more than 65 per cent by 1996. In 1992 INTELSAT commented, "For us capacity is King. Satellite capacity is our fundamental resource. During the past three years we have launched five INTELSAT VI satellites and the INTELSAT K, significantly increasing our capacity in orbit. Nevertheless, INTELSAT capacity is still in short supply due to dramatic growth in global demand."[36]

A significant development in international telecommunication over the past decade has been the rise of international carriers without the traditional relationship to INTELSAT. These carriers may apply to use INTELSAT through a Signatory (or where no Signatory exists, apply directly to INTELSAT) but may also have investment in alternative cable and satellite networks. In fact the carriers with the fastest growing share of international traffic -- Sprint, MCI and Cable & Wireless (C&W) -- no longer have the traditional relationship with INTELSAT (Table 8).

Table 6. INTELSAT Satellites in Orbit 1980-1991

Year	80	81	82	83	84	85	86	87	88	89	90[1]	91
Launches	1	2	2	2	1	3	1	-	1	2	2	2
Turn off/ De-orbit	-	-	3	-	2	2	1	2	1	1	-	-
Type of Satellite in orbit at end of year												
IV	7	7	7	4	2	1	1	-	-	-	-	-
IVA	5	5	5	5	5	4	3	2	1	-	-	-
V	1	3	5	7	8	8	8	8	8	8	8	8
VA	-	-	-	-	-	3	3	3	4	5	5	5
VI	-	-	-	-	-	-	-	-	-	1	3	5
Operational satellites in that year	13	15	17	19	17	18	17	15	14	15	15[2]	17[2]
Operational satellites at end of year	13	15	17	16	15	16	15	13	13	14	15[2]	17[2]
36 MHz units available end of year	233	331	429	489	516	646	626	594	628	744	826[2]	990[2]
36 MHz units in full time use at year end	92	110	136	153	170	247	272	294	353	378	401	434
% occupancy factor[3]	39.5	33.0	31.7	31.2	32.9	38.0	43.0	49.5	56.2	50.8	48.5	43.8

1. One INTELSAT VI (603) satellite launched in 1990 went into the wrong orbit and was reboosted to geostationary orbit in 1992.
2. Net of INTELSAT 603.
3. Unoccupied capacity includes capacity allocated and used during the year for occasional use services and short term leases, capacity allocated and used during the year for cable restoration, capacity allocated for growth, spare capacity in case of failures, capacity that cannot be used for technical reasons such as traffic imbalance and co-ordination constraints and capacity on satellites that are beyond normal end of life and in inclined orbit, which can only be used for limited applications. Excluding inclined orbit capacity would boost the occupancy level to 66 over cent, 75.7 per cent, 75.4 per cent and 67.1 per cent respectively for the years 1988-1991.

Table 7. INTELSAT Satellites 1992-2000[1]

Year	92	93	94	95	96	97	98	99	2000
Launches	1[2]	(1)	(3)	(4)	(2)	-	-	-	-
Turn off/ De-orbit	-	-	-	3	4	3	1	1	1
Type of Satellite in orbit at end of year									
IVA	-	-	-	-	-	-	-	-	-
V	8	8	8	5	2	-	-	-	-
VA	5	5	5	5	4	3	2	1	-
VI	5	5	5	5	5	5	5	5	5
K	1	1	1	1	1	1	1	1	1
VII	-	(1)	(4)	(5)	(5)	(5)	(5)	(5)	(5)
VII-A	-	-	-	(2)	(3)	(3)	(3)	(3)	(3)
VIII	-	-	-	(1)	(2)	(2)	(2)	(2)	(2)
Operational satellites in that year	19	20	23	27	26	22	19	18	17
Operational satellites at end of year	19	20	23	24	22	19	18	17	16
36 MHz units available at end of year	1 104	1 166	1 352	1 483	1 428	1 276	1 222	1 168	1 114
Number of MHz units in inclined orbit	446	554	554	461	250	108	108	54	-

1. As at September 1992. The procurement of additional satellites will be considered by the INTELSAT Board in 1993.
2. One INTELSAT VI (603) satellite launched in 1990 went into the wrong orbit and was reboosted to geostationary orbit in 1992.

While Sprint, MCI and AT&T have no investment share in INTELSAT, wholly or partly owned C&W subsidiaries do represent a number of countries, such as Barbados and Jamaica. In 1991 C&W operated 66 main earth stations in the INTELSAT global satellite network -- more than any other company and had utilisation amounting to nearly 3 per cent of INTELSAT's total. However 81 per cent of this was from Mercury and Hong Kong, for which BT is the Signatory. BT and C&W have an internal arrangement that takes account of this and BT authorised C&W to have direct access to INTELSAT on operational and investment matters. C&W also had a 17 per cent share in International Digital Communications (IDC) which held 16 per cent of the Japanese international market in 1991, and will be providing international services from Australia (24.9 per cent share in Optus) and Sweden (40 per cent share in Tele-2).

The three leading US international carriers have an incentive to use its own fibre optic cable infrastructure where available, in part because they do not have direct access to INTELSAT. While C&W does have direct access, the company's global digital highway is now in operation linking the major world centres of telecommunication traffic via a fibre optic cable network. Like the three leading US international carriers C&W has an incentive to use its own fibre optic cable infrastructure where available. Thus the privatisation of C&W, the development of new US international carriers and the end of balanced loading all have major implications for the incentives these carriers have to use INTELSAT. In 1986 MCI, Sprint and C&W held less than 4 per cent of the top 18 international carrier's MiTT. In 1991 they collectively held 14 per cent. Around 45 per cent of the MiTT of the largest 18 international carriers in OECD countries is handled by carriers who are not direct INTELSAT Signatories and this is expected to grow with further liberalisation.

At the same time a number of the European Signatories in OECD countries use satellites for a relatively small amount of their international telecommunication. For instance in 1991, Austria, Belgium and the Netherlands all carried between 7 per cent to 8 per cent of their international traffic via satellite compared to a country such as Australia with 60 per cent (Table 9). This is why Australia has a larger investment share in INTELSAT than the combined share of these countries but only 22 per cent of their combined outgoing MiTT. Liberalisation in a country such as Australia has the potential to impact on INTELSAT more than the Netherlands despite the latter having a greater relative share of international MiTT. In New Zealand, Telecom NZ's share of international traffic carried via satellite increased by 2 per cent between 1990 and 1991. Yet Telecom NZ's rival, Clear Communications Ltd, perhaps because it is not an ISO Signatory, only used satellites to carry 14 per cent of its international traffic.

As international liberalisation proceeds in Australia and Sweden and based on the UK, New Zealand and US experience, the relative shares of INTELSAT Signatories will decline, even though the overall market may grow. Optus and Tele-2 could not join INTELSAT as Signatories but they can have a direct access relationship, just like C&W does for its Hong Kong and Mercury traffic. In fact such a relationship has already been concluded with Optus. Arrangements have been made for Optus to undertake a pseudo-Signatory role in INTELSAT -- including the ability to invest in (according to usage), to deal directly with and to make payments directly between the two organisations, to take liability for its involvement and to contribute to Australian representation at the Board and Council meetings. Optus has already taken up this option with INTELSAT and having reached the minimum 0.05 usage share, attended its first Board meeting in March 1993. While these arrangements are currently operating satisfactorily, Australia considers them to be complex, costly and potentially difficult. Australia would prefer Optus to be a Signatory in its own right. INTELSAT's fortunes, without direct access, are partly dependent on the relative share of growth captured by its Signatories. In 1991, the 12 largest PTOs, that are direct INTELSAT Signatories, had an average rate of international traffic growth of 9.5 per cent compared to a global average of 13 per cent. Some of the largest INTELSAT Signatories's relative share of traffic declined (BT, France Télécom, KDD). As liberalisation proceeds, more "non-Signatories" will have greater shares of international traffic. In addition existing Signatories are seeking to strengthen cable capacity in North-South directions, such as Teleglobe's plan to lay cables along two US coastlines, C&W's developing system in S.E. Asia & the Caribbean and PacRimEast and PacRimWest cables in the Pacific. While only for one year the relative shares of international MiTT show greatest growth for companies with cable based strategies often in competitive markets. For instance Telefonica's growth is related to the development of TAT-9 and Spain as an entry point into Southern Europe while in Italy, ASST handles intra-continental traffic with Telespazio the Signatory to INTELSAT.

Table 8. The Top 18 International Carriers in OECD Countries

International Carriers	Outgoing MiTT in Millions 1990	Outgoing MiTT in Millions 1991	Per cent Growth MiTT 90-91	Percent of Top 18 Carriers MiTT	
				1990	1991
INTELSAT Signatory Relationship					
DBP Telekom	3 146	3 557	13.1	12.37	12.52
France Télécom	2 126	2 295	7.9	8.36	8.08
BT	2 170	2 213	1.9	8.70	7.79
Swiss PTT	1 356	1 429	5.4	5.33	5.03
Netherlands PTT	905	1 018	12.5	3.56	3.58
KDD	764	850	11.3	3.00	2.99
Belgacom	731	823	12.6	2.87	2.89
Telefonica	611	719	17.7	2.40	2.53
Swedish Telecom	615	659	7.2	2.42	2.32
Teleglobe	565	647	14.5	2.22	2.27
Austrian PTT	559	642	14.8	2.19	2.26
Telstra	565	610	8.0	2.22	2.15
Total	14 113	15 462	9.56	55.51	54.43
non-Signatory or other relationships in OECD area.					
AT&T	6 080	6 557	7.8	23.91	23.08
MCI	1 184	1 600	35.1	4.66	5.63
Sprint	577	723	25.3	2.27	2.55
Cable & Wireless	1 291	1 660	28.6	5.08	5.84
Stentor[2]	1 344	1 425	6.0	5.28	5.02
ASST[3]	837	980	17.1	3.29	3.45
Total	11 313	12 945	14.43	44.49	45.57

1. Wholly or partly owned Subsidiaries of Cable and wireless PLC act as INTELSAT signatory for certain small countries but BT is the Signatory representing C&W's UK (Mercury) and Hong Kong traffic. Nevertheless, C&W share in the UK Signatory functions and have direct access and investment in respect of this traffic. Hong Kong Telecom and Mercury represent 80.7 per cent of C&W traffic shown.
2. Data for US Carriers includes traffic to Mexico and Canada. Stentor was formerly Telecom Canada; Stentor traffic is for US and Mexico only of which approximately 70 per cent was originated by Bell Canada. Bell Canada has a stake in Teleglobe which is a Signatory of INTELSAT.
3. ASST handles intra-continental traffic only; Italcable and Telespazio handle overseas traffic. Telespazio is a Signatory to INTELSAT. IRL, the Italian government holding company, owns Telespazio and Italcable and has operational responsibility for ASST. In 1992 the Italian Parliament passed legislation that will eliminate ASST.

Source: IIC.

Table 9. Domestic and International Satellite Traffic in OECD Countries

Country	National Satellite System	Satellite Telecommunication Traffic as per cent of Total Traffic			
		Domestic		International	
		1990	1991	1990	1991
Australia	Yes	NA	NA	60.0	60.0
Austria	No	0	0	6.65	7.88
Belgium	No	0	0	6.50	7.00
Finland	No	NA	NA	NA	NA
Germany	Yes	<1	<1	40.0	40.0
Luxembourg	Yes	0	0	NA	NA
Netherlands	No	0	0	8.0	8.0
New Zealand	No	0	0	64.0	66.0[1]
Norway	Yes	<1	<1	10.0	10.0
Sweden	Yes	NA	NA	NA	NA
Turkey	No	NA	NA	NA	NA

1. Telecom New Zealand. In 1991, 14 per cent of Clear Communications Limited international traffic was satellite based.

Source: OECD Questionnaire.

SECTION III. SATELLITE MARKET STRUCTURE

1. Services market

The satellite communication market is part of the overall communication market but exhibits a number of unique characteristics. Arriving at a precise figure for the size of satellite services in OECD countries is difficult because of the accounting practices of telecommunication carriers and the vertical integration of some of the largest satellite operators. The latter problem can be overcome to some extent by employing aggregate estimates from organisations such as the US Department of Commerce and the European Commission based on industry sources.

However the accounting practices of PTOs mean that even ISOs often have little knowledge of the revenues attributable to the sale of capacity to end users by Signatories. This is because the revenues annually reported by ISOs fail to capture the additional costs and revenues accruing to Signatories marketing that capacity. The financial accounts of INTELSAT represent a statement of internal transactions between the organisation and its Signatories (i.e. its owners are virtually the organisation's sole customers) that is net of final costs and revenues arising from the sale of capacity to external entities. It might be argued that the additional costs and revenues are negligible given that INTELSAT's charges are constructed to reflect its costs and an appropriate return on capital. Yet the available evidence suggests that additional revenue from the sale of capacity to end users goes considerably beyond direct cost causation. This means that Signatories have a "dual rate of return". As such service revenues are here defined as that which accrues to satellite operators rather than from the sale of their capacity and services by system owners.

In 1990, the telecommunication services industry produced revenues in OECD countries of US$367 billion. For the same year satellite communication service revenues (telecommunication and broadcasting) to satellite operators represented the equivalent of around $1.8 billion (Table 10).

Servicing the broadcasting industry continues to be the major application for satellite services. In 1991 US satellite revenues from television were close to $700 million or 58 per cent of all satellite service revenues (i.e. including international satellite revenue).[37] Video distribution and broadcasting continues to be the major application for satellites. In 1990, around 75 per cent of EUTELSAT's revenue was derived from television distribution.[38] Similarly 100 per cent of Astra and 80 per cent of PanAmSat's business involves sales to broadcasters. Broadcasting is also the largest application of national systems. For 1991 broadcasting made up 50 per cent of Telesat's revenues and 80 per cent of AUSSAT's space segment revenues. Apart from the carriage of international traffic, telecommunication remains a niche market for satellites. In 1991 US VSAT revenues were estimated to be around $30m or 2.5 per cent of satellite service revenues and voice only networks account for only 2 per cent of the total.[39]

The historical revenues for selected satellite system operators are shown in Table 11. These revenues should not be aggregated because they contain revenue transfers from some satellite operators to each other. For instance, INMARSAT's first generation satellites system was made up of two satellites leased from the European Space Agency, the Maritime Communications Sub-systems (MCS) on three INTELSAT V satellites leased from INTELSAT and capacity on three MARISAT satellites leased from COMSAT. INMARSAT's first generation system was spread across eight satellites. In 1990 INMARSAT launched the first of four second generation satellites and two more followed in 1991.

Table 10. Satellite and Telecommunication Revenue, 1990

Country/Region	Telecommunication Services Revenue[1] $m	Satellite Services Revenue[1] $m	Per cent
US	173 961.0	800.0	0.45
Canada	13 049.5	169.0	1.29
Australia	8 716.3	98.0	1.12
Japan	43 621.5	213.0[2]	
Europe	126 751.5	558.5	0.44
North America	187 010.5	954.0	0.51
Australia & NZ	10 082.5	102.0	1.01
OECD	367 465.9	1827.5	0.49

1. Including applicable share of INTELSAT, INMARSAT and EUTELSAT revenues for indicated countries and regions. Excluding ISO Signatory sales to end users.
2. Includes $174 million for Japan Communications Satellite Corporation and Satellite Communications Corporation and estimated satellite revenue for KDD.

