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DEVELOPMENT OF SATELLITE TELECOMMUNICATIONS DURING THE PERIOD 1990 - 2005

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SUMMARY

The global telecommunications market is in the midst of a radical restructuring program. This is driven by the desire of governments to increase competition in existing markets and of companies to diversify their service product portfolio. These changes are taking place as a result of advances in technology as well as three powerful and interconnected forces - privatisation, globalisation and liberalisation.

Introduction of new technologies in the form of Integrated Services Digital Networks (ISDNs) and sophisticated integrated terminal equipment has resulted in the transformation of the telecommunications services market from mainly a single service industry limited by technology constraints into a multi-service industry limited by applications. As a result of privatisation and globalisation, the former national telecommunications carriers are begining to expand overseas in order to grow. In regions where the market regulations have been liberalised, the changes have effectively shattered the highly protected and monopolistic national markets.

These changes when incorporated into the present satellite communications industry indicate a shift in traffic structure as well as in the global satellite market structure.

1 INTRODUCTION

The theoretical concept of long distance communications using satellites was originally forwarded by Clarke[1] in 1945. This considered three satellites located in a geostationary orbit, 22,300 miles above the equator, acting as repeater stations for terrestrial point-to-point communications.

The first communications satellite functioned as an indirect repeater, storing a message transmitted on one part of its orbit and then transmitting it during another part of its orbit. In order to try and achieve direct point-to-point telecommunications, experiments were carried out using aluminium coated balloons which were approximately 100 ft in diameter. Ground stations, located at a large distance from each other were able to communicate by using the balloons as passive transmitters (reflectors). These systems were of limited success because a very powerful transmitter and a highly sensitive receiver was required.

In order to overcome the power limitations of passive systems, the satellite was required to act as an active transmitter, receiving a signal, amplifying it and then transmitting it to the appropriate Earth station. This principle was employed in 1962 by Telstar 1 which operating from a low Earth orbit, allowed television pictures to be transmitted across the Atlantic. However, as a result of its altitude, the satellite was unable to remain simultaneously in the line of sight of two ground stations for more than ten minutes during its two hour orbit.

The subsequent development of more powerful launchers allowed the Relay series of satellites to be placed at a greater altitude. This allowed the connection period between stations to be increased to thirty minutes. However, in order to provide a permanent link between two Earth stations, forty eight equally spaced satellites would be required at this operating altitude. Moreover, ground stations would require large, highly accurate, moving antennae for satellite tracking as well as telecommunications. As a result of the prohibitive costs associated with such a system, the approach of low altitude satellites providing permanent links between Earth stations was abandoned.

Finally in 1964, the continued advances in launcher technology as well as a satellite which incorporated innovatively designed electronics and stabilization systems allowed a communications satellite to be placed into a geostationary orbit. Since the time period at this altitude is equal to the period of rotation of the Earth, the satellite remained at a fixed location above the Earth in the equatorial plane. This allowed ground stations located within the footprint of the satellite to be connected permanently and thus demonstrated the use of long distance satellite communications as a viable alternative to terrestrial communications links.

The domestic terrestrial communications industry was already well established in developed countries by the early sixties. However, long distance transoceanic communications were limited to poor quality, high frequency radio services and a few low capacity point-to-point submarine cables. Overland communications employed chains of microwave line-of-sight links on long distance backbone routes across countries and continents. However, the microwave links require repeater stations to be located within the line of sight of the transmitter. Given the problems associated with transoceanic communications using conventional means of signal transmission, the commercial potential of satellite communications was recognised early by the industry.

In order to reach a compromise solution regarding the ownership of an international communications system, the Communication Satellite Corporation, Comsat, was established in 1962 by the Federal Communications Commission in the United States with the mandate to establish a global satellite communications network. Along with 12 other nations, the United States established the International Telecommunications Satellite Organisation, Intelsat. This was an international consortium to own and operate a global satellite communications network.

The introduction of international satellite communications allowed domestic communication infrastructures to be linked to form a global telecommunications network. The growth both in the revenues and the number of member countries which form the consortium has reflected the growth of the satellite communications industry since its inception.

2 TELECOMMUNICATIONS TECHNOLOGY

The development of the telecommunications services industry is typical of any technology intensive industry. Although the industry is regarded as being global, the relative quality and number of services provided differs tremendously from one region to another.

2.1 Multimedia Evolution

Until recently, the global telecommunications transmission infrastructure consisted of analogue lines and exchanges capable of voice communications with a much smaller infrastructure for data transfer by means of telex. This infrastructure is well established globally although the quality and accessibility vary regionally.

The technological progress and diffusion of personal computer systems and terminal equipment capable of digital transmission led to the introduction of ISDNs (Integrated Services Digital Network), mainly in the developed telecommunications regions of Western Europe and the United States. This has allowed the bandwidth (maximum telecommunications volume) of a transmission cable to be increased by means of digital compression techniques. The quality of the signals received from a digital transmission system is much better than an analogue system. Digital transmission systems also allowed the introduction of low power, compact transmitters.

The introduction of national ISDNs has led to a tremendous increase in the range and quality of services which can be offered over the same network. This has resulted in so-called "multimedia evolution" with a diversification in the product portfolio of the industry, as shown by figure 1. As a result of the diversification, the percentage of revenues generated by voice telephony has decreased steadily, as shown by figure 2.

The telecommunications services technology can be sectored by applications, as shown by figure 3. The sectors consist of voice telephony, data/fixed image transfer and moving image transfer with further subsectors in each sector. The relative sizes of the sectors vary depending on the geographical region as well as the regional diffusion of appropriate terminal equipment. For example, data transfer, in 1989, accounted for 20 percent of the revenues of US Public Telecommunications Operators, whilst in the European Community, this figure was 9 percent. These regional differences are considered[2] to arise from technical, regulatory and economic differences. The future breakdown of revenues[3, 12] generated from various telecommunications applications is shown in figure 4.

2.2 Interconnection of Markets

The market for international telephony has been described[4] as undergoing a "paridigm shift". A few years ago international telecommunications was operated by the national Public Telecommunications Operator (PTO) which interconnected their national domestic circuits to provide end-to-end international telecommnications channels. These facility based "heavy carriers" jointly own Intelsat and through it the international satellite systems which are the essence of the international telecommunications infrastructure.

The advances in network hardware and software along with the liberalisation of national markets through deregulation have altered this model of the telecommunications infrastructure. New "light carriers" have entered the market. They provide international telecommunications service by re-programming the route offered by the PTOs. These carriers are primarily software based and allow the user to choose the cheapest route over the interconnected international network. This is illustrated well by the behaviour of the Canadian carriers. In order to take advantage of cheaper satellite charges in the US, Canadian international calls are transmitted via terrestrial telecommunications links to the United States before being transmitted to satellites.

2.3 Development of Satellite Transmission Technology

Satellite telecommunications has also developed significantly since the days of the Telstar and Relay series. Commercial telecommunications satellites are usually located in geostationary orbits and are used simultaneously for television and telecommunications transmissions.

The growth in capacity, that is to say the number of voice paths per satellite, is well illustrated by the charting the capacity growth of the Intelsat series of satellites, shown in figure 5. In addition to having several hundred times the capacity of the early satellites, present day communications satellites also have much greater design lives. As a result of the increased capacity per satellite, the cost of establishing a satellite voice link has dropped dramatically since its inception, as shown by figure 6.

For the Intelsat series of satellites, the decrease in the cost per voicelink has been achieved by progressively increasing the total transmission bandwidth avaliable on each satellite, until the Intelsat VI series which had a total voice transmission capacity of 80,000 lines. The figure for the next generation Intelsat VII series has decreased slightly as fears of placing too great an investment and reliance on one satellite have arisen. Given these fears, the future bandwidth capacity per satellite is unlikely to exhibit the sustained high growth rates which have been observed to date. Any future growth in capacity is likely to result from electronics, software and digital modulation advances rather than from an increase in the number of transponders per satellite.

2.3.1 The great debate - Satellite versus Cable

Alongside the decrease in the cost of establishing long distance satellite telecommunications links, the cost per link using cables has also decreased steadily. In the eighties, the maturing of fibre-optic technology allowed an increase in the capacity of trans-oceanic cables and as a result, a large decrease in the cost per voicelink.

A study[5] looking at the relative advances in satellite and cable communications technology appears to indicate that the two technologies are complementary with cables having the advantage for short high traffic runs. The study also suggests that future costs of voice links via cable networks are likely to be much cheaper than comparable satellite links.

Another study[6], based upon the assumption that satellite technology remained at present levels concluded that the cost per voice link for satellite systems were favourable compared to the per link cable costs and that satellites links were likely to remain competitive with fibre optic cables over the period 1995-2005. This conclusion has also been attained by other authors[7,8,9] although, depending on the emphasis of the study, a slight advantage is attributed to either system.

A breakdown of the planned trans-oceanic cable and satellite capacity (based on Intelsat planned satellite launches) up to the next century is shown in figure 7. This shows that the number of voice links for cables and satellites across the Atlantic over this period will be similar whilst the satellite capacity across the Pacific will be lower than for cable.

In the long term, cables are likely to provide the majority of point-to-point transmission links over long distances whilst satellite transmission will continue as the primary medium for broadcast signals such as television transmissions, mobile communications etc., which are often aimed simultaneously at multiple destinations.

3 TELECOMMUNICATIONS MARKETS

3.1 Global Telecommunications Markets

The global telecommunications market is immense, with total revenues of $US 400 billion[2, 10] in 1990. The market for telecommunications services constituted approximately 67 percent of this figure during the same year. This breakdown has remained constant since 1985.

Studies[11, 12] have indicated that there is a correlation between the economic growth of a country, its investment in telecommunications and a reciprocity in this behaviour. A good telecommunications infrastructure is viewed, with regards to the regional economuc growth, in the same light as a good transport infrastructure. Underdeveloped countries and regions are looking to rapidly establish an adequate national and international communications infrastructure in order to compete for investment with other more developed countries.

Along with the above mentioned effect of economic growth on telecommunications services, it is also influenced by the technical and regulatory climate. As a consequence of the differences in these factors in various regions of the world, the size of regional telecommunications infrastructures as well as their technical and regulatory complexities, vary. Therefore, it is very difficult to formulate an accurate representation of the relative magnitudes of the regional telecommunications markets.

For this study, the global telecommunications market is structured separately for intra-regional and inter-regional traffic.

3.2 Intra-regional market structure

The relative magnitudes of the intra-regional (domestic) telecommunications markets has been estimated by considering the number of lines in the fixed user line infrastructure. This, along with the frequency of use of the lines, will determine the operational revenue generated per line, and thus the regional market size, assuming that a large proportional of the calls are intra-regional.

