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Performance of the Telecommunications Sector up to 2010 under Different Regulatory and Market Options

Analysys

Final Report to the Commission of the European Communities

Main Report

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Report

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Final Report to the Commission of the European Communities DGXIII/D2

Main Report

This study, "Performance of the Telecommunications Sector up to 2010 under Different Regulatory and Market Options", has been prepared for the Commission of the European Communities. It has been commissioned as one of a series of independent studies to examine the long-term aspects of telecommunications development in the European Community.

This report does not necessarily reflect the views of the Commission, nor does the Commission accept responsibility for the accuracy or completeness of the information contained herein.

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0/ Preface

0.0 Introduction

This volume forms part of the Final Report from a study of the performance of the telecommunications sector up to 2010 under different regulatory and market options, produced by Analysys Ltd for the Commission of the European Communities. Using quantitative techniques, the study projects the financial performance of the telecommunications sector in the EC Member States, EFTA and Eastern Europe, and shows how this performance is affected by different regulatory choices.

This volume is the Main Report. It describes the general European projections for demand, technology and regulation developed in the study. It then presents detailed financial results (at the EC level) under the different regulatory options, in the form of a series of graphs and accounts sheets, with commentary. The results for EFTA and the East European countries are also summarised. An Appendix outlines the methodology underlying the quantitative analysis.

A full discussion of our conclusions and recommendations for policy is included in a separate Executive Report.

The remainder of this Preface presents a reference framework for the study. This material is repeated from other volumes in the report.

0.1 Structure of the Final Report

The report is divided into three main parts:

- **The Executive Report** sets out our conclusions from the study and gives recommendations for policy.
- **The Main Report** (this volume).

- A series of **Annexes** contain the country-by-country results of the study and full details of the approach and assumptions from which these results are derived. **Annex A** (the Technical Reference) explains in detail the methodology underlying the quantitative analysis. **Annex B** analyses each country in terms of a profile, assumptions (including the ways in which the individual country projections differ from the general European projections), and investment and financing implications. A standard set of quantitative results for each country appears in **Annex C**; there is a separate fascicle for each of the 12 EC countries, plus one fascicle each for EFTA and Eastern Europe.

0.2 OVERVIEW OF STUDY AIMS, COVERAGE AND RESULTS

The **aims** of the study are:

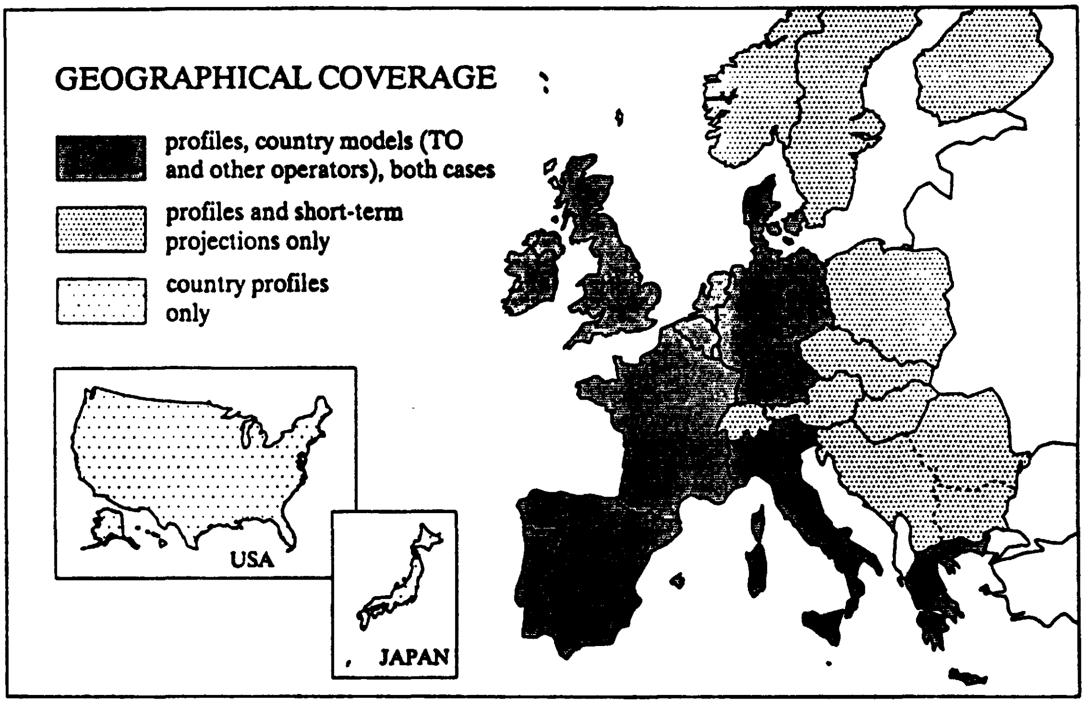
- to forecast the major developments in European telecoms up to 2010, and produce quantitative projections for network investment and revenue country-by-country
- to assess in detail how different regulatory options – 'Expansionist' and 'Minimum' – will affect the market and the telecoms operators' performance
- to demonstrate to what extent financing needs may be met from internal funds, and where assistance may be necessary.

Coverage: The study covers the 12 Member States of the European Community (EC) over the years 1990-2010. For each EC country separate quantitative models have been produced for the national telecommunications operator (TO) and its competitors, to enable a distinction to be made between the financial health of the incumbent TO and that of the country's telecoms operations as a whole. For each of these, results are generated for both the Expansionist and Minimum cases.

Other countries have also been studied (in less detail) in order to put the EC results in context: short-term projections, covering 1990-1995, have been made for each of the EFTA countries[1] and the countries of Eastern Europe.[2] For these countries only one set of results is generated, since no distinction is made between the TO and its competitors, and the two regulatory options are sufficiently close in the short term to make a comparison unnecessary. Country profiles have also been constructed for the USA and Japan, indicating the main points of difference and similarity vis-à-vis the EC.

1 With the exception of Iceland; also Liechtenstein is included with Switzerland, as the Swiss TO operates the network in Liechtenstein.

2 Except for Bulgaria, Romania and Yugoslavia, which are covered in a single aggregate model.



The Expansionist and Minimum Cases: The study finds that considerable expansion of the European telecoms market is possible (and can be sustained by TO finances) over the next 20 years. This goal will, however, require action to be taken in the short term on regulation and reorganisation, and assistance to be made available to peripheral regions of the Community. The countries of Eastern Europe will also require financial assistance. (A full discussion of our conclusions and recommendations for policy is included in the Executive Report.) The report presents the financial consequences for the market and the operators of two different approaches – the 'Expansionist' option (in which these regulatory actions are taken) and the 'Minimum' option:

The Expansionist Case:

■ Represents an innovative, highly competitive market in which telecoms monopolies are removed and competition is allowed in all services (including voice, data, image and other new services) and networks (including fixed, mobile and satellite). The existing TOs and the sector as a whole respond rapidly by becoming commercially-oriented.

continued...

The Minimum Case:

■ Represents the outcome of a regulatory policy which attempts to protect existing interests and does not promote commercialisation. Assumes slow or partial implementation of EC Directives and other liberalisation measures, delayed introduction and take-up of new services and applications, and cautious investment policies.

continued...

The **Expansionist Case** (continued):

■ Assumes rapid demand growth – particularly for mobile, advanced voice, video and data services – matched by rapid and focused investment.

■ The regulatory régime allows sufficient financial resources to be generated to enable forward-looking technology choices to be made, which in turn enable rapid development of the existing network and the generation of new revenues. Competitive pressures drive tariffs towards costs; this process stabilises after approximately 15 years.

■ Total revenues for the telecommunications sector in Europe (including services and CPE) grow rapidly in real terms from ECU 90 billion in 1990 to ECU 322 billion in 2010 – a factor of 3.5.[3]

■ Total annual investment rises in real terms from ECU 33 billion to ECU 142 billion, and over the 20-year period totals ECU 1277 billion.

■ Between 1995 and 2000 the sector can be expected to generate a cash surplus of ECU 29 billion – 13% more cash than will be required to fund investments.

continued...

The **Minimum Case** (continued):

■ Represents relative stagnation in the telecoms sector, and illustrates the consequences of preserving the regulatory status quo.

■ It is assumed that regulators impose tighter control of tariffs in an attempt to prevent abuse of monopoly power and to cut costs. Tariffs therefore become cost-oriented more rapidly than in the Expansionist case; driven by regulatory pressure, the process of cost-orientation stabilises after approximately 10 years.

■ Total sector revenues rise to only ECU 188 billion in 2010 – a factor of 2.1.

■ Total annual investment reaches ECU 76 billion, totalling only ECU 899 billion for the 20-year period.

■ Cash flow is expected to be sufficient to fund investment, but the regulatory régime limits the resources of the sector and the attractiveness of innovation, reinforcing the slow pace of development.

continued...

3 These figures, like all the financial measures used in this report, are expressed in real terms (i.e. adjusted for inflation), in 1990 ECU.

■ Existing TOs' average market share falls from an average of 94% today, but their competitive response enables them to maintain their share at an average of above 70% in 2010. Though operating profit margins are cut (to an average of around 24%), the existing TOs are still in a strong position to expand revenues; over the 20 years their revenues expand in real terms from ECU 85 billion to around ECU 237 billion.

■ The average market share of existing TOs is gradually eroded as they fail to develop a commercial and competitive orientation, and falls to an average of around 75% in 2010. Although this is higher than in the Expansionist case, their revenues rise to only ECU 141 billion (in real terms) over the 20 years. TOs' operating profit margins are cut more severely than in the Expansionist case – down to 19% in 2010.

0.3 Input Data Sources

Note that all financial data are expressed **in real terms**, that is, adjusted for the effects of inflation. The currency used is 1990 ECU; the conversion rates used are those published by the OECD and Economist Intelligence Unit.[4]

The starting-point for each country model is given by 1990 data. These data have been drawn from a range of sources, including TOs' own statistical data (both confidential and public), TOs' annual reports, and other published reports.[5] In some cases, 'start-data' information was not available for the correct year or half-year, and so had to be calculated. In other cases published data had to be adjusted and 'standardised' in format in order to conform with the requirements for consistent model input. Start-data for revenues used in the modelling were for the 1990 calendar year; where 1990 information was unavailable, the revenues were projected forward from earlier years. Start-data for lines and waiting lists were for mid-1990, and so sometimes differ from other published figures, which usually represent the year-end. Where mid-1990 figures were not available, estimates were obtained by extrapolation or interpolation.

The table on the following page summarises the starting-point for the modelling. It shows the 1990 values of certain key measures for the EC as a whole. For definitions of some of the measures shown, see the Explanation of Financial Terms which appears towards the end of this volume.

4 See Appendix to Annex B, Volume 1 for details of the conversion rates used.

5 See Appendix 1 to Annex A for details of data sources.

Selected 1990 Data, Aggregated for the 12 EC Member States

Connections (thousands) by connection type[6] (estimated at mid-year)	Business Telephony	35689
	Residential Telephony	105389
	Mobiles	1862
	ISDN and Broadband	19
	Total (Main Switched Services)	142960
	Other Services	3606
	Total	146566
Population (est. at mid-year)	Millions	341
Financial - Revenue (MECU) by connection type[6]	CPE	16009
	Business Telephony	28968
	Residential Telephony	33392
	Mobiles	1718
	Other	10386
	(Total) Revenue	90472
	Telephony (Bus. & Resid.) as Proportion of all Revenue	69%
Financial - Costs	Capital Outlay (millions of ECU)	33071
	Operating Cost (millions of ECU)	66640
	Operating Cost per Connection (ECU)	455
Financial - Ratios	Operating Profit Margin	26%
	Long-Term Debt	82393
	Fixed Assets plus Net Current Assets	168695
	Long-Term Debt as a Proportion of Total Net Assets	49%
	Ratio of Fixed Assets to Turnover	1.99
TOs' Market Share	% Share of Turnover	94%
	% Share of Investment	95%

The projections for technology, regulation and demand used in the study take account of existing plans, and of expert opinion on likely developments over the 20-year period. They include the completion of digitalisation and the introduction of Synchronous Digital Hierarchies (SDH) and Asynchronous Transfer Modes (ATM); major restructuring of network architectures; the widespread installation of optical fibre in the local loop, beginning in core business areas and spreading to residential areas after 2000; major growth in ISDN, mobile, broadband and image-based services; increased competition; and tariff rebalancing. (The assumptions differ between the Expansionist and Minimum cases, as explained in Section 0.2 above.) Projections of demand take account of economic forecasts made in the first quarter of 1991.

6 Note that connection types are referred to as 'bearer services' on the results graphs in this volume and in Annex C.

One assumption worthy of special note is that governments do not interfere in the financial affairs of the TOs above and beyond the controls and levies that currently exist. It is recognised that in practice governments may intervene, for instance by instituting special tax levies on TOs to divert profits in line with social and political objectives. No account is taken of such interventions in the quantitative results presented here.

It should be noted that activities or events outside of the operators' normal domestic business operations are not included in the financial projections. Care should therefore be exercised in comparing these figures with information published elsewhere about the organisations' financial performance. Also, in the accounts sheets the number of ordinary shares (on which earnings per share depend) has been assumed to be equal to one third of turnover in 1990. Thus the number of shares shown in 1990 should be regarded as indicative only, and not identical to the actual number of shares at that time. No account is taken of any flotations of additional shares during the period modelled.

0.4 Summary of Methodology

In order to achieve its aims, the study takes account of both the *diversity* of the current situation and the *complexity* of the interacting forces which will shape developments. Major differences exist between the national telecoms sectors in Europe (in terms of services, costs, tariffs, networks, technologies, standards, and financial and operational performance); the approach is therefore based on a detailed assessment of each individual country, starting from existing infrastructures and current plans. Future developments will be shaped by existing patterns of behaviour and by the dynamic interplay of demand, technology and regulation; the approach is therefore designed to capture the interaction of these forces in a structured and coherent framework.

The **methodology** therefore has the following main aspects:

- Building **profiles** of each of the countries studied, starting from 1990 data, a study of the telecoms sector and the general economic situation, current plans and established trends. (See Annex B.)

- Making global **projections** for developments in demand, technology and regulation – issues which cut across all countries – supported by expert input. (See the Main Report.)

- Developing a **methodology to forecast demand** within the constraints imposed by economic factors, and using this to make detailed projections of demand for different services on a country-by-country basis. (See Annex A.)

- Constructing a **general reference model** framework capable of capturing these profiles and projections, and of quantifying the costs and funding implications of network investment to meet the forecast demand. (See Annex A.)

- Building and running **country-specific models**, which bring together the profile data, the global projections, and the demand forecasts within the quantitative framework, and generate the financial results. (See Annex C for country-by-country results, and the Main Report for aggregate results at the European level.)

The first stage in the quantitative modelling is therefore the **forecasting of demand**. From input on GDP growth, the elasticity of telecoms spending with respect to GDP, usage patterns, tariff assumptions, demographic trends and the existing customer base, detailed demand forecasts are calculated in terms of the numbers of connections and the levels of usage. These detailed demand forecasts are then used to drive the **investment model**, which calculates the costs of satisfying demand, using input on the initial financial position of the operator, trends in capital, operational and maintenance costs for the main network elements, and the operator's network provision and depreciation policy. The results of the investment model include:

- the costs and quantities of equipment in the network
- the capital investment required
- cash flow, revenue and profitability
- the cost of providing services to customers
- financial information (summarised in the form of profit and loss account, balance sheet and source and application of funds).

Demand forecasts and the costs of service provision are fed into the **calculation of tariffs and revenue**, where account is taken of moves towards cost-oriented tariffs.

Analysys

Performance of the Telecoms Sector up to 2010 under Different Regulatory and Market Options

FINAL REPORT

MAIN REPORT
CONTENTS

1/ General European Demand Projections

An interplay of demand, technological, regulatory and economic factors will determine the magnitude of European network investment over the next 20 years. The aim of this chapter, and the two following it, is to provide a description of how the forces affecting telecoms investment are likely to evolve over the next two decades.

This chapter describes demand projections at the European level; technological and regulatory projections are contained in Chapters 2 and 3 respectively. Important financial and economic issues are included, as well as their likely impact. Although the main themes are set out with reference to the EC generally, country-specific examples are put forward where appropriate. Such examples provide an indication of the current wide differences which exist across European telecoms markets, networks and regulation.

In this chapter we consider likely developments in the demand for telecoms in Europe, and the consequences are put forward in the form of general European demand projections; more detailed country-specific demand profiles can be found in Annex B. Where we attach a date to a trend or development, this relates to our projections for advanced countries in the Expansionist case. We begin in Section 1.1 with a summary of the major developments which are expected to occur by 1995, by 2000 and by 2010. Section 1.2 examines the developments in demand for each service (basic telephony network, ISDN, Broadband, mobiles, cable TV, leased lines and telex).

1.1 Chronology of the Demand Projections

The demand projections are summarised in the diagram on the following page. On the left-hand side we have set out major topics; we have represented their implementation or impact over time by horizontal bars containing commentary. (The density of shading represents scale or degree, according to context.)

We expect the following developments in the 1990-1995 time frame:

- The take-up of ISDN is likely to be slow, as users take time to perceive its benefits; this will be compounded by the relatively slow introduction of customer premises equipment (CPE) and difficulties in achieving a critical mass of users.

- VSAT network growth will be affected by tariffing policies (currently international tariffs within Europe make VSATs very attractive) and the availability of competing networks such as ISDN.

- There will be an ever-increasing demand for higher transmission speeds both in the work-place (with the availability of high-capacity workstations and PCs) and in the home (with the advent of new home entertainment products such as HDTV). This trend will continue into the 21st century.

We expect the following developments in the 1996-2000 time frame:

- ISDN will be well understood, and CPE and applications will proliferate. Larger companies will begin to use Broadband applications over new high-capacity networks and access links.

- Videotelephony will begin to change from a business application used on private networks and limited by cost towards a more widely used switched service.

- Analogue leased lines will be phased out as users take up the widely available ISDN service.

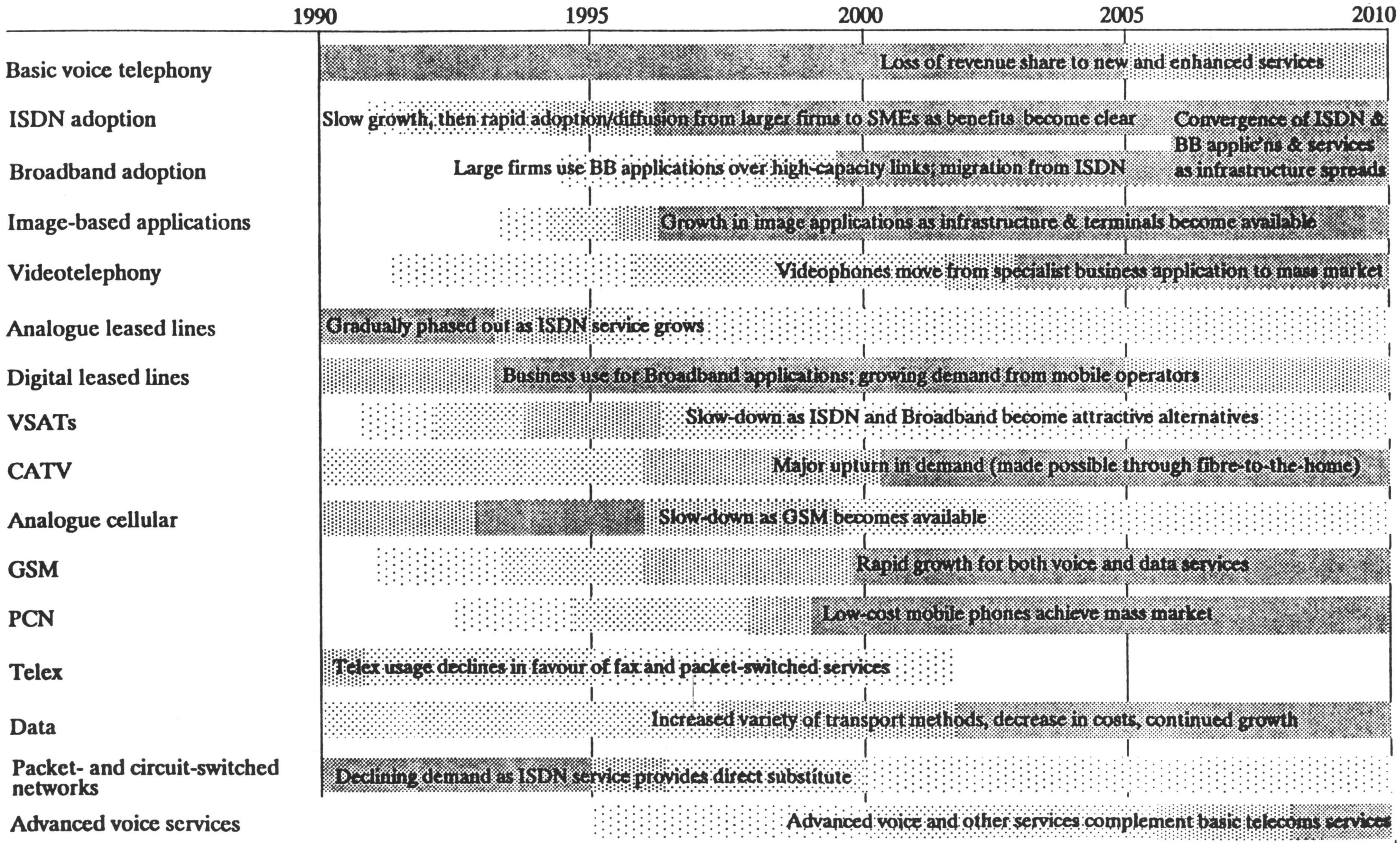
- VSAT development will slow down as ISDN and Broadband become attractive alternatives (and tariffs are progressively rebalanced).

- There will be growth in demand for CATV, and some TOs will begin to implement fibre-to-the-home.

- There will be rapid growth of mobile communications, based mainly on GSM standards, but with separate networks aimed at different market segments and offering varying degrees of functionality. These services will cover both voice and data. As the infrastructure density increases, terminal sizes and costs will fall dramatically.

- Modernisation of networks enable the development of a number of advanced voice and other services (including superior call-forwarding capabilities, and the maturing of 'green numbers'). Increasing use of these services will lead to greater use of transmission services, including mobile communications.

Demand Projection (Expansionist Case, Advanced Countries)



We expect the following developments in the 2001-2010 time frame:

- Towards the end of the period both large and small organisations will migrate from narrowband ISDN to switched Broadband services.

- Image-based terminals – primarily videotelephones and PCs – will be in widespread use, their price having fallen substantially during the 1990s. The falling cost of videophones, combined with an increase in disposable income will see such devices being used by residential subscribers who find them convenient to use at work.

- Analogue cellular and separate data systems may continue to be supported after the turn of the century, but they will face increasingly stiff competition; like telex before them, usage will eventually fade.

- A major change will be the spread of mobile communications; small, inexpensive handsets which are able to access networks through a dense radio infrastructure will be part of a mass market.

- Particularly in the latter part of this period, demand for advanced voice services – e.g. 'green numbers' (such as called party pays and premium service numbers) and call forwarding – will rise as users become increasingly aware of the benefits of such services. Around 50% of connected customers will subscribe to them by 2010, providing a major source of revenue.

1.2 The Demand for Services

The demand for existing and future telecoms services may be assessed with reference to the likely growth in demand for actual applications such as voice telephony, mobile telephony, videotelephony and others. Once we have determined how application demand will change over time we can then map this demand onto bearer services. Below, we summarise likely demand developments by service category as follows:

- current telecommunications networks (1.2.1)
- ISDN (1.2.2)
- Broadband (1.2.3)
- mobiles (1.2.4)
- cable TV (1.2.5)
- leased lines (1.2.6)
- telex (1.2.7).

At the outset, however, it is important to consider how the *overall* demand for applications might develop over time. Two possible sets of demand assumptions are considered:

- an Expansionist case
- a Minimum case.

Expansionist Case

We assume that the full potential of demand growth is achieved, with sizeable increases in demand for all types of telecoms service. This involves the implicit assumption that regulatory conditions are such that the investment needed to support the new demand is brought forth quickly and efficiently. In other words, TOs are in a position to satisfy the higher demand for goods and services.

Given that TOs are able to respond quickly and efficiently to the demand for new applications, we would expect markets to mature earlier than they might otherwise have done; examples of this are the market for advanced voice facilities based on intelligent networking, and the mobile-telephony application. The earlier these applications are accessible to potentially huge customer groups, the greater the propensity of TOs to capitalise on (and further encourage) strong demand growth.

Minimum Case

If the telecoms sector is slow to respond to changes in demand, the result will be a dampening of demand. In this case investment in new services and applications is slow to materialise and existing demand remains frustrated. Such circumstances are likely to bring forth tighter regulatory control over tariffs, as compared to the Expansionist case where any tariff rulings will be strongly supportive of the higher investment levels.

1.2.1 Current Telecommunications Networks

In the short to medium term, demand for PSTN connections and usage will continue to increase. At present, the number of installed lines in the EC is rising by between 3% and 4% annually. This is unlikely to slow down in the next few years, as some countries still have waiting lists to eliminate. The following five countries had waiting lists for connections in 1990:

- in Greece and (Eastern) Germany the waiting lists numbered over one million
- Spain and Portugal both had substantial waiting lists

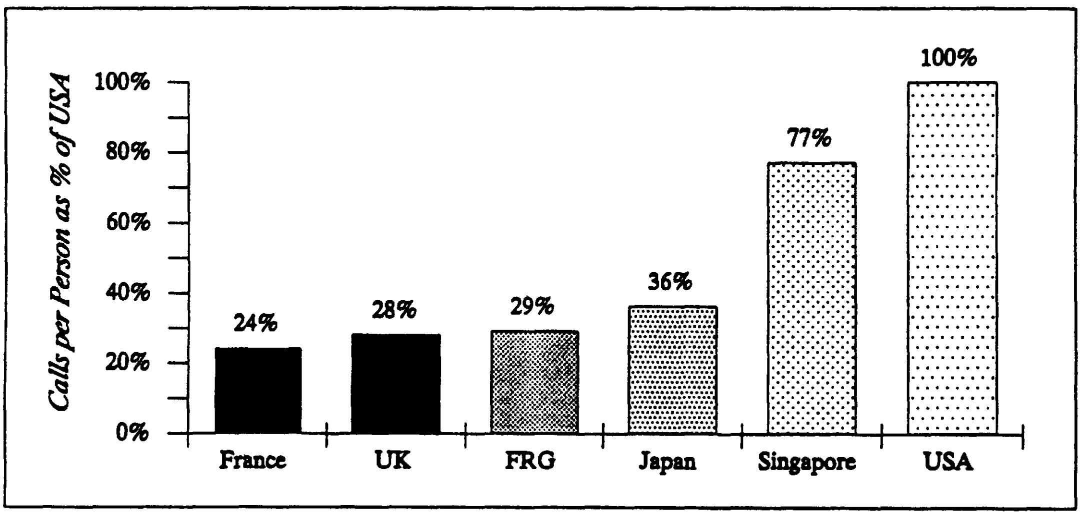
▸ Italy had a relatively short waiting list (under 20 000).