Source: OECD, US Department of Commerce, Commission of the European Communities and Annual Reports.

Table 11. Satellite Revenues for Selected Satellite Operators (US$m)

	1983	1984	1985	1986	1987	1988	1989	1990	1991
INTELSAT (Total Revenue)	366	411	457	488	519	614	613	498	563
INMARSAT (Space Segment)	-	-	-	60	73	96	128	177	256
EUTELSAT (Total Revenue)	-	-	23	39	63	91	118	159	226
COMSAT[1] (Satellite Service Revenue)	291	278	285	320	334	244	273	303	NA
Astra (Total Revenue)	-	-	-	-	-	NA	NA	47	108
Telesat (Total Revenue)	71	84	74	76	89	105	124	152	165
AUSSAT (Space Segment)	-	-	NA	NA	49	71	86	83	89

1. COMSAT revenue, before consolidation with COMSAT General, includes revenue from INTELSAT and INMARSAT and multi purpose earth stations. INTELSAT revenue includes revenue earned from capacity leased to INMARSAT for applicable years.

Source: Annual Reports, FCC, US Department of Commerce.

A number of avenues are available to compare the economic performance of various satellite systems. One method is to measure the revenue earned by a satellite system against available capacity, represented by transponders, for a given year (Table 12). This is broadly akin to comparing revenue against access lines for telecommunication carriers. However using capacity as a measure is subject to greater fluctuation in satellite communication because systems may be in transition from one generation to another or be in radically different stages of development. In addition transponders have different characteristics. This is generally reflected in steeper tariffs for transponders with higher radiated power. It would generally be expected that a broadcasting satellite with high powered transponders would have a greater ratio of revenue to transponders. In future the use of bandwidth as a measure of system capacity may be increasingly invalid due to (a) different bandwidth compression techniques; (b) deliberate spreading (increasing) of emission bandwidth to allow lower per Hz and greater spectrum re-use by other satellite systems.

Another method involves comparing a rolling three-year revenue average against the number of satellites in operation. Systems such as INMARSAT still lead to methodological challenges in comparing economic performance. Table 12 is not a true reflection of the economics of INMARSAT because it includes all satellites used by the ISO. As capacity is leased from other organisations, and some of these satellites are used for other purposes, INMARSAT bears only part of the cost. Moreover capacity on the second generation satellites is about two-and-a-half times that of the largest first generation predecessor. This means INMARSAT may in future substantially reduce the number of satellites used. Comparisons on the basis of transponders are also not appropriate in the case of INMARSAT because satellites effectively have the equivalent of one each. Comparisons between the number of satellites may become less useful as systems with many satellites (such as Iridium with 66) have far less traffic capacity of systems such as INTELSAT with fewer satellites. The capacity of each satellite is therefore highly significant, but the problem is how to measure or compare capacity.

A further complication is that the majority of major US satellite operators are subsidiaries of major corporations that do not publish separate accounts. For the US an aggregate figure is used for the satellite communication services market net of revenue from the sale of ISO capacity. While this may not indicate the individual level of economic performance of various satellite operators it does give a broad overview of the market. What such analysis reveals is that US national satellite systems have had substantially lower revenue against available capacity than other national and international systems. National systems in Australia and Canada had nearly twice the revenue of their American counterparts. Even though INTELSAT's role has historically required excess capacity, the ISO nearly doubled average US earnings per satellite.

There are a number of probable factors causing this situation in the most developed domestic satellite market in the world. The first reason is the level of competition is much greater in the US than any other market. Four major satellite operators compete in a market which had substantial over-capacity for most of the 1980s.[40] By contrast AUSSAT, Telesat and INTELSAT enjoyed virtual monopolies either through regulation or lack of available alternatives. The other significant factor in the US market is the vertical integration of satellite operators. Some operators may be willing to run systems with low margins because they operate in other market segments. The four largest satellite operators in the US either manufacture and market satellites or ground segment equipment. These markets are larger than the domestic services market and the ground segment shows dynamic growth. In addition several satellites were being operated beyond there design lifetime toward the end of the selected period. If allowance is made for these satellite not marketing full capacity the US average earnings per satellite may be slightly increased.

Table 12. Satellite Revenue for Selected Operators and US National Systems

Company	Year	Satellite Revenue $m	Satellites	Revenue per Satellite $m	Transponders 36 MHz 1990	US$m per Transponder
INTELSAT	1989	613	14.0	43.8	-	-
	1990	498	16.0[1]	31.1	776	0.64
	1991	563	18.0	31.3	-	-
3-year average		558	16.0	34.8		
INMARSAT	1989	128	8.0	16.0	-	-
	1990	177	9.0	19.7	-	-
	1991	256	10.0[2]	25.6	-	-
3-year average		187	9.0	20.7	-	-
EUTELSAT	1989	118	4.0	29.5	-	-
	1990	159	5.0	31.8	90	1.76
	1991	226	6.0[3]	37.6	-	-
3-year average		168	5.0	33.6		
Telesat	1989	124	5.0	24.8	-	-
	1990	152	5.0	30.4	120	1.26
	1991	165	7.0[4]	23.6	-	-
3-year average		147	5.0	29.4		
AUSSAT	1989	86	3.0	28.6	-	-
	1990	83	3.0	27.6	56	1.48
	1991	89	3.0	29.6	-	-
3-year average		86	3.0	28.6		
Astra	1990	46	1.0	46.0	12	3.83
	1991	102	2.0	51.0	24	4.25
2-year average		74	1.5	49.3	18	4.11
US Domestic[5]	1989	470	29.0	16.2	-	-
	1990	500	29.0	17.2	706	0.71
	1991	800	30.0	26.6	-	-
3-year average		590	29.3	20.1		

1. Includes INTELSAT 603 stranded in transfer orbit.
2. Although INMARSAT used capacity from 11 satellites during 1991, MARECS-A suffered solar array failures and was retired from service, being replaced by a backup MARISAT satellite.
3. By the end of 1991 EUTELSAT had 7 satellites in orbit, but EUTELSAT II-F3 was not operational until 1992.
4. During 1991 Telesat operated seven geostationary satellites. Anik C1, C2, C3, D1 and D2 provided services. In that year Anik E1 & E2 were launched. Anik D1 was retired and Anik D2 was sold to GE Americom. Anik C2 and C3 were placed in inclined orbits. As services were transferred during 1991 a rolling average of five has been used for the three years.
5. Estimated domestic revenues net of US international satellite revenues from COMSAT, INTELSAT and INMARSAT.

Source: Annual Reports, ITA Office of Telecommunication.

2. Space and ground segment market

A distinctive feature of satellite communication in relation to the overall communication market is the relative size of the services and equipment market. In OECD countries revenues from telecommunication services are four to five times larger than the sale of equipment. In 1990 capital expenditure on investment by PTOs in OECD countries represented the equivalent of 23 per cent of service revenues. This ratio influences the respective size of services and equipment suppliers. The largest 15 equipment companies generate the equivalent of 30 per cent of the top 15 service providers' revenues.

In the field of satellite communication the ratio of services and equipment is markedly different. In 1991 satellite space and ground segment sales represented 69 per cent of US commercial space communication sector revenues compared to satellite services 31 per cent (Table 13).

Table 13. US Commercial Space Communication Sector Sales (US$m)

	Commercial Satellites	Satellite Ground Equipment	Satellite	
			Fixed	Mobile
1988	550	600	600	-
1989	900	790	700	50
1990	1 000	860	735	65
1991	1 300	1 350	1 115	85
1992p	1 100	1 700	1 350	150

1. Including US international satellite revenues from COMSAT, INTELSAT and INMARSAT.
p. = projected.

Source : US Department of Commerce.

In 1992 the balance is projected to be 65 per cent satellite equipment sales and 35 per cent service revenues. Although satellite communication is the most mature commercial application of space technology, in terms of the telecommunication it is still a developing market. While the services market is showing rapid growth in the US and challenging the pre-eminence of the equipment sales, markets for space and ground equipment are actually larger than indicated in Table 13 because of sales in complementary markets (e.g. military satellites, earth observation).

Earth observation is expected to develop into a similar sized market for space segment suppliers during the 1990s. Euroconsult estimate that the world-wide demand for communication satellites will be between $10 - 13 billion from 1990 to 2000.[41] Earth observation sales are projected to be of a similar magnitude over the same period. The military market is the largest satellite market. In 1992 US unclassified defence expenditure for procurement, R&D, test and evaluation of satellites was expected to be $2.3 billion.[42] The US Military spent a further $500 million on satellite control, earth stations and terminals. When these complementary markets are taken into account the ratio of satellite services to equipment sales is the reverse of the telecommunication industry, i.e. around one to four or five.

Commercial satellite manufacturing and demand is principally located in OECD countries (Table 14). This situation is unlikely to radically change over the next decade for geostationary satellites. In part this is due to the high entry costs, fiercely competitive nature of the market, and vertical integration of existing prime contractors, satellite operators and service suppliers. To date successful prime contractors have built core sales in domestic or regional markets and to a lesser extent sales to ISOs. US prime contractors have built international sales on a domestic platform of 30 operational communication satellites, in addition to the earth observation and military market. For European suppliers the EC market of 20 operational communication satellites and the earth observation market has afforded the same opportunity. Yet even European suppliers have found it difficult to compete with leading US suppliers in open markets. No country or region outside the EC and North America will have satellite communication needs of this scale in the foreseeable future. OECD countries are also expected to lead in the production of smallsats. Smallsats weigh less than 1 200 kg and carry less than 12 transponders.[43] In 1992 there were 11 applicants pending before the FCC to construct over 270 smallsats before 1997. While it is unlikely that all will proceed, the value of these satellites is well over US$4 billion. However because smallsats have historically been a military technology, manufacturing capabilities exist outside OECD countries.

Table 14. Commercial Satellite Orders for Delivery 1992-1997[1]

	Source of Order	Per cent	Location of orders by Prime Contractor	Per cent
OECD	53	65.4	77	95.0
INTELSAT/INMARSAT	13	16.0	-	-
Rest of World[2]	15	18.5	4	4.6
Total	81	100.0	81	100.0

1. Identifiable orders as of June 1992.
2. Excludes Commonwealth of Independent States and China.

Source : OECD, US Department of Commerce.

In 1991 US sales of satellite ground equipment increased by 57 per cent. This market is expected to be far larger than the sale of satellites over the next decade. This relates to the drive in satellite communication toward the provision of services to end users rather than network connectivity. Some firms have doubled the size of the networks over the past two years. Between 1990 and 1992 the number of VSAT receivers served by AT&T Tridom rose from 1 770 to 4 943.[44] Over the same period the number of mobile satellite receivers served by IDB Communications Inc., increased from 4 000 to 7 000.[45] The sale of mobile satellite receiver equipment has been projected to grow from a market of $280 million in 1991 (Table 15) to sales of US$1 billion by 1995.[46] While broadcasting and VSAT ground segment markets will face robust competition from alternative technologies, mobile and position fixing systems can be expected to enjoy a unique position for most international and some national applications. However the key to the successful growth of all ground segment markets will depend on the take up of services. This is a critical factor in the strategies of space and ground segment manufacturers, who have shown an increased willingness to take on commercial risks associated with the services industry.

3. Industry structure

The world satellite industry consists of a number of interrelated markets. Three of these, satellite services, the space and ground segment, have been previously outlined. Launch and insurance markets are discussed in Section 7. All these markets are strongly influenced by government space, industrial and communication policy. The development and application of most space technology has been pioneered through national and military space programmes. Where feasible this technology has been transferred to separate public and private institutions for commercialisation. Examples include the US Government's central role in the creation of INTELSAT and the European Space Agency providing the foundation for EUTELSAT. These satellite institutions themselves were shaped in response to existing industry structures in the communication industry, including vertical integration of telecommunication equipment supply, infrastructure and services. The creation of COMSAT was as a result of debates in the United States over AT&T's role in the development and application of satellite technology for international services. By contrast EUTELSAT's formation involved agreement between existing vertically integrated PTOs.

Table 15. US Sales of Ground Segment Equipment, 1991[1]

	$m	Per cent
CATV (Cable Television and Broadcasting Stations)	200	12.1
TVRO (Television Receive-Only terminals)	380	23.0
VSAT (Very Small Aperture Terminals)	550	33.3
GPS (Global Position System receivers)	240	14.5
MSS (Mobile Satellite Service terminals)	280	16.9
Total	1 650	100.0

1. Including sales to military markets.

Source : US Department of Commerce.

In the past it has been possible to characterise the satellite services as domestic and international. The international satellite services segment remains dominated by ISOs discussed in Section 2. While organisations and technologies remained relatively distinct, equipment suppliers (US firms had virtually all commercial satellite sales until the 1980s) did not need to enter the domestic and international services market. ISOs provided relatively independent entities when it came to satellite purchases awarding contracts based on commercial merit. At a domestic level the liberal policies in satellite communications in the US encouraged a number of firms to focus on satellites as an entry point into that country's communication market. Rather than PTOs these were often firms seeking to exploit the "by-pass" capabilities of satellites to provide services to major users, so the market for selling satellites was relatively open. Similarly countries without prime contractors, or those wishing to use purchases to leverage transfer technology, provided ready markets for US manufacturers.

A number of factors acted to change this situation. The first was the development of firms with satellite manufacturing capabilities in a number of countries outside of the US. Some governments were willing to purchase satellites from national suppliers at higher prices than the open market as part of industrial policies. These countries claimed such support matched the economies of scale available to US firms from military production. These trends resulted in national and international markets becoming more competitive. At the same time a number of firms that pioneered the application of satellites in the US domestic market found it extremely difficult to compete with the existing terrestrial networks. Perhaps the most high profile financial losses were associated with Satellite Business Systems (SBS) and early DBS ventures. Several reasons have been forwarded to explain this situation. These include the state of technological development making applications relatively expensive for users and the onset of fibre optic cables. In fact a number of PTOs employed satellites until they developed national fibre networks and then shifted services.

Another major reason was the intensity of competition within the US satellite services market. Encouraged by the liberalisation of communication policies and the pending divestiture of AT&T a large number of firms sought to enter the market. From 1981 to 1985 the amount of capacity available in the US expanded rapidly (Table 16).

Table 16. US Domestic Transponder Capacity (1)

Year	New US Transponders	Total US Transponders	Change from Previous Year per cent
1974	24	24	NA
1975	24	48	100
1976	72	120	150
1977	0	120	0
1978	24	144	20
1979	12	156	8
1980	10	166	6
1981	58	224	35
1982	106	330	47
1983	120	438	33
1984	106	484	11
1985	104	488	1
1986	32	536	9
1987	0	500	-7
1988	30	528	6
1989	0	520	-2
1990	83	565	9
1991	24	565	0

1. Actual transponders, not 36 MHz equivalent.

Source: US Department of Commerce.