The relative size of the regional markets based on the regional fixed user line infrastructure[13] is given in table 1. This was coupled to the regional population distribution, given in table 2, to obtain the regional penetration rates, given in table 3.

Since the revenues generated in each region are likely to be proportional to the usage and the cost of the lines as well as the number of lines, a series of relative factors for the former variables was estimated. These factors were considered to be dependent on the regional fixed infrastructure penetration and are given in table 4.

The combination of these factors along with the relative magnitudes of the regional fixed infrastructures yields the relative magnitudes of the revenues generated from intra-regional telecommunications. This is shown in table 5.

In terms of the revenues generated, the North American and Western European markets are the largest and together comprise 60 percent of the global fixed network. Japan, the Eastern European countries (including the former Soviet Union) and Asia (including Australia and New Zealand) have similar sized markets while Africa and the Middle East have the smallest markets and together generate only 5 percent of the global revenues.

The penetration of fixed telecommunications infrastructures, that is to say, the number of lines per 100 people is shown in figure 9. The average global penetration is 12 links per 100 inhabitants. Three markets, North America, Japan and Western Europe exceed the world average penetration substantially and are regarded as having the most developed regional communication links. The African and Asian markets have penetration rates substantially below the average. The Eastern European market has a penetration approximately equal to the world average while the Latin American and Middle Eastern markets have penetration rates below the average. Regional markets with penetration rates at or below the world average are regarded as under-developed markets and therefore have the greatest potential for growth.

The growth rates of the regional markets for intra-regional voice and data telecommunications have been obtained from a variety of sources. These are shown tabulated in table 6 and in figures 10 and 11 respectively.

3.3 Inter-regional Telecommunications

The inter-regional telecommunications market has been estimated from international telecommunications traffic flows surveyed by the International Institute of Telecommunications[4]. The survey considered the total number of minutes of telecommunications traffic (miTT) originating from various the regional markets. This incorporates the frequency of calls made over a given line as well as the number of lines. Assuming that the cost per unit time is the same globally, it is a reflection of the revenues generated from a particular region. The regional breakdown of this market is tabulated in table 7 and is shown in figure 12.

The estimated figures have been obtained by considering the total inter-regional traffic as a ratio of the regional fixed infrastructure[13] to the world fixed infrastructure magnitude

$$\text{International traffic from region (miTT)} = \frac{\text{Regional (fixed lines)}}{\text{World (fixed lines)}} \times \text{World Market (miTT)}$$

Western Europe dominates this market with nearly 50 percent of the global traffic originating from this region. A large proportion of this traffic originates from the three major countries, Germany, United Kingdom and France. While approximately 40 percent of their traffic is intra-regional, 80 percent of the traffic from smaller countries within the region is intra-regional.

The volume of telecommunications traffic between Western Europe and Eastern Europe remains small. The movement of Western European companies into Eastern Europe and their inherent dependence on telecommunications is regarded[2] as being a catalyst for the upgrading of local infrastructure. At the moment, the demand for links between the two regions is partially compensated for by mobile communication systems.

In order to develop the Eastern European telecommunications infrastructure to Western European standards, it has been estimated[14] that an annual investment of $US 6bn is required. However, current investments have averaged at $US 3.5bn. It is therefore unlikely that the traffic between Eastern and Western Europe is likely to experience a rapid increase over the short-term period. Along with this, any short or medium term requirements, especially for broadband communications are likely to be served by temporary infrastructures such as satellites until the fixed transmission infrastructure is expanded.

The North American market occupies equal market share for both intra-regional and inter-regional telecommunications. The distribution of traffic destinations for this market is much greater than for either Western Europe or the Asian market.

The other major inter-regional telecommunications market is Asia. During the eighties, there was a large increase in the traffic between the Asian and North American markets as a result of the increasing economic and cultural ties between the two regions.

The Japanese share of the inter-regional telecommunications market remains small and its telecommunications market remains comparatively insular. This is evidenced by the small inter-regional to intra-regional traffic ratio for this market compared to the United States or the United Kingdom. as illustrated by the table below

Market	Inter-Regional Traffic Volume / Intra-Regional Traffic Volume
Japan	0.2 %
United States	1.0 %
United Kingdom	2.0 %

A large volume of telecommunications traffic from all market regions remains intra-regional. This is illustrated in table 8. The figure is greatest for Western Europe where nearly 70 percent of international calls are of this type. This, to a lesser extent, is also the case for North America and Asia. The increased European figure may be due to the high degree of intra-European trade which exsists as a result of the European Community.

The world market for international telecommunications is estimated[4] to grow at an average growth rate of 16 - 26 % per annum until 1995. The growth rates of the main regional markets for inter-regional voice and data telecommunications has been obtained from a variety of sources and is given in table 9. Although the growth rates have been specified in the literature upto 1995, it has been assumed that they extend extended to cover the period upto 2005. The global average growth rates have been assumed for the cases where growth rates are unavaliable. The inter-regional data traffic growth rates have been assumed to be twice the voice traffic growth rates.

4 SATELLITE TELECOMMUNICATIONS MARKETS

Satellite Telecommunications forms an integral link in the global telecommunications infrastructure. The satellite infrastructure was established by the public telecommunications operators to interconnect domestic telecommunications markets. Through their shares in the Intelsat consortium, the operators also own the satellite infrastructure. Although privately owned satellites are beginning to make an appearance onto the market, regulations prevent them from transmitting end-to-end international public telecommunications. However, with the deregulation of the terrestrial markets, increasing pressures are being exerted onto governments and regulatory bodies to relax regulations governing satellite transmission.

4.1 Satellite Operators

In its embryonic stages, the market had a single operator, Intelsat. This was a non-profit organisation established initially by 13 countries. As of early 1990, the consortium had grown to include 119 countries. These countries, through their public telecommunications operators own a share of the consortium. Intelsat operates by selling capacity to its customers, namely the PTOs who in turn resell it to users.

The operating revenues generated by Intelsat in 1990 was $600 million while it has been estimated[15] that this capacity is resold by the PTOs to their users for $ 7 billion. The cartel owns and maintains satellites around the world for use by public telecommunications operators to link one intra-regional infrastructure to another and thus to facilitate inter-regional telecommunications links. The growth of the world satellite communications industry is well illustrated by the growth in operating revenues of the Intelsat organisation over this period, although this is a fraction of the overall revenues generated by satellite telecommunications.

Intelsat's monopoly for international traffic is protected by regulations which prohibit separate systems from carrying public traffic. An article proposed by the United States at the inception of Intelsat requires member telecommunications operators to coordinate with Intelsat before initiating satellite systems which could appear to be competitive with the Intelsat system.

The other global telecommunications organisation, Inmarsat, carries maritime and aeronautical voice, fax and data traffic. Its ownership structure is similar to that of Intelsat although its much smaller in size, operating with a small number of its own satellites and leased capacity on Intelsat satellites.

In recent years other regional satellite systems have been established. The revenues for these systems are generated mainly from regional television transmission rather than from telephony.

A recent study[16] into the cost of international telecommunications charges revealed that customers are being charged at approximately 2 to 4 times the actual cost of delivering the call. This is well illustratrated by the fact that the London to Paris call which costs approximately three times the London to Birmingham call. It has also been estimated that a call from the United Kingdom to the United States should be approximately equal to a long distance call in the United Kingdom whereas its actual cost is five times this value.

These high call charges are regarded as being restrictive to the growth of satellite communications. The reason for the high call charges has been attributed to the accounting system which divides up the revenues between the operators who transmit and those which receive and ultimately deliver the call. This allows the receiving PTO to be paid at four times the charge for delivering the call and as a result, the transmitting PTO must charge the caller excessively. A number of PTOs, especially in countries with underdeveloped telecommunications networks use the excessive charges to subsidise their domestic call charges.

A number of private satellite operators have entered the market in recent years although their market share remains small. The goal of these operators is an "open skies" policy where all the satellite operators compete on equal terms. Such a system would result in fierce competition for the provision of the space segment of the communications link. Terrestrial network technology already allows for calls to be routed along the cheapest path. This could be incorporated into the space segment as well and ultimately the behaviour of the space segment would reflect the structure of the terrestrial market.

4.2 Satellite telecommunications markets

The maximum operational volume of traffic which a satellite can administer is dependent on the overall bandwidth of the satellite. This in turn depends on the number and type of transponders on board the satellite.

In the present study, it has been assumed that the satellites contain either C-band transponders, with a bandwidth of 36 MHz or Ku-band transponders with a bandwidth of 72 MHz. The number of satellites, their regional distribution and the number and types of transponders on board for 1990 was tabulated by Interavia[17].

The total regional bandwidth avaliable is shown in table 10. The Intelsat and Inmarsat bandwidth has been divided regionally according to the distribution of international telephone calls (miTT distribution), shown in figure 12. This is based on the assumption that the international operators' bandwidth capacity is directly proportional to the international traffic distribution.

The study also assumed that international telecommunications accounted for an average of 40% of the satellite bandwidth in any region with the remainder being divided equally between domestic telecommunications and television transmission.

The domestic traffic was considered to be 80% voice transmission and 20% data transmission. This distribution was formulated from the domestic revenue distribution in the OECD countries in 1990. Although the volume of domestic data transfer is probably below 20%, the greater bandwidth requirements of this type of data are likely to produce the above distribution.

The international traffic was considered to have a greater volume of data transfer traffic than domestic communications. This was coupled to the greater transmission bandwidth requirement of this type of data in order to obtain the inter-regional bandwidth distribution. The resulting regional bandwidth distributions are shown in figure 15. This has been broken down for each region by application in the ratios shown by figure 16 to yield regional bandwidths for each application as shown by table 11.

The regional terrestrial growth rates for each of the application sectors was then imposed. The subsequent regional bandwidth requirements for 1995, 2000 and 2005 are ahown by application sector in tables 12-16. A summary of the overall bandwidth requirements for the global satellite telecommunications industry is given in table 18 (a) and shown in figures 17(a) and 17(b).

It is considered that through technological advances, particularly by means of digital encoding techniques, the bandwidth capacity per satellite will increase over this period. This will, of course, affect the number of satellites required. In order to take this effect into account, the number of satellites required has been estimated for satellite capacity increases of 0, 10, 25 and 50%. This is tabulated in table 17.

The minimum and maximum number of satellites required given the minimum and maximum bandwidths required for 1995, 2000 and 2005 was calculated for the various capacity growth rates and is summarised in table 18(b) and is illustrated by figures 18(a) and 18(b). In the short term, the number of satellites required is likely to be reflected by the lower capacity growth rates of 0 and 10% whilst in the latter part of the tiimescale, the number of satellites is likely to be reflected by the higher capacity increases.