Also, in Belgium the waiting list has been growing significantly in recent years and reached 22 000 in 1989. In the Republic of Ireland, the penetration of fixed telephony is currently only 26 per 100 population, and the TO hopes to make considerable strides in increasing penetration (particularly for residential users) within the next few years. It is clear that there is significant latent demand for fixed telephony connections in all these countries.

For the remaining EC countries (Denmark, the UK, France, the Netherlands and Luxembourg), penetration is already relatively high and there are no waiting lists. There is still some room for increasing the number of connections, however; for example, the French TO has set itself the goal of 100% household penetration before the end of this decade. Nevertheless, the expansion of demand for connections is not limitless, and as penetration levels continue to rise, TOs are increasingly focusing on ways to expand the levels of telephony traffic.

Network usage in Europe is currently only about one-third of the level in the USA. Exhibit 1.1 below compares telephone calls per person in the USA with the levels in France, the UK, Germany and Japan.

EXHIBIT 1.1: *Network Usage – Calls per Person in France, the UK, Germany and Japan as Percentage of Calls per Person in the USA*



The differences between the five countries are striking. Whilst part of the explanation for this is found in tariffing (some calls are free in the USA), the principal reason lies in the highly dispersed physical structure of the USA, together with cultural factors. In view of the very different spatial distribution in Europe, it cannot be assumed that the gap is purely one of timing and that sooner or later the Europeans will 'catch up' with their American counterparts. Nevertheless, it is reasonable to assume that concerted tariff reform across Europe will encourage higher levels of network usage. Thus, the Expansionist case embodies levels of usage which in the later years are over twice those of the Minimum case.

New services are already becoming available (and more visible) which are just as suitable as the PSTN service for satisfying the demand for voice applications; indeed, services such as ISDN and mobile telephony offer additional attractive features. Thus, as the user becomes more conscious of these features, there arises the prospect of a slow-down in demand growth from the basic telephony service (although this is unlikely to occur until well after the year 2000).

A potential threat to demand for fixed telephony lies in the growing accessibility of mobiles to a mass market. It is reasonable to expect that as the price of handsets and tariffs declines, some users – both residential and business – will actually substitute a mobile connection for their fixed connection. This phenomenon is unlikely to occur until after 2000, when PCN operators have become a strong competitive force.

Whilst the existence of private mobile operators may itself pose a threat to the incumbent TO's fixed telephony service, it is important to note that a proportion of the mobile traffic will be carried on the existing PSTN infrastructure, and TOs will receive income from this. Consequently, TOs might actually expect an increase in revenue as their networks become more open to mobile traffic, provided that they invest appropriately to cater for this traffic, and set appropriate tariffs.

Despite the fact that the PSTN is relatively expensive and transmission quality is often poor, small users with Group 3 faxes and modems still find it their best option; data traffic over the PSTN with data modems still represents approximately 35% of the data connections in Europe. With the development of the ISDN service, however, this type of connection will be drastically reduced (in percentage terms) during the 1990s, even if strong growth in data traffic continues to support modem sales. The falling prices of ISDN equipment such as PC cards will probably make inroads into the modem market after the year 2000; this, combined with take-up of ISDN in small enterprises, will finally squeeze out the use of specialised networks (e.g. PSDNs) and modems from the professional environment.

The ISDN service is a direct substitute for packet- and circuit-switched network services. However, in the short to medium term there is still likely to be strong demand for these services from smaller users who are unable or unwilling to invest in ISDN. We expect existing networks to co-exist with ISDN at least until the year 2000.

In the medium to long term we believe that there will be strong growth in demand for data and image-based applications, and a growing user perception that services other than basic voice telephony (for example, ISDN) are able to satisfy this demand at an acceptable price. Taking into account the knock-on effects from mobile traffic and intelligent network (IN) services (see below) to basic voice and video telephony transmission services, fixed telephony revenue growth (excluding ISDN and advanced voice services) is likely to slow down by about 2005.

Advanced Voice Services

During the next ten years there will be a diversification of telecoms services, including services for which there is no historical guide to likely demand. With intelligent networks will come the development of a number of advanced voice and other services (including superior call-forwarding capabilities, and the maturing of 'green numbers'). Such advanced calling services do not provide a substitute for basic services, since they do not actually provide a means of communication. However, they do complement basic services by providing greater user freedom and individual control, and so the increasing use of intelligent network services will lead to greater use of transmission services.

The early introduction and take-up of advanced voice services is likely under Expansionist case assumptions. We assume that such services will start to become popular around 1997, and that around 50% of connected customers will subscribe to them by 2010. We expect that customers will be prepared to spend around 10% of their total service expenditure on these services; that is, the subscription charge will be about ECU 100. Given the complementary relationship between advanced voice services and the voice telephony application, our Expansionist case also includes the assumption that there is higher growth in demand for the voice telephony application.

1.2.2 ISDN

ISDN offers a unique opportunity for integrated voice/data transmission over the switched local and international network. The problems lie mainly in penetration and high equipment costs. Competition with existing alternatives is still substantial, but looking to the medium term it is likely that falling prices will split the users into two groups:

- one group of users requiring a high volume of data transmission to a few sites – they will continue to use private circuits

- a second group of users with medium- to high-volume communications distributed to a large number of sites – they will choose ISDN when this proves more economical than existing alternatives.

ISDN Adoption

Some advantages of the ISDN service are:

- ISDN is the only option which offers integrated voice and datacommunications on the switched network.
- ISDN offers small and medium-sized organisations – who cannot afford analogue or digital private circuits – an opportunity for high-quality digital transmission.
- The TOs can offer advanced billing services, providing the users with detailed information about the usage of the ISDN link.
- The service can be borne on the existing local copper loop, which makes fast penetration among small to medium-sized enterprises financially viable.
- ISDN offers standardised international voice and datacommunications in the EC, Japan and the USA.

The problems we have identified relating to the penetration of ISDN are:

- The coverage of ISDN will in most European countries be substantially lower than was previously expected. Penetration is behind schedule even in countries like France, where large efforts are being made to promote and develop ISDN applications. The CEC's initial goal was a 5% penetration in each European country by the end of 1992; the forecasted actual penetration for 1992 is currently 0.4% for the UK, 0.9% for France and 0.75% for Germany.
- The prices for ISDN equipment are still very high. The ISDN PC cards necessary to transform the PC into an ISDN workstation cost between ECU 1900 and ECU 2740, and a Group 4 fax costs from ECU 16 400 to ECU 41 000. Prices are falling, but the delayed implementation of ISDN in Europe means that this is happening more slowly than expected.
- ISDN cannot be used by small and medium-sized enterprises as a means of improving their voice-communications services – ISDN PABX interfaces for Basic-Rate access have not yet been standardised, and such PABXs for small users will therefore not be available until 1995.

- Skilled marketing will be required by the TOs to persuade customers of the benefits of ISDN. BT's marketing for the introduction of its ISDN2 services includes the offer of supplementary services (such as calling line identification) free of charge in the first year, and free development laboratory facilities for the terminal manufacturers, to ensure interoperability. BT is also sponsoring a project to increase public awareness of how the capabilities of ISDN might meet the business needs of today. It remains to be seen whether this approach will succeed.

- International interconnection will be based on the TUP+[1] signalling system; this is the lowest common denominator, since only France, Germany, the UK and Italy are planning to implement the recommended ISUP[2] signalling system. As the TUP+ lacks a number of supplementary services, a transition from TUP+ to ISUP is critical to the co-ordination of ISDN internationally.

Chronology of Development of ISDN Demand

Below, we consider the evolution of demand for an ISDN service in three main phases: short term (1990 to 1995), medium term (1996 to 2000) and long term (2001 to 2010).

In the short term (1990 to 1995)

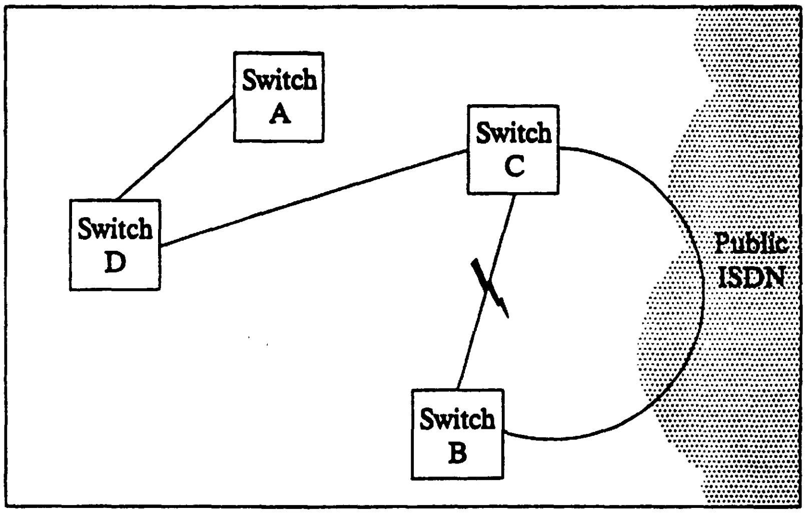
In the first phase, ISDN will be introduced in a majority of the European countries. High equipment costs and an initial cautious marketing effort from the TOs will only result in a slow rate of increase in penetration. Initial users will be organisations with a need for high-quality, reliable communications to a large number of sites (such as retail chains), and organisations with the need for high-quality communications to a number of countries – ISDN really offers a simple and flexible means of communication with the USA and Japan.

ISDN will initially also be very attractive to suppliers and distributors taking part in the 'just-in-time oriented vertical integration' between manufacturers, distributors and suppliers all over Europe. Primary-Rate ISDN access will be taken up by large organisations such as public limited companies, where the use of ISDN PABXs offers voice and data integration, and a flexible means of linking up European subsidiaries and offices. ISDN will also be used to provide back-up for failed leased lines, as illustrated in Exhibit 1.2.

1 The enhanced telephone user part of CCITT signalling system No. 7 (SS7).

2 The ISDN User part of CCITT signalling system No. 7 (SS7).

EXHIBIT 1.2: Back-up for Failed Leased Line



In the medium term (1996 to 2000)

The second phase will be characterised by accelerating take-up. ISDN will be extended to cover not only the whole of the EC, but also the EFTA countries and the majority of the EC's industrial trading partners. The increasing use of ISDN, and the opening of the European market with increased international competition will be reflected in falling equipment prices; the availability of PABXs and other CPE for ISDN Basic-Rate access will allow even the smallest firm to use ISDN.

Small to medium-sized organisations without associated offices will find ISDN an attractive way to communicate with customers and suppliers. Indeed, once the value-added market for ISDN has developed, this offers an attractive way of obtaining a variety of up-to-date information. Organisations with a large number of sites but with low communications needs (such as property brokers, insurance offices and franchise chains) will find that ISDN is cost-competitive, and may replace their data modems and analogue PABX with ISDN systems.

In the long term (2001 to 2010)

Looking at the long-term prospects, the existence of a large number of ISDN equipment suppliers in a maturing market will lead to intense price competition. ISDN will then become the standard for most organisations with more than one subscriber line; this, combined with falling equipment prices, means that ISDN will replace modems and leased lines for a majority of users.

The cost of optical-fibre local loops will have fallen, and large organisations will shift from ISDN to Broadband. Nevertheless, the market for ISDN will still grow as cost-conscious small businesses in less developed regions finally find ISDN financially viable. ISDN will be especially attractive in those markets where demographic developments lead to a sharp increase in demand for residential services, and where a smaller working population will turn productivity and efficiency into key issues for service suppliers.

1.2.3 Broadband

In the early years, the high-speed data transmission capabilities of a switched Broadband service will be of interest chiefly to the business user. However, other applications (such as videotelephony, videoconferencing and high-speed fax) will increase in importance over time and also become more pervasive as falling costs make them economically feasible for residential users (although this is unlikely to occur until well after the year 2000). In the 1990s the growth of demand will rest solely in the hands of the large business user.

Chronology of the Development of Broadband Demand

Below, we consider the evolution of demand for Broadband in three main phases: short term (1990 to 1995), medium term (1996 to 2000) and long term (2001 to 2010).

In the short term (1990 to 1995)

In the short term, we believe that commercial pressures – and a deregulated telecommunications market – will lead to the implementation of MANs in major European urban areas. MANs will be attractive for LAN-LAN interconnect because they will allow users to avoid the costs of leasing private circuits, and because they will enable transmission rates to be increased.

The optical-fibre trunk network will be completed in a majority of European countries, and used mainly for transmission of multiplexed narrowband services and for non-standard Broadband services such as the German IBN (an interim Broadband network which provides videoconferencing and data services). The standard for Broadband will be developed and consolidated during this period, but uncertainty regarding its commercial viability may induce the TOs to delay offering this service. TOs will, however, closely monitor the developments of the MANs, and their customers' requirements.

In the medium term (1996 to 2000)

The introduction of Broadband will be made possible by the availability of synchronous optical networks offering 2Mbit/s to 140Mbit/s subscriber lines, and new developments in optical integrated circuits in the medium term.

Closer to 2000, the prospect of a switched integrated Broadband service offering will grow. Broadband islands will then be linked up domestically and internationally, and successful development of economical Broadband switches will facilitate an integration with the emerging Broadband service. The falling costs of optical-fibre local loops will prompt a phased changeover from ISDN to Broadband as end-to-end high bandwidth transmission becomes possible. However, the changeover will initially only attract large – and to a lesser extent medium-sized – organisations.

In the long term (2001 to 2010)

In the long term, there will be a continuation of the phased changeover from ISDN to Broadband. This will be marked by the use of Broadband systems by all types of organisation. The penetration of Broadband in the residential market will rise, prompted by:

- the low cost of fibre-optic electronics
- the growing popularity of satellite-transmitted television programmes received through the Broadband loop
- the use of HDTV
- the popularity of new advanced value-added services (voice, image and data-based).

1.2.4 Mobiles

The competitive supply of mobile telephony services in the UK and the USA has had a considerable impact on penetration. Competition in the mobile market is now becoming the norm for Europe, but the diversity of geography and culture across countries may prevent a uniform pattern of take-up from materialising. Below, we consider the different issues affecting penetration, and how they might differ from one country to the next.

Issues of Capacity and Penetration

Penetration rates in EC and EFTA countries differ substantially; for example the penetration rate for the UK exceeds 12 subscribers per 1000 population compared with fewer than 3 per 1000 in Italy, despite a simultaneous start-up in 1985. Some of the reasons for this difference are:

- *System capacity*; a number of countries with low penetration rates have adopted the NMT 450MHz system designed for low-density areas. This system was suitable for Scandinavian conditions, and helped countries like Norway to achieve penetration rates exceeding 25 subscribers per 1000 population. However, when installed in urban areas (in Spain and Italy, for example), its capacity was soon fully utilised without penetration rising above 1 subscriber per 1000 population.

- *Upgrading of system*; whereas the Scandinavian countries upgraded their 450MHz systems to the high-capacity 900MHz systems in the mid-1980s to satisfy the increasing demand, most European countries have delayed the replacement of their systems. This may be explained by monopoly inertia, or simply the fact that these countries wanted to wait for the development of digital systems and European standards.

- *Competition*; examination of a number of cellular markets, both monopolistic and competitive, shows that an important factor for penetration is the provision of sufficient capacity, either by enhancing the existing network (with micro cells, for example) or by upgrading the system to higher frequency and/or to digital cellular. With few exceptions, competitive markets seem to respond quicker to the need for sufficient capacity; competition leads to intense marketing aimed at educating target customers quickly, which should lead to faster take-up of the service, provided there is sufficient capacity.

- *Population density*; if there is sufficient capacity and the service is reasonably priced, the take-up rate (defined as the number of subscribers per 1000 population) of cellular systems is strongly determined by population density. Despite the competitive markets in the UK and the USA, their take-up rates are lower than in countries of low population density (such as New Zealand, Australia, Norway, Sweden and Finland).

If we take account of the development of various competing technologies (such as PCN and cordless telephony), additional factors are seen to impact on market share and penetration:

- *Prices of handsets and tariffs*; these have an important influence on market share for services such as cordless telephony which are aimed at the lower end of the market and compete with low-cost alternatives such as public payphones. Handset prices and tariffs will also be important factors for market entrants such as PCN operators who compete with current cellular systems. Tariffs will be affected by the level of network investment required, which in turn can be influenced by regulation; for example, the UK has granted its three PCN operators permission to share their network infrastructure in rural areas, giving an estimated saving of 10% of investment.

- *Geographical coverage*; PCN systems in the UK will begin with a geographical coverage of less than 50% of the country, and will only achieve coverage rates equal to those of the current cellular systems by the year 2000. Whether this will seriously affect their market competitiveness remains to be seen.[3] Despite the positive market-share effect of its low tariffs and low handset costs, cordless telephony has received only a weak market response in the UK; analysts are quoting the limited number of base stations as the main reason for this. The main marketing advantage of satellite mobile services is their European and maritime coverage; they are expected to retain this advantage until at least 2000.

Likely Penetration in EC Member States

Current penetration for Europe as a whole is 3.6 subscribers per 1000 population; if the UK is excluded, the penetration falls to just 1.9 per 1000. When considering the development of cellular systems in the national markets, four distinct groups may be discerned (see below).

We put forward a rather conservative picture of how demand might develop for each of these groups below. In recognition of the possibility that a mass market for mobiles may emerge earlier than predicted in our conservative (Minimum) case, in the modelling we also consider the effects of a less conservative (Expansionist) case. In the Expansionist case, we assume that demand for the mobile application will be higher (by as much as twice the demand of the Minimum case) in all countries.

- *Progressive Markets*. This group contains the UK and Denmark, the only EC countries where the cellular mobile service is actively promoted and demand is satisfied, either through a competitive market or through the efforts of the TO. Both countries use high-capacity 900MHz systems, have high penetration rates and intend to offer digital services within two years. Digital implementation will bring penetration to more than 40 (subscribers per 1000 population) in 1995 for the UK and 60 for Denmark. The digital service will also solve the problems of service quality, such as those experienced in highly urbanised areas of the UK. The term 'progressive' also implies that new operators may enter the market, offering new applications of the digital cellular technology (such as PCN).

3 This issue has divided UK market analysts; whereas Philips and Drew (London) quoted this as one reason for the total PCN market to be limited to 4 million subscribers, Barclays DZW (London) estimates the total market to be 7-10 million by year 2000, disregarding the coverage as an issue.

- *Potentially Progressive Markets.* This group contains Germany, France, Belgium and Italy. These countries are, for a variety of reasons, set to experience the 'mobile revolution' which has already taken place in the progressive markets. In some cases, implementation of a digital system has been decided on; in Germany and France, a competing digital operator has been allowed. In Italy, demand increases have been linked to the growth of the tertiary sector of the economy. Although initial take-up has been slow, with subscribers taking time to appreciate the benefits of the service, penetration rates of above 15 per 1000 population will be achieved after 1995. It is up to the regulatory body in each of these countries to determine whether they will become 'progressive markets' by allowing operators with new applications such as PCN to enter the market. In such cases, penetration rates above 70 per 1000 could be achieved by the year 2000.

- *Conservative Markets.* Countries which we classify as conservative markets include Luxembourg, the Netherlands and Spain, where penetration has been limited by the early 450MHz system and where the TOs have been reluctant to upgrade the system to satisfy demand. These countries are now finally upgrading their system to 900MHz, which will allow penetration to continue to grow, but the growth will be gradual, and the operators will probably have further capacity problems when penetration reaches 10 per 1000, (after the year 2000 for most of these operators). The Netherlands TO was transformed into a private company two years ago, and this has brought various changes in terms of service offerings and marketing; the Netherlands may change pace in the 1990s, and has the potential to become a progressive market. The Republic of Ireland is another conservative market for mobiles; penetration only reached 3 subscribers per 1000 population after five years of operation, despite a high-capacity 900MHz system.

- *Late Entrants.* The late entrants group contains Portugal and Greece, which are both starting up a cellular service. Portugal has a C450 cellular system. Greece appears to be more optimistic than Portugal, and aims to achieve a penetration of 5 subscribers per 1000 population within the first two years of operation. However, a more conservative estimate would put penetration no higher than 2 or 3 per 1000 population within the first five years.

Chronology of Development of Mobile Demand

Below, we consider the evolution of demand for mobiles in three main phases: short term (1990 to 1995), medium term (1996 to 2000) and long term (2001 to 2010).

In the short term (1990 to 1995)

The penetration of cellular systems will continue to increase in the short term. Growth will be particularly strong in the *progressive markets* which are fully prepared to take advantage of cheaper handsets and lower tariffs. There will also be substantial growth in the *potentially progressive markets*, where a penetration of above 15 subscribers per 1000 population is expected by 1995. Growth in the *conservative markets* will be less radical than in the potentially progressive markets, and we consider a penetration of more than 5 per 1000 to be optimistic for 1995.

Towards the end of this phase, PCN services will only be offered in the UK, and considerable uncertainty surrounds the initial rate of take-up. Given the high profit margins of existing cellular operators (and the flexibility of digital cellular systems), the new market entrant is faced with strong competition. Existing cellular operators enjoy very high profit margins and are, combined with the new flexibility of the digital systems, in a very strong position to compete with any new market entrant. Cordless telephony will be offered in the UK, France and Germany, but is expected to achieve only modest growth; the limited number of cordless telephony base stations will persuade the majority of the potential customers to choose the cellular system. Once 'single-cell' cellular (requiring no hand-over from cell to cell) is offered, the market for cordless telephony will cease to exist.

Maritime satellite communications will be strong during this period, replacing the current radio-communications systems. The total number of terminals sold for the European market will probably be close to 10 000. The prices for mobile satellite terminals are expected to fall sharply during this period, making it commercially viable for customers in the transport industry, where satellite will be the only means of ensuring pan-European coverage. The potential market for coastal maritime traffic will, however, be substantially reduced, because of improvements in cellular coverage.

In the medium term (1996 to 2000)

In the medium term (1996 to 2000) we expect that the *progressive markets* will reach a state of maturity, with penetration of cellular systems exceeding 65 per 1000 population. GSM will be available, and will gradually lead to a decline in the demand for analogue cellular. Towards 2000 there will be rapid growth in the demand for GSM services. The combined effect of increased geographical coverage and aggressive marketing strategies will bring an increase in the penetration levels of PCN. It is also likely that some *potentially progressive* markets will allow PCN operators to compete with existing cellular operators. *Conservative markets* approaching penetration levels of 10 per 1000, will allow competing digital systems in 1995.

In the long term (2001 to 2010)

In the long term (2001 to 2010) the demand for mobile services will grow rapidly. The GSM service will have matured, and UMTS will be operational before 2005.[4] Most markets will install competing digital cellular systems, and PCN will be a strong competitive force in the *progressive* and *potentially progressive markets*, mainly with other cellular systems, but also to a large extent with fixed-wired telephony. The penetration rates in countries with competing cellular systems based on the PCN concept will exceed 100 subscribers per 1000 population, and other countries (apart from the late entrants) will have a penetration of at least 70 per 1000.

Competition in the local loop will intensify, with the TO, cable TV operator and PCN operator competing for market share, and this will exert strong downward pressure on tariffs. PCN operators are likely to be highly price-competitive in the offering of new 'local loops', but not in terms of existing copper loops; the TOs' market share in terms of local loops will fall only slightly during this period, and they will continue to have the largest market share.

By 2010, with pan-European coverage achieved, cellular operators will present a strong competitive force for land mobile satellite operators. Having enjoyed a monopoly on the offer of pan-European coverage for a 15-year period, such operators will now find their potential market limited to those requesting coverage of Europe and adjacent areas such as the Near East and North Africa.

1.2.5 Cable TV

European cable TV systems complement rather than replace normal broadcasting, their purpose being to improve the offering of television and radio entertainment. The

4 UMTS relies on GSM, and international compatibility for a country's service would be possible within three years of that country introducing GSM.

penetration (number of homes connected compared to the number of homes passed) differs greatly within Europe.

The likely progress of cable TV during the next two decades is very important for telecoms service providers, given that within ten years it will be technologically and economically possible to deliver telecoms and television services to the home over the same access links. More households in Europe have a television set than a telephone, so there is a potentially large market for a service which offers increased television viewing potential with simultaneous telecoms capabilities, bundled at an attractive price. In the short term, however, before this combined service is available, there is unlikely to be major growth in the take-up of cable TV. We expect the major progress in take-up to commence in the medium term, when there will be some implementation of fibre-to-the-home. In the long term, once telecoms and entertainment services are offered over the same access links, cable penetration will receive a further boost.

Penetration Issues

Below we consider a number of issues which influence the penetration of CATV.

- *Availability of programmes*; Belgium has a penetration of more than 90%, and the Netherlands has a penetration of 70%. In the early 1980s penetration was boosted by the ability of these countries to offer a multitude of programmes imported free of charge from their 'TV-budget rich' neighbours. Large TV producers like the UK and Germany will also have cable TV operators with a range of programme sources, but limits on sources of new material will inhibit growth in smaller European countries.

- *Multi-linguistic audience*; the scope for importing programmes is determined by the language skills of the audience. This has been of importance to the penetration in the BeNeLux countries, but may also stimulate growth in areas with large ethnic minorities[5] and areas with large groups of expatriates.