By the mid-1980s this led to over-capacity (labelled by the trade press as a "transponder glut") and lowering of prices to stimulate demand. In December 1984, 42 per cent of transponders had not been used in the two previous years.[47] At this time 16 companies had applications filed with the FCC for the launch of more than 50 satellites. Many of these applications failed to reach completion in the face of over-capacity and the financial performance of existing operators. The experience of SBS was a major influence on the satellite market at this time. Formed in 1975 by IBM, Aetna Life and COMSAT, SBS was designed to compete in the liberalising telecommunication market across a range of services (e.g. data transmission, long distance telecommunication, video conferencing) rather than broadcasting. Between 1979 and 1984 the system operated at a loss of over US$500m.[48] In 1984 COMSAT sold its share of SBS to the other consortium members.[49] At the same time COMSAT ceased plans for an experimental DBS system incurring substantial costs and shortly after discontinued its loss making TVRO manufacturing operations.[50] Other system operators were also reporting disappointing results at this time such as RCA Americom.[51]

SBS's failure to capture more than one per cent of the US long distance telecommunication market, the rapid growth of fibre systems and slower than expected growth for new services forced the company to refocus on the video distribution market. In 1985 the system passed to MCI in exchange for IBM taking a 16.6 per cent share of that telecommunication carrier.[52] The increased number of launches during this period brought its share of failures forcing insurance premiums to record levels at a time when transponder prices were being forced downward.

The applications that benefited most from over-capacity were distribution of video services to the growing US cable television market. In the shake out that followed the "transponder glut" few of the systems initiated in the 1970s remained in the hands of the same owners (Table 17). Fairchild sold its half share of the American Satellite Company (ASC) to Contel in 1985. COMSAT gradually reduced its domestic satellite capacity, General Electric (GE) merged with RCA and GTE merged with ASC Contel. The SBS satellites, along with Western Union Hughes, the manufacturer of both systems. Other systems that had been planned in the mid-1980s, such as Ford Aerospace's system, failed to materialise or were sold on to overseas operators (e.g. Astra).

Table 17. Ownership of US Domestic Satellite Capacity

System	System Owner 1981	Space Capacity Transponders (36 MHz)			System Owner[1] 1991
		1981 per cent	1986 per cent	1991 per cent	
Comstar	COMSAT	42.1	7.7	-	-
Satcom	RCA	31.6	26.9	23.0	GE
Westar	Western Union	15.8	9.6	6.5	Hughes
SBS	IBM	10.5	7.7	9.9	Hughes
Galaxy	Hughes	-	11.5	16.4	Hughes
Telstar	AT&T	-	11.5	9.9	AT&T
Spacnet/G Star	GTE	-	19.2	30.6	GTE
ASC	Am. Satellite	-	5.7	4.9	GTE

1. Excludes satellite beyond design lifetime. Alascom Inc. shares GE's Satcom 5.

Source : Euroconsult, US Department of Commerce, OECD.

By 1991 over half the US domestic satellite capacity was owned by leading satellite manufacturers Hughes (33 per cent) and GE (23 per cent). Although non-satellite producers, GTE and AT&T also manufacture and market ground segment equipment. While aerospace corporations have had long standing investment in US domestic systems (e.g. RCA launched its first Satcom satellite in 1975), the growth in their involvement steadied the satellite industry during a turbulent period. The actions of the satellite manufacturers can be seen in terms of protecting and developing their primary market. The US aerospace corporations in the satellite communication market have been influenced by relative size of the services and space segment and the strategies of each other and PTOs.

Separate satellite systems are mostly owned by public PTOs or vertically integrated firms operating across the hardware and services market. European, Canadian and Japanese manufacturers have adopted a similar strategy of vertical integration to their US counterparts. In addition US space and ground segment suppliers have sought to extend investment in services companies in Europe and Japan. This pattern of space segment suppliers entering the services market is replicated in the satellite earth observation market in both the US and Europe, as policy-makers seek to commercialise the industry.[53]

For the 1990s vertical integration appears to be the key to understanding the evolving satellite communication industry structure. If proposals for innovative global satellite communication systems proceed it will be vertically integrated firms that have laid the foundation. Tables 18 and 19 illustrate the presence of aerospace corporations in the satellite services industry. Corporations such as Hughes, GE, Spar Aerospace and Mitsubishi already have investments in satellite services companies.

Table 18. Vertical Integration in the Satellite Industry, North America and Japan

Company	Group Revenue 1991 $ B	Space/Ground Segment Supplier	Related Services Company[1]	Operational satellites 1992	Orders & potential orders for delivery from related companies
General Motors	123.8	Hughes Aircraft	HCI	12	3
			JCSAT	2	-
			AMSC	-	1
			DirecTv Inc	-	2
			Atlantic Satellite	(defunct)	-
			Tritium	-	(3)
General Electric	60.2	GE Aerospace	GE American	6	3
			Satellite Japan Corp	2	-
			SES/ASTRA	2	-
AT&T	63.1	AT&T	AT&T Skynet/Tridom	3	-
GTE	19.6	GTE	GTE Spacenet	9	-
TRW	7.9	TRW	TRW Pacificom	-	1
Scientific Atlanta	0.5	Scientific Atlanta	Scientific Atlanta	-	-
Motorola	11.3	Motorola	Iridium	-	(66)
Lockheed	9.8	Lockheed	Iridium	-	-
Loral Corporation	3.3				
Aerospatiale/Alcatel/ Alenia/DASA	-	Space Systems Loral	Globalstar	-	(24-48)
		(Formerly Ford Aerospace)	Services company sold to AT&T	-	-
Spar Aerospace	0.4	Spar Aerospace	Telesat	5	-
			Telesat Mobile	-	1
ComDev	NA	ComDEV	Orion	-	-
Mitsubishi	24.0	Mitsubishi	Space Communications Corp	2	(NA)
Toshiba	33.2	Toshiba	-	-	-

1. Where parent company has equity in services company (e.g. In 1992 GE American Communications had a shareholding in Astra).

Table 19. Vertical Integration in the Satellite Industry, Europe

Company	Group Revenue 1991 $ B	Space/Ground Segment Supplier	Related Services Company[2]	Operational satellites 1992	Orders & potential orders for delivery from related companies
Alcatel	28.4	Alcatel Space & Defense	Globalstar	-	-
			Argentinean Domsat	-	-
IRI[1]	64.1	Alenia	ASI/Telespazio	-	1
			Orion	-	-
			Locstar	(defunct)	-
			Globalstar	-	-
			Argentinean Domsat	-	-
			RAI/ASI	-	2
Aerospatiale[1]	8.6	Aerospatiale	Globalstar	-	-
			Argentinean Domsat	-	1
Daimler Benz	57.3	Deutsche Aerospace	Globalstar	-	-
			Argentinean Domsat	-	-
		MBB	Iridium	-	-
		Dornier			
Matra	4.0	Matra Marconi Space	Orion	-	-
			Locstar	(defunct)	2
			Iridium	-	-
		Fairchild	Ellipsat	-	(24)
			(strategic alliance with		
			Mobile Communications		
			Holdings Inc.)		
Swedish Space Corp.[1]	NA	Swedish Space Corp	Nordic Satellite Corp.	1	-
British Aerospace	18.9	BAe	Orion	-	(2)
			Locstar	(defunct)	-
			BAe Comms	-	-
			Iridium	-	-

1. Government owned.
2. Where parent company has equity in services company.

Notes : In 1990 Aerospatiale, Alenia and Alcatel purchased 49 per cent of Space Systems Loral in equal parts of 16.3 per cent. In 1992 Deutsche Aerospace announced it would purchase 12 per cent of Loral. Alcatel says the partnership has created the world's largest supplier of satellite systems. In January 1993 Aerospatiale, Alcatel, Alenia and Deutsche Aerospace, who together with Embratel of Brazil won the rights to build and own Argentina's domestic satellite system. In 1992, British Aerospace was reported to be negotiating the sale of its satellite manufacturing and services business.

To interpret the objectives of space segment suppliers it is necessary to understand what they see as the market. The largest existing market for the sale of communication satellites is government (including state-owned companies) and ISOs. As of June 1992 governments and state owned companies provided 43 per cent of the orders for commercial satellites to be delivered between 1992-97. International or regional organisations, such as INTELSAT, INMARSAT, EUTELSAT and the European Space Agency provided another 22 per cent. Excluding entities recorded above, a further 17 per cent of orders were for companies either owned by space segment suppliers or by companies in which they have significant equity. The remaining 18 per cent of order orders are from independent private companies. To further explore how much of the market is open to all suppliers Table 20 illustrates the distribution of orders for commercial communication satellites according to equity relationships. Over a third of orders are to entities in which corporations and governments have direct ownership of the prime contractor and the customer. Taking into consideration the industrial policies of several countries, only around 40 per cent of the world market for communication satellite hardware is fully competitive.[54]

Where open market conditions do apply US corporations have been the most successful in attracting orders (Tables 21 and 22). This may be one reason European countries have been reluctant to liberalise the satellite communication services market. State owned monopoly suppliers provide a favourable market for Europe's space segment suppliers and counter the economies of scale available to US producers from their domestic military market.

Table 20. Commercial Satellite Orders for Delivery 1992-97

Manufacturer[1]	Customer				
	Related[2] Government or Private Organisation	OECD[3] Government	Non OECD[4] Government	International[5] Satellite Organisation	Private[6] Organisation
North America	14.0	2.0	10.0	12.0	19.0
Europe	11.0	6.0	-	1.0	-
Japan	-	2.0	-	-	-
ROW	4.0	-	-	-	-
Total	29.0	10.0	10.0	13.0	19.0
Per cent	(35.8)	(12.3)	(12.3)	(16.0)	(23.4)

1. Location of prime contractor.
2. (a) Governments (including government owned companies) and private sector companies which own, or have an equity relationship with, the prime contractor.
   (b) Space agencies and regional satellite organisations where a Member owns prime contractor.
3. OECD governments (including government owned companies) and OECD country space agencies with no equity relationship to the prime contractor.
4. Non OECD governments and state owned companies.
5. INTELSAT and INMARSAT.
6. Ownership at January 1, 1992.

Source : OECD, US Department of Commerce.

Table 21. Selected Manufacturers Satellite Orders 1988-1997

Prime Contractor	Satellites in Operation				Satellite Orders delivered in 1992	Backlog of Orders for Satellites 1992
	1988	1990	1992	1997 (Forecast)		
Aerospatiale	3	5	8	12	3	NA
Hughes	37	44	51	58	7[1]	29[2]
Mitsubishi	1	2	2	6	1	NA
SS Loral	13	14	12	16	2	15

1. Seven satellites launched plus one reboost.
2. HS376 and HS601.

Source : OECD Questionnaire.

Table 22. Commercial Satellite Orders by Year, 1992 - 1997

Manufacturer[1]	1992	1993	1994	1995	1996	1997	(To be determined)
USA	12	11	13	14	2	1	2
Canada[2]	-	-	1	-	-	-	1
France	6	3	-	-	-	-	-
Italy	-	2	2	-	-	-	1
UK	1	-	1	1	-	-	-
Germany	1	-	-	-	-	-	-
Japan	-	1	-	-	-	-	1
Rest of World[3]	-	1	1	1	-	-	-

1. Location of prime contractor.
2. MSAT 1 & 2 have joint prime contractors Hughes and Spar Aerospace and are respectively shown here under Canada in 1994 and the USA in 1995.
3. Excludes Commonwealth of Independent States and China.

Source : OECD, US Department of Commerce.

However European producers are more competitive now than in the past and based on the US experience liberalisation can be expected boost the overall market. It is also possible that as communication liberalisation increases European manufacturers will increase equity participation in satellite services companies. Together with the strategic alliances that are being formed in Europe's aerospace industry, (through interlocking ownership, joint marketing companies and shared investment in non EC subsidiaries) liberalisation should not adversely impact on the EC's current share of world satellite production. Globally the number the communication satellite manufacturing industry can be expected to follow a similar path to the production of telecommunication exchanges. Most likely there will be fewer manufacturers at the turn of the century than at present. Hughes Space and Communications estimate current world satellite manufacturing capacity to exceed demand by a factor of more than two.[55]

4. Satellite cost and tariffs

The construction cost of satellites varies enormously depending on the intended application and type of satellite. Generally the most expensive satellites are built for military applications, although all satellites must be built to rigorous standards, military satellites need to be "hardened" to meet potential threats and require advanced technologies not demanded by the commercial market. The total capital expenditure for Canada's two Anik E satellites was $491 million excluding the cost of financing and capitalised satellite performance incentive payments.[56] The development cost components of Australia's second generation satellite system was $343 million, although the full cost was projected to be $474 million on completion and delivery of two satellites in orbit.[57] Both these systems are multi-purpose and can be used for a range of satellite communication services. The Optus system contains an L-band mobile satellite package on each satellite.

By contrast Telesat has joined with the American Mobile Satellite Corporation (AMSC) to contract two satellites for mobile communications (MSAT). Each of these satellites has a construction cost of $105 million.[58] Japan's Superbird-A had a construction cost of approximately $117 million, including operational ground segment.[59] The Orion system contract provides for the design, construction, launch, and delivery in orbit of two satellites and certain launch risk insurance provided by one of the consortium members at a fixed aggregate purchase price of approximately $425 million.[60] In September 1992, INTELSAT announced GE Astrospace and Space Systems Loral had been awarded contracts for three satellites. GE will supply two INTELSAT-VIII series satellites valued at $165 million and Loral one INTELSAT VII satellite valued at $140 million.[61] Launch, insurance and finance costs can be expected to add around $100 million to the in-orbit cost of these satellites (Table 23).

Launch agencies (with the notable exception of China, and perhaps Russia) have gradually brought the industry towards cost based pricing.[62] One estimate for the cost of a dedicated shuttle flight places it at well over US$350 million.[63] The European Space Agency (ESA) subsidised the development and promotion stages of the Ariane programme from 1979-1984. Since that time the average price to launch one satellite on a shared Ariane ride has risen from US$16 million to US$66 million by 1990.

Some satellite operators have taken advantage of the introductory pricing offers of a number of launch agencies through the 1980s and early 1990s. This is likely to become less prevalent as the available launch vehicles establish themselves in the market, and international agreements seek to protect existing operators from ongoing under-pricing. One advantage of introductory pricing has been the incentive for some satellite operators to extend the lifetime of satellites through the inclusion of more station keeping fuel without incurring the full penalty in terms of launch cost.

Since the first efforts were made to commercialise the satellite communication industry, the risk of launch and satellite failure has been a serious problem. Governments and the military have the ability to self-insure and less than 30 per cent of launches are presently insured.[64] Commercial entities need to insure against a catastrophic failure of a satellite launch. For Anik-E, Telesat achieved a premium of 15.95 per cent that was the lowest rate since 1984 (Table 24).

Table 23. Service Prices of Launch Vehicles, 1989

Country	Launch Vehicle	Launch Price $m	Maximum Launch Mass in Kg[1]
US			
	Delta 2	40-50	1 800
	Altas 2	60-85	2 300 - 3 600
	Titan 3[2]	130-140	4 500
Europe			
	Ariane 4	100-110	4 400
Japan			
	H2	NA	4 400
China			
	Long March	30-60	1 400 - 2 500
Soviet Union			
	Proton[3]	30-65	4 600
	Zenit[2]	80	NA

1. Launch into geostationary orbit.
2. Needs and additional perigee kick motor.
3. Delivers to geostationary orbit with a D booster (4th stage).