The study indicates a shift in the composition of the traffic from being mainly based on voice telecommunications to being based on data and television transmissions.

4.3 Satellite Television

The regional growth rates for television terminals have been estimated by the British Broadcasting Corporation[18]. It has been assumed, based on the operational revenue breakdown of Intelsat that satellite television accounts for 30 percent of the total revenues generated.

5 CONCLUSION

The study concludes that satellite telecommunications is likely to grow substantially over the next fifteen years as a result of the growth of various sectors of the terrestrial telecommunications market.

The demand for the 1990 - 1995 period is estimated at between 10 and 30 additional satellites to be launched annually in order to satisfy the bandwidth demand, assuming a 10 percent increase per annum in satellite bandwidth capacity over this period.

The demand for the 1995 - 2000 period is estimated to be between -13 to 27 satellites launched annually assuming a 15 percent increase in the bandwidth capacity per satellite in this period.

It is difficult to determine the demand beyond this period and the figures estimated for this period should be treated with caution.

REFERENCES

1]	CLARKE, A C	EXTRATERRESTRIAL RELAYS Wireless World, October 1945
2]	SEMA GROUP MANAGEMENT CONSULTANTS	TELECOMMUNICATIONS SERVICES Panorama of European Community Industry 1991-1992
3]	UEHARA, K NISHIDA, H	LOOKING BEYOND THE FAX MACHINE The Global Telecommunications Traffic Report - International Institute of Telecommunications 1991
4]	STAPLE, G	THE YEAR IN REVIEW The Global Telecommunications Traffic Report - International Institute of Telecommunications 1991
5]	PEARCE, F	THE GREAT DEBATE - CABLE VERSUS SATELLITE Far Eastern Economic Review, vol 141, July 1988, pp59-61
6]	CROCKETT, B	THE CHANGING ROLE OF SATELLITES IN TELECOMMUNICATIONS Telecommunications (North America ed.) vol 23, June 1989, pp37-46
7]	BRADSHAW, D	TRAPPED IN A REGULATORY MIRE Financial Times Survey on International Telecommunications, April 1990
8]	PELTON, J N	THE SATELLITE COMMUNICATIONS INDUSTRY - NEW DOORS OPENING Telecommunications (North America ed.)vol 23, June 1989, pp59-60
9]	GILHOOLY, D	REWIRING EUROPE The Global Telecommunications Traffic Report - International Institute of Telecommunications 1991
10]	DIXON, H	THE SLEEPING GIANTS AWAKEN World Telecommunications, Financial Times Survey October 1990

11] SINGH, I B — NEW MARKETS FOR SATELLITE COMMUNICATIONS
Telecommunications (North American edition) vol 22, pp 88-96, 1988

12] KELLY, T — PERFORMANCE INDICATORS FOR PUBLIC TELECOMMUNICATIONS OPERATORS
OECD report, 1990

13] HAY, T
ROBERTS, S — INTERNATIONAL DIRECTORY OF TELECOMMUNICATIONS - markets, trends, companies statistics and personnel - 3rd edition
Longman, 1988

14] DANDELOT, M M — PROMOTING THE MODERNISATION AND EXTENSION OF TELECOMMUNICATIONS IN EASTERN EUROPE
FT Conference on World Telecommunications - Dec 1991

15] McLUCAS, J L — SPACE COMMERCE
Harvard University Press, 1991

16] DIXON, H — CARTEL DISTORTS WORLD ECONOMY
International Telecommunications - Financial Times Survey - April 1990

17] WILSON, A — INTERAVIA SPACE DIRECTORY 1991 - 1992
Jane's Information Group International Institute of Telecommunications 1991

18] BRITISH BROADCASTING CORPORATION — WORLD RADIO AND TELEVISIONRECIEVERS
International Broadcasting and Audience Research
June 1991

Regional market sector	Population distribution in 1990 (%)
North America	5.4
Western Europe	7.1
Eastern Europe	8.3
Middle East	3.4
Latin America	8.2
Japan	2.4
Africa	11.7
Asia	53.4
GLOBAL POPULATION	5,052 million

Table 1 Population distribution in regional markets - 1990 (ref 13)

Regional market sector	Fixed telecommunications infrastructure distribution in 1990 (%)
North America	31
Western Europe	32
Eastern Europe	9
Middle East	2
Latin America	6
Japan	11
Africa	2
Asia	8
Global Telecommunications infrastructure	630 million

Table 2 Relative size of intra-regional telecommunications markets based on the distribution of fixed telecommunications infrastructures (reference 13)

Regional market sector	Fixed infrastructure penetration in 1990 (per 100 inhabitants)
North America	72.0
Western Europe	56.0
Eastern Europe	13.8
Middle East	8.5
Latin America	8.5
Japan	54.0
Africa	1.8
Asia	1.8
Average global penetration rate	12.0

Table 3 Regional penetration rates for fixed telecommunications infrastructures

Penetration rate (per 100 inhabitants)	Relative user frequency	Relative overall cost
< 10	1	3
10 - 30	2	2
31 - 60	3	1
> 60	4	1

Table 4 Relative factors used for the estimation of operational revenues generated from intra-regional telecommunications infrastructures

Regional market sector	Relative market size for intra-regional telecommunications in 1990 (%)
North America	30
Western Europe	30
Eastern Europe	13
Middle East	3
Latin America	5
Japan	10
Africa	2
Asia	5

Table 5 **Relative magnitudes of intra-regional telecommunications markets (based on estimated regional operational revenues)**

Regional market sector	Intra-regional market revenue growth rate per annum (%)	
	Voice	Data (*)
North America	4 - 7	40 - 80
Western Europe	5 - 7	40 - 80
Eastern Europe	4 - 11	20 - 60
Middle East	5 - 20*	20 - 60
Latin America	10 - 20*	30 - 60
Japan	5 - 10	40 - 80
Africa	5 - 20*	10 - 20
Asia	10 - 20	30 - 60

(*) estimated figure

Table 6 Growth rates for intra-regional voice and data telecommunications markets (references - various)

Regional market sector	Relative market size for inter-regional telecommunications (%)
North America	32
Western Europe	48
Eastern Europe	6
Middle East	1
Latin America	3
Japan	2
Africa	1
Asia	6

Global market for international telecommunications = 30,000 million miTT

Table 7 Relative magnitudes of inter-regional telecommunications markets based on traffic flow measurements (reference 4)

Region	**Destination of inter-regional traffic (%)**			
	Western Europe	Asia	North America	South America
North America	19	10	38	8
Asia	10	40	18	n/a
Western Europe	68	31	1	n/a

Table 8 Destination of inter-regional traffic from major markets based on telecommunications traffic flow measurements (reference 4)

Regional market sector	Inter-regional market revenue growth rate per annum (%)	
	Voice	Data (**)
North America	15 - 20	30 - 40
Western Europe	12 - 15	24 - 30
Eastern Europe	16 - 26*	32 - 52
Middle East	16 - 26*	32 - 52
Latin America	16 - 26*	32 - 52
Japan	10 - 35	20 - 70
Africa	16 - 26*	32 - 52
Asia	20 - 30	40 - 80

(*) estimated figure

(**) the growth rates for international data transfer makets have been assumed to be approximately double the international voice telecommunications growth rate

Table 9 Growth rates for inter-regional voice and data telecommunications markets (reference - various)

Regional market sector	Satellite bandwidth distribution in 1990 (%)**
Intelsat (*)	20.0
Inmarsat (*)	0.3
North America	43.4
Western Europe	10.8
Eastern Europe	7.2
Middle East	1.8
Latin America	1.5
Japan	8.5
Africa	0.0
Asia	6.6

(*) International consortium
(**) Total global satellite bandwidth capacity (1990) = 103280 MHz

Table 10 Regional distribution of satellite bandwidth capacity (reference 17)

Regional market sector	**Bandwidth distribution (MHz)**				
	Domestic		International		Television
	Voice	Data	Voice	Data	
North America	12373	3093	10312	10312	15467
Western Europe	5801	1270	4235	4235	6342
Eastern Europe	2081	520	1735	1735	2602
Middle East	1932	483	1610	1610	2415
Latin America	519	130	433	433	649
Japan	2195	549	1829	1829	2744
Africa	50	126	420	420	649
Asia	1932	483	1610	1610	2415

Table 11 Regional distribution of satellite bandwidth capacity (by application)

Regional market sector	Satellite bandwidth requirements for intra-regional voice telecommunications (MHz)						
	1990	1995		2000		2005	
		minimum	maximum	minimum	maximum	minimum	maximum
North America	12373	15054	17354	19048	24340	22283	34147
Western Europe	5081	6809	7126	8690	9995	10563	14019
Eastern Europe	2081	2633	3507	3204	5909	3748	9957
Middle East	504	675	1254	862	3121	1048	7765
Latin America	519	696	1291	888	3124	1079	7996
Japan	2195	2942	3535	3754	5693	4563	9169
Africa	50	67	124	86	310	104	770
Asia	1932	3423	4807	5512	11962	8070	29776
TOTAL	24735	32299	38998	42044	64544	51458	113599

Table 12 **Estimated regional satellite bandwidth requirements for intra-regional voice telecommunications during the period 1990-2005**

Regional market sector	Satellite bandwidth requirements for intra-regional data telecommunications (MHz)						
	1990	1995		2000		2005	
		minimum	maximum	minimum	maximum	minimum	maximum
North America	3093	16635	58444	89466	1104346	481172	20867359
Western Europe	1270	6830	23998	36735	453449	197571	8568234
Eastern Europe	520	1294	5453	3220	57175	8012	599519
Middle East	126	314	1321	780	13854	1941	145268
Latin America	130	483	1363	1792	14294	6654	149880
Japan	549	2953	5757	15580	60363	85407	632954
Africa	13	21	32	34	80	54	200
Asia	483	1793	5065	6659	53106	24723	556861
TOTAL	6184	30323	101433	154246	1756667	805534	31520275

Table 13 Estimated regional satellite bandwidth requirements for intra-regional data telecommunications during the period 1990-2005

Regional market sector	Satellite bandwidth requirements for inter-regional voice telecommunications (MHz)						
	1990	1995		2000		2005	
		minimum	maximum	minimum	maximum	minimum	maximum
North America	10312	20741	25560	41718	63849	83909	158877
Western Europe	4235	7464	8518	13153	17133	23181	34460
Eastern Europe	1735	3644	5510	7654	17449	16076	55572
Middle East	420	882	1334	1853	4236	3892	13453
Latin America	433	909	1375	1910	4367	4012	13869
Japan	1529	3211	4856	6745	15421	14167	48974
Africa	42	88	133	185	424	389	1345
Asia	1610	4006	5978	9969	22195	24805	82409
TOTAL	20316	40945	55364	83187	145074	170431	408599