- *Satellite-transmitted programmes*; the growth of satellite-transmitted programmes has proven to be the biggest incentive for potential subscribers to the cable network. A large number of competing satellite programmes, and the lack of rapid price falls for the satellite dishes for the home, have made cable the only economical alternative for those who want to receive a range of satellite programmes.

5 An electronic snapshot of viewing in an area with a large Asian population in the UK showed that 27% of the audience watched Indra Dhnushm, a cable TV channel showing Hindi films and television programmes 16 hours a day.

- *Penetration of video recorders*; a high penetration of video recorders, and a strong distribution network for pre-recorded video tapes could be barriers to entry for the cable TV operator, especially in the offering of pay-per-view services.

- *Market regulation*; the EC Green Paper sees one-way cable TV and receive-only satellite terminals as clear candidates for liberalisation. However, a decision regarding two-way cable TV systems has been deferred. The current regulatory environment differs greatly within the European Community.

  UK regulators have defined 136 cable franchise areas; each operator is required to provide a certain coverage of the awarded area. The UK cable TV operators are allowed to receive and transmit television programmes as well as offer a local telephony service, although currently this requires dispensation from the regulatory authority (Oftel). At present, switching has to be via one of the two national carriers (BT and Mercury), but this requirement would be removed under planned legislation. In France, the provision of cable TV has been liberalised, and considerable activity is now taking place; for example, two major water utilities have made heavy investment in switched-star cable TV systems. In Germany, where cable TV is the responsibility of Deutsche Telekom, there has been a costly implementation of optical-fibre based cable TV systems, but subsidised tariffs have allowed a high level of penetration to be reached.

- *Local telephone service*; when cable TV operators are allowed to offer a telephony service, it provides them with a significant source of additional revenue for a small additional cost. In addition, the cable service becomes more attractive to potential subscribers, as they can receive both a telephony and television service in one package deal.

- *Venture capital*; when (as in the UK) the cable TV market is offered to private investors, the availability of risk capital is important.

- *Potential for telecommunications*; the majority of investors in the UK come from the USA, and a substantial proportion of these are the Regional Bell Holding Companies (RBHCs) who are not allowed to operate cable TV networks in the USA. The RBHCs are hoping to use cable TV networks as a bridge-head into the supply of telecommunications. Cable TV operators in the UK with switched-star systems intend to offer telephony in the future, but this will only be economical when the penetration is higher than the current estimated break-even point of 25% to 30%.

Chronology of Development of CATV Demand

In the short term (1990 to 1995)

In the short term we expect a fairly slow implementation of cable TV systems in most European countries, with much of the growth coming from markets where cable TV franchises are awarded for regional areas, or where TOs have undertaken to provide national coverage. Most of the European TOs will find that their undertakings in terms of optical-fibre trunk networks, network digitalisation and ISDN will limit their ability to invest in cable TV.

The majority of European markets are therefore likely to allow private investment where a franchise is awarded for each region, where satellite programmes can be transmitted and where the choice of whether to offer interactive services or not is left to the investor. The result will be a Europe with a mix of different systems with different service offerings.

In the medium term (1996 to 2000)

The growth of cable TV will be highest in the medium term, i.e. 1996 to 2000. The fibre-to-the-home concept will be on the verge of becoming economical (assuming that cable TV can be offered on the local loop), and this will initiate a period of high growth. It seems likely that the TOs will install and maintain residential optical-fibre loop, and that a private cable TV operator will transmit the television and radio over the TOs' lines, in either broadcast or interactive mode.

The proportion of homes passed will grow dramatically, and penetration (homes connected) will typically increase from 20% to 50% of homes passed, as the number of channels transmitted by satellite grows substantially, and as more people regard reception of satellite programmes as important as reception of the national programmes. The growth will be slowest in the southern area of Europe. In Spain, Portugal and Italy, for example, the shortage of satellite-transmitted or imported programmes in suitable languages will prevent growth, except in the metropolitan areas.

In the long term (2001 to 2010)

Looking at the longer term, we see the *potential* for the voice-telephony monopoly to be broken, with the establishment of competing national carriers in some European countries. Given appropriate regulatory change, private cable TV operators with switched systems will be able to enhance their revenues by offering voice telephony. The pressure to carry both TV and telecoms on a single access link will be considerable, and convergence of TV and telecommunications can therefore be expected; the full effect on voice-telephony monopolies will probably only be felt at the end of this period at the earliest.

1.2.6 Leased Lines

With the introduction of ISDN it is anticipated that the demand for analogue – and some digital – leased circuits will fall. However, one source of expanded new demand will come from mobile operators. As competition is encouraged and new private mobile operators offer services there will be an additional demand for both narrowband and Broadband leased lines for interconnection.

A main development will be the growth in importance of VSATs. There is a large potential market for VSATs, mostly major international organisations who see VSATs as a quick means of implementing a pan-European digital data network and of providing a back-up to their existing terrestrial services. The VSAT market may also include organisations which have high-volume data-transmission requirements and see VSATs as a way of reducing their communication costs.

Chronology of the Development of Demand

In the short term (1990 to 1995)

In the short term, analogue leased lines will continue to be used by SMEs where cost is more important than speed or quality. As ISDN becomes more widely available we expect a decline in demand for analogue leased lines. Although digital private circuits offer the same transmission quality and speed capability as ISDN, and require no special ISDN equipment, they will really be an option for high-volume users communicating with a limited number of sites.

In the short term we also expect a greater use of the space segment. The growth of international VSATs is dependent on satellite deregulation; the process has started, but is opposed by a large number of TOs because it poses a by-pass threat to their fixed networks and could trigger direct competition between the administrations. We therefore expect the growth of international VSATs to begin only towards the end of this period, perhaps 1993 or 1994. Domestically, VSATs will prove popular with large organisations, mainly to provide a back-up service to their leased lines.

In the medium term (1996 to 2000)

The growth of VSAT installations will be relatively short-lived. Towards the end of the 1990s, the rate of growth in demand for VSATs will decrease; the installation of ISDN and Broadband networks will provide high-quality and reliable networks offering very high transmission speeds, and so the attraction of VSATs as a back-up system will diminish. The speed at which VSATs can be installed could lead to new service offerings; for example, the facility to have one or more VSATs installed for a limited period while terrestrial links are being repaired or new optical-fibre lines are being installed.

In the long term (2001 to 2010)

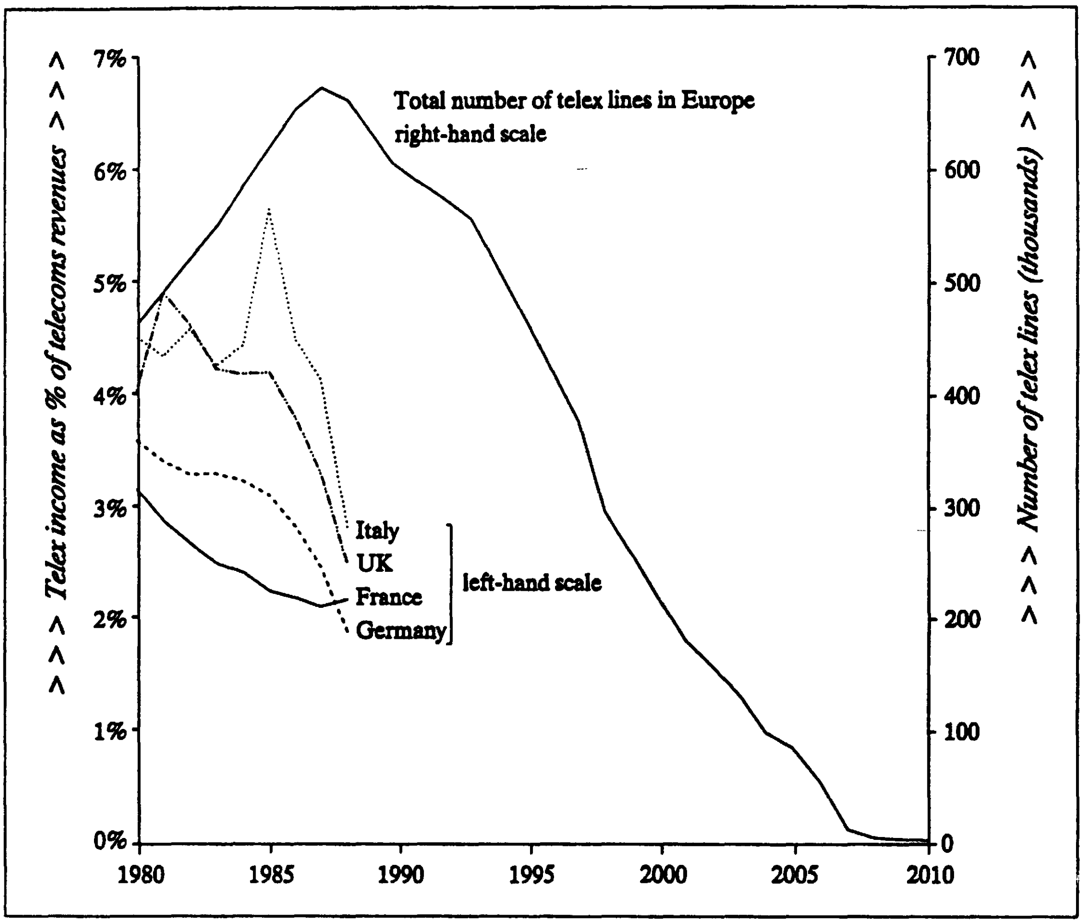
Analogue leased circuits will finally be phased out in the first decade of the 21st century. By then, the main competitive edge of the VSATs will be their pan-European coverage and relatively low transmission cost when used for long-haul transmissions. The demand for VSATs will thus continue to grow, but at a very slow rate; by 2010, terrestrial optical-fibre networks will provide extensive coverage and be more cost-effective than VSATs.

1.2.7 Telex

Penetration Issues

Exhibit 1.3 overleaf demonstrates how the number of installed telex lines started to decrease after 1987 in Europe. This decrease is expected to continue as the majority of small and medium-sized organisations with little need for intercontinental communications stop leasing telex equipment. The rate of decline will eventually slow down as a large number of international organisations still depend on the telex service.

EXHIBIT 1.3: Projected Telex Lines and Revenues



Chronology of Development of Demand

Telex is still considered important by most large international organisations, and telex networks will therefore continue to be maintained during the 1990s and beyond. However, a number of smaller users will stop using the service, as their communication needs within Europe are better satisfied by other services (such as the Group 3 fax or packet-switched data). Notable exceptions will be rural areas in southern Europe where the number of installed lines will continue to increase until around 1993. We assume that the number of installed telex lines in the European Community will decline sharply during the 1990s from the current level of 600 000.

2/ General European Technological Projections

This chapter describes our technological projections at the European level; demand and regulatory projections are contained in Chapters 1 and 3 respectively. Important financial and economic issues are discussed, as well as their likely impact. Although the main themes are set out with reference to the EC generally, country-specific examples are put forward where appropriate. Such examples provide an indication of the current wide differences which exist across Europe.

Where we attach a date to a trend or development, this relates to our projections for advanced countries in the Expansionist Case.

Following an overview of the main milestones in the technological projections (Section 2.1), we go on in Section 2.2 to consider basic aspects of networks and technologies, with particular reference to current networks (PSTN, leased lines, packet- and circuit-switched data networks) and their future integration. In Section 2.3 we discuss other network services, under six headings:

- ISDN
- Broadband
- mobile communications
- cable television networks
- satellite communications
- telex.

Section 2.4 sets out the conclusions on the technological projections.

2.1 Overview of the Technological Projections

In common with the projections relating to regulation and demand, the technological projections are split into three time periods: 1991-1995, 1996-2000 and 2001-2010. They incorporate not only the techniques and equipment which might be implemented but also the possible roll-out of network infrastructure. In effect, the technological projections identify the earliest dates at which technologies may be expected to be generally available to the market in Europe, and consequently, the dates of introduction of those technologies into countries that are likely to be technological leaders.

In the technological projections we have considered the potential course of events in the more advanced countries; in this sense the projections do not represent a European average. Peripheral and underdeveloped countries (such as Eastern Europe and Spain) will seek to develop good penetration and will use modern technology to do it. Differences in timing for individual countries are the subject of country projections discussed in Annex B.

The technological projections are summarised in the diagram opposite. On the left-hand side we have set out major topics; we have represented their implementation or impact over time by horizontal bars containing commentary. (The density of shading represents scale or degree, according to context.)

We expect the following developments in the 1991-1995 timeframe:

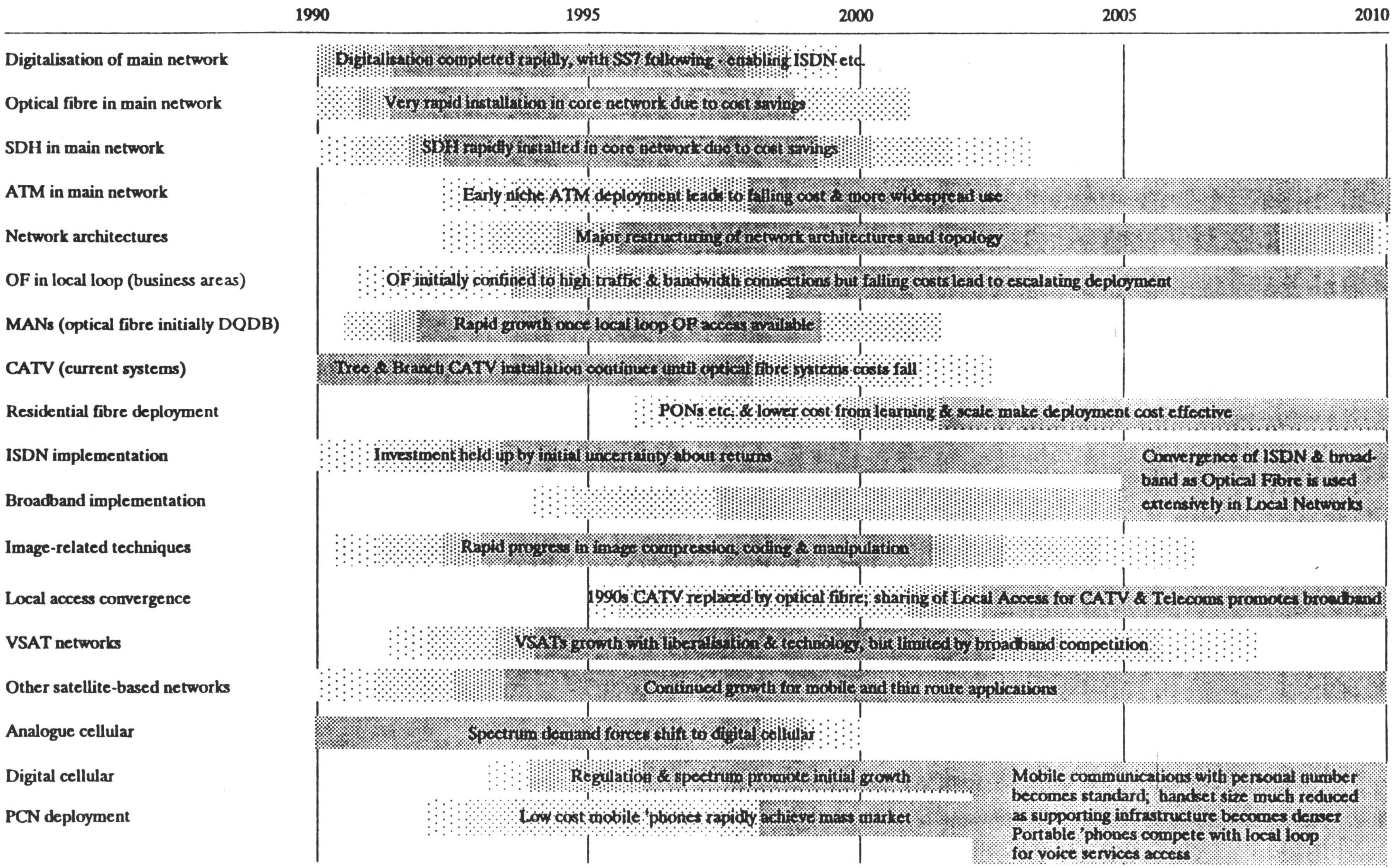
- *From 1991* – rapid digitalisation of all networks will be well underway, with the corresponding implementation of CCITT Signalling System Number 7 (SS7) to allow the support of ISDN and enhanced facilities. A major development will be the start of ISDN implementation. Many local exchanges are already capable of supporting ISDN, and the main change will be in the availability of line cards and ISDN multiplexers to provide local access.

- *From 1991* – introduction of Synchronous Digital Hierarchy (SDH) equipment in place of plesiochronous multiplexers. The deployment of optical fibre and the use of SDH will be driven by cost savings in transmission, in terms of capital costs and operations and maintenance.

- *From 1991* – in mobile telephony, there will be a rapid growth of existing analogue cellular, and service providers will seek to implement technological improvements to fend off competing digital technologies.

- *From 1992* – a rapid growth of MANs (metropolitan area networks) in major European urban areas for high-speed data, and as a general alternative to high-capacity leased lines. This will be possible because of the gradual deployment of optical fibre in some areas beyond the core network. The growth of MANs will be limited by the extent of this local access and the rate at which alternative ISDN-based solutions become available.

Technology Projection (Expansionist Case, Advanced Countries)



- *From 1993* – GSM-based digital cellular and PCN systems will be introduced. PCNs will be aimed at mass markets, and will establish themselves as major systems by 1995.

- *From 1993* – liberalisation will allow the use of VSATs, and developments in consumer electronics will enable customer units to be introduced at low cost. Satellites will retain their strong position in niche applications such as mobiles and thin routes. Further improvements are likely in both ground- and space-based transceiver technologies, but the economics of fibre cable systems are expected to become increasingly competitive for both terrestrial and submarine applications.

- *Before 1995* – little change in the choice of technology for CATV provision, as low-cost distributive solutions will continue to be attractive. There will, however, be continued growth in CATV implementation, with some limited use of optical fibre in primary distribution, giving rise to mixed metal and optical fibre systems.

- *By 1995* – major changes will be underway in network architecture. The introduction of optical fibre and SDH will alter the economics of telecoms networks in favour of longer transmission routes; switching will begin to retreat towards the core of the network; multiple hierarchical layers will start to be replaced with much flatter structures; some local access will move towards mixed ring and star topologies with much longer access line lengths via optical fibre, remote multiplexers and digital cross-connects.

- *From 1995* – direct optical-fibre connections will still be mainly restricted to larger businesses, but a stronger deployment of optical fibre will be evident towards the end of the decade.

We expect the following developments in the 1996-2000 time frame:

- *From 1996* – residential subscribers will begin to be served via the first Passive Optical Networks and related developments (fibre-to-the-curb). Such systems will become the preferred solution for new CATV ventures which seek to offer distributed and interactive video services, as well as the option of access to conventional telephony.

- *From 1996* – the new architectures and transmission technologies will lead to the early application of ATM as a transmission technique, and its selective use in switching in support of data and related services. However, standards issues – and the complexity and cost of ATM – will initially prevent its more widespread applications.

- *From 1996* – considerable progress will be made in image-processing techniques, and they will begin to be used in CPE to exploit the rapidly expanding bandwidth available on new infrastructure. These technologies will enter a mature phase, enabling substantial cost reductions in capturing, encoding, transmitting and processing images. Videotelephony in particular will begin the transition from a business application (used on private networks and limited by cost) to a more widely used switched service.

- *From 2000* – optical fibre will become the principal (but not the only) method of providing new access to public telecoms facilities. Most businesses will have – at least potentially – access to high bandwidth on optical-fibre systems (possibly by means of shared multiplexers).

- *From 2000* – transmission costs will have continued to fall during the decade, so that flat network structures will be consolidated, and switching will become highly concentrated. Most local access will have been restructured to accommodate these changes, although in the final drops (and other parts of the network close to customers) many copper pairs will remain.

- *From 2000* – the development and use of analogue cellular and overlay data networks will stagnate, a decline helped by gateways which provide access to and from newer networks and technologies.

- *From 2000* – the role of satellites will be limited to specific mobile applications, thin route applications, and broadcast. Although satellites can be expected to provide higher-power output, and receivers to become more sensitive, the rate of development is unlikely to out-pace technological advances in fixed networks. The relative importance of VSATs is likely to decline.

- *From 2000* – ATM will become increasingly important through its ability to flexibly handle wide ranges of service bandwidth and support intelligent networking – for example, the ability to integrate the fixed and mobile networks into one seamless service.

We expect the following developments in the 2001-2010 time frame:

- *From 2005* – all new CATV and residential telecoms will be based on optical fibre, either as passive or as active local access networks. The change in network architectures will mean that the vast majority of subscribers will use optical fibre at some point in their local access network.

- *From 2005* – communications will be based on personal numbers rather than on location, and will rely on increasing network intelligence.

- *From 2005* – very advanced coherent optical techniques (including the use of solitons) for making more efficient use of optical fibres and for switching will be used extensively in the trunk network.

2.2 Basic Network and Technology Aspects

Below, we include an overview of current telecommunications networks (2.2.1), then describe in greater detail the major network and technology trends which will have an impact in the next 20 years (2.2.2), and briefly discuss developments which are likely in the longer term (2.2.3).

2.2.1 Overview of Networks

The four basic telecommunications networks – Public Switched Telephony, Private Circuits (leased lines), Packet-Switched Data and Circuit-Switched Data – form the core of telecoms. Although mobile communications and CATV have become increasingly important, the evolution and convergence in the basic fixed networks are likely to dominate strategic thinking in telecoms over the next decade and beyond. In this section we briefly discuss the attributes of the four basic networks, and use their future development through ISDN and beyond as the basis for a more general discussion of the development of telecoms technologies and the crucial issue of network architectures. Other networks and services such as mobile CATV are discussed in Section 2.3. The four basic telecoms networks are currently logically and physically separate, as Exhibit 2.2 demonstrates.

Public Switched Telephone Network

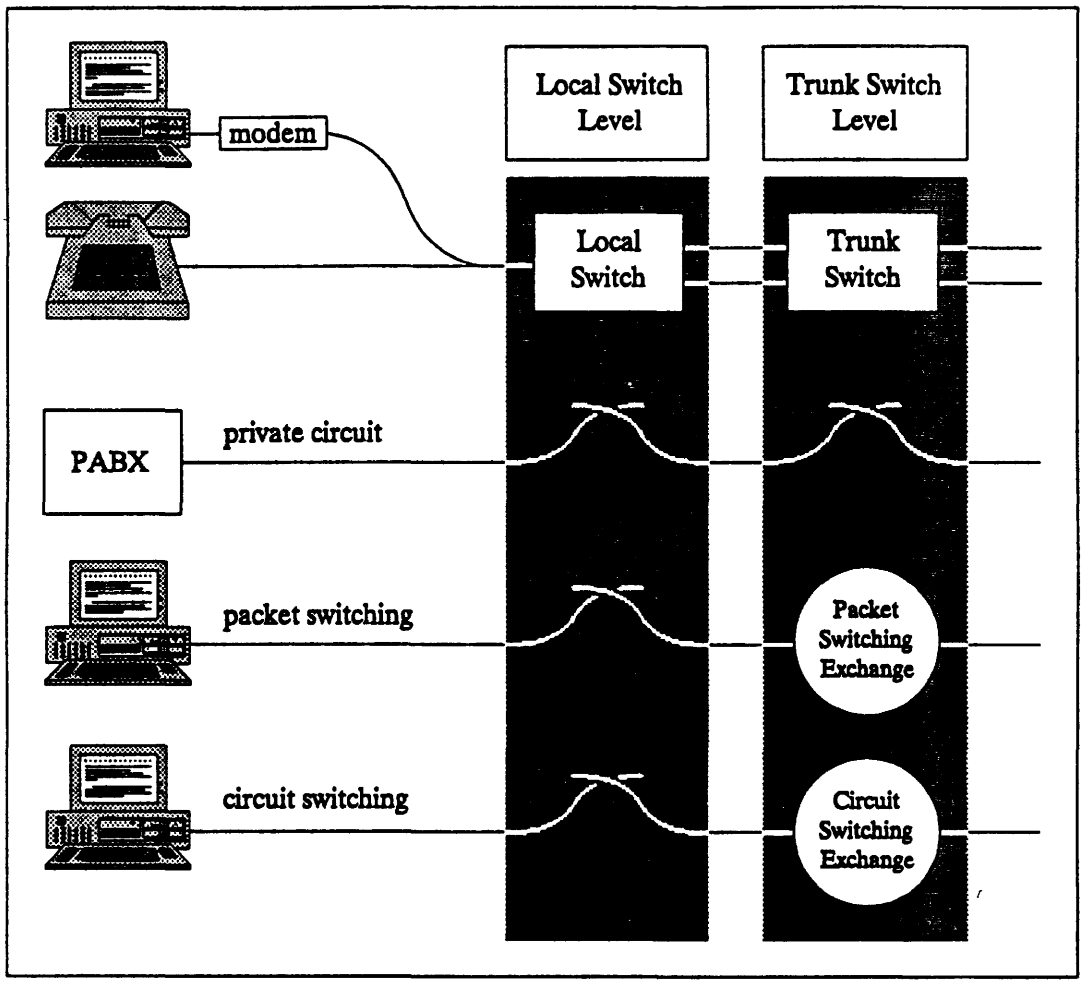
The traffic on the public switched telephone network is driven both by voice and data traffic. The voice traffic has been boosted both by a growth in the number of installed lines – currently growing at 3% to 4% per year in Europe – and by increased telephone usage stimulated by economic growth and a general fall in tariffs in real terms, especially for long-distance calls.

Data traffic over the PSTN is a popular choice for organisations with a low volume of data transmission and where quality problems are not critical. Over the last five years there has been significant growth in data transmission using fax machines over the PSTN. The transmission speed normally used for data traffic is 2.4kbit/s, but technological developments have made transmission speeds of 9.6kbit/s and 19.2kbit/s possible.[1] Organisations with a need for data transmission frequently use circuit- or

[1] Group III fax machines use transmission rates in this range, but adjust their speed to one of a few recognised rates (according to line conditions).

packet-switched networks or leased lines, as these provide higher quality and reliability. However, in the future ISDN offers a transparent 64kbit/s communications channel; as equipment prices fall, PSTNs will become a viable alternative.