Source : Congressional Budget Office, Estec.

Table 24. Total Space Insurance Market (Launch, Initial Operations, In Orbit Insurance World-wide Premium and Loss History) US$m

	Gross Premium	Losses	Insurance Rate (Band per cent)
1976	8.3	0.0	9-11
1977	10.4	29.1	8-11
1978	8.0	0.0	8-10
1979	13.1	92.0	5-13
1980	10.0	0.2	9-11
1981	34.2	0.4	5-14
1982	66.5	90.5	5-8
1983	100.3	14.3	8-10
1984	116.7	251.1	10-16
1985	180.9	273.9	16-22
1986	82.0	82.0	24-26
1987	88.1	53.0	22-26
1988	163.8	145.7	20-26
1989	181.2	6.0	18-26
1998	377.2	394.4	16-24
1991	302.2	98.9[1]	NA

1. Does not include pending losses estimated at $26 million.

Source : US Department of Commerce, Australian Space Insurance Group.

Based on the preceding "national" and "international" examples, as well as the launch and insurance market, the current cost of an in orbit multi-purpose satellite is between $200 - $250 million. These costs are reliant on the particular requirements of satellite system operators and could vary considerably for other applications and financial arrangements. However these satellite systems include most applications such as international communication services, DTH broadcasting and mobile services. It is also useful to compare the cost of satellite applications over time. One method is to calculate the cost of providing a satellite circuit for a number of series of satellites. Table 25 shows the estimated circuit cost per year for five INTELSAT satellite series. This analysis suggests the cost of providing an annual satellite circuit will decline by around 30 per cent between 1985 and 1995. With the application of digital circuit multiplication equipment technology actual efficiency gains are five times this improvement, although the improvement may be less for other systems. This technology can also be applied to fibre optic cable systems making the basic circuit capacity of both systems the most relevant for cost comparison.

The cost of circuits on international cable systems is also falling rapidly (Table 26).

Table 25. Historical INTELSAT Satellite Cost

INTELSAT Designation	V	V-A	VI	VII	VII-A	VIII
Year of first launch	1980	1985	1989	1993	1995	1995
Lifetime (Years)	7	7	13	10-15	10-15	14-18
Number of Satellites	9	6	5	5	3	2
Typical Capacity	12	15	24	18	22.5	22.5
Circuits (000)	2	2	3	3	3	3
TV (theoretical maximum with DCME, 000)	-	-	120	90	112.5	112.5
Total estimated cost[2] ($m)	777	654	1 300	985	700	NA
Cost per satellite ($m)	86.3	109	260	197	233	NA
Cost per circuit per year ($)	1 027	1 038	833	730[2]	690[2]	NA

1. Includes estimated construction, launch, insurance and ground segment cost where applicable. Figures do not include cost of capital, representing around 45 per cent of total INTELSAT costs.
2. At 15 years.

Note : Excludes the purchase of INTELSAT K and figures are constant year dollars.

Source : INTELSAT, Euroconsult.

Table 26. Cable System Cost

	Year	Capital Cost ($m)	Nominal Capacity (Voice Grade Circuits)	Total Capacity (Voice Path)	Cost per voice bearer circuit ($)	Cost per derived voice circuit ($)
TAT-1	1956	49.58	36	89	1 377 222	557 079
TAT-2	1959	42.7	48	98	899 583	435 714
TAT-3	1963	50.6	138	175	366 667	289 143
TAT-4	1965	50.4	138	138	365 217	356 217
TAT-5	1970	70.4	720	1 440	97 778	48 889
TAT-6	1976	197.0	4 000	8 000	49 250	24 625
TAT-7	1983	194.6	4 200	8 400	46 333	23 167
TAT-8	1988	335.4	7 560	37 800	44 365	8 873
TAT-9	1992	405.0[1]	15 000[2]	80 000	27 000	5 062
TAT-10	1992	300.0	22 680	113 400	13 228	2 646

1. Includes $56m interest charges.
2. Minimum Assignable Unit of Ownership (MAOU).

Source : FCC.

Making cost comparisons between different technologies is fraught with difficulty. One method involves comparing the cost of a circuit on a series of INTELSAT satellites and an undersea cable such as TAT-8. The first step in such analysis is to arrive at the overall system cost. For a satellite system, the amount would need to include the cost of satellites (including launch and insurance) and ground segment. Comparing the cost of a series of satellites, such as INTELSAT VII, is preferred because it may confer the advantage of economies of scale over smaller systems.

The cost of a cable system would need to take into account all elements of the technology and installation and maintenance. When comparing capacities, the actual capacity able to be used, rather than the theoretical capacity, may be a superior method. It should also be noted that it is difficult to predict the end of life of a facility as well as the take up of capacity. Cable based systems currently have twice the operational lifetimes of satellites. This means a satellite circuit would have to be replaced at least once during the life of a cable. While it may be possible to design a satellite system that would have a lower unit cost than the INTELSAT series, comparisons between hypothetical systems would not yield insights into the efficiency of existing alternatives in competitive areas.

A more detailed analysis of relative costs would need to consider the institutional arrangements surrounding both infrastructures. This is rarely acknowledged but would take into account the tax status of ISOs and their Signatories and the different treatment of cost of capital. For instance, interest charges constitute 14 per cent of the cost of TAT-9. By contrast, the INTELSAT capital costs stated do not include cost of capital, but when they are converted into charges to be shared by users, the compensation for use of capital during the construction period alone could add between 20 per cent and 30 per cent. Beyond institutional structures are the contributions made by external institutions. Some 25 per cent of the cost of TAT-9 is made up of direct R&D expense. Whereas cable R&D is predominantly undertaken in the private sector and costs met by users, satellite operators have the advantage of expenditure by international space agencies, national space programmes and the military, to the extent benefits flow to civilian applications. At the same time, INTELSAT contracts do contain substantial non-recurring costs that are equivalent in character and of a similar relative level to the R&D component of the cost of TAT-9.

Satellite suppliers also include their in house R&D in their overheads. A further complication is that most major PTOs have cable and satellite R&D programs that do not get allocated against specific projects.

Based on a more simplistic analysis a clear cost advantage exists for fibre optic cable on point to point telecommunication routes between the US and Europe (Table 27). While the economics of INTELSAT would be improved by assigning costs against TV channels on board all series, it would appear that TAT-10 can provide capacity on a more cost efficient basis than INTELSAT VII for point to point telecommunication.

While TAT-9 can provide the equivalent of 80 000 transmissions at one time, a trans-Pacific cable beginning service in 1995 will have the capacity to handle some 600 000 simultaneous calls.[65] Although the economics of satellites are expected to improve, the current pace of fibre development will be very difficult to match. The cost of fibre optic cable construction fell from $6.7 per circuit kilometre for TAT-8 to $3.1 for TAT-9. It has been projected that per circuit kilometre cost of TPC-5 will be US$0.8 in 1996.[66] Thus while INTELSAT VII-A may improve circuit cost by that date, reductions to fibre circuit construction costs are likely to significantly exceed this gain. As trans-oceanic cable is more expensive than equivalent land based systems, a comparison between fibre and satellite for land based point to point applications can be expected to further favour terrestrial transmission.

Table 27. Cost of Satellite and Cable Circuits

	TAT-8	TAT-9	TAT-10	INTELSAT		
				VI	VII	VII-A
Year	1988	1992	1992	1989	1993	1995
Unit Cost ($m)	335	405	300	260	197	233
Capacity (Circuits)	7 560	15 000	22 680	24 000	18 000	22 500
Lifetime (Years)	25-30	25-30	25-30	13	10-15	10-15
Circuit Cost per Annum, $[2]	1 479	900	441	833	730	690

1. Although calculated at current prices it is probable that both systems will reduce circuit costs over the period due to technological improvement. Including a cost of money component in calculating annual cost would tend to offset the relative benefit of cables' longer lifetimes.
2. As per maximum life indicated.

Source: FCC, Euroconsult, INTELSAT, OECD.

These cost trends raise the question of what is likely to occur in the price of international telecommunication. Historically there has been a close relationship between INTELSAT price reductions and the rate of utilisation growth. This is particularly true for the period 1978 through to 1981 (Table 28). In 1988 INTELSAT changed its tariff structure to reflect the gains made possible by digital circuit multiplication equipment.[67]

Since the introduction of fibre optic cable and DCME, growth in the use of INTELSAT has reached a plateau. In 1988 growth in the use of satellite circuits returned to levels experienced at the beginning of the 1980s. This was due to a delay in the introduction of TAT-8, the first price decrease for a telephone half circuit since 1981, and INTELSAT signing long term contracts with Signatories.

INTELSAT's major market is between the US and Europe. The impact of fibre, DCME, and to a lesser extent alternative satellite systems, is notable in the decline of COMSAT's overall leased circuits for 1989 and 1990 (Table 29).

Since 1988 international traffic has increased at a much faster rate than INTELSAT utilisation. This is evident from an examination of US international telecommunication traffic (Table 30). Until 1988 balance loading ensured satellites received an equal share of traffic growth. Since that time an agreement between COMSAT and AT&T has ensured INTELSAT still receives around one-third of AT&T's traffic growth.[68] AT&T is free to determine on which routes growth is allocated. Although new leases signed between 1988-94 would be contracted for ten years, the AT&T Comsat agreement is due to expire in 1994. Other US PTOs are free to determine the most efficient available option.

Table 28. INTELSAT Utilisation and Tariffs

Year	Full-Time Satellite Use (Channels)	Change to Full-Time Satellite Use (per cent)	Change to COMSAT leased Circuits (per cent[2])	Satellite Utilisation Charge[1] US$	Change to Utilisation Charge (per cent)
1977	20 199	NA	NA	7 380	NA
1978	25 293	25.2	NA	6 840	-7.3
1979	32 418	28.2	NA	5 760	-15.8
1980	40 615	25.3	NA	5 040	-12.5
1981	50 266	23.8	NA	4 680	-7.1
1982	59 474	18.3	NA	4 680	0
1983	65 506	10.1	NA	4 680	0
1984	72 656	10.9	NA	4 680	0
1985	81 030	11.5	NA	4 680	0
1986	89 747	10.7	NA	4 680	0
1987	96 047	7.0	16.5	4 440	-5.1
1988	116 353	21.1	25.4	4 440	0
1989	118 885	2.2	-11.3	(a)	(a)
1990	120 906	1.7	-8.1	(a)	(a)

1. Telephone Half Circuits per Annum (INTELSAT price to Signatories).
2. As per Table 29.
(a) Because of modifications to INTELSAT tariffs, the 1989 charge is not comparable to previous years.

Source : US Department of Commerce, FCC.

Table 29. Communications Satellite Corporation (COMSAT) Full Time Voice/Data Half Circuits Leased at December 31

	1986	1987	1988	1989	1990
US Mainland to Europe	9 108	10 237	13 229	9 344	6 442
US Mainland to Mid East	1 400	1 739	1 774	2 040	2 833
US Mainland to Africa	741	787	932	1 193	1 262
US Mainland to South America	2 113	2 432	2 986	3 918	4 073
US Mainland to North & Central America	1 007	1 135	1 282	1 219	1 843
US Mainland to Caribbean	1 073	1 413	1 743	2 193	1 908
Total US Atlantic	15 442	17 743	21 946	19 907	18 361
Total US Pacific	5 119	6 210	8 104	6 735	6 110
Total US Half Circuits	2 0561	23 953	30 050	26 642	24 471

Source : FCC Statistics of Common Carriers.

Table 30. United States International Telephone Traffic and Tariffs, 1980-90

	Minutes Originating and Terminating in US (000)	Change per cent	Minutes from US (000)	Change per cent	Price per Minute from $	Change per cent
1980	1 261 567	28.7	791 443	NA	2.01	NA
1981	1 624 039	28.7	972 214	22.8	1.66	-17.4
1982	2 017 261	24.2	1 227 564	26.3	1.39	-16.3
1983	2 472 463	22.6	1 569 461	27.9	1.36	-2.2
1984	2 897 963	17.2	1 882 535	19.9	1.29	-5.1
1985	3 403 165	17.4	2 172 348	15.4	1.23	-4.6
1986	3 998 293	17.5	2 642 660	21.6	1.16	-5.7
1987	4 723 371	18.1	3 154 791	19.4	1.16	0
1988	5 668 813	20.0	3 768 099	19.4	1.18	1.7
1989	6 712 066	18.4	4 462 890	18.4	1.18	0
1990	7 819 104	16.5	5 257 931	17.8	1.20	1.7

Source : FCC Common Carrier Statistics.

Although minutes of international telephone traffic originating in the US grew by around 40 per cent from 1988 to 1990, this did not stimulate equivalent growth rates in full time leased satellite circuits. A problem for ISOs without direct access to customers is that there is little guarantee that price reductions will be fully passed on to the market. Although INTELSAT in 1987 had a tariff reduction of 5.1 per cent, and COMSAT had an across-the-board rate reduction averaging 12.6 per cent, these decreases were not translated into a decrease for US consumers making international telephone calls in that year. On the other hand PTOs could argue that substantial reductions had been made in earlier years when INTELSAT's prices remained constant. Another problem for the ISOs in the international switched services market is that their costs already represent only a small part of end customer prices (e.g., the cost of a digital circuit on a 15-year term with INTELSAT, and equipped with DCME, represents less than two US cents per paid minute of a telephone call). Thus further price reductions, if passed on cent for cent, will not stimulate the market significantly, but they may influence carrier choice between facilities. This situation does not apply to the same degree for most satellite services other than switched telephony.

The US situation is both more complex and transparent due to the existence of COMSAT as Signatory to INTELSAT. When a US consumer makes an international telephone call via satellite, the circuit has respectively passed through the marketing departments of INTELSAT, COMSAT and a PTO (e.g. AT&T). Each sets charges and tariffs to the next user in the chain. In most other countries, the PTO is the Signatory. This has the advantage of not placing an additional entity between the ISO and the end user. By contrast such an arrangement tends to be less transparent than the US, where price information at every stage is a matter of public record. Also, by contrast, COMSAT, unlike PTO Signatories, is required by law to provide non-discriminatory access to all customers licensed by the FCC to own and operate antennas in the US. This facilitates access to space segment and forces the unbundling of space and ground segment rates.

The available evidence indicates the mark-ups imposed between INTELSAT's price, which does not recover the full costs of providing an initial satellite circuit, and PTOs in the US are substantial (Table 31). The difference in INTELSAT's tariff and the cost to US PTOs is largely due to COMSAT's recovery of its expenses, investment and taxes. In 1987 COMSAT's tariff for an IDR circuit represented a 94 per cent price increase over INTELSAT's initial tariff. Similarly a TDMA circuit leased on a 12-month basis was marked up by 195 per cent. The COMSAT prices include ground station and other connection costs to the terrestrial network. As COMSAT is the US Signatory to INTELSAT these access facilities are not provided on a competitive basis.