Table 14 Estimated regional satellite bandwidth requirements for inter-regional voice telecommunications during the period 1990-2005

Regional market sector	Satellite bandwidth requirements for inter-regional data telecommunications (MHz)						
	1990	1995		2000		2005	
		minimum	maximum	minimum	maximum	minimum	maximum
North America	10312	38288	55460	142160	298279	527829	1604218
Western Europe	4235	12415	15724	36397	58363	106704	216772
Eastern Europe	1735	6953	14077	27864	114218	111663	926730
Middle East	420	1683	3408	6745	28505	27867	231282
Latin America	433	1735	3513	6954	28505	27867	231282
Japan	1529	6127	12406	24555	100657	98405	816698
Africa	42	168	341	675	2765	2703	22434
Asia	1610	8659	16682	46570	117021	250465	1856204
TOTAL	20316	76028	121811	291920	748313	1153503	5095620

Table 15 Estimated regional satellite bandwidth requirements for inter-regional data telecommunications during the period 1990-2005

Regional market sector	Satellite television (MHz)						
	1990	1995		2000		2005	
		minimum	maximum	minimum	maximum	minimum	maximum
North America	15467	19740	21693	25194	30426	527829	1604218
Western Europe	6532	28483	48236	127717	366288	572687	2781502
Eastern Europe	2602	1941	13394	24223	75264	73953	404788
Middle East	629	3383	4776	18194	36721	97852	275435
Latin America	649	1981	4928	6044	37425	18846	284193
Japan	2744	3502	4222	4470	6496	5705	9995
Africa	63	252	329	1012	1822	4055	9801
Asia	2415	25323	45633	265332	862268	2784305	16293137
TOTAL	30921	84605	143211	472186	1416260	4084432	21663069

Table 16 Estimated regional satellite bandwidth requirements for satellite television during the period 1990-2005

Satellite bandwidth capacity growth rate per annum (%)	Average bandwidth per satellite (MHz)			
	1990	**1995**	**2000**	**2005**
0	1170	1170	1170	1170
10	1170	1884	3035	4887
25	1170	3570	10896	33253
50	1170	8884	67468	512335

Table 17 Estimated growth of satellite bandwidth capacity in the period 1990 - 2005 for various growth rates

Growth rate	1990	1995	2000	2005
Minimum	103280	266735	1031603	5771523
Maximum	103280	461452	4132002	58045029

Table 18(a) Summary of the estimated global bandwidth requirements during the period 1990 - 2005

	Number of operational satellites required							
Satellite bandwidth capacity growth rate (%)	0		10		25		50	
Market growth rate (%)	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
1990	90	90	90	90	90	90	90	90
1995	228	394	142	245	74	130	30	52
2000	882	3532	340	1361	95	379	15	61
2005	4933	49611	1181	18177	174	1746	11.3	113

Table 18(b) Estimates of the number of satellites required to furnish the global bandwidth demand in the period 1990 - 2005

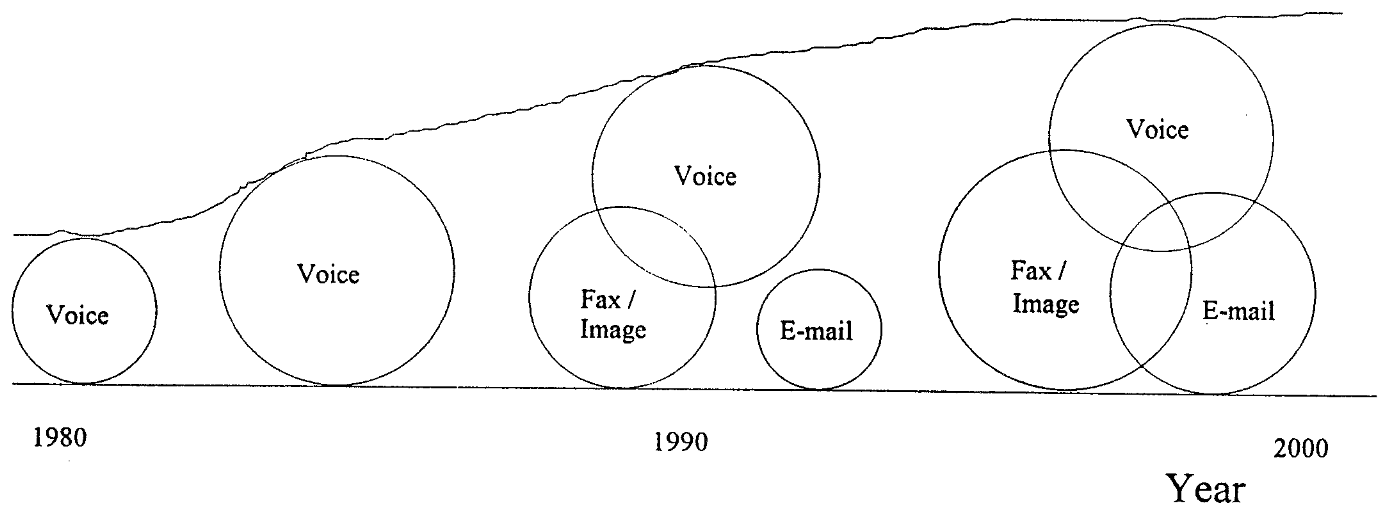


Figure 1 **The evolution of multimedia transmission systems - an ever broader electronic pipe (reference 3)**

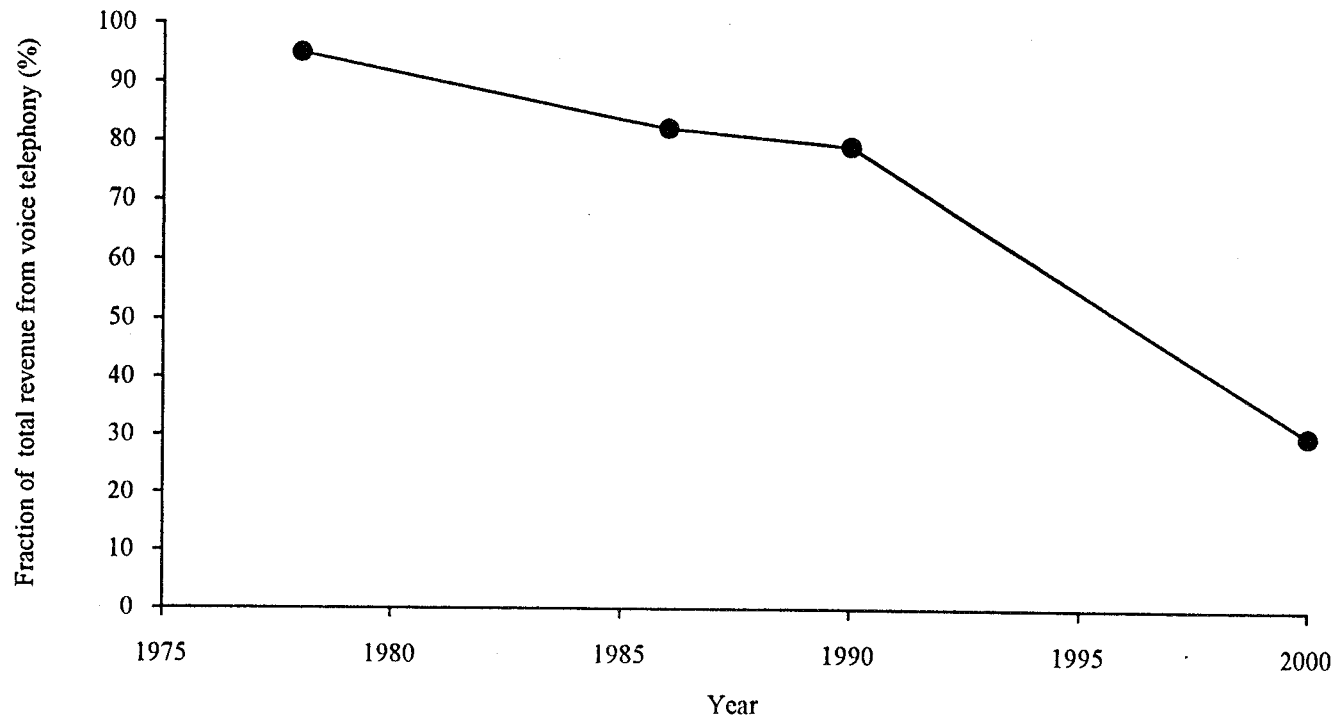


Figure 2 **Fraction of PTO's revenues from voice telephony (OECD average 1990- reference 12)**

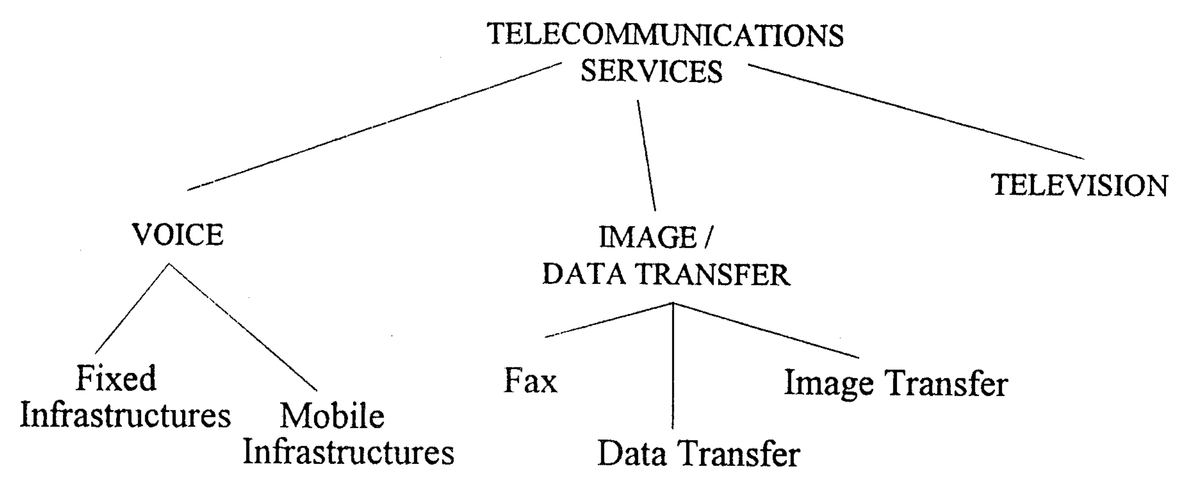


Figure 3 - Structure of the telecommunications services market (by application)