EXHIBIT 2.2: Current Telecommunications Networks



Leased Lines

Leased lines (also known as private circuits) – use the public network infrastructure to offer non-switched one-to-one communication lines. These lines may be either voice-band analogue or else digital, operated at a wide range of transmission speeds. Leased lines are cost-effective for high-volume data or voice transmission between fixed locations. Leased lines are also a popular choice for users with critical requirements for security, availability or a quick call set-up time.

Packet Switching

Packet-switched data was developed during the late 1970s and 1980s as a means of supporting intermittent, short-burst datacommunications. It can be supported on the public transmission infrastructure (providing this is digital), but uses its own packet switching exchanges. Packet switching is attractive for a wide range of applications, for several reasons: it has a low error rate; it can be used to link dissimilar computers; and tariffs are almost independent of distance (being based largely on the volume of data transmitted).

Access to packet-switching networks is achieved either through dedicated data lines or via a Packet Assembler/Disassembler (PAD) which provides user interfaces for access via the PSTN, and may include various forms of protocol conversion for specialist applications.

A packet-switched data service is available today in nearly all EC Member States, but continuous problems with international transmission[2] have slowed the growth of the service, and forced a number of potential users to choose international leased lines as their transmission media, despite the higher costs.

Circuit-Switched Data Networks

Circuit-switched networks provide a continuous link between both parties. This is an attractive option for those organisations looking for protocol transparency and guaranteed bandwidth, and it may offer better economy for those users who would otherwise use digital leased lines. Other popular applications are for various types of custom-designed transaction-oriented systems where short call set-up and holding times – but high data rates – are important. Circuit switching is being offered on a very limited scale in Europe (in Denmark, France, Germany and Italy). Speeds of up to 9.6kbit/s are available in all these countries, and France and Germany are also offering speeds up to 1.92Mbit/s. ISDN is a direct substitute for this service and so overlay circuit-switched data networks are not likely to survive very long.

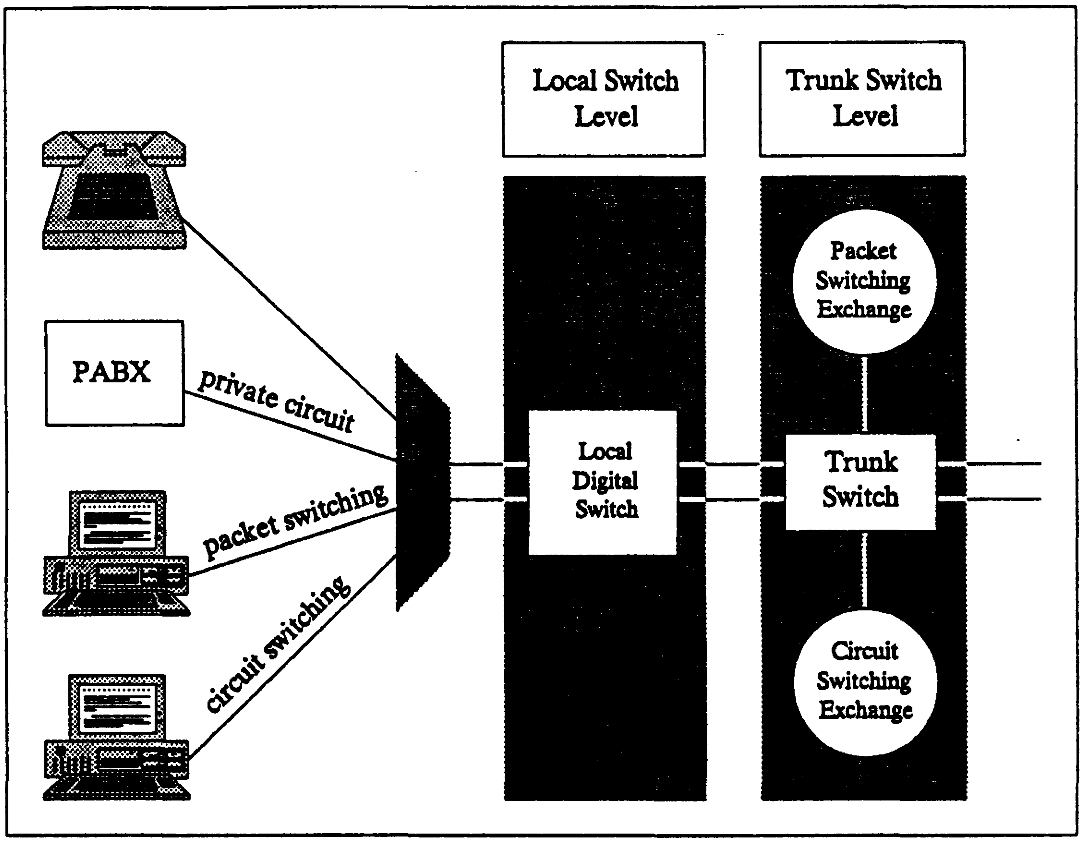
Network Integration

European networks are becoming increasingly digitalised; mainly in the trunk transmission networks, but also in trunk and local switches. Digitalisation enables the integration of transmission resources, bearer functions and physical handling, leading to a more effi-

2 According to a study done by Eusidic (the European Association of Information Services) in 1989, 25% or more of international calls failed in six out of the twelve EC Member States.

cient use of the network infrastructure, as well as efficiency gains in operations and maintenance. A typical digital integrated network is shown in Exhibit 2.3.

EXHIBIT 2.3: Integrated Telecommunications Networks



Apart from improving the utilisation of physical resources, digital PSTNs will also provide the basis for the introduction of ISDN, a service which competes directly with the packet- and circuit-switched network, as well as with both analogue and digital leased lines. The specific development of ISDN is discussed in Section 2.3.1 below.

2.2.2 Major Trends

The basic technologies for transmission and switching are expected to evolve over the next 20 years and consequently will continue to have an impact on telecommunications networks. Dramatic improvements in cost and performance will lead to major changes in all areas:

- The development of new processes and manufacturing technologies, coupled with the use of new materials mean that the techniques and components used (in signal processing, image compression and encoding, switching and transmission etc.) will progress at – or above – historical rates.[3] Cheap mass storage and processing power, together with rapidly falling transmission costs are being brought about through improvements in basic components and the techniques for using them. These techniques include advances in integrated circuit technologies, opto-electronics and optical fibres, allowing wave-division multiplexing (WDM) and coherent multi-channel systems (which are already being implemented in some core networks), extremely high-capacity transmission systems and the potential for practical optical switching.

- These techniques and components feed through into telecommunications products; they allow existing equipment to be made more cheaply and more reliably. More importantly, they bring about fundamental shifts in the cost structure of telecommunications networks.

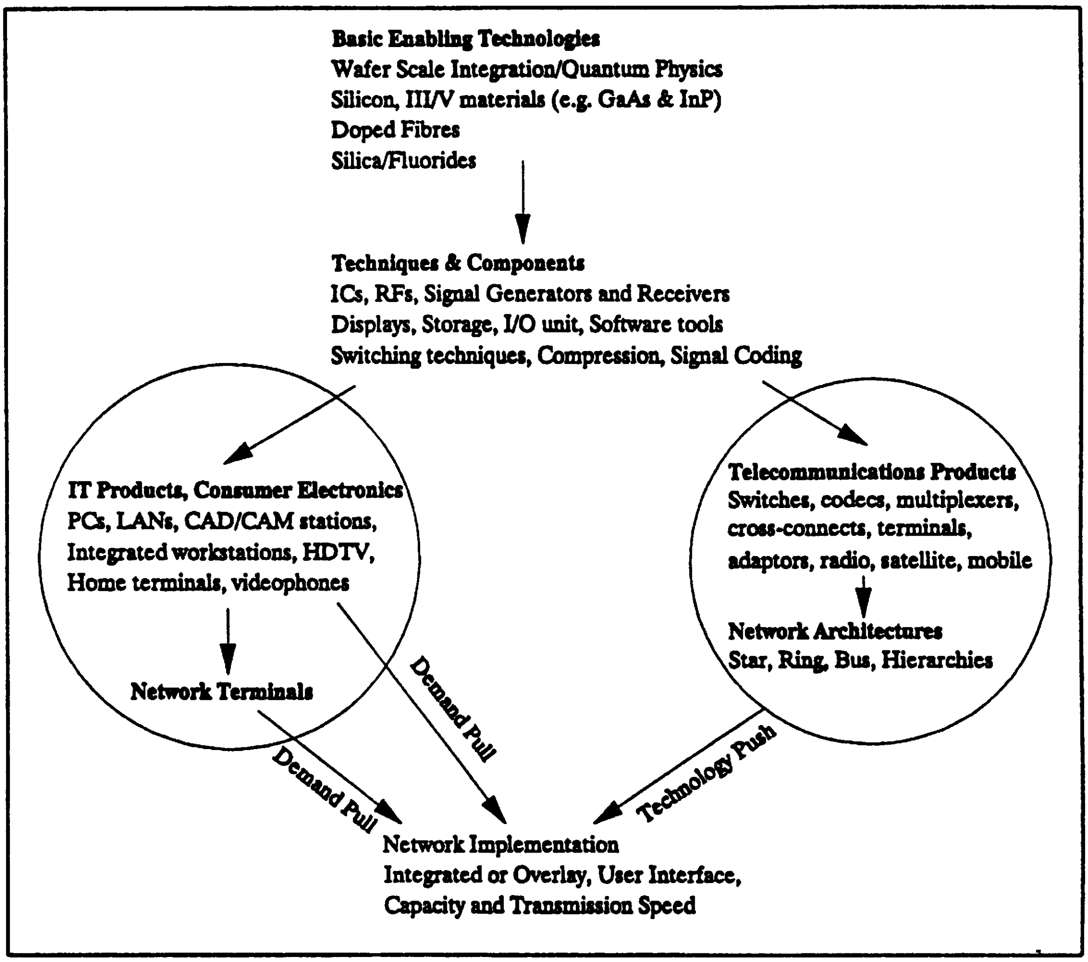
- The changes in cost structure lead to changes in network architectures; for example, as transmission costs fall relative to switching costs, the economically optimum number of switching nodes declines. Once optical fibre becomes economic to install, the transmission cost per bit can be very low. This process rapidly leads to the centralisation of switching and other network processes.

- Parallel to these developments in network equipment and architectures, the improvements in cost performance and capability of general IT products lead to correspondingly greater demands being put on the telecommunications networks for transmission of high-volume information, particularly images. Developments in system design, software, displays, I/O devices and disk drives will force the development of new high-speed computers and workstations, as well as home entertainment products such as HDTV. These developments will also ensure that the subscribers' demand for transmission speed and connectivity in the telecommunications network will continue to grow into the 21st century; although organisations are currently looking for 10Mbit/s LAN-LAN interconnect speeds, they may well be looking for 140Mbit/s interconnect by the mid-1990s. Increased demand for transmission speed and connectivity, and the rapid technological developments are reinforcing the changes in the architectures of the future telecommunications networks.

This process is shown in Exhibit 2.4:

3 The semiconductor industry does not envisage any limits on the speed of developments, even beyond 2000. Recent developments have improved the speed, cost, processing and memory capacity of components; integrated circuits offered a memory capacity of 256kb DRAM in 1983, 1Mb DRAM in 1986, 4Mb DRAM in 1989, and are expected to offer 16Mb DRAM in 1992 and 64Mb DRAM in 1995. During the same period, the access time has fallen from 200ns. in 1983 to 20ns. in 1995 *(Source: The Semiconductor Business Research Dept, Toshiba, Japan)*. Similar rates of development can be expected in opto-electronics, optical fibres and other technologies, provided that market volumes grow.

EXHIBIT 2.4: The Relationship Between Technology and Network Implementation



The Exhibit demonstrates how development of basic enabling technologies and techniques leads to new products, both in the telecommunications supplier area and the telecoms user area. The developments will certainly lead to improved telecommunications products, which will facilitate the introduction of Broadband – initially for the business subscriber, and eventually for the residential subscriber. The improvements in computing capabilities will certainly continue, and new SLSI[4] based consumer electronics products – especially image application products – will require very high transmission rates.

New networks and services such as Broadband will therefore not simply be pushed into the market, but will be the result of both new technology making Broadband available and the demand arising from new business and residential applications.

[4] Super Large Scale Integration.

Basic Enabling Technologies, Techniques and Components

Important basic enabling technologies, techniques and components are:

- *Semiconductors*. Improved methods of wafer scale integration and research into quantum physics methods will improve semiconductors (integrated circuits). Replacing silicon with new Group III/V materials (e.g. GaAs) will increase speed and memory capacity. The costs of integrated circuits are expected to continue to fall at 20%-30% p.a. over the next ten years.

- *Opto-electronics*. These components convert signals between optical and electrical media by the use of lasers or LEDs over fibre optics. Current research is directed towards integration of the various components onto one semiconductor substratum. This will lead to a dramatic cost reduction as well as higher performance.

- *Photonics*. Current research is using doped fibres as lasers or amplifiers to improve transmission speed capabilities. Integrated optical devices are being developed, using optical waveguides to perform switching functions at tens of Gigabits per second (Gbit/s) transmission speeds. Improvements to the fibre itself are also being researched; the use of fluorides instead of silica would further reduce transmission losses, and thereby lower the costs of global traffic. The current limitations mainly arise from the electronics, and this research will therefore have greatest impact in the next century.

- *System and software design*. Software is now performing a key role in telecommunication systems, and its importance will continue to grow. The system design of the software ensures that implemented systems are flexible and adaptable, and the software quality is crucial for reliability. The reliability issue is also growing in importance as software upgrades can be distributed almost instantaneously across a network, rendering it vulnerable to a single fault; most major equipment suppliers have recently revised system design procedures in order to ensure higher software quality. The quality requirements have, however, lowered programmer productivity, and have initiated the development of Computer Aided Software Engineering (CASE). The establishment of CASE, together with similar developments, has the main purpose of standardising the software production to encourage the use of 'ready-made' modules and to increase productivity without compromising quality requirements.

Telecommunications Products and Techniques

Major developments in telecommunications products and technologies using techniques such as those described above – and other enabling technologies – are likely to include the following:

- *Switching*. The capacity of a typical electronic switch is currently 64kbit/s. This is now being increased to 2Mbit/s, and advances towards 140Mbit/s and 600Mbit/s are expected before the year 2000. The development of asynchronous transfer mode (ATM) switches will lead to bandwidth flexibility and better utilisation of the switching resources - ATM has been adopted by the CCITT in its first draft recommendation for Broadband. Optical switches, which will offer switching speeds exceeding 600Mbit/s (being dependent only on the bitrate of the transmitted signal), are expected to enter the market between 2005 and 2010.

- *Transmission*. The migration towards fibre optics as a transmission medium has led to a drastic reduction in the number of repeaters (or amplifiers) required; fibre optics as long as 100km without repeaters are now practical at 140Mbit/s, and optical amplifiers are being developed which will enable fibre optics to cover even greater distances, without the need for opto-electronic conversion. Travelling wave semiconductor laser amplifiers (TWSLA) are now available; these facilitate transmission over 1000km or more, at rates of 140Mbit/s to 10Gbit/s using 12 amplifiers. Experiments are being conducted with non-linear fibre amplifiers (such as the erbium-doped fibre laser amplifier) to achieve better bandwidth, higher frequency and lower noise. Developments in methods of modulation are expected to increase the capacity; during trials with sub-carrier modulation (SCM), systems spanning 1000km using ten optical amplifiers have achieved transmission rates of over 16Gbit/s.

- *Multiplexers*. Plesiochronous multiplexers in current use build up capacity through a hierarchy of multiplexing modules - requiring units at three multiplexer levels to split a 140Mbit/s frame down to 2Mbit/s tributaries. The move to SDH (synchronous digital hierarchy) or SONET (synchronous optical network), allows a 155Mbit/s frame to be broken into 2Mbit/s tributaries using only one electronic unit. SDH/SONET also offers the option for the switching and add-drop of circuits at rates of N x 2Mbit/s or N x 1.544Mbit/s.[5] The new systems take the opportunity to add improved network monitoring, management and control facilities, which increase network flexibility and reduce overall costs. Within the SDH framework, ATM is likely to become increasingly important as a transmission protocol, enabling efficient multiplexing of traffic and usage of capacity.[6]

- *Passive Optical Networks*. The use of active optical fibre systems in the local loop is expected to be economical only by 2000 at the earliest, and to be limited by the cost of the equipment at the subscriber's end. Passive optical networks (PONs) are an

5 The T1 rate.

6 ATM (asynchronous transfer mode) is sometimes wrongly regarded solely as a switching technique. It is better to think of ATM as a transmission protocol which can facilitate both multiplexing of variable (or widely divergent) bitrate streams and switching. The construction of an ATM switch is a *consequence* of ATM being used in a network, not a cause.

attempt to break the economic constraints preventing the installation of fibre optics to the residential subscriber through switched star networks, remote stars or digital loop carrier (DLC) systems. The rationale of PONs is that, by eliminating much of the electronics (such as remote multiplexers) required, optical fibre can be made economical, even just for conventional narrowband services alone, thereby giving the TOs the double benefit of improving conventional services and also preparing painlessly to upgrade to Broadband services. PONs are broadcast systems, using a tree structure of passive optical splitters to distribute the exchange signals to the subscribers; equally, return signals from the subscriber are returned by the splitting network to the exchange.

- *Signalling systems.* The development and implementation of common channel signalling systems will improve the utilisation of the current networks, by using a separate channel for the call set-up signalling. Common channel signalling also facilitates the offering of advanced services and applications; current differences in implementation of signalling systems[7] will, for example, limit the number of international ISDN services.

Changes In Network Architecture

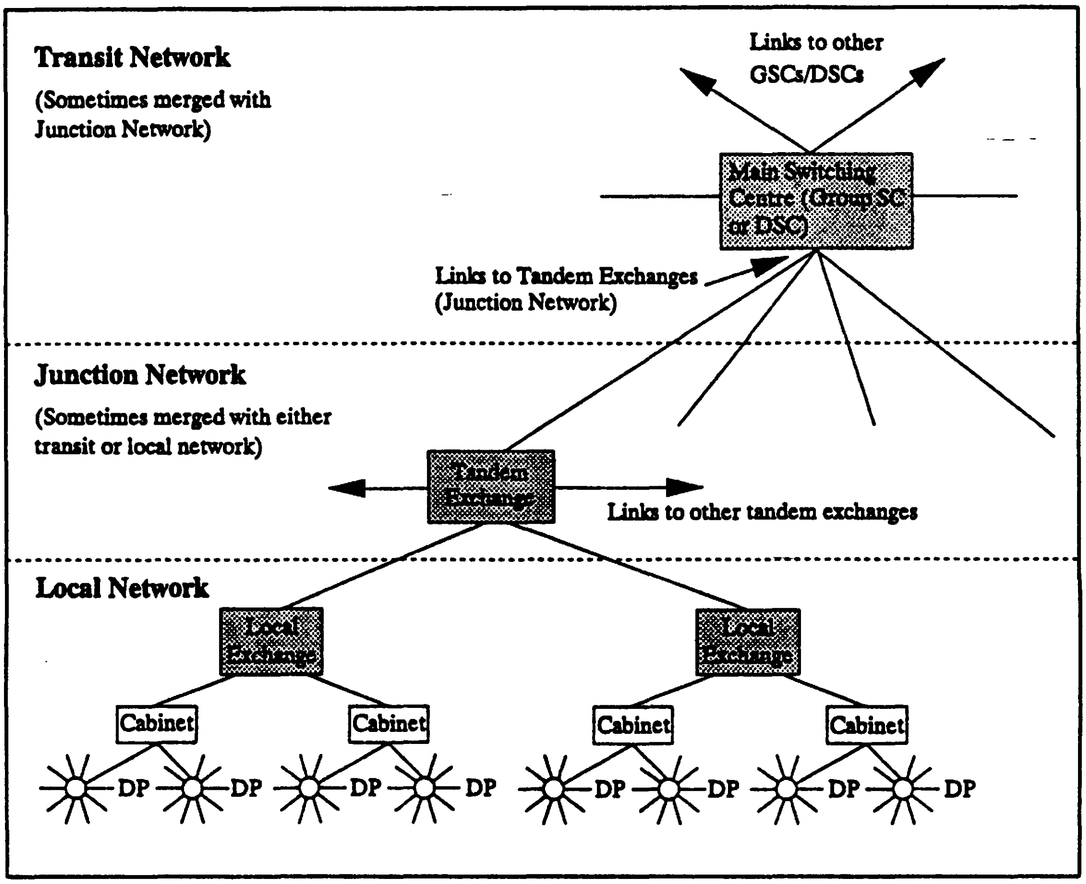
The technological developments described above will result in a series of changes to a telecommunications network architecture which has remained largely stable for at least 50 years. Changes in network architecture are pivotal to the development of future telecommunications networks; network architecture will be the focus for the most important issues affecting the development of telecommunications over the next 20 years.

These changes will be driven by massive falls in the costs of transmission and processing; they will affect the location of functions in the network, enable functionality to be 'plugged in' at arbitrary points, and open up access to high bandwidth. They will significantly impact on whole-life cost (by rebalancing capital expenditure against lowering operations and maintenance costs). Furthermore, they will generate demand for new types of investment and enable the rate of innovation to be increased.

To illustrate these points, we have traced the possible evolution of telecommunications network architectures. The current situation may be characterised by the following Exhibit:

[7] International interconnection will be based on TUP+ signalling (the enhanced Telephone User Part of SS7), since this is the lowest common denominator in Europe.

EXHIBIT 2.5: Hierarchies in the Current Network

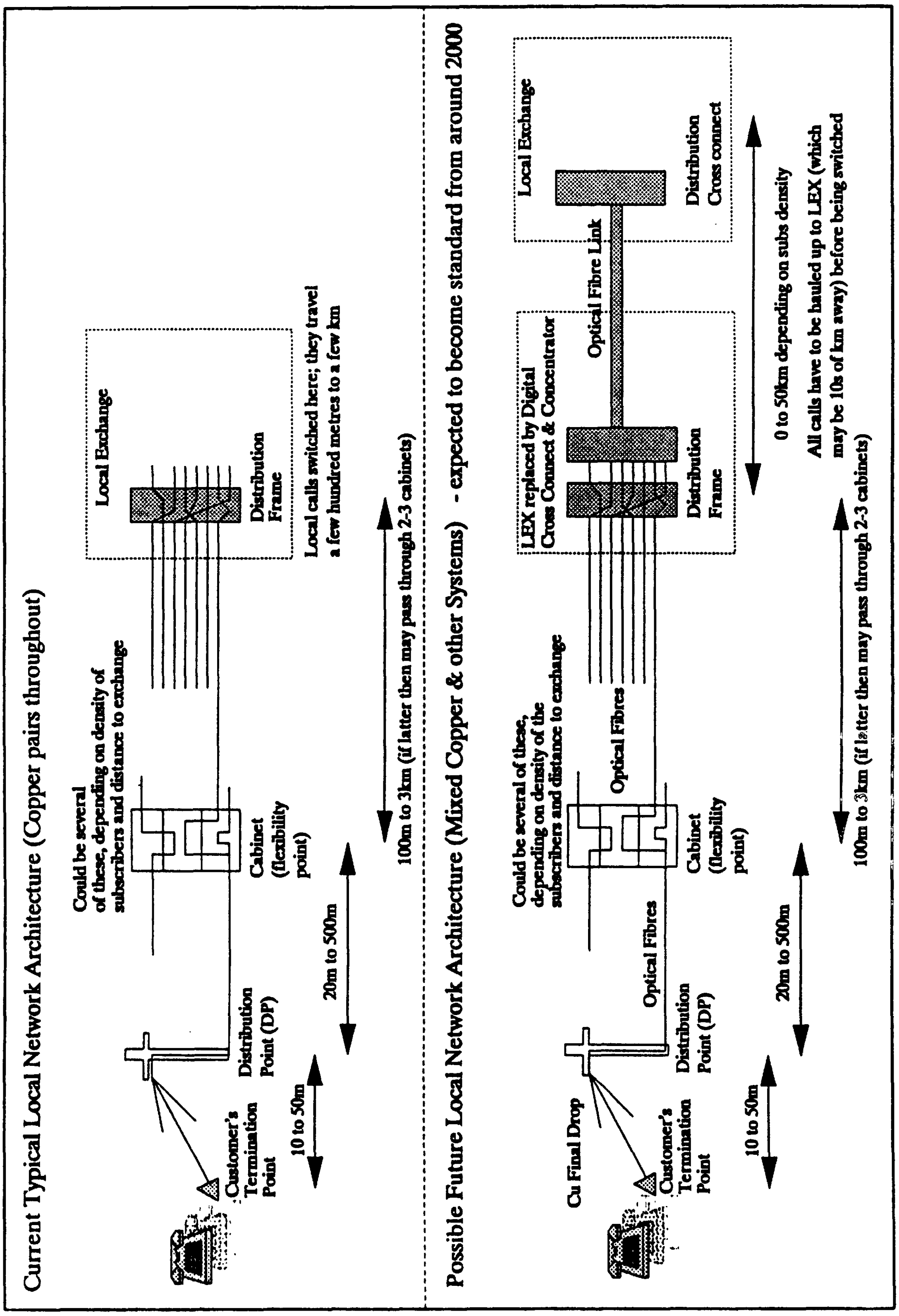


The majority of subscribers are connected to the network via copper pairs; in most cases each subscriber has one pair from its premises to the local exchange.[8] The pairs are distributed in cables from the local exchange. Each cable contains several hundred pairs, and is progressively sub-divided through road-side cabinets or man-holes until the Distribution Point (DP) is reached. One or more of the 10 or 20 pairs reaching the DP is then taken to the subscriber's premises.