While the penalty for not dealing direct with INTELSAT appears to be severe, PTOs seemingly more than compensate for this with substantial price increases for the same circuit to end users (Table 32). An international satellite circuit purchased from COMSAT for $1 000 per month is being sold for around three times that amount by PTOs in the US.[69] While the termination and connection charges are probably quite steep, the mark-ups are very high.

In Europe, where there is less price transparency than the US, circuits originally purchased from INTELSAT for less than $400 per month are retailed at an average price of over $6 000 by PTOs (Table 33). Even though some European PTOs would have to meet the cost of transit on terrestrial routes and termination costs (e.g. earth stations etc.) the mark up, particularly for services which directly access INTELSAT satellites, is extremely high.

Data from both the US and Europe indicate that PTO tariffs for both satellite and fibre are roughly comparable. On average PTOs have chosen to price cables at a slightly lower rate than satellite but there is little indication that either tariff bears much relationship to the cost of providing a circuit. The available evidence indicates that the pricing of international satellite circuits contains substantial mark-ups at each level. On an annual basis an international satellite circuit that may cost less than $1 000 to place in orbit is being retailed by European PTOs at an average of $73 000 (Table 34). Even taking into account that the cost of the ground segment may be greater than space segment charges, particularly for carriers that have few circuits per earth station, the levels of price escalation at the very least warrant greater transparency.

Current ISO, Signatory and separate satellite system pricing indicates that the introduction of limited competition has posed little or no threat to the economic health of INTELSAT. INTELSAT has concluded that to date there has been no experience of actual diversion of traffic because the system is fully utilised. The available evidence indicates that allowing direct access by users to INTELSAT may substantially cut prices to end users. Another view is that passing on price cuts does not necessarily require direct commercial access. Where competing carriers on-sell ISO capacity or foreign Signatories can sell capacity, there should be an incentive for them to pass on price reductions. This may be offset to some extent by the fact that Signatories as well as being potential competitors are also cooperative owners of the same system.

Table 31. INTELSAT and COMSAT Tariffs

INTELSAT IDR Service Tariff Rate per Month[1]	COMSAT IDR Service Rage
(one-half of a two-way 64kbit/s service)	
Earth Station A & C	Earth Station A & C
$585 $390 Long Term Commitment	NA
$450 (1987 - five year commitment for 64 kbit/s) $273 (1992 - five year commitment for 2.048 mbit/s) $240 (1992 - ten year commitment for 2.048 mbit/s) $210 (1992 - fifteen year commitment for 2.048 mbit/s)	$875 ten-year commitment for 64 kbit/s $960 five-year commitment for 2.048 mbit/s $350-690 ten-year commitment for 2.048 mbit/s $305-650 fifteen-year commitment for 2.048 mbit/s
INTELSAT TDMA Service Tariff Rate per Month	COMSAT TDMA Service Rate
(64 bit/s Information Channel)	
Earth Station A	Earth Station A
$507 (1987) $275 (1992) Long Term Commitment	$1 495
$390 (1987 - five-year commitment for 64 kbit/s) $240 (1992 - five year commitment for 2.048 mbit/s) $210 (1992 - ten year commitment for 2.048 mbit/s) $180 (1992 - fifteen year commitment for 2.048 mbit/s)	$875 ten-year commitment for 64 kbit/s $960 five-year commitment for 2.048 mbit/s $350-690 ten-year commitment for 2.048 mbit/s $305-650 fifteen-year commitment for 2.048 mbit/s

1. Subsequent INTELSAT prices for 1992 are recorded as indicated. Note: In 1987, COMSAT did not offer a five-year rate. COMSAT's tariffs vary based on additional factors, such as volume.

Source : INTELSAT, COMSAT.

Table 32. Selected US Telecommunication Carrier Leased Satellite and Fibre 64 kbit/s Tariffs, 1992[1]

Carrier	Satellite 64 kbit/s $ per month	Fibre 64 kbit/s $ per month
AT&T	3 000	3 400
IDB	2 800	2 800
MCI	2 640	2 300
OTI	2 900	2 600
STARS	3 650	4 000
TRT/FTC	3 800	2 800
US Sprint	-	2 900
Vitacom	2 270	-
Worldcom	3 950	3 700
Average	3 126	3 062
Alpha Lyracom	3 000	-

1. Tariffs are for one-year contracts for continuous duplex service, except TRT/FTC whose satellite tariffs are for 18 months. Rates are from New York to the UK, except for the following: STARS US terminal is in Houston, and Alpha Lyracom US termination is in Miami.

Source : AIIT, OECD.

Table 33. Selected European Countries Leased Satellite and Fibre 64 kbit/s Tariffs, 1992[1]

Country	Satellite 64 kbit/s $ per month	Fibre 64 kbit/s $ per month
Belgium	5 590	5 590
Denmark	5 033	5 033
France	4 770	4 490
Germany	6 100	6 100
Ireland	4 550	4 550
Italy	11 220	11 220
Netherlands	5 290	4 930
Spain	9 570	9 570
Sweden	5 270	5 270
Switzerland	7 210	7 210
UK (BT)	4 900	4 900
UK (Mercury)	3 920	3 290
Average	6 119	6 065

1. Tariffs are for one year contracts for continuous duplex service, excluding tax. Ireland tariffs were awaiting government approval at time of publication.

Source : AIIT.

Table 34. International Cost and Pricing of Satellite Circuits

	United Sates ($)	Europe ($)
Circuit Cost to INTELSAT per annum[1]	833 - 1 038	833 - 1 038
INTELSAT 1992 price to Signatories per annum[2]	3 330	3 300
COMSAT 1990 price to US PTOs per annum	12 000	-
PTOs 1992 price to users per annum[3]	37 512	73 428

1. Excluding financing, management and operating costs.
2. Based on a five year commitment.
3. Average price 64 kbit/s international circuit for eight US international carriers and 12 European carriers for a 12-month contract.

Source : INTELSAT, COMSAT, AIIT, OECD.

SECTION IV. SATELLITE SERVICES AND REGULATION

1. Technology innovation and convergence

A major factor in the relative competitiveness of satellite technology with terrestrial alternatives is the cost of reception equipment. As network connectivity ceases to be the major market for satellites and applications taking advantage of point to multi-point capabilities increase, a primary objective of satellite innovation becomes reducing the size and cost of receivers.

The traditional axiom of satellite communication was that a trade-off existed between the power of the transponders and the size of earth stations. Transponders are the mechanisms on satellites that receive signals from earth and retransmit them over the satellites field of coverage (sometimes called footprints or beams). Because the signal received by the satellite is relatively weak, transponders amplify the power as they radiate services back to earth. By increasing the power of a transponder it is possible to reduce the size of the reception equipment. This is a significant factor in point to multi-point applications when there are sometimes many thousands of receivers, such as DTH broadcasting.

Other techniques can also be used to improve the economics of this equation. For instance, it is possible to design antennas to focus the satellite's signal over relatively small footprints and in some cases to alleviate spectrum congestion. These "spot beams" concentrate power over a certain area and make possible the use of small inexpensive receivers. This gain involves a trade-off against having larger antennas with complicated feed arrangements.[70] To comply with the payload capacity of some launch vehicles, large antennas often have to be folded until final deployment. This adds an element of risk if the antenna fails to deploy.

Moreover, concentrating power over part of a footprint may entail having larger dishes in areas outside the spot beam. To compete with terrestrial technologies for certain applications some satellites in the current generation being launched are minimising a primary advantage -- uniform coverage at uniform cost -- and increasing the cost and complexity of some parts of the space segment. By concentrating capabilities in spot beams, the technology is mimicking the point to point transmission capabilities of terrestrial alternatives.

The satellite, instead of being a simple transmission device in orbit, increasingly takes on other characteristics of a terrestrial network such as the ability to switch signals. This is because providing connections between terminals in different spot beams involves some form of switching.[71] At present some of the more advanced satellites use a switching system which routes the signal to different beams according to the time it was received by the satellite. The next generation of satellites is expected to use a baseband switch which can route signals according to their destination leading to more efficient use of the satellite's telecommunication capability. In the long term, on board processing and inter satellite links are expected to become important technical attributes of satellites. Such technologies have the potential to eliminate delays caused by "double hopping" signals over more than one satellite. Inter-satellite links may significantly reduce the cost to the user as a number of international nodal points are by-passed - this is a major factor in regard to the cost advantages of LEO MSS systems over conventional GSO systems.

These developments do not mean that the cost of satellite communication is increasing in real terms. As section 7 showed, advances in other areas are reducing the cost of circuits. However the emphasis of research and development has shifted from reducing the cost of traditional trade-offs. Rather development of satellites is aimed at increasing the efficient utilisation of power (rather than the power itself) and the reliability of equipment and components (Table 35).

Table 35. Selected OECD Country Public Expenditure on Civilian Communication Satellites, 1991

	Public Expenditure on Civilian Satellites ($m)	Total Space Budget ($m)	Satellite Expenditure as Share of Total Space Budget (per cent)
NASA[1]	156.0	12 292.0	1.2
ESA	280.0	3 026.6	9.2
Japan[1]	213.8	1 261.6	16.9
France	38.1	1 740.9	2.2
Italy	146.6	968.9	15.1
Germany	4.0	921.8	0.4
Canada	8.6	357.4	2.4
UK	3.5	259.6	1.3
Switzerland	(2.0)	100.0	_

1. 1990 (1989 exchange rate for NASDA's 1990 expenditure in Japan)
2. No public expenditures for civilian satellites excepet for budgetary participation in ESA and EUMETSAT (weather)

Source : Euroconsult, US Department of Commerce.

Some of the more advanced applications are technically realisable at present (e.g. On Board Processing & Inter Satellite Links) but are not yet demanded by most users. However, there is market pull for increasing the efficiency of bandwidth utilisation, partly due to finite spectrum limitations. Here developments are responding to the demands of different applications. From the perspective of satellite operators the escalating capacity of fibre optics make increased capacity for satellites a competitive necessity. Technologies such as DCME address this requirement but also boost the efficiency of fibre optic cables. Where satellites are offering point to multi-point communication, technologies such as demand assigned multiple access (DAMA) are increasing the efficient utilisation of existing capacity.[72] Such technologies enable capacity to be shared between users. In the case of DAMA a transmission channel is only assigned for the duration of a call (e.g. telephone call, data packet, etc.). Bandwidth can also be more efficiently utilised with frequency re-use and beam separation. While only some 1 080 Mhz of spectrum is available in the two frequencies used by INTELSAT VI the total effective bandwidth, even after allowing 10 per cent for guard bands between transponders is 3 300 Mhz. This is achieved by sixfold frequency reuse of parts of the band and twofold reuse of the rest.

From the perspective of most users, being able to use existing capacity more efficiently is of greater importance. This demand is currently driving the development of compression technologies. In the past a general rule of thumb has been that one transponder could be used for a single television channel or 1 000 voice circuits. Use of digital video compression potentially enables several TV channels to be broadcast over the same transponder. The rate at which this technology is applied depends on a number of variables including reducing the cost of decoders and increasing the quality of signals. The cost of coders at each site is currently tens of thousand of dollars.[73] The technology also needs to be developed in such a way as to be compatible with existing receivers. In 1992 Scientific Atlanta and Mediatech, Inc. announced plans to install the industry's first operational digital video compression satellite TV advertising delivery and insertion system for broadcast stations and cable systems.[74] Telesat, considers digital video compression will be commercially available in the third quarter of 1992 but that the real impact of compression will occur in 1994, with a four to one compression ratio.[75] In late 1993, Hughes plans to launch a DBS system called DirecTv with service beginning in 1994. Use of video compression could potentially allow the provision of 150 channels on two HS601 satellites.

As well as efficiency advances in the functions satellites perform, other innovative developments are occurring to the satellites themselves. In terms of the satellite bus, the general trend has been towards larger spacecraft to supply greater power and support to the satellite payload. The dimension of satellites has expanded from around 1 metre in the early 1960s to 15.6 metres for INTELSAT V and 20.2 metres for INTELSAT VII. Meteorological satellites under construction have spans of 26.8 metres. The dry mass in orbit of the INTELSAT V series was 1 090 kg while the INTELSAT VI series was 2 546 kg. Launched in 1985, Australia's first generation satellites weighed 655 kg while in 1992 its second generation increased to 1 300 kg. If these trends continue in future, it may be more economical to employ "antenna farms", where a number of satellites are replaced with a single large platform. This would be a long term development because large satellites are already increasingly complex and difficult to manage.

While the total mass of satellites has increased, the mass of subsystems has generally decreased for a given requirement. The reduction in component mass is expected to continue along with reductions to the weight of the satellite bus. Methods to accomplish this may involve more efficient propulsion systems, centralisation of processing systems and new structural composites.[76] The savings from more efficient propulsion systems could be considerable as the propellant carried for satellite systems can amount to half the total spacecraft mass; roughly 40 per cent to achieve the required orbit and 1 per cent per annum to maintain position for a decade.[77] The centralisation of processing systems can involve the reduction of 15 to 20 black boxes down to one or two units, while the use of composite materials can substantially reduce spacecraft mass.[78]

Perhaps the most important development for geostationary satellites is the increase in operational lifetime of satellites. The current generation of satellites with lifetimes of seven to ten years are being replaced by satellites with mission lifetimes of ten to 15 years. INTELSAT VIII satellites will have operational lifetimes up to 18 years. In part this is due to increasing reliability of components. It is also true that many operators have chosen to bear increased launch costs as a price of including more propulsion and station keeping fuel. Generally the cost of launching extra weight is more than compensated by extended working lifetimes and some operators have been able to take advantage of the introductory pricing of some launch vehicles. The trend toward larger satellite buses, that in themselves increase launch costs, adds further incentive to extend the operational lifetime.

It is also possible to extend the operational life of satellites through improved management techniques at the beginning and end of their lifetime. In 1992 INMARSAT deployed a satellite fractionally north of the equator. By allowing the satellite to drift slowly south, INMARSAT could reduce the use of station keeping fuel and reportedly add three years to the operational lifetime of the satellite.[79] In addition improved tracking capabilities enable the operational lifetime of satellites to be extended through the use of inclined orbits. This technique, sometimes referred to as the "COMSAT Manoeuvre", basically allows the satellite to be tracked in inclined orbits as it becomes low on station keeping fuel. This technique can also be used to maintain older satellites as back ups or retain management as they are sold to another operator.

Two streams of service innovation can be identified based on current and potential technological developments. The first is the improved efficiency of existing services, through the use of techniques such as multiplexing and video compression. These capabilities enhance the ability of satellites to complement terrestrial networks such as distributing programming to cable-TV networks and additional mediums for broadcasting. Most OECD countries have been able to receive signals from satellite broadcasting for at least a decade. Generally this capability has been used to provide television to remote or under served regions or to supply programming to terrestrial transmission systems. Current technological developments driving down the cost of receivers are making the technology another option to provide broadcasting services to mass markets. Financially many DTH services have yet to prove themselves. In 1991 their were 64 major programme channels and 14 minor programme channels being broadcast in Europe over 85 transponders. Only a handful were actually or almost profitable.[80] Digital video compression could reduce the space segment cost for service providers, but it is unclear what impact this would have on elasticity of demand for transponders.