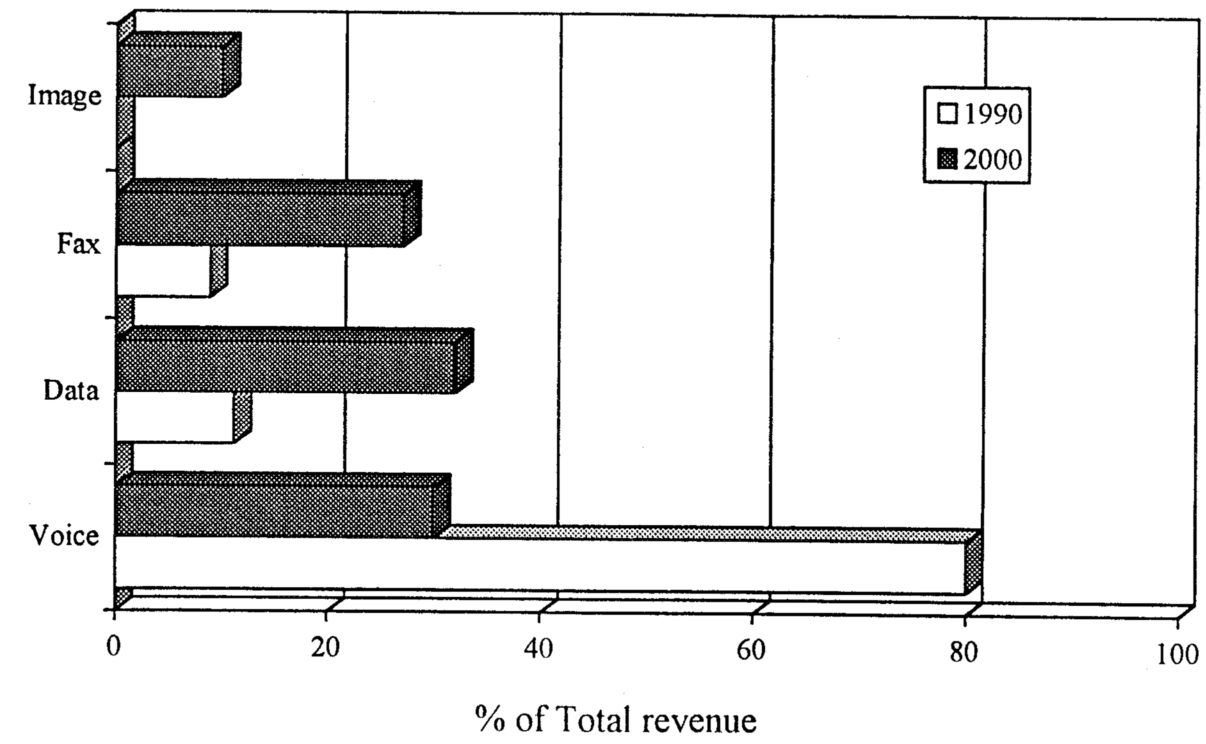


Figure 4 Revenue breakdown for telecommunications services according to application (references 3 & 12)

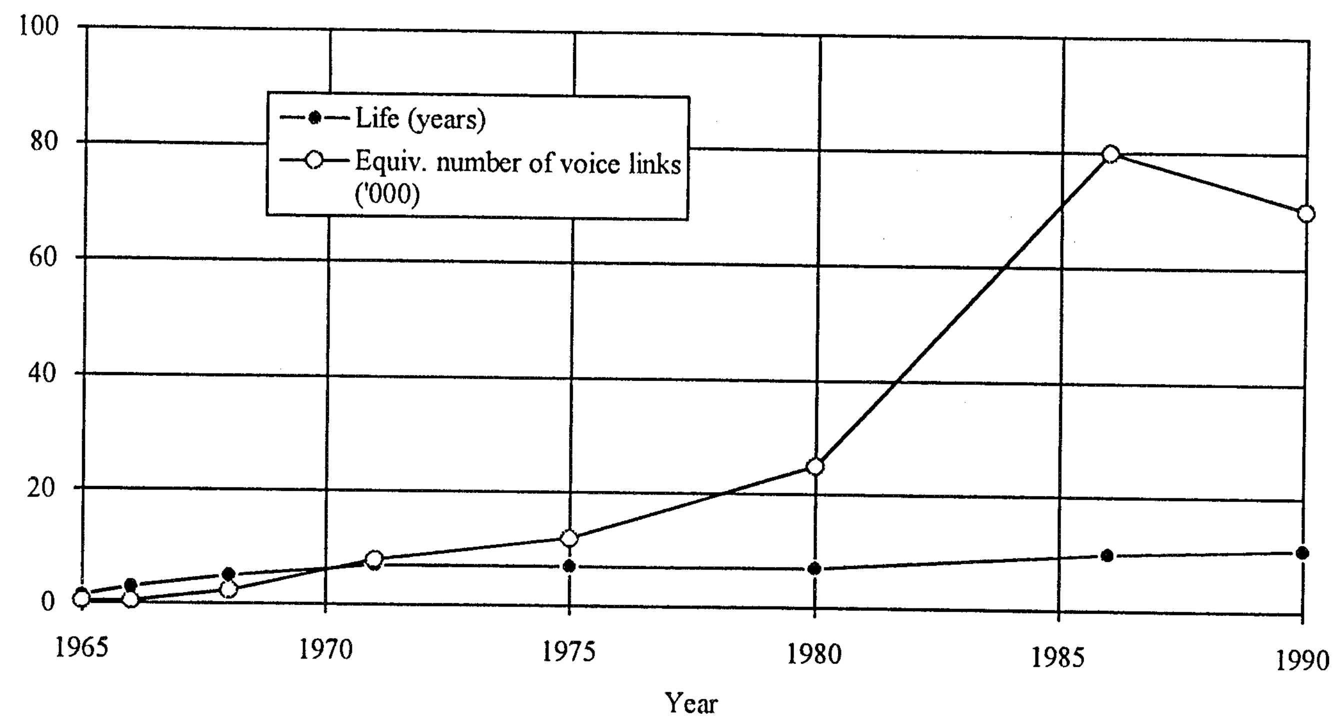
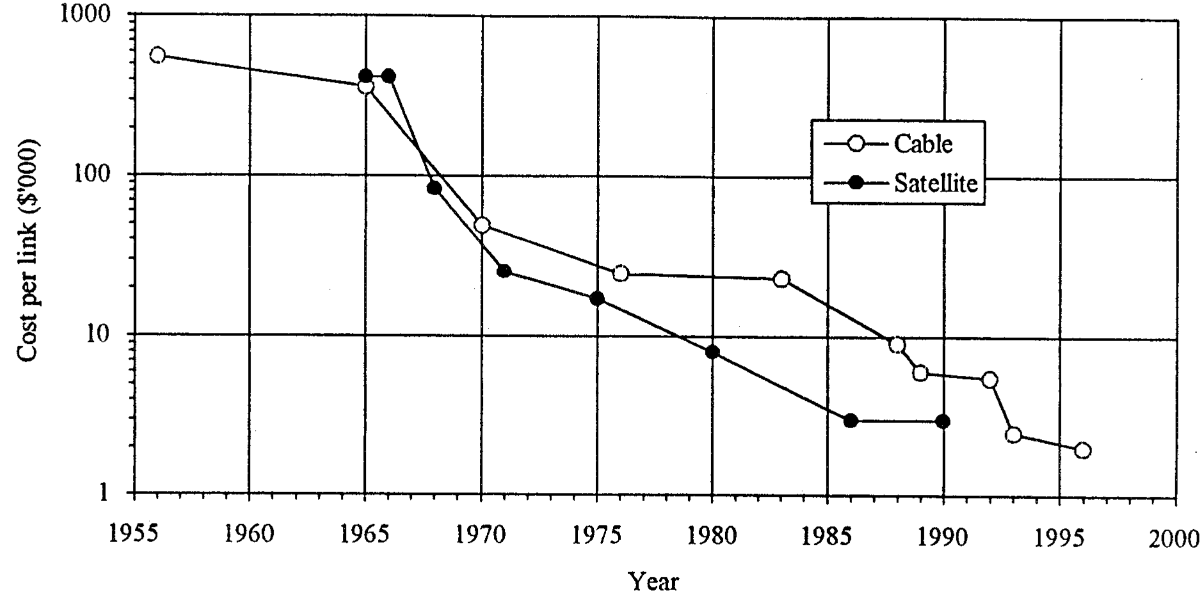
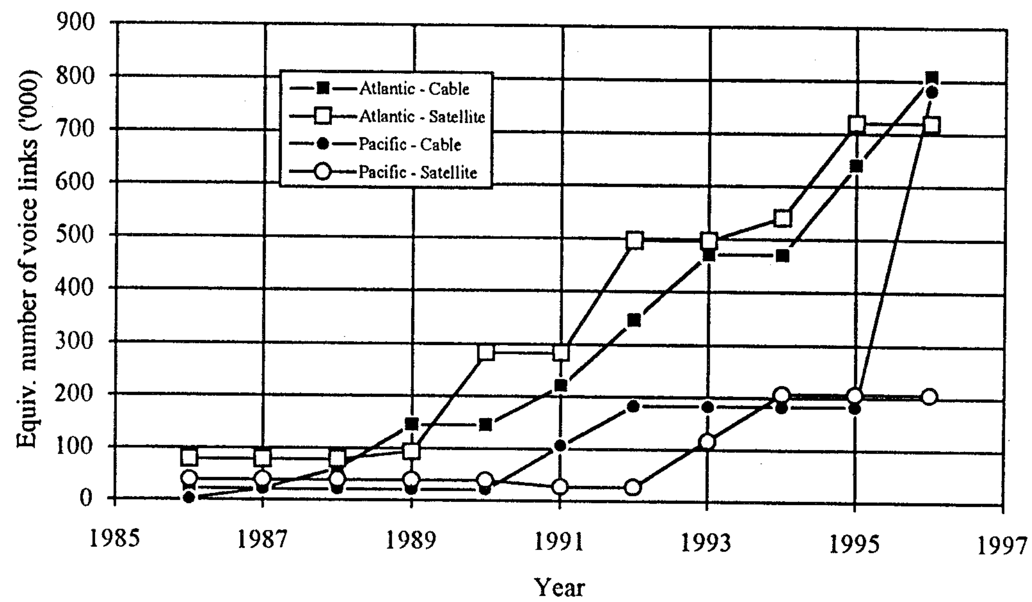


Figure 5 Evolution of satellite technology according to the Intelsat series of satellites (reference 4)



NOTE : The per voice link costs for satellites have been estimated from the Intelsat series of satellites based on a total cost of initial manufacture, installation and operation for each satellite of $200 million (1990)

Figure 6 - Evolution of the cost per equivalent voice link for satelllites and trans-oceanic cables (references 4 & 17)