The main network (consisting of the local exchange and beyond) is usually a complex interconnection of switches and links based on a strict hierarchy. Local exchanges are connected to transit or tandem exchanges which switch calls but do not have any direct connection with subscribers. A call between subscribers on the local exchange is switched locally; a call between local exchanges must go via some form of tandem or transit switching function. Sometimes this will be done close to the subscriber, in which case the call will not travel up and down through many levels; long-distance and

8 The connection may in fact be achieved with radio, microwave, coaxial cable or optical fibre, and even with copper pairs there may be some concentration or multiplexing of traffic on the same pair. However, we are dealing with the majority case, and in architectural terms it is currently largely equivalent for alternative technologies.

EXHIBIT 2.6: *Current and Possible Future Local Network Architectures*



international calls, however, will travel through a large number of switching points. Exhibit 2.5 shows only three levels; in practice, a national network may have five or more levels.

The changes to network architecture will affect both the local access network and the main network; Exhibit 2.6 (opposite) shows changes in the local network. In the current typical local network architecture, distribution from the local exchange involves line lengths averaging around 2km, with a maximum length limited by 10dB transmission loss and loop resistance of 1000 ohms. The cables are divided as they fan out from the distribution frame in the local exchange, via a series of cabinets and DPs.

From about 2000 a new local network architecture will become the norm. The low cost of high-capacity optical fibre by this time will enable replacement of at least some of the local access network, and offer the potential for direct fibre connection. It is likely, however, that in most cases the final drop to the customer will remain copper for some time (at least for residential and small business customers), as the cost of the opto-electronics for converting to metallic transmission can be cut by a factor of 10 or 20 if this is done at the DP rather than on the subscriber's premises.[9]

Equally important (from the network operator's point of view) is that once the traffic is being carried on a low-cost optical fibre it is cheaper to haul the traffic up to a remote switch rather than use the existing local exchange (LEX). The LEX will then be replaced by a multiplexer and concentrator (and also possibly a digital cross-connect for alternative access routes), and linked to the previous LEX site by optical fibre. In this case the access line lengths could be increased substantially, and may average over 20km or 30km.

These changes will also affect the topology of the local network (which is no longer quite so 'local'). This is illustrated in Exhibit 2.7 (overleaf), where the current method of hierarchical switching is compared to a future, flatter network structure, which will become the norm around the year 2000. The LEXs will all be replaced by concentrators and multiplexers with no switching functions, and linked together by an optical-fibre ring. Switching will then be done at one point (which may of course either be in the ring or remote from it). The ring represents one possible form of the optical-fibre link shown in the previous Exhibit.

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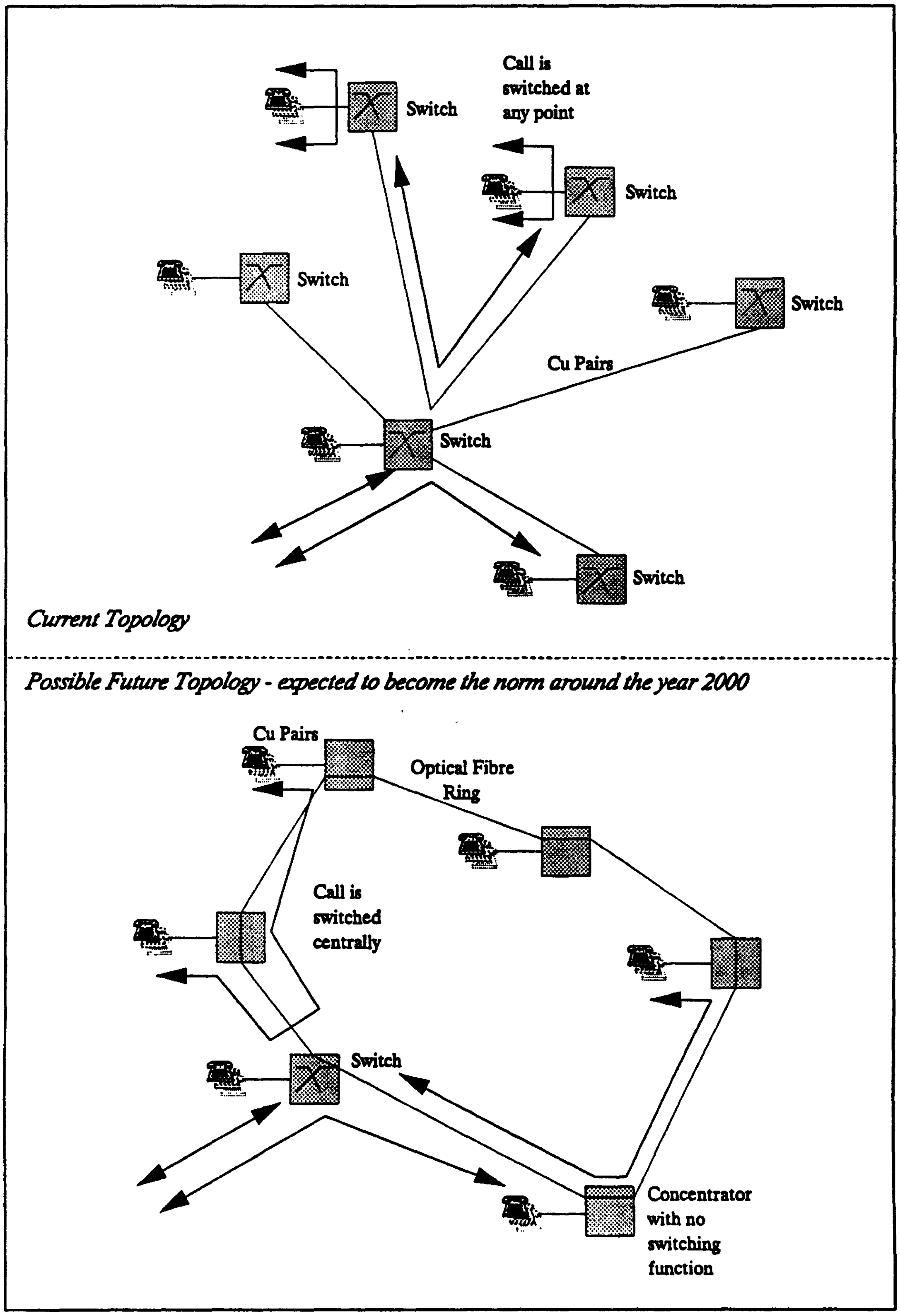
9 See the notes on Passive Optical Networks in Section 2.2.2, under *Telecommunications Products and Techniques*, page 37.

EXHIBIT 2.7: Current and Future Local Access Topologies



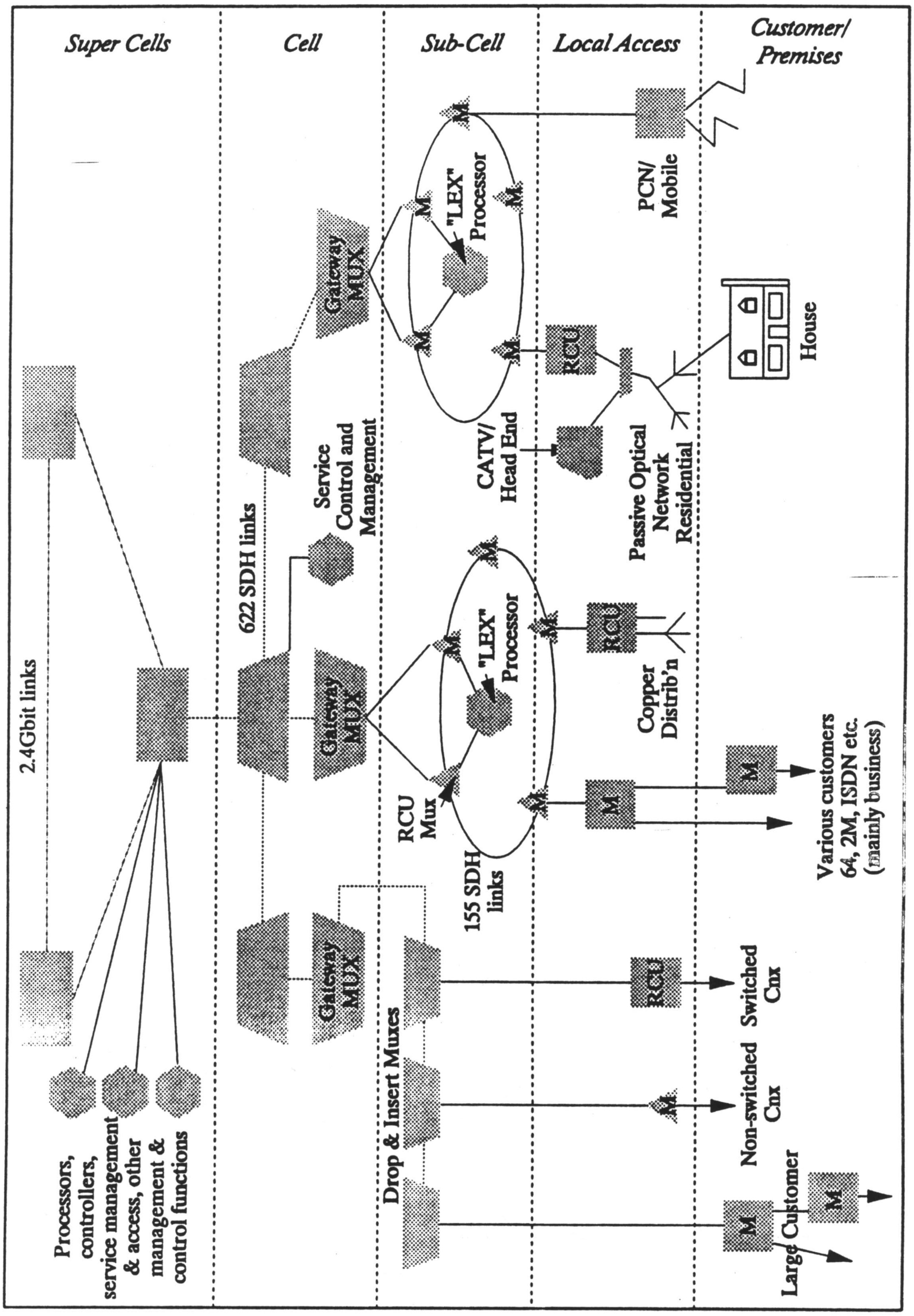
The changes are just as profound for the overall network. Optical-fibre systems (either as rings or other structures) will be interconnected via multiplexers and cross-connects; switching will be carried out in the higher reaches of the network, and the switching nodes will be interconnected with very high-capacity links. Processors, controllers, service access, management and other functions will also be remotely located; with transmission no longer a scarce resource, these can be situated anywhere and linked into the network at a high level. These changes mean that the network could evolve towards the kind of overall architecture shown in Exhibit 2.8 (overleaf); we expect this to become the norm soon after the year 2000. In this illustration local access is achieved via a mixture of optical fibre, copper pairs and radio systems. For residential subscribers a CATV system shares passive optical and other type of distribution networks; business subscribers have a wide variety of access capacities and techniques open to them via multiplexers (on their own premises in the case of larger establishments, and via remote units in the case of small businesses).

In Exhibit 2.8, 'M' represents a multiplexer, and 'RCU' represents a remote concentrator unit. The many hierarchical levels of the old network have been superseded by a flatter structure based on interconnected cells and sub-cells. Within cells, SDH rings and drop-and-insert links provide the connection between the local access and the main network. Some switching is done at this level for connections parented on individual rings; these rings and other links are connected via gateways to high-capacity SDH systems, which together cover a cell spanning hundreds of thousands or perhaps millions of subscribers. Management of the services within each cell would probably be achieved at this level. The cells themselves are interconnected via extremely high-capacity systems which would span distances of up to several hundred kilometres, and encompass many millions of subscribers.

2.2.3 The Longer Term

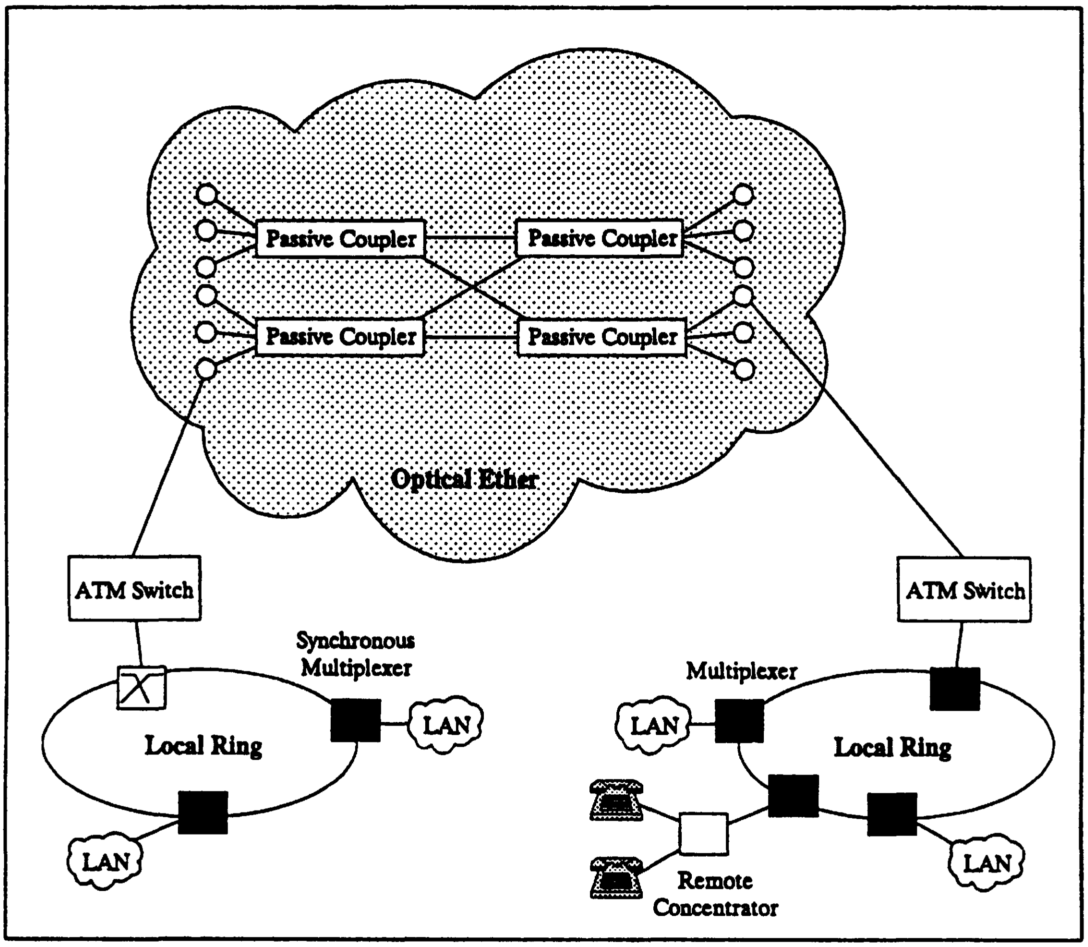
Beyond the developments described above, the provision of a complete fibre-optic network will form the basis for the introduction of Broadband. Initially, this will be for business subscribers, as indicated in Exhibit 2.9 (overleaf). Eventually, however, it will be feasible to extend Broadband to all subscribers, including small businesses and residential customers. The speed of this process will depend on the cost/performance developments of both the transmission media (optical fibre) and the switching equipment – as well as on the circumstances in individual states (subscriber density, for example). As ATM is considered extremely efficient and flexible in terms of bandwidth allocation, it will be used initially for transmission and then for switching purposes, combined with the synchronous transfer mode in the distribution, by using a standard 'cell' length, and by making ATM and the 'physical media dependent' layer independent of each other. This may make initial implementation complicated, but enables the TOs to offer Broadband early, while maintaining flexibility for future networks.

EXHIBIT 2.8: *Overview of Future Network Architecture (expected soon after 2000)*



In the longer term, towards 2010, the ATM solution is most suitable, and the implementation of Broadband is therefore most likely to take the shape of an overlay network gated to the existing circuit-switched network. The overlay network may take the form illustrated in Exhibit 2.9, where the existing optical-fibre trunk network is utilised, and an optical ether network is used in the ATM-ATM interconnection to by-pass the problem of switching the high bitrates corresponding to the total data throughput; this approach requires no new infrastructure. The 'optical ether' approach would require a system of wavelength references and combinations, and multi-access protocols, but this would overcome the electronic limitation on the total throughput of information. Such an approach would be consistent with the development of the network architecture shown in Exhibit 2.8. The functionality of the optical ether concept has already been successfully tested – by BT Research Laboratories during 1989.

EXHIBIT 2.9: Long-Term 'Optical Ether' Network (expected to become the norm soon after 2000)



Sometime after the year 2000, we expect that optical switches will emerge, perhaps with a commercial entry as early as 2005. Once these begin to be installed, high-capacity integrated circuits will enable the use of distributed switching (that is, switching at each distribution or subscriber point). Ultimately, the network will then be flattened even further, with very few high-capacity main switching centres and with the local switching distributed to the distribution or subscriber termination point. The fibre optical 'rings' will be interlinked via digital or optical cross-connects, electronic or optical multiplexing and the main switching centre.

At that point (probably beyond the scope of this study), improvements in the utilisation of fibre optics as a transmission medium, coupled with electronics and opto-electronics capable of handling high transmission speeds, will lead to the offering of local loops with transmission speeds exceeding 600Mbit/s. This capacity may be used for high-quality videotelephony services, and new interactive value-added services; these would utilise the improved transmission rates to offer fast response times and high-quality video displays.

2.3 Other Telecommunications Network Services

Having discussed basic services, in this section we consider both the current situation and future developments for a number of other telecoms network services (which could be carried on the networks described above):

- ISDN (Section 2.3.1)
- Broadband (Section 2.3.2)
- mobile communications (Section 2.3.3)
- cable TV (Section 2.3.4)
- satellite communications (Section 2.3.5)
- telex (Section 2.3.6).

2.3.1 ISDN[10]

Overview

Increasing cost-effectiveness means that the implementation of digital transmission and switching is accelerating in all European countries. Many TOs now have the ability to

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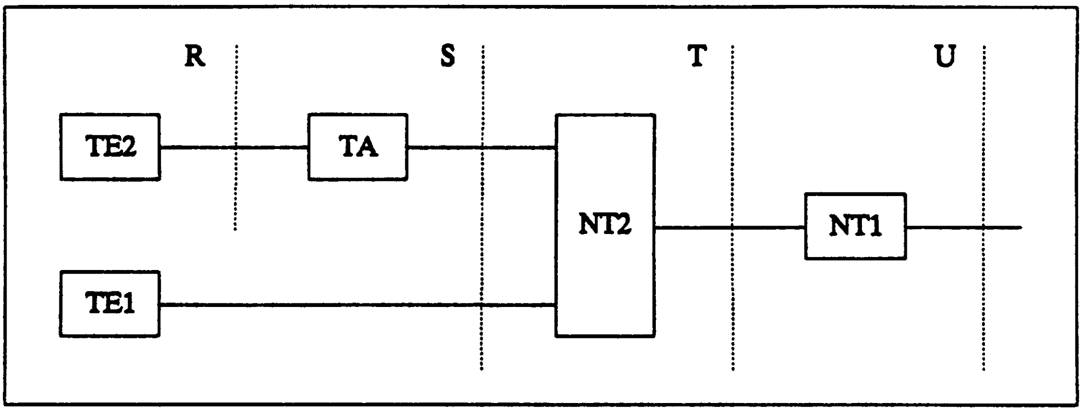
offer end-to-end switched digital bearer services – the main one being completely transparent 64kbit/s channels using standard interfaces: ISDN.

In anticipation of the completion of network digitalisation, the CCITT initiated the work of developing ISDN, a standard for the provision of integrated digital network services. The resulting functional groupings and reference points can be studied in Exhibit 2.10:

EXHIBIT 2.10: Functional Groupings and Reference Points in the CCITT ISDN Reference Model



TA Terminal Adapter: allows non-ISDN terminals to connect to the ISDN
TE1 ISDN terminal
TE2 Non-ISDN terminal
NT2 Customer premises network (e.g. PBX, LAN, multiplexer, communications processor)
NT1 Customer interface to ISDN

ISDN offers two interfaces:

- Basic-Rate access; two 64kbit/s channels for speech or data, and one 16kbit/s channel for signalling and data transmission – a total of 144kbit/s.

- Primary-Rate access; 30 x 64kbit/s channels for speech or data, one 64kbit/s channel for data and signalling and one 64kbit/s channel for framing and alarms – a total of 2.048Mbit/s.

Since the packet-switched data services are aimed at the same target market as ISDN, the CCITT has recommended the provision for packet access via the data channel;[11] considering the low signalling rate required to handle the 64kbit/s speech or data channel, the 16kbit/s data and signalling channel in the Basic-Rate access should be able to

11 The demand for packet-switched data services is increasing rapidly with the new developments in computer and information technology. There is no doubt that this trend will continue, even with the introduction of fast circuit-switched data services such as ISDN.

support most packet-switched terminals up to 9.6kbit/s. If packet terminals operating at 48 or 64kbit/s are to be used, they have to use the main 64kbit/s channel. To avoid complex problems of channel selection for incoming virtual calls to ISDN-based packet terminals, the customer will already register for packet access for either the 64kbit/s channel or the 16kbit/s channel.

ISDN Features and Services

ISDN offers the following features for subscribers:

- *ISDN Telephony calls*. Calls with a complete digital transmission path will benefit from improved voice quality with little or no noise. The 64kbit/s channel can either be used for higher bandwidth (e.g. 7kHz) to further enhance speech quality compared to the standard 3.1kHz bandwidth, or to carry more than one voice channel. Other benefits will include fast call set-up, and call identification.

- *ISDN Data calls*. The transmission of data does not require a modem (although other equipment will be required to provide the necessary interface).

- *ISDN Voice/Data calls*. When this option is specified in the call set-up, the network will set up the call as a voice connection, but ensure that an all-digital connection is being used. The user can - during the call - switch to the data mode (e.g. in order to send a fax) and back, and the signalling channel will ensure that the appropriate ISDN terminal is seized.

These features will be used to provide a number of services, such as:

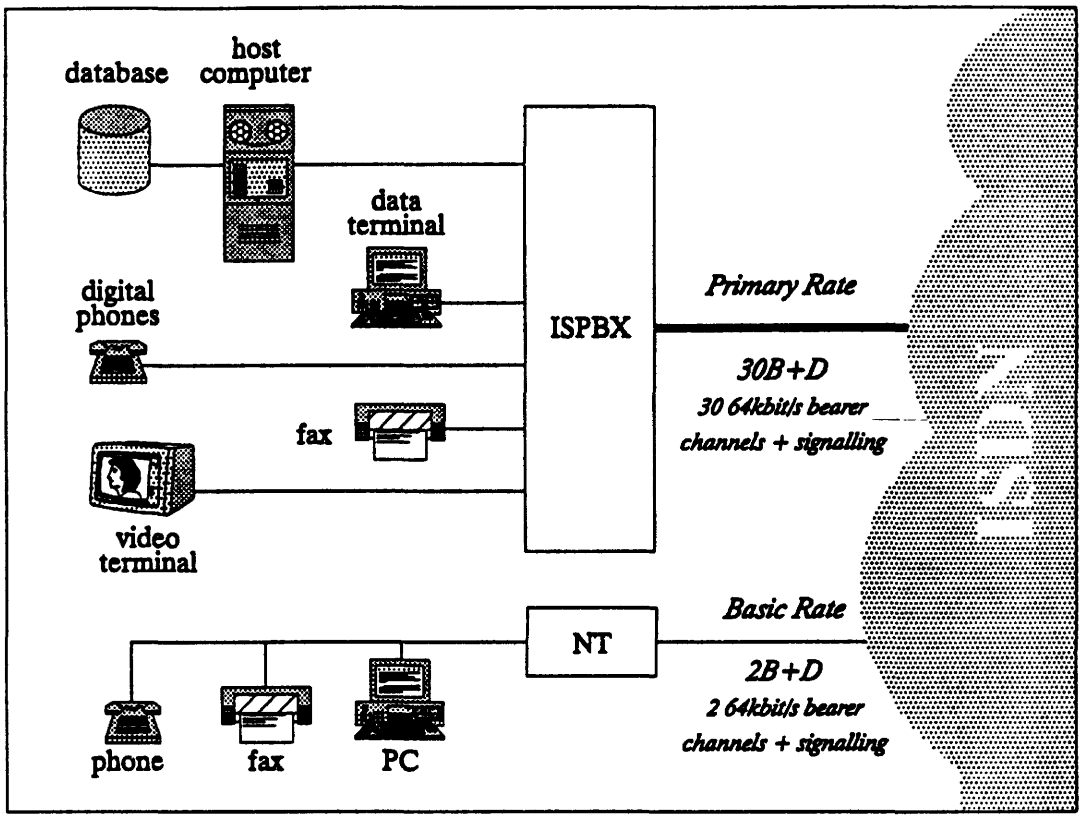
- *Group 4 facsimile*. The transmission time for an A4 page with the 64kbit/s rate will be reduced to 6-10 seconds. This, combined with higher picture quality, makes it very attractive for a number of professional groups.

- *Slow-scan TV*. The refreshment time for a 64kbit/s rate TV is 3-4 seconds, making it sufficient for the security and medical markets.

- *Videotex*. Existing services are based on analogue transmission systems, typically operating at 1.2kbit/s. An increase to 8kbit/s or 64kbit/s will make the service faster and make videotex more attractive in applications such as retailing where customer service time is important.

Exhibit 2.11 illustrates how the different services can be connected to the ISDN access. Access to the ISDN is handled in two ways, to take account of the wide range of applications ISDN can support, and different user requirements. Large corporate users wishing to integrate voice and data communications through their PBX will generally opt for the 30-channel option known as Primary Rate. Smaller organisations, and those requiring less frequent access will take the Basic-Rate option, which provides two channels. Each channel – whether in the Primary or Basic-Rate option – provides transmission capacity of 64kbit/s. In both options there is also an extra channel for signalling (the D channel).

EXHIBIT 2.11: Primary Rate (30B+D) and Basic Rate (2B+D)



The penetration of ISDN in Europe depends on a number of factors: the availability and coverage of ISDN, the marketing efforts put forward by the TOs, the quality of the offered service, and the costs for the user in comparison with existing alternatives.