The second form of innovation is the provision of new services through technological improvement. Examples of such services include VSAT networks which represent a move toward the terrestrial network characteristic of affordable connectivity with end users, but with rapid roll-out time and flexibility in network configuration. Shared hub networks, first developed in the US, are allowing small users to avoid the cost of a dedicated hub station. Convergence is also evident in the VSAT market. For instance Hughes Communications currently provides multi-site, full motion, video teleconferencing over VSAT networks. Both the voice link and video image are two way interactive. The system uses compressed video which has a lower image quality than broadcast services. At present broadcast quality can be distributed over VSAT networks but only one way from hub to VSAT and without compression.

Taken to its logical conclusion this application is further enhanced through the introduction of mobility. For instance the media can use satellite technology for satellite news gathering. INTELSAT offers a SNG service to over 300 transportable receivers in more than 28 countries. Where a reporter's story may once have been terrestrially transmitted to a studio and carried internationally by satellite other options are now available. News may be gathered via satellite and transmitted internationally via satellite or fibre optic cable. The service advantage of satellite technology is its mobility and flexibility rather than international transmission. At the same time digital audio broadcasting (DAB), introduced in 1991 by INTELSAT to relay programmes, will become possible to a mass broadcast market.

Mobile applications represent the fastest growing sector of the satellite market. INMARSAT's transmission of telephone minutes increased by 50 per cent in 1991 (Table 36). With the introduction of smaller less expensive terminals this market is expected to grow rapidly. In 1991 INMARSAT-C terminals were introduced to provide data communication to small portable terminals. In 1994 INMARSAT plans to launch a global paging system to coincide with the launch of its third generation satellites. While maritime communication still provides INMARSAT's core market, generating 78 per cent of revenue, land mobile has grown to 29 per cent. While representing only 0.1 per cent of INMARSAT revenue in 1991, the first year of service, the aeronautical market is also expected to become a significant part of the mobile market.

INMARSAT developments are at the leading edge of driving satellite technology toward lower cost and more portable terminals. At the same time as capabilities of fixed receivers become more mobile and transportable receivers become portable, ISOs are offering the same services. Just as INTELSAT provides satellite news gathering, INMARSAT provides electronic news gathering.

Table 36. Key INMARSAT Indicators

	Space Segment Traffic		Mobile Earth Stations		Aeronautical
	Telephone Minutes (000)	Telex Minutes (000)	INMARSAT A(1)	INMARSAT C	
1987	9 620	12 103	6 200	-	-
1988	14 043	14 484	8 000	-	-
1989	20 138	16 955	10 000	-	-
1990	29 178	20 613	12 871	-	-
1991	43 994	25 412	16 271	2 539	97

1. Rounded figures 1987-1989.
Source : Annual Report.

The growth in mobile satellite communication has attracted interest from a number of existing and proposed separate satellite systems. The 45 per cent growth of INMARSAT's space segment revenues in 1991 is a magnet for other service providers. On a national basis Australia and North America will both soon have satellites capable of providing mobile services. In Europe most OECD countries either have, or are planning to introduce, services via EUTELSAT and INMARSAT. While having complementary capabilities with terrestrial networks, national systems will face greater competition than international systems. The extension of cellular mobile services to areas of greatest population and along major transport routes will largely preclude more expensive mobile satellite systems from these markets. Satellite operators aim to integrate service options. For example an AMSC telephone will be able to function on a terrestrial cellular network. Therefore the commercial success may depend on how many users are willing to bear the additional expense of a mobile satellite receiver.

National systems can potentially provide important niche services but, in liberal markets with direct access, will face increasing competition from ISOs. According to INMARSAT, ISOs have an advantage over regional operators because their potential markets are larger and they enjoy economies of scale. Thus while they are confident about the global market, INMARSAT has stated, "The economic viability of regional mobile satellite operations ... may be open to greater speculation. An operator providing services to only one country or region must face the fact that markets are limited by the potential of the region ... Yet the capital costs of establishing a satellite system and a network of ground stations remains high. Even among those potential operators who do manage to secure financing and get systems up and running, there may eventually be a shake out which could result in failures, mergers or other changes in a competitive environment. Inevitably, some mobile satellite systems will likely be established not solely because of their potential profitability, but for other reasons as well, such as national pride or support for domestic industry."[81]

In future, ISOs may face competition from separate satellite systems employing smallsat technology and other orbits (Table 37). Perhaps the best known of these is Motorola's proposed Iridium system. Originally named on the basis of the system having 77 satellites in low earth orbit, a revised proposal now calls for 66 satellites. Essentially the system operates in the same way as terrestrial cellular systems except that cells pass above terminals rather than users passing through cells. Other systems have been proposed for low earth orbit utilising fewer satellites and Hughes has proposed an alternative global system using geostationary orbit. INMARSAT is developing its own global system for portable voice communication called Project 21.

Table 37. Proposed Small Satellite Systems (FCC Applications)

System	Sponsor	No. of Satellites	Service
Low earth orbit			
Iridium	Motorola	66	World-wide cellular
Orbcomm	Orbital Sciences	20-24	Messaging (US)
Ellipso	Ellipsat Corp.	24	World-wide cellular
GlobalStar	Loral/Qualcom	24-48	Voice, data, positioning
SmartCar	Leosat	24	Voice messaging
Aries	Constellation Comm.	48	Voice, data, positioning
Vita	Volunteers in Technical Assistance	NA	Communications
Starsys	Starsys Global Positioning	12	Positioning
Medium earth orbit			
Odyssey	TRW	12	Messaging and data transmission
Geostationary orbit			
Tritium	Hughes	1	World-wide mobile comm.
Afrispace	Afrispace	4	Direct broadcast radio

All systems are categorised according to proposed orbit although several intend to offer the same services.

Source : US Department of Commerce.

One hurdle these systems need to overcome is finding enough capital. Iridium could ultimately cost between $3 billion to $4 billion.[82] Such an amount is larger than the value of INTELSAT's current communication plant of $2.2 billion and INMARSAT's $0.7 billion in fixed assets. Sponsors of global smallsat proposals include a number of manufacturing firms seeking to vertically integrate the rapidly growing mobile market. The development of smallsats has encouraged low cost methods to be developed for launch into low earth orbits (LEO). The Orbital Science Corporation has developed the Pegasus system which uses rockets launched from aeroplanes for payload between 250-400kg at a cost of around $10m. Another project under development is the Taurus system that uses three stages of Pegasus together with the first stage of a ballistic missile.

2. Satellite services and equipment regulation

Policy-makers around the world are reviewing the application of satellite technology and service regulation. The available evidence indicates that some regulatory frameworks are restraining the efficient application of satellite technology. The regulation responsible for restricting the development of satellite applications has been the extension of more general communication policies to satellite services. In most cases this involved rules governing the provision of services and equipment.[83] Regulatory frameworks determined who could provide services and in what markets. They also governed installation, maintenance and ownership of equipment.

Historically this regulatory framework penalised potential service providers rather than users. In the 1960s and 1970s satellite technology had not evolved to the point where it could be economically installed for most end user applications. Satellites were predominantly used to provide international connections between networks or as an option of last resort where terrestrial alternatives were prohibitively expensive. Communication monopolies prevented new carriers from providing alternative terrestrial and satellite networks. It could be argued that this imposed a penalty by limiting competition but it would not have been economic for even the largest users to install a dedicated alternative satellite or terrestrial network. As PTOs provided the most economic connectivity between satellites and end users, prohibiting direct access was not a pressing issue.

As the technology has evolved it became economically viable for greater numbers of users to install satellite networks using leased capacity. For instance the cost of VSAT receivers declined to the point where satellite communication could bring significant advantages for some applications. This meant that regulation once mainly penalising alternative infrastructure providers, restricted application growth by users. What has primarily differentiated the regulation of satellite communication from other areas of communication has been the structural regulation of the industry. More than 40 per cent of the world's satellite capacity, comprising ISO and some the capacity of some national systems, cannot be directly accessed by users.

Satellite regulation was generally consistent with overall communication policies. In many countries, PTOs' communication monopolies were simply extended to include satellite communication. It could be argued that regulation hindered the development of satellite communication and the alternative provision of service and equipment through other mediums. However proponents of satellite market liberalisation have often contended that satellite technology was further impeded by the PTOs' primary commitment to terrestrial networks. Sometimes communication liberalisation has preceded reform of satellite regulation. For instance, the European Community specifically excluded satellite equipment from the 1988 Terminals Directive deregulating most categories of telecommunication equipment. In 1990 this precedent was followed when the Services Directive, aimed at liberalising telecommunication services, specifically excluded deregulation of satellite services.[84] In some countries there has been a temptation to retain reserved satellite services as a means to increase the value of privatisation. Policy-makers have generally specified dates when such privileges will be phased out after the sale of a satellite system.

Together with the EC Services Directive, this means provision of switched satellite communication services by anyone other than a national PTO is still the exception rather than the rule in OECD countries (Table 38). In some countries a monopoly applies even though the PTO does not offer domestic switched satellite telecommunication services. This regulatory situation is gradually changing in line with an overall trend toward communication liberalisation. A growing number of countries are allowing resale of satellite capacity by users. Several countries restrict the interconnection of satellite resale at both ends of a domestic and foreign network, because of the lack of international reciprocity. Bilateral agreements are one method to ease such restrictions. While allowing users an opportunity to reduce their costs, resale will not act to substantially lower prices because the capacity must be purchased from a Signatory. As these original prices contain substantial mark-ups that appear unrelated to cost, users would not be in a position to apply robust price disciplines even with efficiency gains. However a policy of direct access together with liberalised resale could be expected to substantially lower the price of international communication. Even the weaker liberalisation measure of multiple or controlled access coupled with international resale may act to curb the more excessive price distortions.

Table 38. Satellite Services Regulation

Country*	Services reserved for PTO(s)	Private users ability to resell satellite capacity			
		Domestic Data	International Data	Domestic Voice	International Voice
Australia	Switched network services	Yes	Yes[1]	Yes	Yes[1]
Austria	Switched Telephony	No	No	No	No
Belgium	Switched Telephony	No	No	No	No
Canada	(2)	Yes	Yes	Yes	Yes
Denmark	NA	No	No	No	No
Finland	Switched Telephony[2]	No	No	No	No
Germany	Switched Telephony	Yes	Yes	No[3]	No[3]
Luxembourg	Switched Telephony	Yes	Yes	No	No
Netherlands[4]	Switched Telephony	Yes	Yes	Yes	Yes
New Zealand	None	Yes	Yes	Yes	Yes
Norway	All, except receive only	No	No	No	No
Portugal	Switched Telephony	No	No	No	No
Spain	Switched Telephony	Yes	Yes	Yes	Yes
Sweden	None	Yes	Yes	Yes	Yes
Switzerland	Switched Telephony	Yes	Yes	No	No
Turkey	Switched Telephony, TV & Radio Transmission	No	No	No	No

1. International satellite capacity/services acquired from a carrier can be resold on a double-ended interconnection basis providing it is in the public interest. There is a prima facie assumption that all services are in the public interest. Where international satellite capacity/service is acquired from a non-carrier it is subject to own use or single ended interconnection conditions.
2. Telesat can not obtain a broadcasting licence and is a licensed carrier of PSTN only.
3. A new Act comes into force after October 1992 with greater liberalisation.
4. Only insofar as there is a special authorisation for the telephone service via satellite in and with the New Federal States of Germany.
5. Also the commercial provision of telex and telegraph using satellite earth stations. The commercial provision of data transport service using a satellite earth station is reserved till 1 January 1993. Private users are able to resell satellite capacity but not commercial services using earth stations.

* Responding to Survey.

Source : OECD Questionnaire.

Consistent with overall deregulation of customer premise equipment in OECD countries, has been increasing liberalisation of the satellite ground segment. In the European OECD area the pace of liberalisation has trailed the other Member countries, because many countries have not gone beyond the Terminals Directive. INMARSAT reports that equipment regulation and type approval is still a problem in certain areas of the world. In some countries restrictions are placed on the use or importation of satellite equipment inhibiting the development of land mobile services. The International Committee of the Red Cross has stated they have encountered enormous difficulties in the use of satellite communication for humanitarian relief in the context of natural disasters.[85]

In October 1991, a meeting convened to consider trans-border restrictions was attended by representatives of 33 countries and 16 international organisations. The Meeting unanimously agreed that governments should allow the transport of mobile satellite communication terminals across borders and simplify regulations for use in commercial and disaster relief operations.[86] The Meeting requested that INMARSAT,

> *"as a longer term measure, to undertake in consultation with its Parties and Signatories, other interested States, the ITU and regional intergovernmental telecommunication organisations, the preparation of multilateral agreements such as a Memorandum of understanding, designed to permit the transborder movement and use of INMARSAT land mobile earth stations (LMESs)." 3A(v)*[87]

While supporting efforts to facilitate transborder movement and use of LMESs, the US Delegation did not concur with 3A(v) in so far as it limited transborder use to the INMARSAT system.[88] The US suggested the agreement should be extended to cover all LMESs and other transportable earth stations, consistent with national law to facilitate the most open regime for transborder use of terminals. The final recommendations were not specific to any mobile satellite operator.

Liberalisation of broadcasting terminal equipment tends to be running ahead of equivalent areas in satellite telecommunication. Regulation of TVROs is now liberalised in most OECD countries (Table 39). Greater regulation tends to apply to the use of VSAT terminals (Table 40).

Table 39. TVRO Receiver Equipment (Ownership and Installation)

Country	Licence Required		Liberalised		SMATV Licence required
	(<1 metre)	(>1 metre)	(<1 metre)	(>1 metre)	
Australia[1]	No	No	Yes	Yes	No
Austria	C-Band	C-Band Ku-Band>3.6m	Ku-Band	Ku-Band>3.6m	Same
Belgium	-	-	Yes	Yes	No
Denmark	No	No	Yes	Yes	No
Finland	No	No	Yes	Yes	No[2]
Germany[3]	Yes	Yes	Yes	Yes	Yes
Luxembourg	Yes	Yes	Yes	Yes	No
Netherlands	No	No	Yes	Yes	No
New Zealand	No	No	Yes	Yes	No
Norway	NA	NA	Yes	Yes	No
Portugal	NA	NA	NA	NA	NA
Sweden	No	No	Yes	Yes	No
Turkey	-	-	-	-	-

1. In Australia a license is required for TV receive only stations where they are to be used for `business or commercial purposes'. Few stations fall into this category and most do not require a license.
2. Up to service provided by central antenna system to 200 access points when a CTV-license is needed.
3. All applications may be subject to a Licence with subsequent individual authorisations or subject to individual authorisations without a prior licence.

Source : OECD Questionnaire.