NOTE : The satellite voice path figures are based on the planned Intelsat launch schedule (July 1991)

Figure 7 **Estimated growth of trans-oceanic satellite and cable infrastructures (references 3 and 4)**

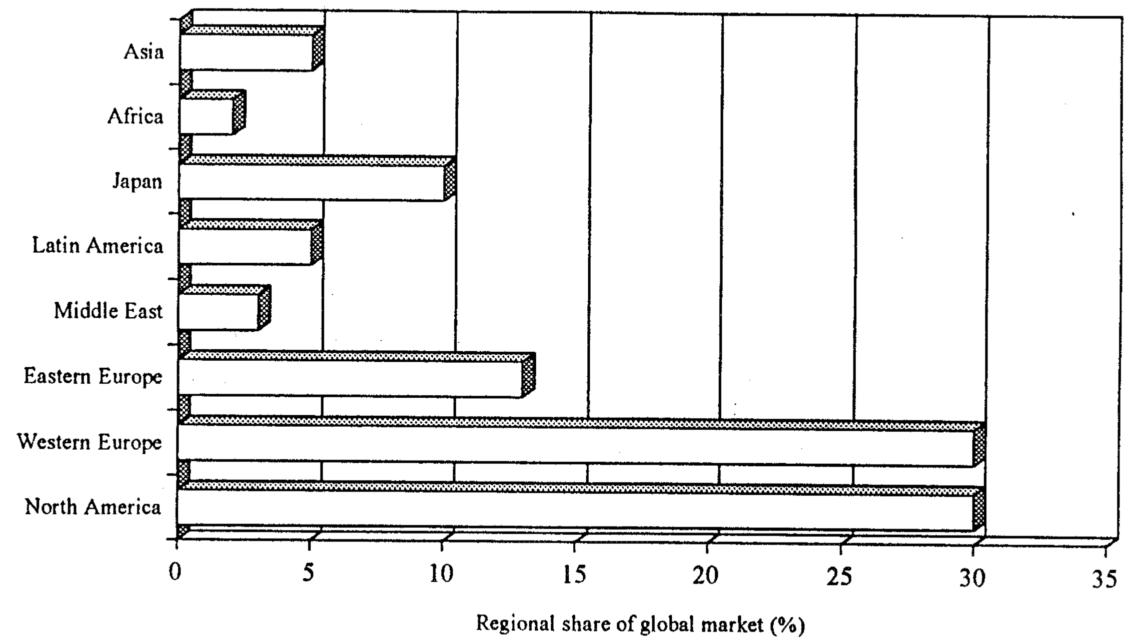


Figure 8 Relative market size of intra-regional telecommunications (based on the regional fixed telecommunications infrastructure distribution)

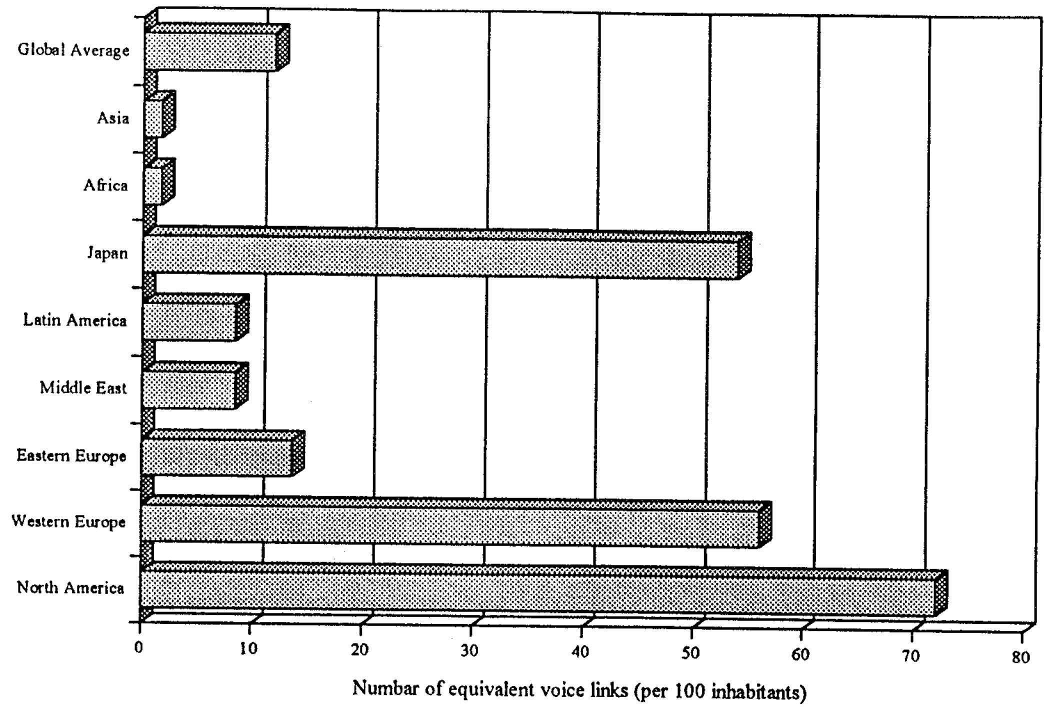


Figure 9 Regional penetration of fixd telecommunications infrastructure (reference 13)

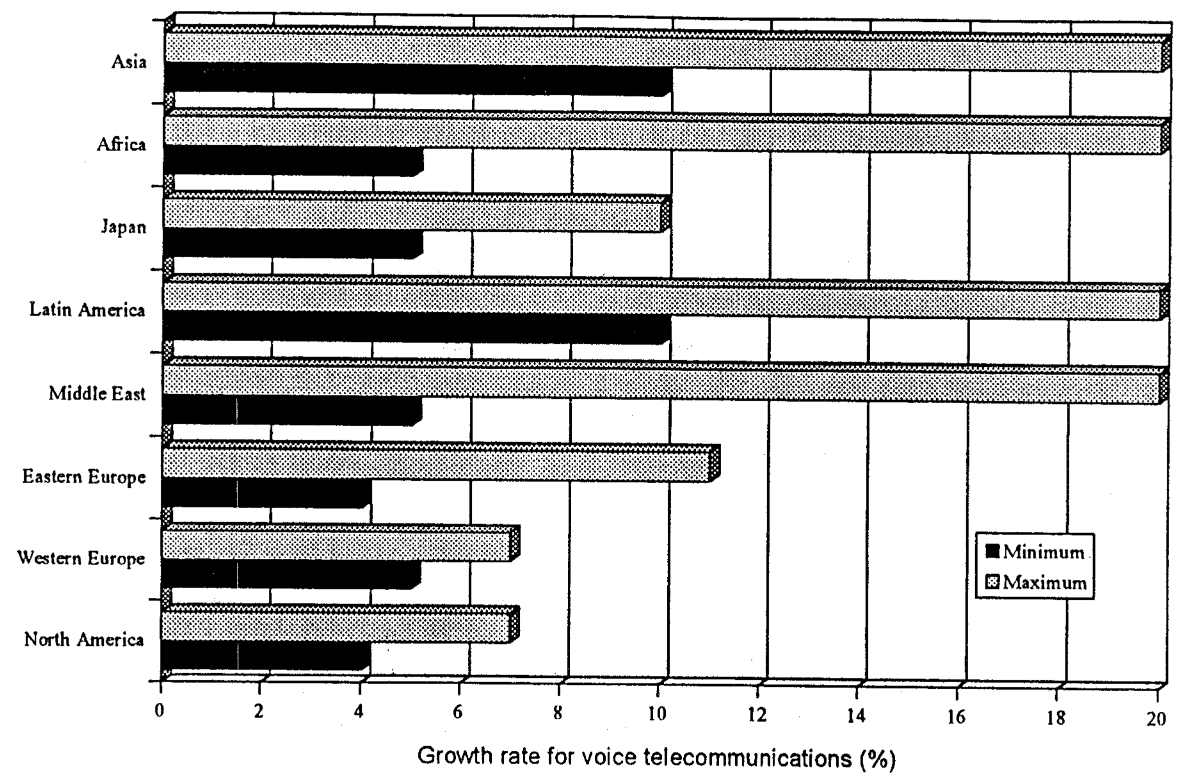


Figure 10 Estimated regional growth rates for intra-regional voice telecommunications during the period 1990 - 2005