The availability and coverage of ISDN services is determined by the digitalisation of the national network. Countries such as the UK, France and Germany can already provide widespread or nationwide deployment of ISDN, and indeed have begun to do so. However, the majority of the EC countries are still in the early phase of shifting from an analogue to a digital network, and only ISDN trials or pilot services on a limited scale are being offered. This cautious introduction of ISDN is partly a result of the delays experienced by the CCITT in setting final ISDN standards. The delays in offering ISDN in Europe mean that the costs of ISDN equipment for the customers' premises will be higher than originally expected, thus suppressing penetration.

Alternatives to ISDN

The existing alternatives to ISDN can be grouped as follows:

- *Digital leased lines.* These lines offer the same transmission quality and speed capability as ISDN. They also exclude the need for special ISDN equipment, but are only suitable for high-volume users communicating with a limited number of sites.

- *Analogue leased lines.* This is a declining option but still suitable for a small to medium-sized user where cost is more important than speed or quality.

- *Packet- and circuit-switched networks.* Although these are more limited in application than ISDN, they do remain a strong alternative for the smaller user unwilling to make substantial investment in ISDN equipment. These networks are well developed in a number of European countries, and will probably co-exist with ISDN for some time.

- *Public switched telephone network.* Although expensive and providing low transmission quality, the PSTN is still the best alternative for small users with Group 3 faxes and modems.

2.3.2 Broadband

Overview

By providing a transparent 64kbit/s communications channel, ISDN will open up possibilities for integrated voice and data transmission. However, requirements from the business community will continue to grow in terms of both services available and transmission speeds; both the demand pull and technology push will move networks towards the ability to support Broadband.

Broadband offers the integration of voice, high-speed data transmission and audio-visual transmission. Initially, the business community will mainly be interested in the high-speed data transmission capability, but other applications such as videotelephony, videoconferencing, retrieval services and high-speed fax are expected to grow in importance.

ISDN is based on digital 64kbit/s transmission; it can be implemented on existing digital networks. Similarly, Broadband will be based on high-capacity transmission and switching systems implemented in order to take advantage of the cost and operational benefits of new network architectures. Broadband needs new switching technologies and high-capacity trunk systems to cope with higher transmission rates; the current digital switches are based on circuit-oriented synchronous time-division technologies, and therefore cannot easily or cheaply support rates above 2Mbit/s (or 30 64kbit/s channels). But, within the new architectures, new systems based on SDH, ATM and optical fibres in the local loop can provide the high capacity necessary for the provision of Broadband.

We conclude from this that the take-up of Broadband will be considered economical for small and medium-sized organisations only by the end of the 1990s, and not until the 21st century for residential users.

Broadband Standards

The CCITT study group XVIII has made recommendations for Broadband, including a definition of functional characteristics, service aspects, general network aspects and user-network interface.

We expect that Broadband will offer the subscriber an interface with transmission speeds based on 2Mbit/s, 45Mbit/s and 145Mbit/s on the network terminal interface equipment. The subscriber can then (in a flexible manner, through the terminal adaptor) have this capacity split into a number of Basic-Rate Access (144kbit/s), Primary-Rate Access (2Mbit/s) and Broadband access (between 2Mbit/s and 145Mbit/s) channels. This split will enable the subscriber to use existing ISDN equipment such as ISPBXs, Group 4 faxes and ISDN PC cards.

Broadband Services

Broadband would offer the following services in conjunction with the existing ISDN services:

- *Videotelephony*. This service is proving particularly useful in complex discussions which can be supported with the interactive use of graphs, pictures and computer-stored graphics.[12]

[12] Note, however, that improvements in image compression techniques and the falling cost of processing power mean that full motion colour videotelephony is already available over N-ISDN links. The critical issue will be whether the improved quality will be worth the additional cost of Broadband.

- *Videoconferencing*. By replacing the need for frequent travel, videoconferencing is set to become popular within large organisations. The service is already available in the USA and Europe, where it is proving especially popular within the aerospace, telecommunications and drugs/pharmaceutical industries; it is also used by computer and non-bank financial organisations.

- *High-Speed Data Transmission*. Potential applications include LAN-LAN interconnection and real-time distributed graphics processing for CAD/CAM systems. LAN-LAN interconnection is today based on lines leased from the TO, generally limiting the transmission rate to 64kbit/s or 2Mbit/s; typical LAN rates are 4Mbit/s to 10Mbit/s. Other applications lie in the areas of videotex, documentary databases and moving images.

- *High-Speed Fax*. This is based on a transmission speed 30 times higher than that for a Group 4 fax, and will provide very fast high-resolution transmission of colour documents.

Broadband Implementation

The obvious initial service offering on Broadband for the residential subscriber is cable distributed television and radio. By combining cable TV and telephony, fibre-to-the-home may be considered economical by the late 1990s. The development of cable TV service varies across Europe, but one possible outcome in European countries is that the TOs will implement and control the Broadband facility for the subscriber, and that separate commercial cable TV organisations will provide television and radio transmission, and possible interactive services over the TO's subscriber lines. Residential subscribers will then initially be offered Broadband services through passive optical networks, these being most economical for the network provider. Services with very high transmission requirements such as cable TV will initially be provided through broadcasting on a common channel on the fibre but, with improved signal-transmission equipment, narrowcasting and switched services may be made available.

A possible path towards an integrated Broadband communications network (IBCN) is through an evolutionary process; firstly, the creation of Broadband islands in metropolitan areas; secondly, a limited switched Broadband network formed by interlinking the islands; and thirdly, integration of the Broadband islands networks with the Broadband networks and the broadcasting networks. This new approach has been adopted by the CEC's RACE Programme for several reasons:

- there is a perceived early demand for Broadband services such as LAN-LAN interconnection (which requires high transmission rates)

- the value of a Broadband network will be in its universality, so the wider the geographical scope the better the chance of early adoption and development

- users willing to pay high prices can be given access without having to build a complete network.

The first stage of this development is the creation of metropolitan area networks (MANs). MANs are intended to offer LAN data rates and above (up to 100Mbit/s) over a large area, thus breaking the speed restriction of current private wide area networks (WANs), which are based on TO leased lines. MANs are currently being developed in the USA; Bell Atlantic, Nynex and US West scheduled trials in 1990 for LAN-LAN interconnection.

The development of MANs may be further accelerated by the deregulation of the data-transmission market in 1992, in accordance with the EC Green Paper. Private operators may in 1992 provide MANs without the voice facility, but based on optical-fibre technology, and with the possibility of incorporating voice at a later stage. Furthermore, private MANs are considered to be a part of a future IBCN.

The next phase in the path towards IBCN is the link-up of the European MANs. This is being developed on three fronts:

- EC Member States have undertaken to link up all capital cities of the Community by 1994, based on completing existing and planned optical trunk networks. This activity is being co-ordinated through the CEC's RACE Programme.

- International administrators such as Cable and Wireless are planning to invest substantial amounts in the optical fibre link-up of major European economic centres, achieving economies of scale and marketing advantages by integrating the European network with its intercontinental network.

- A consortium formed by European railway operators is currently considering entering the optical fibre trunk network market. By using existing railway lines, the consortium would enjoy two advantages: a fast and cheap implementation of a Europe-wide fibre optical network, and a network which has access to the centre of the metropolitan areas where link-up with MANs and other networks can be achieved without the need for ducting (thus by-passing the TOs).

The increasingly competitive situation on the Broadband trunk network indicates that transmission costs are set to fall, and that European-wide coverage may be achieved more quickly than predicted.

2.3.3 Mobile Communications

Overview

Radio telephony has traditionally been implemented by using high-powered antennas covering large areas, with a fixed frequency allocation for each subscriber or call. Wasteful use of the radio spectrum limited the number of subscribers, and interference problems gave a patchy and unreliable geographical coverage. These systems were eventually improved by the availability of a wider radio spectrum and, as importantly, by the development of technologies which maintained service availability as the mobile passed between cells. This meant that boundaries could be drawn around small areas or cells, and frequencies could be re-used in other locations where interference would not occur. Technical developments also meant that the price and weight of the radio handsets could be reduced, whilst their functionality could be significantly increased.

These changes led to the introduction of analogue cellular systems which dramatically improved the subscriber capacity and network reliability. The booming demand for this new service surprised even the most optimistic service provider, and the potential of the service has led to considerable interest and investment; mobile services seem set to grow rapidly through the 1990s.

Cellular radio systems are the main area of development in mobile technology. They are based on the following network architecture:

- *Base Stations*. A base station forms the centre of a radio cell, and – together with other base stations – is linked to a particular base switching unit. The functions of the base station are: to receive calls (either new calls from a subscriber or 'hand-over' calls from a different base station); to initiate calls to a subscriber; and to administer the frequency allocations within the cell.

- *Base Station Controller*. The most obvious effect of the cellular system is that each call must be tracked, so that when it leaves one cell it can be handed over to the next cell automatically without call interruption. This function involves substantial inter-cell control and signalling, which is handled by the Base Station Controller.

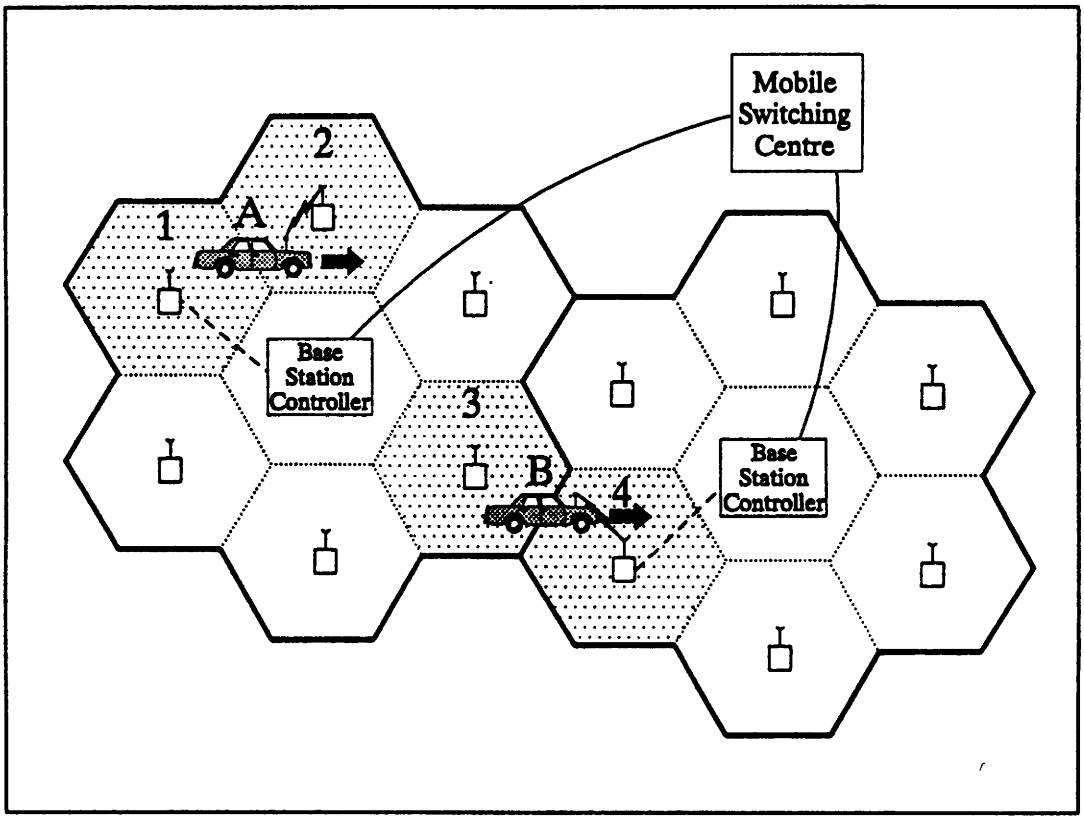
- *Mobile Switching Centre*. The Mobile Switching Centre links all Bases, and controls the roaming between different Base Station Controllers. It also handles the interface with the operations and maintenance unit and the billing systems.

- *Operations and Maintenance Centre*. This plays a role in the operations, maintenance and administration of a mobile system. Cost and revenue control is particularly important, as a significant portion of cellular traffic uses parts of the TO's network.

- *Multiplexing units and radio links.* The link-up of base stations and the Base Station Controllers can either be done through leased lines and multiplexing, or using a radio link.

The tracking (or roaming) facility of the cellular systems is illustrated in Exhibit 2.12 below.

EXHIBIT 2.12: Cellular Systems: Roaming



Subscriber A's transfer from base station 1 to base station 2 is controlled by the Base Station Controller, which controls the base stations in those two cells. Subscriber B's transfer from base station 3 to base station 4 is initially controlled by the Base Station Controller connected to base station 3; realising that the subscriber is moving out from its area, the Base Station Controller interacts with the Mobile Switching Centre in order to locate the receiving Base Station Controller. The subscribers are allocated a new frequency when they enter a new cell, which facilitates an efficient use of the available radio spectrum.

The cost of building a cellular system depends greatly on the number of base stations required, which in turn depends on geographical coverage (limited by frequency band)[13] and channel capacity.

A cell's capacity is determined by the frequency spectrum. If this capacity is exceeded (in very urban areas, or along congested traffic routes, for example), special configurations involving smaller cells have to be used. This makes inter- and intra-cell control and signalling very complicated and requires the use of substantial amounts of capacity in the Base Station Controller. The use of smaller cells in very urban areas can also be costly in terms of finding and negotiating sites.

Despite the use of smaller cells, current operators of cellular systems in very urban areas such as London have not avoided the problems of call interruption interference and crossed lines. The use of smaller cells can only expand capacity up to a certain extent; this is one reason why most operators are looking to introduce digital cellular systems.

Digital Cellular Systems

The digital systems, apart from offering higher transmission quality, better use of the frequency spectrum,[14] and enhanced security, enable the operator to use smaller cells in order to boost capacity. Smaller cells also mean that the handset can be made smaller, with reduced battery needs, which in turn implies lower costs and potentially higher penetration.

- The higher transmission quality will enhance call quality and facilitate the use of ISDN services through the cellular handset. The data rate available over air limits the number of ISDN services that can be used, but it does facilitate datacommunications without the need for an external modem.

- VLSI technology and standards will enable equipment suppliers to provide subscriber and base station equipment which is both cheaper and smaller than the current systems.

- Digital systems will enable the operator to offer pan-European mobile services based on the GSM[15] standard. This will enable the user to use the handset in any

13 The geographical range of a base station depends to a great extent on the frequency the operator has been allocated. The early 450MHz systems have a maximum coverage of 20km, suitable for low-density areas where high geographical coverage is desirable, and the more advanced 900MHz systems with a coverage of a few kilometres, more suitable for high-density areas. The new GSM standards (DCS 1800) have much smaller ranges and are suitable for very low power handsets and high demand densities.

14 The digital systems facilitate the use of time division multiplexing (TDM) – this can boost capacity within a cell by a factor of 2 to 3 by using the radio spectrum in a more efficient way.

15 Global System for Mobilecommunications, previously referred to as 'Groupe Spéciale Mobile', a standard developed by CEPT for digital cellular systems.

European country (with the billing transferred automatically). Alternatively, foreign telephones can be used (this requires a smart card from the user's own telephone to be plugged in).

- The capacity can be further boosted in very congested areas by the use of micro-cell technologies.

Digital systems will not only enhance the service offering from the cellular operators, but will also act as a springboard for Personal Communication Services (PCS). One of the most important service offerings here is likely to be the PCN (Personal Communications Network). PCN operators intend to offer the user a small, light, pocket telephone that can make and take calls throughout the network. The PCN concept differs from current cellular systems in a number of ways:

- *Size of the handset*. Current cellular handsets are dimensioned primarily to be installed in cars and for use in large cells. The personal communications network will consist of a very large number of small cells, thus decreasing the need for transmission power from the handset.[16]

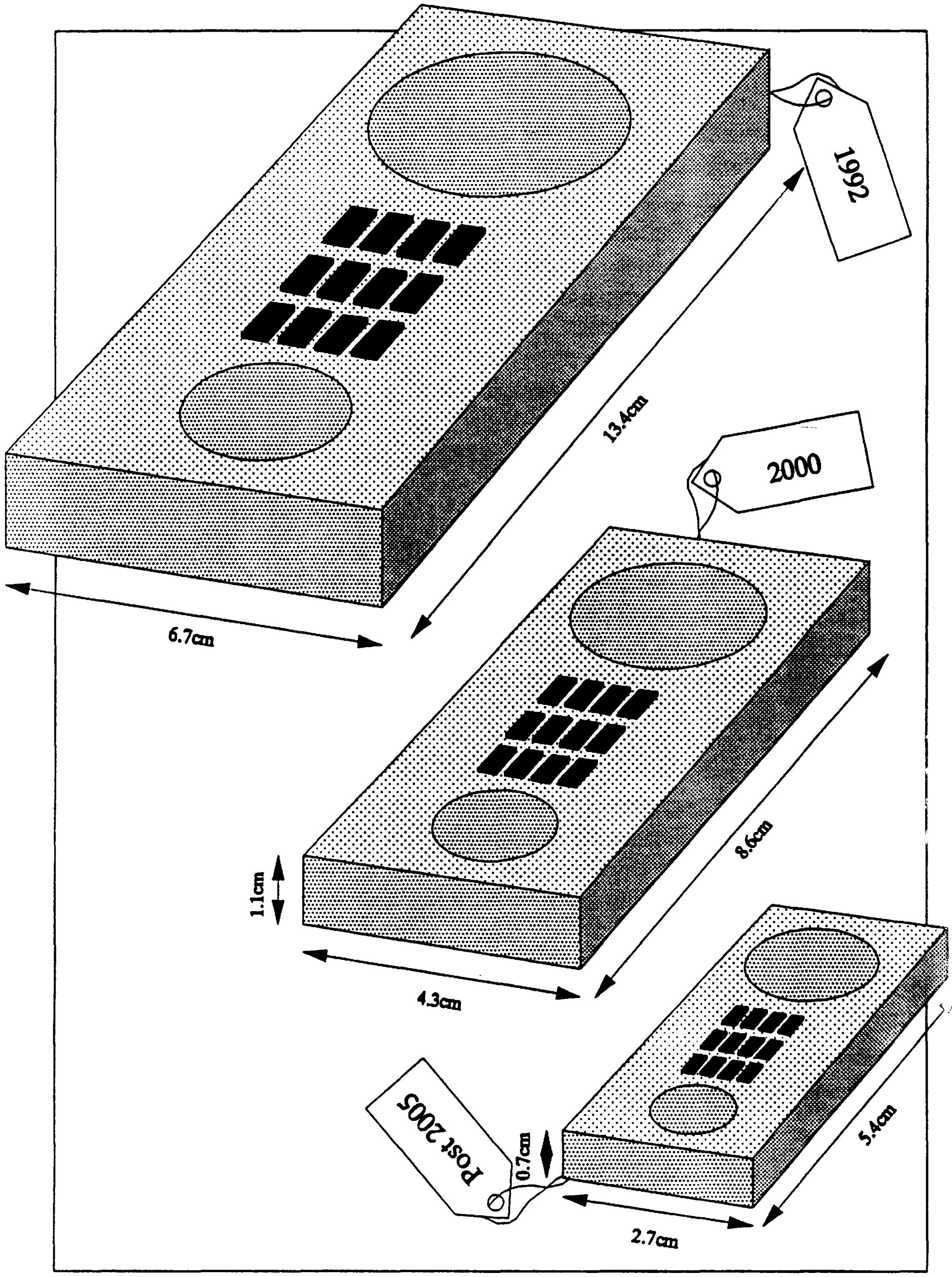
  An example of the developments projected by the Japanese TO (NTT) is shown in Exhibit 2.13 overleaf; the sizes and weights of such devices open up the possibility of a completely new era in mobile communications. Handset size depends on network availability; the greater the number of subscribers, the greater the density of base stations, and the more rapidly handset size can be reduced.

- *Differentiated roaming facility*. The operators will offer subscribers different levels of roaming: with the basic level, calls can only be set up and received in pre-specified areas; the second level allows the subscriber to set up and receive calls in any area, but not to change cell during the call; the third level is the full roaming facility. Less inter-cell control and signalling also reduces the load on the Base Station Controllers, and makes the network cheaper, both in terms of investment and maintenance.

The marketing drive will be particularly important for the success of PCNs. Since the capital investment required for the implementation of a network consisting of small cells on a national scale will be relatively high, PCN operators will be able to survive only if they achieve high penetration. Furthermore, if high penetration is achieved, it will be

16 Mercury Personal Communications, one of the three UK PCN consortia, specifies its PCN handset as weight 255 grams, size 35 x 68 x 120 mm with a maximum output of 1 watt.

EXHIBIT 2.13: Personal Communications Handset Size – Same or Increased Functionality – by Date of Introduction



possible to reap economies of scale in terms of handset production, and prices will fall. As usage charges fall, PCNs may become price-competitive with the fixed telephony service. Consequently, PCN operators may pose a significant competitive threat to the TOs, in view of the additional advantages they can offer (personal handsets and – eventually – a Community-wide roaming facility).

Mobile Data Networks

Another new application of digital cellular technology is mobile data networks. Based on the same architecture as for the cellular systems, it offers a cost-effective way for fleet operators (such as the police, transport companies and taxis) to transmit data. Fleet operators have traditionally been allocated a limited number of radio channels for voice traffic. Thus, each operator had to implement a complete radio system which had only limited capacity and was very wasteful in terms of radio spectrum. This system could be improved with the implementation of a trunked radio network, but a system based on the digital cellular technology can offer a number of additional advantages:

- Data transmission to a data terminal is a more reliable way of communicating complex instructions and messages. Encrypted transmission also offers greater security.
- The cellular architecture offers a flexible way of providing geographical coverage. The service is focused on urban or very urban areas, but some nations are building national mobile data networks.[17]
- The system can be shared by an unlimited number of operators, which makes it very price-competitive with current trunked radio systems.
- The system offers high capacity, which can be further boosted by the use of micro-cells in very congested areas.

Cordless Telephony

Cordless phone technology (which can be based on an analogue or digital system) brings the subscriber the ability to make phone calls in a pre-specified zone with a lightweight

17 Cantel, the Canadian National Cellular service provider announced in 1989 that it will build a national mobile data network for Canada. It will use the Mobitex system, which also offers voice communication, in exceptional circumstances only. At least three competing mobile data networks will be launched in the UK during 1991-92, and similar announcements have been made in France and the USA.

handset. The CT2 (Cordless Telephony 2) service is based on a FDMA/TDD[18] system, and its main applications are:

- in the office for two-way cordless telephony
- for residential use as a two-way cordless telephone
- for public access (Telepoint services).

The competing digital European cordless telephone (DECT) is based on a TDMA/TDD[19] system. This system will become available in 1992 and will offer improved spectrum efficiency vis-à-vis the CT2 system. Due to the nature of the components required for DECT it is likely that it will be more costly than CT2.

In the UK, Telepoint services have been in operation since 1989. By allowing the subscriber to make outgoing phone calls only within 100 to 200 metres of a base station (an area described as a 'zone'), and by denying the subscriber mobility, the Telepoint operator gains several advantages:

- Base stations do not have to receive incoming calls from other base stations, and they do not need to search in order to set up a call to a handset. This keeps the base-station equipment and the network simple.

- The operator does not need to provide full geographical coverage. Base stations will simply be positioned where the target customer groups are concentrated – in places such as congested high street areas, train and bus stations, for example.

- Without roaming facilities and with minimum transmission power, handsets are very small and cheap.

- The Telepoint service can be combined with a paging facility (including the offering of handsets with built-in pagers); this effectively makes Telepoint a limited two-way communications service, since calls can be originated as well as received. Another possibility is to offer a facility for the subscriber to log on to the system when situated within a Telepoint zone – the subscriber will then be able to receive incoming calls during the log-on period.

To date, however, the Telepoint services in the UK have not been a success. There was an initial problem of incompatibility between the different CT2 networks,[20] which was eventually resolved by the adoption of a standard Common Air Interface (CAI). Other problems included the high price of handsets and the lack of awareness of the service

18 Frequency Division Multiple Access/Time Division Duplex.

19 Time Division Multiple Access/Time Division Duplex.

20 Four different operators were granted licences to run CT2 networks.

and what it offered. A possible explanation for the failure of Telepoint marketing efforts is that the wrong customer group had been targeted. CT2 may have been better applied to the office market (cordless PABXs) rather than the Telepoint offering, so that immediate cost savings (in the form of wiring costs) would be apparent to a potentially huge customer group.

Satellite Mobile Communications

The new digital cellular systems based on GSM are intended to offer Community-wide mobile telephony. The actual coverage of Europe will, however, continue to be patchy for the foreseeable future, and this, combined with a non-existent cellular coverage of the open-sea areas, means that satellite mobile communications will have an important role to play in the future European telecommunications market.[21]

The basic architecture of mobile satellite systems is similarly independent of the application; the mobile unit is equipped with a mobile terminal antenna and a mobile terminal. This communicates with an earth station through a space transponder. The earth station can function both as a hub, forwarding the communication to another mobile unit, or as a gateway to the public telecommunications network.

Inmarsat, which currently operates a global satellite system for maritime and aeronautical satellite communications, provides for:

- Maritime mobile satellite services; based on the analogue standard-A terminals, it includes PSTN services such as telephony, data and limited video transmission and can be used to link up a ship's local area network. Cheaper, lighter and better than conventional radio communications, it is set to replace the current radio equipment during the 1990s. A new digital standard-B terminal will be on the market in 1992-93 for the top end of the customer market, offering data rates of 9.6kbit/s.

- Aeronautical mobile service; the installation of special aircraft earth stations facilitates telephony service for aircraft in most areas of the world. The service was initiated in the beginning of 1989 and several carriers including Singapore Airlines, Cathay and Virgin have declared their intention of offering this service.

- Land mobile service; using standard-C earth stations[22] which are compact, lightweight, and transmitting data at 600bit/s, this service is currently being implemented in Europe. The service will be an interesting alternative for those involved with long-distant transport in areas without sufficient cellular coverage. A standard-M

21 An example of this is the application proposed by Motorola in the Iridium Project.

22 These are currently available in a pre-production format.

terminal is being developed; it is expected to be offered at the same price as a standard-C terminal, and to offer telephony and 2.4kbit/s data transmission (facilitating group 3 fax traffic). The standard-M terminal can also be used by smaller maritime vessels.