Table 40. VSAT Receiver Equipment (Regulation of Ownership and Installation)

Country*	PTO Monopoly		Licence Required		Liberalised Ownership	
	(1-way)	(2-way)	(1-way)	(2-way)	(1-way)	(2-way)
Australia	No	No	No	Yes	Yes	Yes
Austria	No	Yes	No	Yes	Yes	No
Belgium	-	-	Yes	Yes	-	-
Denmark	No	Yes	No	Yes	Yes	No
Finland[1]	NA	NA	No	No	Yes	Yes
Germany[2]	NA	NA	Yes	Yes	Yes	Yes
Luxembourg	-	-	Yes	Yes	-	-
Netherlands[3]	No	No	Yes	Yes	Yes	Yes
New Zealand	No	No	No	Yes	Yes	Yes
Norway	No	Yes	-	-	Yes	No
Portugal	NA	NA	NA	NA	NA	NA
Sweden	No	No	No	No	Yes	Yes[4]
Switzerland	No	No	Yes	Yes	Yes	Yes
Turkey	-	-	-	-	-	-

1. No license is required for ownership and installation but is for operating and providing communications to third parties.
2. All applications may be subject to a Licence with subsequent individual authorisations or subject to individual authorisations without a prior licence.
3. VSAT (receive only), officially needs a licence but this is not enforced and is being phased out. Type approval is necessary for connection to PSTN. VSAT (transmit & receive) may be owned and installed by anyone under licence if certain technical conditions are met. A licence may only be given for VSATs with a dish diameter up to 4 meters and a maximum transmission of 2Mbit/s.
4. Frequency permit required.

* Responding to Survey

Source : OECD Questionnaire.

As overall communication policy reform has been implemented in OECD countries, satellite regulation has generally followed. For instance the advantages of separating service providers from regulatory functions has been recognised by a number of OECD countries. As regulation and communication service provision have been separated so too have satellite communication and regulation at a national level. The logical extension of such reform to international communication has not taken place, although there are differences and difficulties in an international rather than a national context. At an international level, satellite regulation and service provision are yet to be separated, in so far as Signatories determine the rules of competition with ISOs (Table 41). Signatories should be able to make commercial decisions relating to their investment share and the efficient operation of ISOs. However there should be a clear separation between Signatories and the agreements governing separate satellite systems, particularly where potential conflicts exist.

In countries with liberal satellite services and equipment regulation, such as the US, growth in applications has been determined by markets rather than PTOs. In 1992 the US had nearly seven times the number of private satellite networks than Europe. There are no doubt a number of contributing factors for the relative pace of VSAT development in the US and Europe. Some would include reasons that are unrelated to communication regulation such as the US being more than twice as large as the combined land mass of European OECD countries. In addition network density as measured by mainlines per square kilometre is three times greater in Europe than in the US. The greater integration of the US economy on a national basis, as opposed to national European equivalents, can also be expected to have been one factor.[89] In addition demand by US Government agencies, again to provide services over a much larger mass than any single European country, has contributed to VSAT growth. The vertical integration of the industry may also have provided an incentive for service providers to under price capacity as a loss leader.

Table 41. Regulation of Satellite Communication and Service Provision

Country*	International Satellite Organisation Signatory	Satellite Regulatory Authority	Satellite Marketing
Australia	Telstra	Ministry/AUSTEL	Telstra/Optus
Austria	PTT Austria	PTT Austria	PTT Austria
Belgium	Belgacom	Ministry P&T	Belgacom
Denmark	Tele Danmark Plc	General Directorate for P&T	Telecom Denmark
		Ministry of Transport	
Finland	Telecom Finland	and Communications	Telecom Finland
		Ministry P&T	
Germany	DBP Telekom	Ministry des Comms.	DBT Telekom
Luxembourg	P&T Luxembourg	Ministry P&T	P&T Luxembourg
Netherlands	PTT Telecom BV	Dept. Commerce[1]	PTT Telecom BV
New Zealand	Telecom NZ	Norwegian	Telecom NZ
Norway	Norwegian Telecom	Telecommunication	Norwegian Telecom
		Regulatory Authority	
		ICP	
Portugal	CPRM Marconi	Swedish National Telecom	CPRM Marconi
Sweden	Swedish Telecom	Agency	Swedish Telecom
		Bakom	
Switzerland	Swiss PTT		Swiss PTT,
		PTT Turkey	third parties
Turkey	PTT Turkey		PTT Turkey

1. Ministry responsible for overall communication policy.
* Responding to OECD Survey

Source : OECD Questionnaire.

However, the single most important factor in the slow take up of satellite services in Europe compared to countries such as the US and Australia has been regulation. Whereas a user in the US or Australia has direct access to national satellite operators, users are denied that right on a pan-European basis. This leads to a number of tariff anomalies that cannot be explained in terms of cost causation. These include, by way of example, a 64 kbit/s satellite circuit leased from the UK to France costing 38 per cent more than the reverse direction (Table 42). Similar arbitrary pricing exists with ISO circuit for routes outside Europe. A circuit leased from the UK to Japan or Hong Kong can be 47 per cent more expensive than a circuit leased from France to the same destinations.

One element exerting downward pressure on prices in the US has been excess capacity and fierce competition among a number of suppliers. On the other hand some have suggested European PTOs are willing to create artificial shortages of capacity by reserving transponders they do not actively market or price beyond the market.[90] With the cost of satellite circuits for telephony declining to the point of "invisibility" relative to international tariffs, reserving excess capacity does not inflict undue penalties on a Signatory, yet may prevent other service providers from gaining access. However if Signatories have to meet the full cost of reserving capacity for television, as has been suggested, this would inflict a harsher penalty on such practices. A possible exception could arise if Signatories were to trade capacity amongst themselves to inhibit access by competitors.

Table 42. European Satellite Tariff Comparison 64 kbit/s circuit per month, December 1991, $US

	France	UK	Germany	Japan	Hong Kong
France	-	3 253.5	3 253.5	5 235.6	5 235.6
Germany	4 450.2	4 450.2	-	7 479.4	-
UK (BT)	4 487.7	-	4 618.5	7 713.2	7 713.2

Source : Eurodata.

Restrictions on direct access were found to be severely impeding the efficient development of SNG in a study undertaken by Booz Allen & Hamilton.[91] One market distortion that has arisen is the practice of lease-leaseback arrangements. In these cases a SNG operator which has leased capacity in one country, has to lease it back to an ISO and then re-lease from the Signatory in another country where they wish to up-link. In one instance this involved a user having to pay an additional $8.65 per minute for capacity they had already paid for from another PTO.[92] Booz Allen further reports,

> *"In another case, CBS was forced by a PTO to pay $3 000 a day in order to uplink an INTELSAT VI F4 transponder which it leased from BT. CBS wanted to uplink to INTELSAT VI F4 from its own mobile SNG unit, but was told by the PTO that it could not do so. Instead, the PTO said that CBS could either use its own unit in order to uplink to one of the PTO-owned EUTELSAT transponders, or CBS could uplink to its own INTELSAT transponders from one of the PTOs'ground stations."*[93]

Yet if each OECD country adopted a carbon copy of US regulation it is arguable whether such problems would be overcome. This is essentially for reasons of geography. For satellites to have advantages in Europe they have to be able to offer telecommunication services in more than one country. In the US satellite systems licensed in other OECD countries are not permitted to offer services and PTOs still access ISOs via COMSAT. If US liberal domestic policies and co-operative international policies were adopted by European countries the full benefit of satellite application would not be realised. This is because in the European context adopting US international regulation would restrict direct access by users to EUTELSAT or other ISOs. A user in one country would still have to approach an ISO Signatory in each country they wanted to operate satellite services. Even if controlled access via a single Signatory ameliorated this problem, it would still preclude direct access. There would still be an artificial layer between an ISO and user adding additional costs and rigidities. For satellites to come into their own in Europe, international liberalisation with direct access is necessary.

The European Commission, in its Green Paper of satellite communication, has recommended four major changes to the regulatory environment in Europe:

- 1. Full liberalisation of the earth segment, including the abolition of all exclusive or special rights in this area.

- 2. Harmonisation measures as far as required to facilitate the provision and use of Europe wide services.

- 3. Free (unrestricted) access to space segment capacity.

- 4. Full commercial freedom for space segment providers.[9]

Some OECD countries have already adopted these principles, or are in the process of moving toward similar policy positions. If implemented on a uniform basis throughout the OECD these principles would allow ISOs and former national systems to compete on equal terms with each other and terrestrial networks. It would allow users maximum flexibility in configuring the most efficient network for their needs. However it would have major implications for the current structure of international communication. Increased direct access for users and ISOs would necessitate change to the constituent documents of ISOs.[95] For example Article 15 of the INTELSAT Operating agreement states:

> *"any application for allotment of INTELSAT's space segment capacity shall be submitted to INTELSAT by a Signatory or, in the case of a territory not under the jurisdiction of a party a duly authorised telecommunications entity."*[96]

A policy of direct access would entail a revision of the current financing arrangements of ISOs. It is notable that INTELSAT has recently entered capital markets for the first time ending the sole reliance on the provision of direct capital by Signatories.

3. International regulation

The institutional arrangements that made possible the pioneering application of satellite technology have come under the same pressures for change as most national policy frameworks. The charters of the two largest ISOs are now thought of in technological (INTELSAT -- fixed satellite services and INMARSAT -- mobile satellite services) rather than geographical terms (INTELSAT -- international and INMARSAT -- maritime). INTELSAT now provides domestic communication capacity for some countries while INMARSAT has developed land and aeronautical mobile satellite services. The new institutional demarcations have occurred at a time when policy-makers are expressing a preference for "technology neutral" regulation. Just as the geographical distinctions rapidly became obsolete it can be expected that current technological demarcations will be increasingly difficult to sustain. Developments in satellite communication reflect a wider trend of technological convergence in communication. For instance the distinction between mobile and transportable receivers is increasingly arbitrary.

Perhaps more important are the evolving technological strategies of the ISOs seeking to reach out to greater numbers of end users rather than simply providing connectivity between networks. The areas of fastest growth in satellite applications are in the provision of services to end users rather than connectivity between networks. INTELSAT VIII satellites will incorporate the highest C-band power ever for an INTELSAT satellite. Merely connecting networks faces ever increasing challenges from alternative transmission mediums. The first group to take advantage of these capabilities could be the ISO Signatories, often in tentative competition against each other for the first time (i.e where controlled access policies apply). In the case of INMARSAT, the ISO operates on the basis of a policy of controlled access due to the system design. A user accessing the satellite has the choice of downlinking through any INMARSAT land earth stations that can be seen by the satellite. As these earth stations are operated by different Signatories (and in a few cases by non-Signatories) they may offer different prices. In some cases Signatories have established consortiums to market aeronautical satellite communication.

As technological development unfolds, the ISOs can be expected to be provide similar capabilities in some regions. INTELSAT continues to keep the provision of mobile communication under review.[97] It is possible that three ISOs could be providing mobile capacity across Europe in future. This may be in direct competition with separate mobile satellite systems in low earth or geostationary orbit. Moreover the make up of the ISOs is changing as many countries elect to privatise or corporatise and admit new PTOs to their domestic and international markets. This is likely to result in a greater commercial orientation of the ISOs, both in corporate strategy and their relationships with users.

Such developments raise many questions that need to be addressed by policy-makers. Among the most important of these are whether end users should have direct access to ISOs. In the past a technological basis could be established for Signatories marketing services, since they provided final connectivity between end users and satellite systems. This demarcation is increasingly unsustainable. Moreover the available evidence suggests it limits the market for satellite application by increasing prices and decreasing the flexibility available to users. Direct access could be expected to benefit users and efficient ISOs. If direct access was introduced there would need to be an assessment of whether the privileges available to ISOs, by international agreement, act to constrain the development of separate satellite systems. One approach would be increase the transparency of universal service obligations and privileges to best inform policy makers.

The goal of communication reform is increased efficiency. Competition and co-operation are two tools available to policy-makers to achieve this goal. There is considerable evidence that a balance of the two policies is the best way to achieve an efficient industry structure but that the current mix is not delivering optimal results. The existing institutional structures may provide actors with a number of distorting incentives. ISOs may have an incentive to over supply the market with capacity along international routes. At the same time ISO capacity is not being marketed with maximum efficiency by Signatories. Moreover, ISOs have to rely on Signatories to provide information about end users and potential demand.

In the present industry structure the costs generated by inefficiency may be passed to users in the form of monopoly rents. However the cost of an international satellite circuit has declined to the point of near "invisibility" relative to the total cost and price of telecommunication services. This is primarily a factor of the increased amount of circuits that can be incorporated onto a satellite and more intensive use of that capacity. The satellites themselves may actually be larger and more expensive. Therefore cost efficiency is dependent on making use of the expanded capacity. If the utilisation is substantially below the level of redundant capacity needed for a well managed system, such systems may not be optimal for all Signatories.

Taking into account the expansion of fibre optic capacity, in which many Signatories have significant shares, substantial capital investments are being made in new satellites against possible under-utilisation of the system as a whole. Nevertheless some Signatories may feel such investment is justified as a means to limit market entry by new competitors. At the same time they face increasing demands for investment capital in other areas (e.g. competition in domestic network development, globalisation activities). This is a factor in INTELSAT's decision in 1992 to introduce debt funding into its capital structure for the first time.[98]

While INTELSAT should have the commercial freedom to manage its financial affairs as efficiently as possible, access to capital markets raises a number of issues. ISOs with government backing and associated privileges might be expected to have a lower cost of capital than a competitor such as PanAmSat. In practice there are many ways to arrive at an ISO's cost of capital. For instance it might be suggested that historically the ISOs' cost of capital was equivalent to the compensation paid to

Signatories. Because investment funds were raised from Signatories, through a wholly internal transaction, the actual cost of capital was that borne by the Signatories. In return Signatories were able to charge monopoly rents for services and received a dual rate of return from the sale of ISO capacity. Where the cost of money to a Signatory was lower than the compensation paid by ISOs, Signatories received a further gain. As an ISO, such as INTELSAT, introduces debt capital, a prime consideration in its cost of capital is the rating applied by credit agencies. Such ratings will be highly related to government backing expressed through treaties and the privileges they confer. Another way to look at an ISO's cost of capital is the return to Signatories. Seen in this way INTELSAT's cost of capital has been relatively high (i.e. 14 per cent) but may be eased with the progressive introduction of debt capital.

While the capacity expected to be provided via private international systems by 1995 is minimal compared to that of the ISOs and further limited by co-ordination restrictions on connections to the PSTN, increased competition in the provision of services is likely in the second half of the decade. Much of this competition may come from separate satellite systems owned by Signatories and between ISOs. In addition the share of international traffic handled by "non-Signatories" together with the challenge of rapidly advancing alternative technologies, all suggest the traditional role of ISO needs to be vigorously debated.

While proponents claim ISOs equitably develop and maintain international connectivity for developing countries, the level and direction of support is not transparent under current arrangements. Although it is often assumed that thick route satellite communication subsidise the provision of thin route services, this is not self evident. A factor counting against the assertion of cross subsidisation is that satellite technology can enable the provision of services at uniform cost. Uniform tariffs along routes with varying traffic intensities do not imply cross subsidisation in satellite communication. As INTELSAT's uniform charges are set to recover costs, and contributions to capital costs are made based on usage, by definition all Signatories are paying their way. While discounts are available on all routes (thick or thin) for long term commitments the system may benefit more sophisticated Signatories to a greater extent. In addition as the ground segment is owned by Signatories or users, this is not a variable cost borne by ISOs.