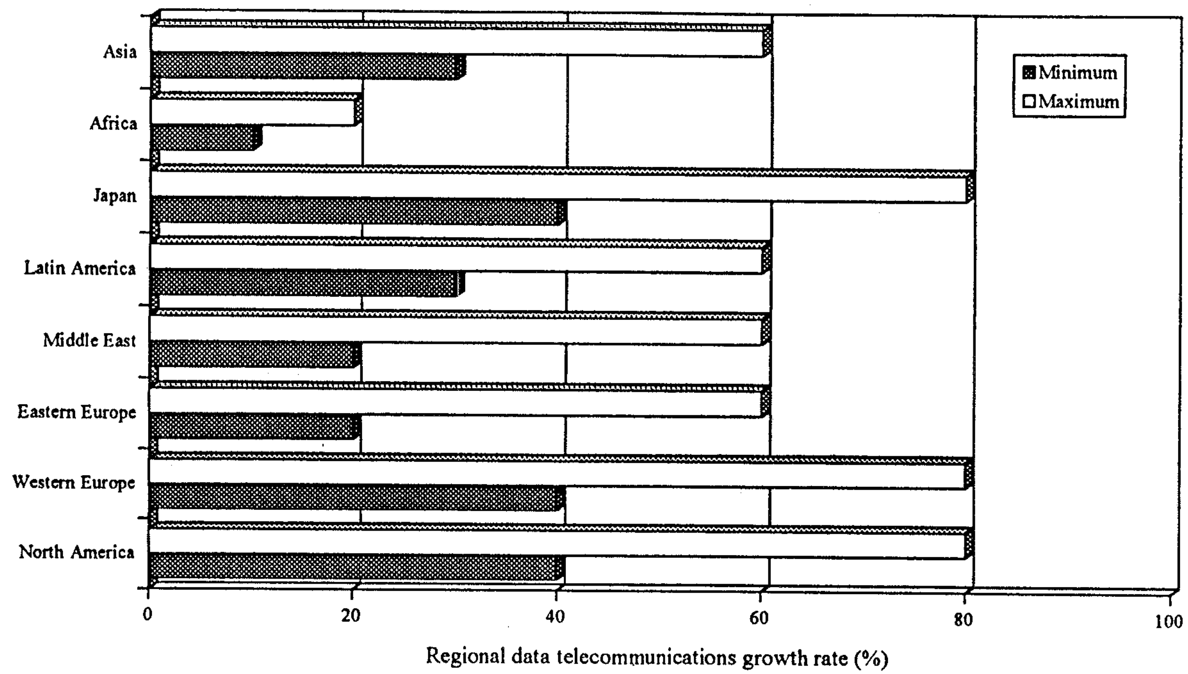
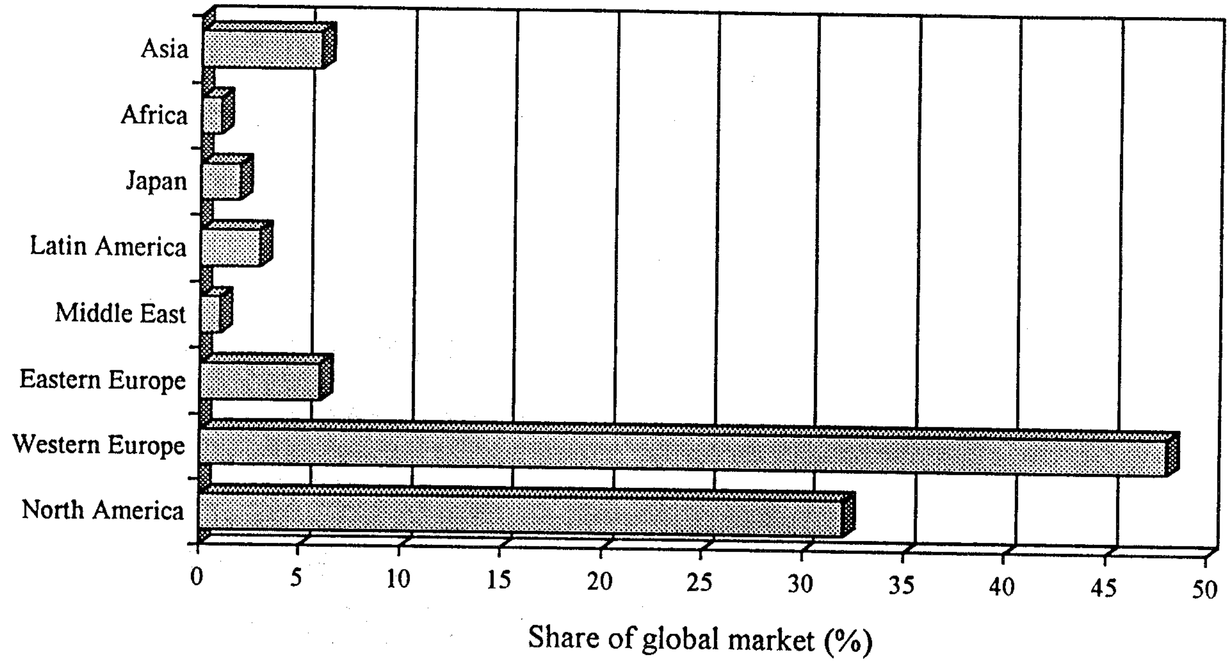


Figure 11 Estimated regional growth rates for intra-regional data telecommunications in the period 1990 - 2005



Note - Figures based on regional outgoing telecommunications volume (measured in miTT)

Figure 12 Relative size of inter-regional telecommunications markets

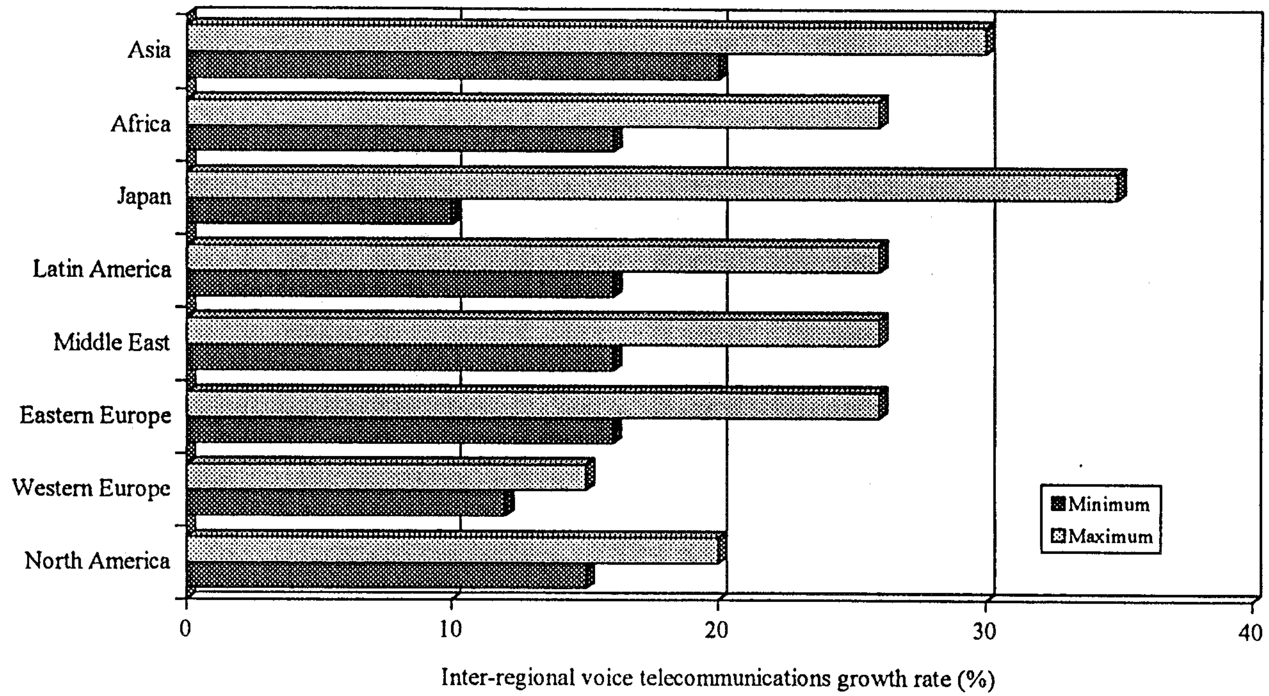


Figure 13 Estimated regional growth rates for inter-regional voice telecommunications in the period 1990 - 2005

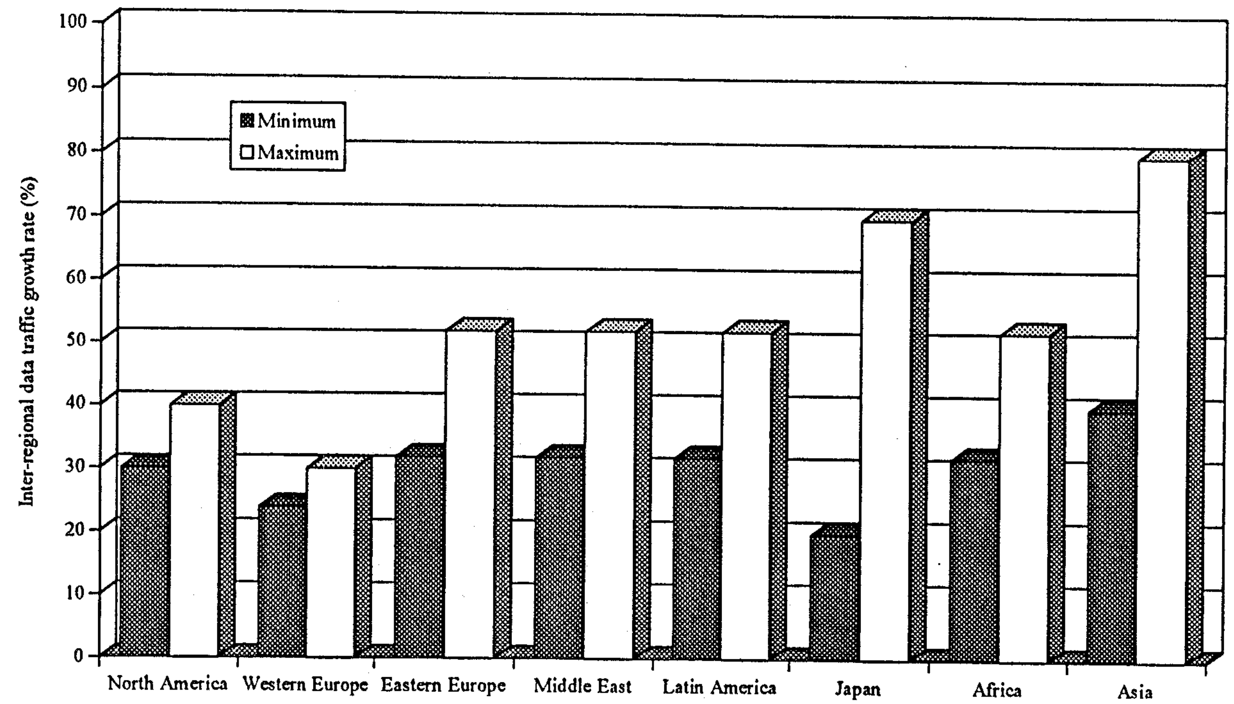


Figure 14 Estimated regional growth rates for inter-regional data telecommunications in the period 1990 - 2005