2.3.4 Cable Television Networks

Overview

Cable television (CATV) networks have been in existence for almost 50 years, and were initially introduced as a way of providing TV and radio to people living in areas where terrestrial transmission techniques did not work satisfactorily. Technically, the solution was to invest in a high-performance receiving antenna (the head end) and to connect all served households with cable through signal amplifiers. Two cable TV denominations have developed from this:

- Community antenna television systems distribute the received signals to a large number of homes in towns and villages. They contain special compensating equipment to handle the signal loss which occurs during the signal travel. These systems are today growing in importance and are what we refer to as 'cable TV' or CATV.

- Master aerial television is generally used for limited distribution – to a block of flats, for example. These systems avoid the need for amplifiers, but normally use frequency conversion equipment to avoid problems with off-air direct pick-up interference. Clearly, master aerial television is limited in terms of applications.

All European countries now broadcast their television programmes on a nationwide basis. Terrestrial signal transmission systems are used, and each transmitter serves an area with a diameter of 50km to 70km. The surrounding areas cannot, however, re-use the same frequency within a distance of 200km to 300km without the risk of interference, and this leads to the use of several frequencies for each transmitted television channel. The end result is that of the 14 to 16 TV channels allocated to the country by WARC,[23] only three or four different television channels can be offered.

There are two ways of offering more than three or four channels:

- *Satellite transmission*. This method has already been adopted by pan-European programme distributors such as Sky Television, MTV and CNN News Network, but is not considered economical for national transmission.

23 World Administrative Radio Communications, of the International Telecommunication Union (ITU).

- *CATV systems*. These have a capacity of more than 20 channels, and can also be interlinked nationwide through trunk lines or microwave links. The CATV systems have, with their substantially larger user-base, the potential to offer a mix of national programmes, internally produced material, and material received from other sources such as satellite and video recorders.

Once the provision of optical fibre to small sites becomes economical, its deployment for residential subscribers will be feasible. In the short term we expect only limited use of optical fibre in primary distribution, which will give rise to mixed metal and optical-fibre systems for CATV subscribers. In the absence of any significant telecoms traffic, however, the existing basic technology will be used for CATV provision. This will change from about 1996 with the first deployment of Passive Optical Networks and related techniques for residential subscribers. Gradually, metallic CATV systems will be replaced with distributive and interactive services being offered on the same access links. We assume that from 2005 all new CATV and residential telecommunications will be based on optical fibre, either as passive or as active local access networks.

The amount of research and development in the field of local access convergence differs markedly within Europe. Some countries (such as the UK and Germany) are already running trial fibre-to-the-home projects. In the Netherlands a study was commissioned in the 1980s regarding the integration of cable and telecoms, and the government has adopted the recommendations. Current plans are for the integration of the two networks with the formation of one broadband loop. Deployment of fibre-to-the-home in certain areas is expected to start from 1995. By contrast, in Italy little effort is being concentrated on the issue of local access convergence at present, although the policy will be the subject of a future review.

Network Architectures and Topologies

Two different network layouts can be used in the installation of CATV systems:

- *Tree and Branch systems*; these systems are the most efficient in terms of cable and distribution equipment usage when signals have to be distributed in only one direction. The system consist of head-end equipment, main trunk feeders, and branch feeders connecting the subscriber to the trunk feeder. A disadvantage is that the system cannot recognise individual subscribers, which makes it difficult to arrange for individual payments to be made for particular programmes that have been received. This problem can be solved by using filters or switching equipment at each house, but these are expensive and inflexible.

- *Switched Star systems*; these consist of a head end, which transmits all television, radio and data signals that are being offered on the system – see Exhibit 2.14

opposite. Transmission is done on a trunk network, with a layout similar to the tree and branch configuration. Each 'branch' on the network leads to a star switching point. Each star switching point serves 50-60 subscribers and handles the communication of commands and requests between the switch and subscriber over the (normally coaxial) drop cable. The star format makes the system capable of a wide range of interactive services, and by implementing the switching capacity at the 'end' of the network, head-end processing capacity is released for more sophisticated operations (such as audience analysis, billing, operations and maintenance).

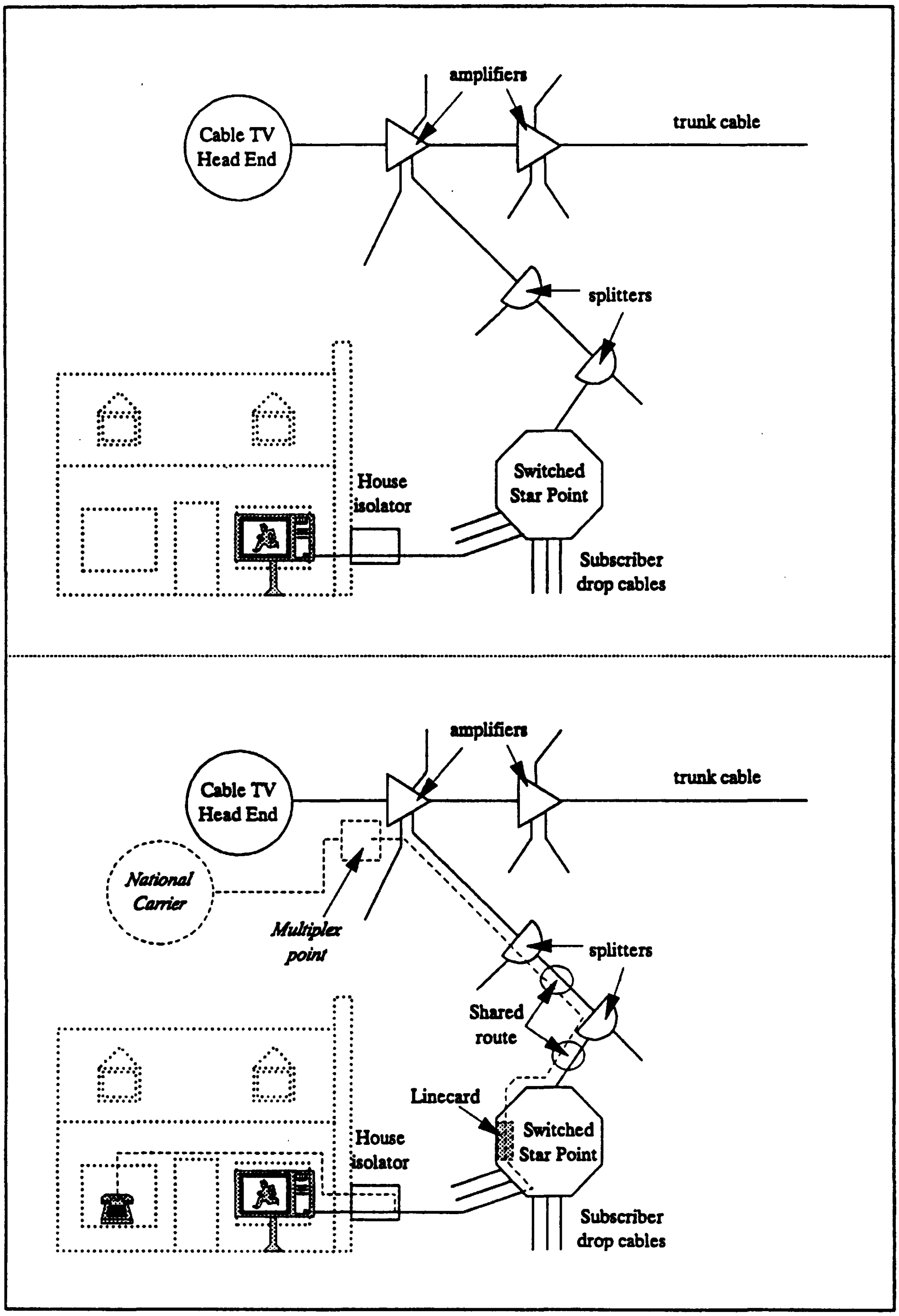
In early switched star systems, all processing was carried out centrally at the head end. This led to capacity problems as the systems grew, and the switched star systems were therefore largely rejected by cable TV operators. New developments, and the availability of distributed switching, have convinced new cable TV operators that switched star systems can also be reliable and used in expanding systems.

Apart from the offering of interactive services, which may prove very profitable for cable TV operators in the future, the network layout of the switched star systems has the inherent advantage of facilitating implementation of a telephony service. The telephone service can be implemented after the drop cable has been installed – by simply changing the house box (the network termination interface) and by installing a line card in the switched star point. The telephone service would then use an overlay network, made of additional telephone cables using the same duct routes.

The advantage for the cable TV operator is that the drop cables have already been installed, and the addition of the telephone service is therefore very cost-effective.[24] The telephony switching will, however, continue to be carried out outside the switched star system (by a national carrier, for example). Alternatively, if the network was originally dimensioned for telephony, the cable between the switched star point and the trunk cable could be shared, thus reducing costs even further.

[24] Cabletime Limited, an English company, estimates that the additional cost of providing telephony over the drop cable is £15, excluding the costs for the telephony line and multiplexers between the star switching point and the telephone exchange.

EXHIBIT 2.14: Telephony in Switched-Star Cable TV Networks



2.3.5 Satellite Communications

Overview

Intelsat, an international communications satellite consortium launched its first two satellites, Intelsat I and Intelsat II in the 1960s. Both satellites used omni-directional antennas and accommodated as many as 240 telephone circuits by using frequency division multiplexed, multiple-access (FDMA) C-band carriers (6/4GHz) to achieve a fully interconnected network between earth stations located in the USA and Europe.

The effectiveness of a communications satellite is measured both in lifetime and capacity, which in turn depend on radiated power and bandwidth. As the technology developed, improvements were made to all these areas.[25] The lifetime for a typical satellite has improved from 1.5 to 10 years, and the capacity has risen from 240 to 30 000 telephone circuits. A key determinant of the useful life of a satellite has been the fuel required for station keeping; satellite operators now believe that the use of xenon ion fuel thrusters (and other advanced propellants), more efficient solar-cell electrical conversion, and the development of new in-orbit electrical storage batteries will increase the lifetime from 10 to 20 years during the 1990s.

Each satellite carries a number of transponders (e.g. the Intelsat VI carries 48), and a typical transponder operating at 72MHz has a transmission capacity of 140Mbit/s. This capacity is mainly used by European TOs for international and intercontinental telephony, and as a standby system for submarine cables. Satellite capacity is shared by the use of time division multiplexed, multiple-access (TDMA) or FDMA signalling. A geostationary satellite views almost half the earth's surface from its position at an altitude of 22 300 miles. This makes it the ideal communications media for point-to-multipoint broadcast and one-way or two-way communications between locations separated by geographical barriers, such as mountains, or by undeveloped local telecoms networks.

Satellite Technology and VSATs

Satellites with transponders operating at higher frequencies and with a higher radiating power, combined with the use of spot or pencil beams, have led to a drastic reduction in the size of the receiving dishes, making them cheaper and easier to install. Very small aperture terminals (VSATs) are now available in the Ku-band with receive dish sizes of 1.2 to 1.8 metres, and the costs are falling rapidly:[26]

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25 Three frequency bands are now used: C-band 6/4GHz, Ku-band 14/11GHz and Ka-band 30/20GHz.

26 The larger C-band 3m-4m dish stations can be up to ten times as expensive.

- Costs for electronics to control the TDMA function continue to fall. These elements have always been a major factor in the cost of the interactive VSAT; TDMA is a mechanism for allowing satellite bearer-frequency sharing between a number of base stations by allocating each base station a fraction of an overall frame. This apparently simple system is complicated by timing; ground stations are at different physical distances from the satellite and, although nominally geostationary, the satellite has a complex motion of its own. The solution is to use complex methods of clock generation and distribution, leading to high electronics costs.

- The cost for the RF amplifying unit is falling.[27]

The availability of low-cost one-way and interactive VSATs have opened up new possibilities for organisations with communications needs which span over large geographical areas. VSAT services can be used in several ways:

- *Interactive systems*. By leasing transponder capacity and using a master earth station (MES) for switching, an operator can offer a high-performance cost-effective alternative to terrestrial service for data networks. Typically, an operator with one MES can offer an interactive 64kbit/s service to 1920 VSATs by leasing two 72MHz (140Mbit/s) transponders.

- *Meshed systems*. These offer interactive communications directly between VSATs. Applications for this service are limited to large private international networks and domestic digital overlay networks; because each VSAT has to have MES capabilities, it is very costly.

- *Point-to-multipoint broadcast*. This is suitable for the broadcasting of time-critical data, such as financial information (exchange-, stock- and commodity markets) to a large number of receivers. The service is normally addressable and coded, enabling several users to share the system without losing integrity.

- *Remote data collection*. Data can be transmitted from VSATs to the central hub for applications in seismic surveys, surveillance etc.

The interactive VSAT service is an attractive alternative for organisations with pan-European datacommunications needs. As it competes with packet- and circuit-switched data networks as well as with leased lines, its cost advantage would mainly be determined by the distance between the communication centres. The inherent advantage of

27 Another major cost for satellite dishes is the transmitter/receiver and the associated amplifiers. Because signal levels are very weak, very sensitive low-noise equipment must be used. There have been substantial improvements in these technologies, some of which have been prompted by the growth in direct satellite broadcasting.

satellite communications is that they are independent of distance, and this has made the service very popular in the USA. Other important advantages are:

- They give users total control over their communications networks, and release them from having to interact with a number of national TOs. We estimate that one-stop shopping will be implemented in 1992-93, thus providing a boost in demand from medium-sized international organisations.

- In most European markets, there is a much shorter lead time for the installation of VSAT dishes than for leased lines or packet-switched data lines, and VSATs offer great flexibility for the user to reconfigure the network.

- For users requiring high-reliability, VSATs can be used as a high-capacity back-up to a terrestrial system, or be installed to provide temporary extra transmission capacity.

- Tariffs for cross-border calls are kept at excessive levels by the national TOs, who have increased the cost for international data network communications. A recent study[28] compared the costs to a retailer with 7500 outlets in 15 European countries of a) using a packet-switched network and b) using a VSAT system. Assuming a life-time of ten years, the Net Present Value surplus using the VSAT system would be ECU 102 million.[29]

- VSATs provide the user with instant access to a 64kbit/s network to any location in Europe, thus by-passing any undeveloped local networks. This will be valuable for rural regions which are trying to attract investment; VSAT is a way of offering high-quality communications as a 'temporary' solution in anticipation of a future digital network with ISDN. The greatest interest in VSATs from business users occurs in countries such as Spain, Greece, Turkey, Yugoslavia and Italy where the establishment of terrestrial data networks is complicated and time-consuming.[30]

Viability of VSATs

European TOs have consistently resisted liberalisation in the area of satellite communications; their strict control over all satellite uplinks and downlinks through earth stations

28 By the PA Consulting Group, 1990.

29 Net Present Value (NPV) represents the value of an investment discounted at a particular rate, so that income in the future is worth less than income now. The discount rate used to calculate NPV is usually set equal to or greater than the rate of interest payable on the money market; it should also reflect the degree of risk of the investment with a high discount rate for higher risks. The interest rates used in this study are real interest rates, i.e. adjusted for the effects of inflation. NPV is usually quoted before tax and dividend payments; this represents the overall value to the sector. Assuming a US$:ECU exchange rate of 1.35, and a discount rate of 8% p.a.; capital/annual cost is US$52m/US$38m for the packet-switched network and US$68m/US$15m for the VSAT system.

30 A study carried out in 1988 by Cap Scientific Ltd.

effectively prevented any VSAT systems being offered in Europe. A number of developments in the regulatory area are now set to change the prospect for VSAT systems:

- The CEC's draft for a Green Paper suggested rapid liberalisation of the satellite market. Opposition to these plans by various organisations led to modifications; the Green Paper takes a more cautious view towards deregulation, although it still emphasises the principles of direct access to satellite capacity including signal transmission towards the satellite, earth segment liberalisation and landing rights for VSAT services.

- The CEPT[31] is pushing its members to sign bilateral one-stop shopping agreements for VSAT services, and the VSAT group within CEPT's commercial action committee (CAC) is drawing up a 'model bilateral contract'.

- France's telecoms regulatory body, Direction de la Réglementation Générale, has agreed to remove most of the restrictions to one- and two-way satellites, and to give private operators open access to France Telecom-owned satellite hub stations.

- Deutsche Telekom has suspended its monopoly on basic telephone services over VSATs for communications with East Germany for an unspecified period, and is allowing services to be offered to third parties.

The commercial viability of VSATs was demonstrated in a recent study[32] which considered a fast-growing business enterprise with 1760 small sites spatially distributed in Europe (with 110 small sites per regional office), interlinked by 64kbit/s and 2Mbit/s leased lines; see Exhibit 2.15 overleaf. The study evaluated the financial implications to the enterprise of making a licence bid which would allow it to operate a private satellite system across Europe. Tariffs for the leased lines were based on the competitive tariff structure used in the UK, with 10% p.a. reductions in real terms to reflect further liberalisation initiatives. Results from the study indicated that the development of a satellite system[33] would be beneficial to the organisation, so long as its retail and small sites were excluded from the satellite link-up, and that spare transmission capacity was leased to other organisations.

The conclusions from the study were as follows:

31 Conference of European Postal and Telecommunications administrations.

32 *The Economics of Commercial Satellite Systems in a Liberalised European Environment*, Analysys STEM RACE Research Briefing Number 3, March 1990.

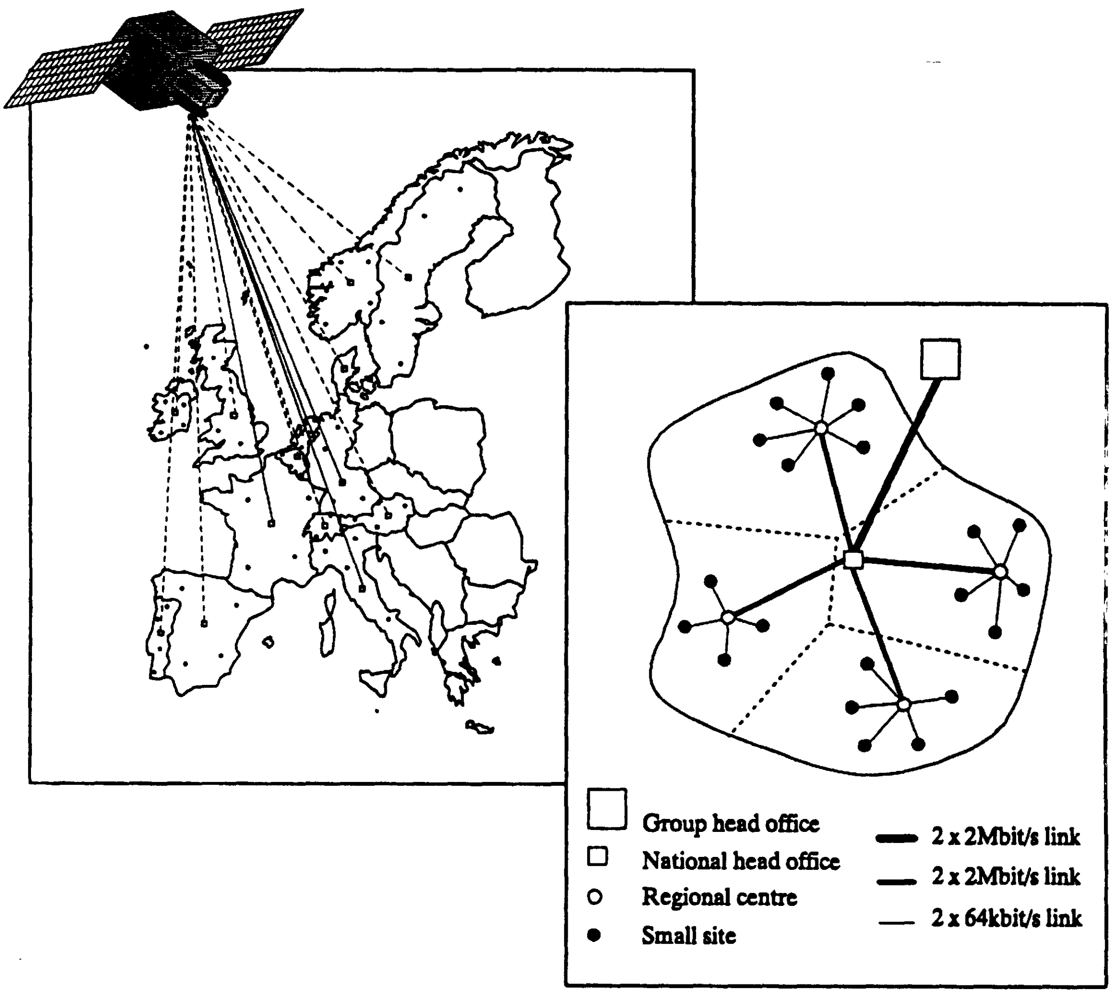
33 In this study the regional and national sites operated at 2Mbit/s duplex, and might therefore be described as a small antenna (SAT) system, rather than a VSAT system.

- VSAT systems are price-competitive, despite competitive tariff structures for leased lines, but only when used for long-distance transmission.

- All satellite capacity must be utilised to ensure economical viability. This suggests that only a few VSAT systems will be set up and operated by users. Most VSAT systems will probably be run by TOs, and private and public companies (which will then lease the capacity to several users).

- If the tariff structure for leased lines is competitive, VSATs will not prove a threat to the 'regional' leased-line market.

EXHIBIT 2.15: Private Satellite Network



Other Developments

Major technological developments in the satellite area will relate to the selectivity of transmission, improved transmission power and capacity, as well as extended satellite lifetimes and falling earth-station costs. Nevertheless, there are some other interesting developments in the areas of space-based switching systems and low earth orbit systems.

Space-based switching systems are currently being researched; the basic idea is to place a switching unit in the satellite and to let the switching be controlled by a master earth station. The main application of this technology would be to offer switched digital satellite communications, and thus allow the immediate implementation of ISDN in, for example, remote areas where there is no digital terrestrial network. The main problem is the fact that expensive switching equipment is located where maintenance and repairs cannot be carried out. This could be resolved in future, however, by placing a total switching system on a manned space platform.

New sophisticated satellite control systems are needed when satellites are placed in low earth orbit. The obvious advantage of low earth orbit satellites is the vastly increased signal power received on earth, which makes communications with hand-held units possible. At the beginning of 1990 Motorola revealed its plan to launch 77 low earth orbit satellites in seven circular polar orbits, with 11 satellites per plane. By providing a near-total coverage of the earth, this mobile radio system will give complete geographical coverage; the service is primarily targeted at rural and remote areas not served by terrestrial systems. The project has only recently started, and Motorola's plan to begin full service as early as 1996 appears rather optimistic.

2.3.6 Telex

Overview

In the early days of teleprinter (or telex) communications, the public telephone network was used. To send a telex message a telephone call was made to the required number and when the connection was established both subscribers switched from telephone to teleprinter, and the message was transmitted. Limits on transmission speed led the TOs to set up a completely separate switching network for the European telex service, which was completed during the 1950s.

The telex service proved particularly popular with organisations which need a printed record of their communications. Even today, the telex service is still vital for organisations with a need for communications with countries outside Europe, where time zones makes voice communications impractical and problems with the quality of transmission makes the use of faxes unreliable. In Western Europe, however, the use of telex is declining where Group 3 faxes and packet-switched services are better alternatives for the majority of potential users.

2.4 CONCLUSIONS

Looking at the short term (1990 to 1995), we expect digitalisation of European networks to continue. Initially digitalisation will concentrate on the trunk networks and the main switching centres, but digitalisation of local exchanges – a pre-requisite for ISDN – will follow quickly. A major aspect of this will be the introduction of the CCITT No 7 signalling system, optical fibre and Synchronous Digital Hierarchies (SDH) as the basic transmission mechanism. These developments will in turn lead to changes in network architecture.

Faced with emerging competition from the VSAT systems, TOs will have to respond; their strength lies in their network infrastructure, and they may begin to offer switched Broadband services based on an overlay network.

Between 1996 and 2000, the changes arising from network digitalisation will bring profound developments in network architecture, initially focused on a reduction in the number of network hierarchies.

The cable TV market will grow rapidly with the rise of numerous satellite operators, and the growing demand for cable TV will enable some TOs to begin to implement fibre-to-the-home in an economical fashion. The costs of opto-electronics will fall rapidly as a consequence both of economies of scale in production and new production techniques. ISDN will become widely available, and many leased-line users will migrate to ISDN during this period.

One problem for the TOs will be the existing networks. The packet- and circuit-switched networks were initially intended as an interim solution towards ISDN implementation, but the services have been quite popular, and CEPT has therefore agreed to continue to develop and promote them for at least another ten years (to the year 2000), despite the emergence of ISDN. This move indicates an uneasy co-existence supported in part by the D-channel which will enable ISDN users to interact with the packet-switched network. Early implementors of ISDN such as the UK, France and Germany will, however, discontinue their packet-switched service (with the exception of that operating through the ISDN access) towards the year 2000, and the service will therefore start to decline after that year.

In the longer term (between 2001 and 2010), Broadband will be implemented on a wide scale, both to business and residential subscribers – although the nature of the services provided in each case will be very different. Implementation will be possible due to massive increases in network capacity, and changes to the network architecture.

Business users have new high-capacity PCs and CAD/CAM workstations which need to be interlinked, and residential users will demand HDTV and video-based interactive value-added services as well as videotelephony. Part of the Broadband access will be used for ISDN; both business and residential subscribers will find this service attractive as equipment prices fall, and the popularity of telecommuting increases.

Analysys

3/ General European Regulatory Projections

This chapter describes our regulatory projections at the European level; demand and technological projections are contained in Chapters 1 and 2 respectively. Where we attach a date to a trend or development, this relates to our projections for advanced countries in the Expansionist Case.

We describe the European regulatory trends which are projected to emerge and develop between now and the year 2010, beginning in Section 3.1 with a summary of the major developments which are expected to occur by 1995, by 2000 and by 2010. This is followed in Section 3.2 by a discussion of the forces which have shaped European telecommunications regulation over the last ten years, together with a summary of the general philosophy of European telecommunications policy, and a comparison with the situations in the USA and Japan.