It may be that INTELSAT's mandate to provide global connectivity has imposed certain costs not incurred by specialised separate systems (e.g. greater reserve capacity). Offsetting these costs are benefits such as taxation privileges, government support in international frequency allocation proceedings, spin-offs from civil space programmes, economies of scale and reserved services. Yet if serving thin routes does impose additional space segment cost, it presumably also confers competitive advantage along these routes. Hughes Communications New Venture Group have commented, "The liberalisation of telecommunication regulations internationally, combined with digital technology advances, is opening up the market for thin route satellite applications."[99]

The fact that competitors are willing to risk substantial amounts of capital in the face of these advantages suggest they believe the market is not currently operating at an optimal level of efficiency. However if the market entry is attractive only because uniform ISO tariffs create an opportunity for "cream skimming", fibre optic cables are likely to make a significant impact on such calculations. If London - New York satellite traffic ever has cross subsidised Aregoa - Ankara this is not sustainable in the face of the relative cost trends of cable and satellite on the trans-Atlantic route. If satellites are not cost competitive on high density routes, system planners need to emphasise those areas where satellites have significant advantages. Together with developments driving the provision of services to end users, this should act to enhance the focus on developing regions.

Competition does not pose a threat to global connectivity, not least because there are immense externalities from connectivity between all countries. This does not mean problems that have been experienced in the transition to competitive national communication markets may not emerge. One such problem is that existing operators may seek to cross subsidise competitive areas from monopoly rents. Uniform tariffs currently act to mitigate such an eventuality. Yet without transparent cost allocation there is little way of knowing whether areas not served by competition are subsiding the provision of advanced capabilities necessary to compete with fibre optics. One reason for scepticism over past cross subsidy arguments is that the data necessary to test such an hypothesis has not been systematically collected. An alternative view is that there is adequate control of this aspect through Signatories in the governing Boards protecting their own interests and through government regulatory authorities having oversight and control of certain matters dealt with in the Boards.

In 1992 INTELSAT commented in respect to its research and development programme,

> *"Given the prospective growth in competition from separate satellite systems, and recognising the very large R&D investments which continue to support competing fibre-optic systems, pursuit of primary R&D targets represents the most beneficial use of a resource unique to INTELSAT."*[100]

If INTELSAT's overall strategy is primarily driven by competition with fibre optics and separate satellite systems, it raises the question of whether this is the most efficient means of developing communication infrastructure appropriate for all countries. For instance the technological innovation necessary to compete with fibre optic cables, offering advanced services not yet in widespread use in developed countries, could in principle increase space segment cost to Signatories. This may be offset by R&D that improves system efficiency and reduces cost.

While Signatories pay an investment share proportionate to their utilisation this formula may not allocate costs against causation. A Signatory that primarily makes use of plain old telephone services rather than leading edge satellite applications could find its contributions or liabilities rising to pay for advanced capabilities. This may be further exacerbated as Signatories in some countries shift traffic from satellite to fibre. If these PTOs have lower investment shares their incentive to use alternative technologies, in which they have greater equity, rises. This may be one factor in INTELSAT's decision in 1992 to raise the future rate of return for Signatories from 14 per cent to 16 per cent. This rate is superior to the current return of many Signatories and certainly outweighs returns from most national satellite systems.

While Signatories can request investment shares greater or less than their relative utilisation percentage, a minimum of 0.05 per cent applies. In December 1991, 35 Signatories held the minimum investment share. As competition increases the ISO response is likely to involve utilising more advanced technologies and reducing tariffs in contested areas. This is one reason why there needs to be increased transparency in cost allocation within the ISOs to all Signatories and appropriate government regulatory authorities. This would contribute toward fair competition for separate satellite systems and ensure that cost causation principles are applied to charging for advanced services.

SECTION V. SUMMARY

A key finding of this report is that certain forms of regulation that may have once been appropriate for the development of satellite technology are now restraining efficient application. Satellite technology is evolving toward the provision of services to end users rather than merely connecting networks. International market structures still reflect the traditional role of ISOs while past technological, geographical and commercial distinctions are rapidly receding. The current structure (including the inability of non-PTOs to own and operate earth stations, lack of unbundled space and ground segment rates, and the lack of direct access) is producing a number of market distortions in terms of price and the efficient use of all available technologies. ISOs could be permitted to commercialize this potential as efficiently as possible, upon consideration of removing the obligations and privileges they have as treaty organisations. If they are not permitted to market sevices directly to users they will be increasingly by-passed by "non-Signatory" carriers and Signatories with cable-based strategies. Separate satellite systems should be encouraged to apply market disciplines.

In some cases reform that recognises these changes is being initiated. Elsewhere policy-makers will face increasing pressure to react as the pace of change increases. Satellite providers may find it increasingly difficult to plan precisely for their future needs. Consequently, in some circumstances, there may be excess capacity. Some contend this capacity may have been initiated as an anti-competitive measure by the ISOs.[101] This claim is rejected by ISOs and there may be shortages in some areas, as indicated by plans for increased capacity (e.g. South East Asia). They point to oversight by governing boards, and where applicable government regulatory authorities, as providing a guard against anti-competitive practice. It is important to note that under current arrangements satellite organisations, such as INTELSAT and EUTELSAT, will not be able to efficiently market this capacity. There is a need for direct access or other improved access options to stimulate new services and lower prices to encourage use of available capacity. If this does not occur system costs for all Signatories will be higher than necessary. This could draw resources away from those countries least able to afford communication development.

The principles for structural change to the satellite services market, suggested by the European Commission, provide sound guidelines for OECD countries that have not already initiated policy reform. Full commercial freedom for space segment providers and users can be expected to improve efficiency. However several other steps would seem to be advisable given the experience of liberalisation in national markets such as a clear separation of regulation of international communication markets and commercial decision making. In the interim greater transparency in the pricing of international satellite services should be encouraged. Unbundling price information including the publication of ISO and Signatory tariffs for a service would increase transparency for end users and allow international efficiency comparisons. Extending liberalisation of resale, while allowing users greater operational flexibility, would need to be coupled with measures such as direct access or other improved access options before it would act to apply substantial price disciplines. In this regard, consideration needs to be given to measures that could ultimately facilitate direct access or otherwise improve space segment access, such as the closer alignment of rates to their respective costs. This should be ensured through effective regulatory mechanisms in each country. Other factors to be taken into account could include the unique characteristics of particular national markets (i.e. whether effective separation of regulatory functions from commercial decision-making has been accomplished), and distinguishing features of particular user segments, such as users of television services.

The financial impact of direct access on PTOs may be minimal because satellites could remain a technology serving niche markets for the foreseeable future. The greatest impact is likely to be on PTOs responsiveness to users in the provision of international communication. For the future it should be a commercial decision for all Signatories as to whether they retain a shareholding in all three ISOs or whether a restructuring occurs. When competitors gain an agreed market share of global satellite traffic, ISOs could be given the option of remaining as carriers of last resort or relinquishing privileges. Uniform ISO tariffs should be retained unless a clear case can be made for greater cost causation on an a particular route. Greater liberalisation will not penalise thin route services because cost trends clearly favour fibre optics over thick routes. On the contrary increased competition can be expected to benefit thin route services where the application of satellite has maximum strength.

GLOSSARY OF TERMS

AMSC	American Mobile Satellite Corporation
Anik	Canadian Satellite
ARABSAT	Middle Eastern Satellite System
ASC	American Satellite Company
AsiaSat	Asian Satellite System
ASST	ASST handles Italy's intra-continental traffic
Astra	Luxembourg Satellite System
AT&T	American Telephone and Telegraph
AUSSAT	Australian Satellite System (Now called Optus)
B-Sky-B	A direct satellite broadcasting system in the UK
BT	British Telecom
C&W	Cable & Wireless
COMSAT	Communications Satellite Corporation
DAB	Digital Audio Broadcasting
DAMA	Demand Assigned Multiple Access
DATEs	Duly Authorised Telecommunications Entities
DBP Telekom	Deutche Bundespost Telekom
DBS	Direct Broadcasting Satellites
DCME	Digital Circuit Multiplication Equipment
DTH	Direct to Home Broadcasting
EC	European Community
7uESA	European Space Agency
ESA	The European Space Agency
EUTELSAT	European Telecommunications Satellite Organisation
FCC	Federal Communications Commission
GE	General Electric Corporation
GTE	GTE Communications Corporation
Hispasat	Spanish Satellite System
IBM	International Business Machines
ICP	Instituto das Communicações de Portugal
IDC	International Digital Communications
INMARSAT	The International Maritime Satellite Organisation
INTELSAT	The International Telecommunications Satellite Organisation
INTERSPUTNIK	An International Satellite Organisation based in former USSR.
Iridium	Proposed low earth orbit satellite system
ISO	International Satellite Organisations
KDD	Kokusai Denshin Denwa
Kopernikus	German Satellite
LEO	Low Earth Orbit
LMES	Land Mobile Earth Stations
MAOU	Minimum Assignable Unit of Ownership
MCI	MCI Communications Corporation

MCS	Maritime Communications Sub-systems
MSAT	Canadian Mobile Satellite System
Optus Communications Ltd	Australian Public Telecommunication Operator
PanAmSat	Pan American Satellite System
PSTN	Public Switched Telecommunication Network
PTOs	Public Telecommunication Operators
SBS	Satellite Business Systems
SNG	Satellite News Gathering
SES	Société Européenne des Satellites
SMATV	Satellite Master Antenna Television
TAT	Trans Atlantic Cable system
TDMA	Time Division Multiple Access
Tele-X	Swedish Satellite System
Teleglobe	Canadian International Telecommunication Carrier
Telstra	(former Australian and Overseas Telecommunication Corporation) Telesat
Telestat	Canadian Satellite carrier
TPC	Trans Pacific Cable
Turksat	Turkish satellite System
TVRO	Television Receive Only
VSAT	Very Small Aperture Terminal

NOTES

1 Irving Goldstein, "INTELSAT: Embracing change in the International Telecommunications Environment", Europa 1992 Communications, Atalink, 1992. p 123.

2 With the exception of the European Broadcasting Union.

3 In some cases users can deal directly with ISOs if they seek permission from the Signatory where service is to be provided or they are outside a territory with a Signatory.

4 Denton Hall Burgins & Warren, "Direct Access to the Space Segment", a Study prepared for Directorate General XIII of the Commission of the European Communities, 1992.

5 Dawn Hayes and Karen Lynch, "Star Wars", *Communications Week International*, 21 September 1992, p. 22

6 VSAT's are based not just on size but also on the particular system formats and control techniques.

7 Canadian Radio-television and Telecommunications Commission, "Telecom Decision CRTC 92-17", Ottawa, September 1992. p. 17.

8 In addition major carriers are moving to share fibre networks. Refer Dawn Hayes "Carriers to Pool Global Fibre Systems", *Communications Week International*, 19 October 1992. p. 7.

9 For a lay-person's guide to the engineering aspects of satellite communications consult Robert M. Walp, "Communication Satellites: Technology Applications and Future Prospects", Centre for International Research on Communication and Information Technologies, Policy Research Paper No 6, Melbourne, 1991.

10 *Ibid.* p. 3.

11 *Ibid.* p. 4.

12 In practice the cost of the ground segment can be affected by location. For instance satellites are sometimes designed to concentrate power over a certain area to reduce reception costs rather than providing a uniform cost across the whole footprint.

13 Jon Chaplin, "Development of satellite TV distribution and broadcasting", *Electronics & Communication Engineering Journal*, February 1992, p. 38.

14 Denton, Hall, Burgins & Warren, *op cit.*

15 Some Governors represent more than one Signatory. By combining the shares of smaller Signatories around 85 per cent of the members, representing 91 per cent of the share-holding, were represented on this governing board in 1992.

16 INTELSAT, 1991/92 Annual Report, Washington, 1992.

17 *Ibid.* pp. 26-27.

18 INTELSAT, (Correspondence), November 1992.

19 Denton Hall Burgins & Warren, *Op cit.* p. 33.

[20] INMARSAT, 1991 Financial Statements, London, 1992. p. 3. INMARSAT's return on total financing amounted to 11.7 per cent in 192, compared to 16.3 per cent in 1991. Return on total financing represents INMARSAT's surplus of revenues over expenditures before interest and tax payments, divided by average total financing (long-term liabilities plus equity).

[21] Denton Hall Burgins & Warren, *Op cit*. p. 34.

[22] EUTELSAT, 1990 Annual Report, Paris, 1991. p. 28.

[23] Signatories are, of course, taxed nationally on their returns from ISOs as part of their overall operations. Exemption from taxation, customs duty etc. does ensure host governments do not receive double taxation. However from the standpoint of new market entrants treaty privileges confer competitive advantages on ISOs. If ISO privileges were assessed to be a problem in a competitive market, one possible option would be for taxation to be levied at the rate of the host country and distributed to Parties (i.e. governments) according to their Signatories investment share. This would avoid windfall gains by the host government but assist in creating a level playing field.

[24] Hayes and Lynch, *Op cit*. p. 25. Refer also Jean Grenier, "EUTELSAT - in a Decade of Competition", Europa 1992 Communications, Atalink, 1992, p. 139.

[25] Dawn Hayes, "INTELSAT To Float Bonds", *Communications Week International*, 20 April 1992, p. 8.

[26] INMARSAT, "1991 Annual Review", London, 1992, p. 25.

[27] Olof Lundberg, "INMARSAT: A perspective on the growth of Mobile Satellite Services", Europa 1992 Communications, Atalink, 1992. p. 131.

[28] INTELSAT, "INTELSAT Focus: Central & Eastern Europe: A Survey of Recent Service Developments & Network Applications in Central & Eastern Europe", Washington, 1992.

[29] Telesat became a member of Telecom Canada by virtue of a Connecting Agreement in 1976. The terms of the agreement provided the company with an after tax minimum rate of return being the after tax weighted average return on the common equity achieved by Bell Canada and British Colombia Telephone Company. The agreement was amended in 1985 with settlements limited to C$20 million until 1987.

[30] Douglas Goldschmidt, "Leveling the Playing Field", *Telematics and Informatics*, Vol. 4, No. 2, 1987, pp. 121-132.

[31] Albert D. Wheelon, "Trends in Satellite Communication", Paper presented to the 4th world Telecommunications Forum, Geneva, 28 October 1983. Refer also Goldschmidt, *Op cit*.

[32] Future Systems Incorporated, "The Impact of Future National and Regional Communications Systems on INTELSAT", prepared for the Office of Telecommunications Policy, Gaithersburg, February 1978, p. 4.

[33] Grenier, *Op cit*. p. 139

[34] CCIR, *Satellite Communications Handbook*, ITU, Geneva 1988, p. 107.

[35] International Institute of Communications, "Telegeography 1992", London, September 1991.

[36] Goldstein, *Op cit*. p. 125

[37] Office of Space Commerce, "Space Business Indicators", U.S. Department of Commerce, June 1992.

[38] Comission of the European Communities, "Towards Europe-wide systems and services - Green Paper on a common approach in the field of satellite communications in the European Community", Communication from the Commission, Brussels, November 1990, p. 14.

[39] Jon Chaplin, "Satellite Communications Systems - An Overview", IBC Conference on Satellite Communications, London, 1992.

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