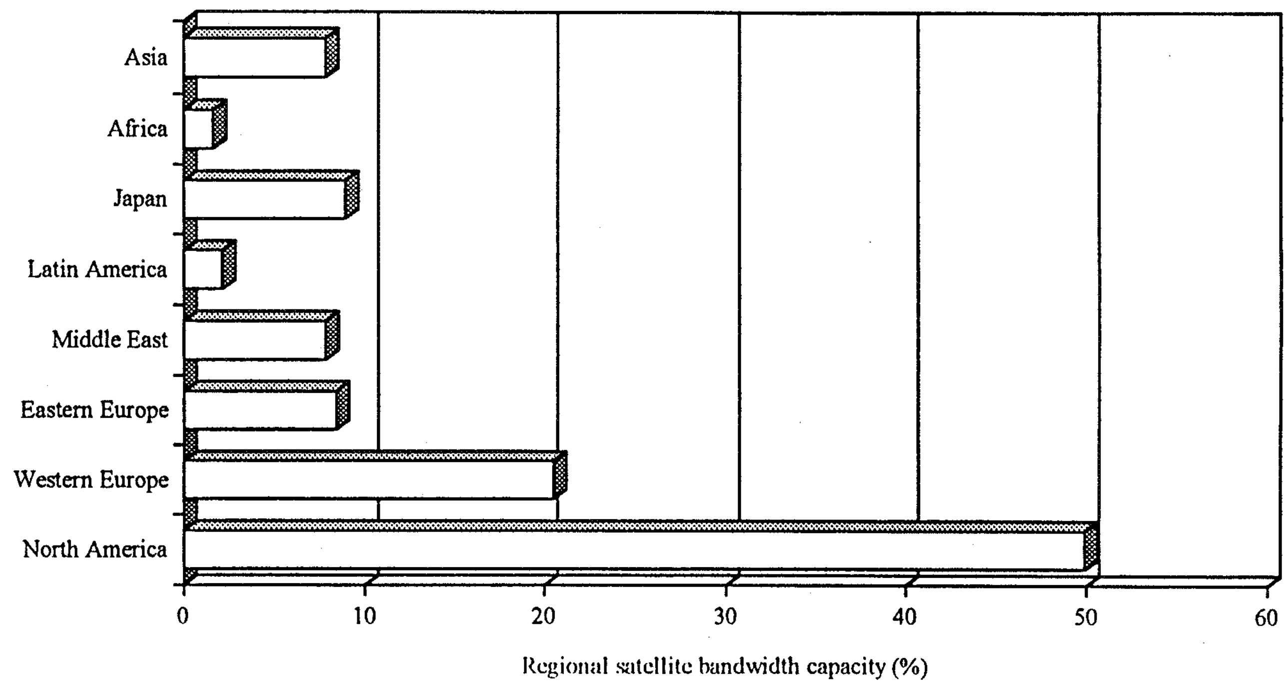
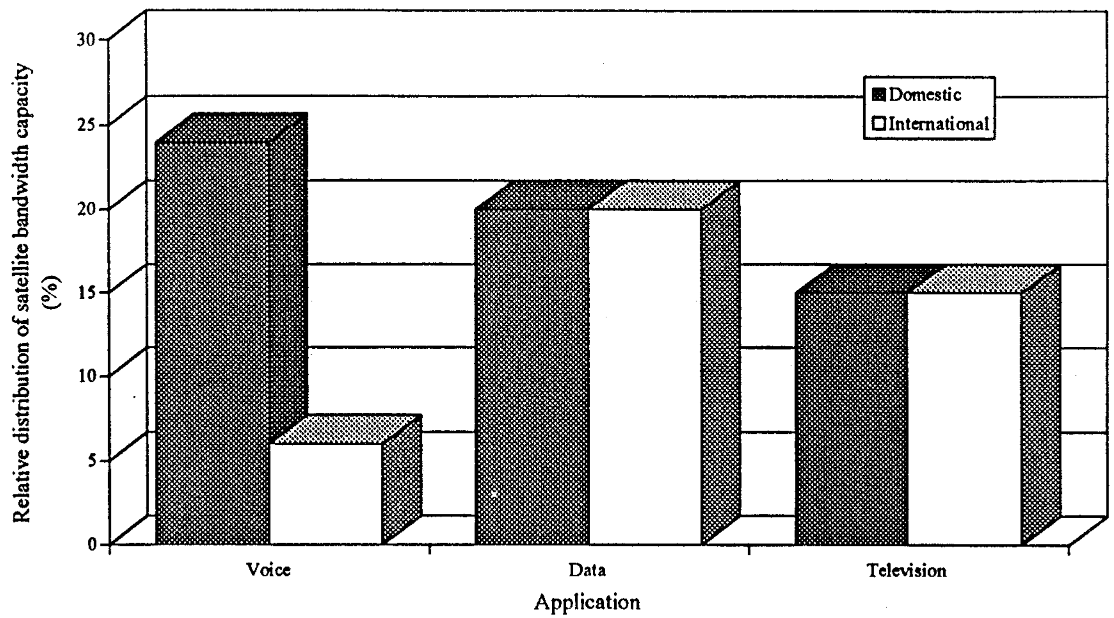
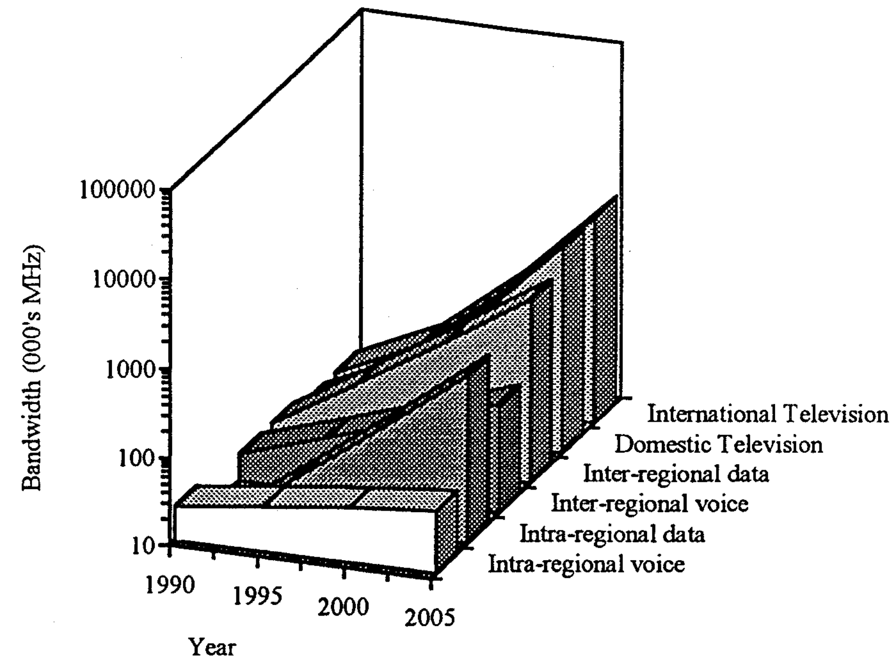


Figure 15 - Regional telecommunications satelllite bandwidth capacity as a fraction of the global satellite bandwidth capacity (1990)

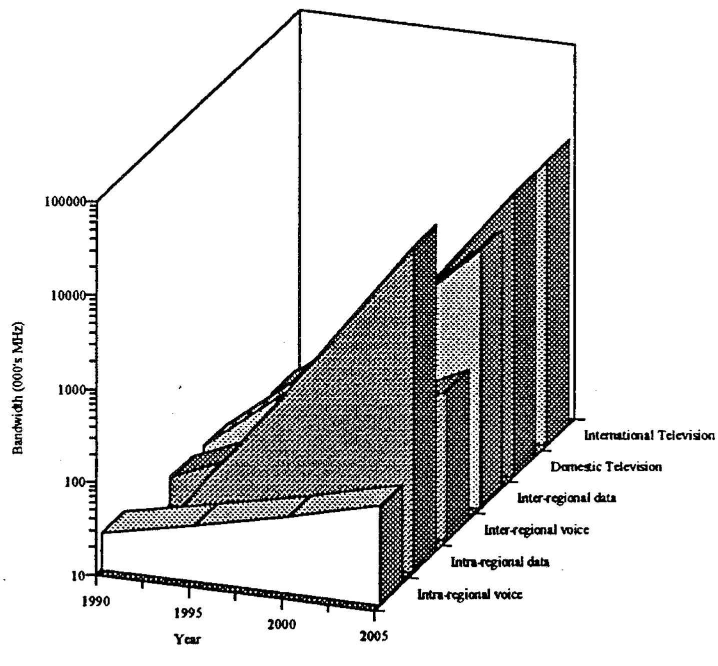


Note - In the present study, the above presumed distribution has been considered in all global regional market sectors

Figure 16 Relative distribution of regional satellite bandwidth capacity (by application)

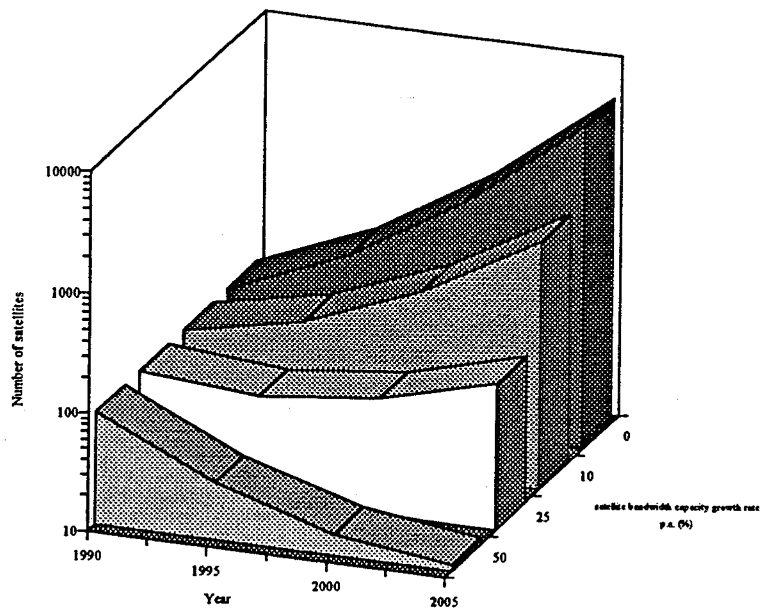


(a) assuming minimum growth rates

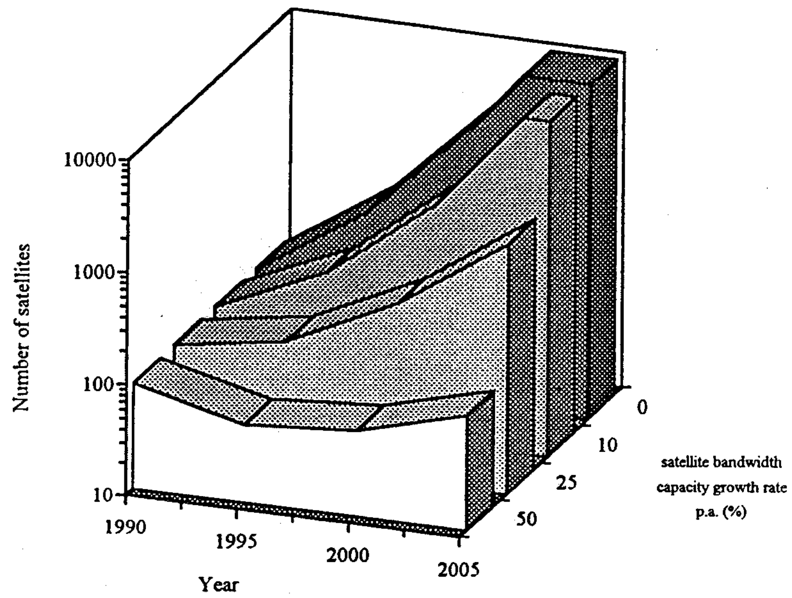


(b) assuming maximum growth rates

Figure 17 Estimated requirements for global satellite bandwidth capacity during the period 1990 - 2005



(a) assuming global bandwidth requirements are as for minimum growth rates



(b) assuming global bandwidth requirements as for maximum growth rates

Figure 18 Number of operational telecommunications satellites during the period 1990 - 2005