In Section 3.3 we consider the future regulatory development of European telecommunications, and in Section 3.4 we summarise the likely impact of regulation on both telecommunications investment and new technologies. Finally we summarise the consequences of the Single European Market (Section 3.5).

3.1 CHRONOLOGY OF THE REGULATORY PROJECTIONS

The regulatory projections are summarised in the diagram overleaf. On the left hand side we have set out major topics, and have represented their implementation or impact over time by horizontal bars containing commentary; the shading represents scale or degree according to context.

By 1995 we expect the following developments:

- Completion of the split between regulator and operator. By the mid-1990s regulators will have moved from supporting the dominant TO against 'unfair competition' to setting precise performance targets in order to prevent abuses of monopoly power. The TO's themselves will respond by implementing new commercially oriented organisational structures and goals.

- Tariffs throughout Europe are out of line with costs. Such imbalances prevent fair competition either by allowing new entrants to make high profits (in international and long-distance transmission) or by preventing entry by charging less than cost (in local access). In the long run these imbalances must be removed if competition is to be possible in telecommunications. Initially rebalancing will mean a significant fall in international and long distance tariffs the beginnings of which will be observable before 1995.

- In the short term, competition in the local loop from alternative cable-based networks will be limited.

- Mobiles will be at the forefront of competition in telecommunications; they are important because they also provide the possibility of competition in the local loop. Competing mobile operators will be introduced in many parts of the EC.

- Network competition will begin in some Member States and at the European level in pan-European networks.

- Efforts to encourage regulatory change at the European level will be spearheaded by the CEC, including application of EC competition rules partly in response to pressure for a more open environment from the GATT framework. ONP will be applied to leased lines, packet-switched data, satellites and voice telephony. ONP Directives on both ISDN and Intelligent Networks (IN) will set down some minimum standards of open access to network signalling and software-defined features; this will stimulate competition and innovation in VAS. Rapid developments in interconnection and competition will prompt a review of ONP.

- The CEC Satellite Directive will lead to:

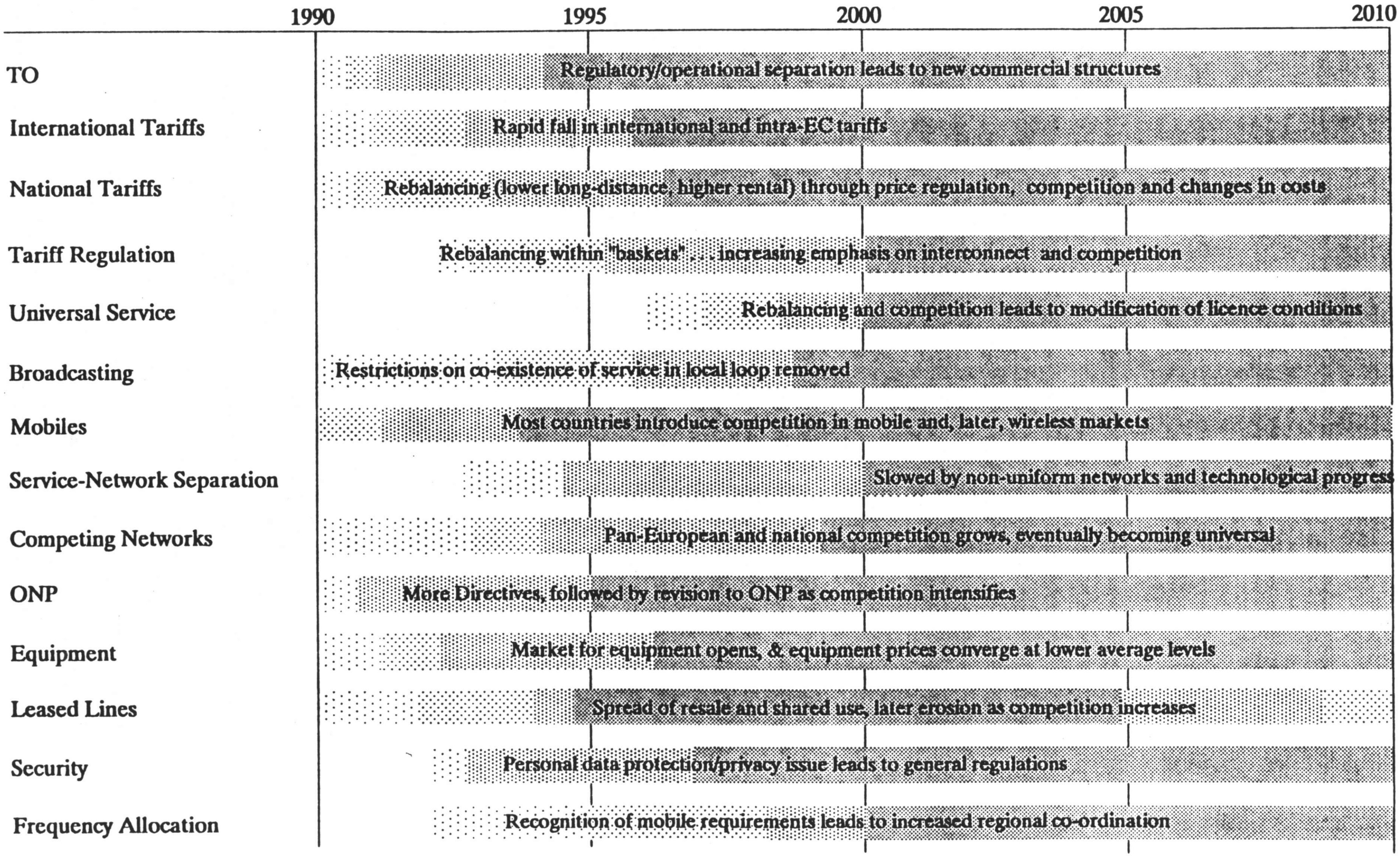
- full liberalisation of the earth segment[1]
- unrestricted access to space capacity[2]
- full commercial freedom for space segment service providers[3]

1 Including both receive-only and receive/transmit terminals, subject to appropriate type-approval and licensing procedures to implement necessary regulatory safeguards.

2 Subject to licensing procedures, in order to safeguard exclusive or special rights, and regulatory provisions set up by Member States in conformity with Community law (and based on the consensus achieved in telecommunications policy).

3 Including direct marketing of satellite capacity to service providers and users, subject to compliance with the licensing procedures mentioned above and in conformity with Community law (especially competition rules). Access should be on an equitable, non-discriminatory and cost-oriented basis.

Regulatory Projection (Expansionist Case, Advanced Countries)



- harmonisation for the provision of Europe-wide services.[1]

- ▶ The pressure for true open procurement rather than from national suppliers will begin to grow as a result of the drive to cut costs.

- ▶ At present there are differing national regulatory stances in Europe regarding the conditions for resale of leased-line capacity. In the short to medium term, it can be expected that unrestricted resale and shared use of leased-line capacity will begin to spread across Europe. Conditions for the interconnection of private networks to the public network are likely to converge under the influence of ETSI's work (Network Code of Practice) and common standards (e.g. those recommended under ONP).

By 2000 we expect the following developments:

- ▶ There will be increasing emphasis on rebalancing both through direct tariff controls (such as have been introduced in Denmark, Germany and the UK) and the introduction of competition (at first in international services across Europe and in national services in some countries).

- ▶ There is likely to be considerable pressure for a change in the system of universal service provision during the 1990s, as the incumbent TOs face competition in all parts of the network. By 2000 these developments are likely to have lead to a re-defined (if not wholly replaced) system of licensing to ensure access to basic telecommunications services on acceptable terms for customers.

- ▶ Competition policies for services and networks in the local loop will start to change in the medium term as more liberal countries allow the sharing of local access links between CATV and telecommunications.

- ▶ The development of new services supported by advanced network architectures will enable services and infrastructure to be provided by different operators – including multiple service providers using the same network. New regulatory régimes will then be needed; the timing of their introduction will depend on how easily the potentially very complex regulations can be drawn up, and on the technical progress made in network implementation. Separation for some services is possible now (as with Minitel in France), but more widespread application of this principle is unlikely before the late 1990s.

1 Harmonisation measures as far as required to facilitate the provision of Europe-wide services. In particular, this concerns the mutual recognition of licensing and type approval procedures, frequency co-ordinating and co-ordinating with regard to satellite service providers outside the European Community.

- Technological change and growth in demand for new services will result in new networks being introduced throughout the EC.

- True open procurement and purchase of equipment from diverse sources will result in prices converging at lower 'European' levels than in the current situation where some countries with restrictive purchasing policies are paying up to three times as much as others for the same equipment.

- The opportunity for exploiting tariff anomalies through the use of leased lines will gradually disappear in the long run as competition increases.

- Security, privacy and data protection will become increasingly important as the telecommunications networks become more sophisticated and capable of offering services based on information about individuals (for example their location) as well as accessing and transmitting information about them. The increasing communication of information between Member States and, potentially, to countries outside the EC will lead to action at the European level on these issues.

- Increasing demands for frequency capacity and the use of mobiles throughout the EC will lead to frequency allocation issues being discussed and co-ordinated at the European level.

By 2010 we expect the following developments:

- Regulators will require networks to have the capability for competition in the cable local loop by means of different service providers renting alternative wavelengths – a kind of optical interconnection requirement.

- With optical fibre widely deployed in the local loop and ATM transmission becoming the norm by 2010, the central goal of regulation will become the equitable sharing of infrastructure costs between services – the free-rider problem familiar in economics.[2]

- Further changes in tariffs will have occurred. Tariffs will not be completely cost-oriented, but the combination of competition and regulation will have ensured that alignment is sufficiently close to prevent cross-subsidisation or exploitative tariffing

[2] This is the problem where it is impossible to separate those who pay for a project from those who benefit. For example, if a trade union secures improved pay and conditions for all workers in a company, those who are not union members (i.e. who have not paid union fees) benefit without cost. With optical fibre in the local loop, extra bandwidth is available at virtually zero marginal cost. It is not clear whether each service using that fibre should pay a flat access fee (regardless of bandwidth), or whether there should be time- or volume-related charges. If investments are recouped from early services (such as cable TV and telephony) then later services using the new infrastructure will inevitably benefit from inertia in tariff régimes.

whilst enabling the service providers and TOs to vary tariffs in response to market conditions.

- Consolidation of the regulatory changes set in train in the 1990s with licensed competition allowed for all services and networks.

3.2 A Decade of Change

In this section we describe the forces leading to changes in European telecommunications regulation over the last decade (3.2.1). We then discuss the general philosophy of European telecommunications policy (3.2.2), and provide a brief comparison between the European situation and that in the USA and Japan (3.2.3).

3.2.1 The Driving Forces For Change

In the 1970s the telecoms sector was characterised by strict regulation, an extensive monopoly of telecoms administrations, and a focus on voice telephony. A number of factors have combined to challenge the state monopoly over telecommunications in Europe, not least of which is the increased technological complexity and enormous growth in the demand for new services.

Technological progress has provided alternative technologies (such as satellite) to compete with traditional delivery systems. Customer premises equipment has become increasingly sophisticated. New opportunities have arisen as the boundaries between telecoms, data-processing and broadcasting have blurred. A more liberal environment has been required as service providers have become increasingly independent of the network operator. In such a situation regulatory bodies have been faced with a choice between increasing regulation to control the growing technological capabilities, or developing a more flexibly defined telecoms regulatory framework, calling into question the rationale for current tariff structures.

The rapid growth in demand for new specialised services has generally outstripped the ability of the national TOs to respond, thus supporting arguments for liberalisation. The lack of any clear concept of community service or social objectives in the provision of data and mobile voice services to business means that a potential political objection to open markets in network provision is sidestepped.

Technological progress has also brought about a dramatic cost reduction in transmission. Optical-fibre technology weakens the relationship between cost and distance, and in addition to this trend, business user groups have become increasingly successful in applying national and Europe-wide pressure to force changes in their favour. One instance of this is the abolition of cross-subsidisation of local service and consumer access by the long-distance market.

Deregulation elsewhere has had an effect on the European regulatory process. In particular, the divestiture of AT&T in the USA in 1984 has set a compelling precedent. An important factor in this has been the fear of falling behind the USA and Japan in such a strategically important sector (with the subsequent loss of business opportunities). Europe is a major target for increasingly internationally-minded US companies. The TOs are now facing competition both from other European TOs and US and Japanese companies to offer global services. The extent to which the regulatory framework allows European TOs to finance and fulfil their plans, and gives them the freedom to compete successfully will have a decisive effect on investment.

With the gulf between European and Japanese telecoms steadily widening, and with the established international order breaking down as the number of bilateral deals proliferates, telecoms has also become a major issue in protectionist trade legislation. The Uruguay Round of GATT has become the major forum for determining a future framework for trade in telecoms-related services, and Value-Added Services in particular.

3.2.2 European Telecommunications Policy

Although taking different organisational forms, a common feature of the Western European telecoms sector is the continuing dominance of monopoly telecoms operators, usually under full state ownership.

Even in the case of the UK – where network competition has existed since the privatisation of BT (British Telecom) in 1984 – the Government maintained its 49% stake of BT until very recently, and still maintains its control through the regulatory body OFTEL. BT still dominates the market, and regulation prevents it from competing head on with Mercury.[3]

However, over the past 10 to 15 years the pace of regulatory change has begun to increase dramatically, fundamentally as a result of the changes in technology, but also as a result of the example of US liberalisation and the 1992 internal market initiative. The potential of technology in communications is amply demonstrated by the advanced services and networks of the USA which are offered on an extremely competitive (in international terms) basis. More recently, initiatives launched by the CEC in advance of the internal market in 1993 have increased the rate of change.

3 For example, in provision of leased lines to the City of London, BT must tariff its offerings at its standard national schedules. Mercury can easily undercut this in the densely populated financial district.

A lack of common policy objectives has led to a noticeable divergence in the telecommunications policy of European states. At one extreme lies the UK which split its TO into separate postal and telecommunications organisations a long time ago (a full decade ahead of Germany), then privatised it and, uniquely in Europe, has allowed a competing domestic carrier. The UK pioneered the model of competition in cellular networks (now widely adopted across the world) and in the local loop, particularly by licensing three PCNs.

Other countries are, to differing degrees, less progressive. The majority of TOs in continental Europe have undergone restructuring, commonly involving the separation of regulatory functions from network operation and service provision. Privatisation of TOs along UK lines is not being widely considered, although conversion to joint-stock company status is being discussed in some countries. Change is proceeding at differing rates, with Germany leading VSAT liberalisation, and planning to license PCNs next year.

3.2.3 Comparison with USA and Japan

The European situation contrasts markedly with the USA, which has a regulated privately-owned monopoly of the local loop (comprising the seven RBHCs, GTE and nearly 1300 other independent companies, many of them local, in 1989) and full competition between inter-LATA[4] carriers. In many LATAs, users may choose between alternative inter-exchange carriers simply by dialling a different access code (this happens in only one small city in Europe at present[5]) and PABXs are often programmed to select the lowest cost or preferred carrier (a common feature for larger businesses in the UK which use both BT and MCL networks).

Deregulation in 1984 in the USA turned AT&T from a monopoly carrier to just one of the many competitors (albeit a dominant one) in the US telecoms services market. Intense competition between the various long-distance carriers has led to significant reductions in the cost of long-distance traffic. As a result of the liberal environment and the carriers' desire to avoid sharing revenue with local telephone companies, so-called 'by-pass alternatives' have become commonplace, in which larger business customers are connected directly to inter-LATA carriers. The revenues of the local network companies are thus reduced, even though they are subject to state regulations specifying that certain social objectives – such as universal service – be attained.

4 Local Access and Transport Area.

5 In Kingston-upon-Hull in the UK, the local telephone company (which was not included in the 1912 nationalisation of all other local telephone companies as the district government refused to sell it) offers its customers a choice between British Telecom and Mercury Communications – customers dial either 12 or 13 before any call out of the Hull area.

US pressure on the Japanese government to open up its telecommunications market has had some effect. Up until 1985, Nippon Telegraph & Telephone Corporation (NTT) had a monopoly over domestic telecoms services, while Kikusai Denshin Denwa (KDD), a regulated private enterprise, had a monopoly on international services. The break-up of NTT was contemplated, but the first step taken was to license competing domestic and international carriers. In addition, some structural separation measures have been taken (whereby subsidiaries offer Value-Added Services in open competition). Competing carriers have been highly successful in reducing NTT's market share (though none of them has a market share greater than 3%), and in forcing generally lower prices for users. One reason for the success of competing carriers is that they are owned by conglomerates which provide them with all the business they need.

An example of the contrasting philosophies in Europe and the USA is given by the satellite area. Because of their potential to transmit voice and data without using public-switched terrestrial lines, satellite communications networks offer the greatest threat of 'by-pass' to national TOs. US experience has shown that once liberalisation occurs, there will be an immediate demand for the provision of VSATs as an alternative to leased lines.

Although the USA has adopted an 'open skies' policy in relation to domestic services, the RBHCs have tried to restrict the availability of new technologies, in order to safeguard revenues. The 'open skies' policy does not apply fully to international communications. The European situation contrasts markedly with that in the USA:

- Unlike the USA, where the market in VSAT-based systems has prospered, current regulatory procedures in Europe have stifled a potentially large market – one where user demand and mature technology exists.

- The CEC's 1988 Terminals Directive deregulated ownership and operation of one-way satellite terminals within the Member States, thereby encouraging the receive-only segment of VSAT. However, the regulatory structure surrounding two-way VSATs has hampered any market development.

Pressures for change in the European regulatory environment have come from users, private satellite operators, equipment suppliers and Eutelsat (the European Telecommunications Satellite Organisation). The CEC's Satellite Green Paper now offers support for an 'open skies' policy, in so far as this is compatible with the services liberalisation compromise.

3.3 Future Developments

Much of the framework for the opening up of European telecoms markets is in place. The task now facing the CEC involves implementation of existing measures and management of the remaining obstacles, so that the envisaged benefits come to fruition.

To quote the 1987 Green Paper, the problem facing the CEC is one of 'a delicate regulatory balance':

- On the one hand, technically and financially capable network operators are desired, to enable advances to be made in networks, and the introduction of new services.
- On the other hand, a more competitive market is generally desirable; this will allow the full use of networks and freedom of choice for the user.

3.3.1 General Trends

While at the European level the CEC is setting the pace of reform (in satellites, for example), competition in the local loop and in the mobiles area is driven by events at the national level. There are still great differences of approach between the Member States,[6] but a number of general observations can be made:

- Recent trends towards the reduction of restrictions and entry barriers will continue, thus allowing the development of new activities. As a result, the protection TOs currently enjoy will be increasingly reduced.
- Implementation of the Green Paper proposals will increasingly draw upon full application of EC competition rules. The CEC already has a strong legal basis to act, resulting from the earlier ONP and Services Directives, and the European Court decision on Article 90 for terminals. However, the Guidelines on the Application of EC Competition Rules in the Telecommunications Sector allow a global application which is more effective than the case-by-case approach often taken in the past. Whilst, on the one hand, the CEC indicates that 'telecommunications operators should be encouraged to establish the necessary co-operation mechanisms to ensure Community-wide full interconnectivity between public networks, . . . the full applic-

6 The response of different countries to the pressures for change (outlined in Section 3.2.1) will depend on a number of factors, including, most importantly, political considerations. To date some European countries have adopted a more conservative stance than others regarding the liberalisation of telecoms markets. Unless major political changes occur it is probable that these countries will be slower to implement regulatory changes. This is discussed in much more detail in Annex B, but for an easy comparison of likely future regulatory timing the group of more 'conservative' countries includes Belgium, France, Greece, the Republic of Ireland, Italy, Portugal and Spain.

ation of competition rules forms a major part of the Community's overall approach to telecommunications'.[7]

- ONP Directives and Recommendations will be applied to specific areas in telecommunications over the next few years.

- The TO monopoly of the local loop is likely to remain for some time but competition in this area will come from PCN and fixed wireless systems (voice telephony) or satellite (for television distribution and by-pass in business communications) and cable TV systems. Eventually the local loop monopoly will be broken through having different networks focused on specific market segments.

- Downwards pressure on cross-border tariffs will be exerted by a number of sources: VSATs, ventures such as the pan-European optical-fibre network proposed by the railways, CCITT reform[8] and competition for networking business between the 'regional' TOs in the EC. In the short term, this may reduce TO funds available for investment, but will also hasten the process of tariff rebalancing.

- The CEC, in setting the regulatory environment of the future, should be seen as part of the GATT framework, which is exerting pressure towards a more open environment generally.

- The proliferation of satellite and mobile systems, and their growing importance, will lead to increasing pressure for European rather than national frequency allocation.[9] Within allotted bands, spectrum auctions are likely to become more common as a method of allocating this scarce resource.[10]

Below we consider in more detail developments in the areas of tariff rebalancing, USOs, interconnection, mobiles and cable television.

7 From 'Guidelines on the Application of EEC Competition Rules in the Telecommunications Sector' (Brussels, September 1991).

8 Theodore Irmer (director of the CCITT) believes that a significant lowering of international tariffs can be brought about within the next two years through changes in the accounting rates on which international tariffs are based. Reforms would take time because of the differing costs of world telephony (due to variations in the technological advance of networks and political factors). However, a reduction in accounting rates does not necessarily mean that international tariffs will come down, as it is government regulators that fix prices and not the accounting rates in themselves.

9 The new European Radiocommunications Committee and European Radiocommunications are a step in this direction.

10 The recent cellular spectrum auction in New Zealand is an example of this trend.

Tariff Rebalancing

Currently, European governments exercise considerable influence in the setting of telecoms tariffs. Typically, price increases are subject to government approval or there is some explicit rule relating changes in tariffs to the Retail Price Index. In Denmark, tariff changes must be kept 2% to 3% lower than changes in the Retail Price Index. In the UK, BT is obliged to cut tariffs by 6.25% p.a. in real terms.

Tariff rebalancing policies are already in force in some EC countries, although the pace of change differs markedly from one country to the next. Regulatory reforms in 1989 obliged Deutsche Telekom to move German telecoms in the direction of cost-based pricing. However, there have been accusations from user groups and potential market entrants that the TO has not yet adjusted tariff policies in line with the intentions of the Reform Act. In the Netherlands, some tariffs have been cut by 30% since privatisation.

Some TOs appear to have adopted the goal of eliminating cross-subsidisation, recognising that it may lead to efficiency gains and combat the competitive pressure being exerted from leading-edge markets. Cross-border tariffs will suffer the greatest pressure, an example being the threat of by-pass by the VSATs which are soon to be licensed. This threat puts considerable downward pressure on international leased-line tariffs. Other sources of pressure on cross-border tariffs include ventures such as the pan-European optical-fibre network proposed by the railways, and competition for networking business between TOs.

In some cases it has been recognised that the elimination of cross-subsidies would lead to a much needed expansion in funds available for network development. This is particularly applicable to both Portugal and (the former) East Germany, where local services have historically been substantially under-priced.

In the past cross-subsidisation has been used as a mechanism for getting new services off the ground. The French experience with the Minitel service is an example of this. However, where the TO uses cross-subsidies between monopoly services and (perhaps newly) liberalised services, the policy will become unsustainable – at least beyond the very short term. Of course, those services with the highest margins are exactly the ones which will attract the greatest interest from potential new operators. Prices for such services will inevitably fall, and the incumbent will be compelled to increase charges for subsidised services.

The pressure to make tariffs more cost-oriented will continue and intensify, particularly in the medium term. Currently, there is a major divergence between price (i.e. tariff) and cost for access charges, and so users are being significantly undercharged. At the same time, however, many usage tariffs are set much higher than cost. Thus, any significant move towards cost-oriented tariffs generally implies higher access charges and lower usage charges.

Universal Service Obligations

Consideration of the split between telecoms operators and telecoms regulators raises the question of what will happen to existing Universal Service Obligations. There is likely to be considerable pressure for a change in this system during the 1990s, especially as the incumbent TO loses (fixed network) voice-telephony market share to PCNs, and also the data-communications market starts spilling over into voice, bringing competition from another direction. The combined force of these two developments may lead to a re-defined (if not wholly replaced) system of licensing and direct government subsidy in the more advanced states, and the gradual erosion of the Universal Service Obligation.

Interconnection of Private Networks

At present there are differing national regulatory stances in Europe regarding the conditions for resale of leased-line capacity. In the short to medium term, we expect that unrestricted resale and shared use of leased-line capacity will gradually spread across Europe as tariffs are rebalanced.

With the growth of private networks, especially mobile networks, increasing attention will be paid to the question of interconnection arrangements. These issues are currently in the national domain. Eventually, however, conditions for the interconnection of private networks to the public network are likely to converge under the influence of ETSI's work (Network Code of Practice) and common standards (such as those recommended under ONP, for example).

Mobiles

At present, many national regulators are attempting to foster competition by licensing mobile operators to run systems in competition with the incumbent operator. Differing systems may be used in the 'radio local loop', but the basic principle is that without the cost of building a distribution network, entry barriers are lowered considerably. In the short to medium term this policy should encourage the rapid growth of digital cellular systems.

It should be noted that in some countries (such as Belgium and the Republic of Ireland), there has been no definite commitment from regulators to license a mobile operator to compete with the incumbent's service. Arguments against such licensing typically focus on the small size of the country and the ability of the incumbent TO to provide a satisfactory service. By contrast, governments in the old Eastern bloc have quickly seen the advantages of licensing private cellular operators (with foreign participation), as the TOs are faced with the huge task of modernising and extending the existing fixed network, and are not in a position to provide such services themselves. The main motivation in this case, however, is to provide an immediate solution to unsatisfied demand, rather than to stimulate competition.

Cable Television

In the short term there will be no active regulatory promotion of competition in the local loop from alternative cable-based networks (with the exception of the UK, where this is already occurring). Policies will start to change in the medium term as more liberal countries allow the sharing of local access links between CATV and telecommunications. After 2000 PONs will be deployed more widely for residential users.

By 2010 we may see some countries introducing even more liberal regulatory policies in order to encourage competition. For example, there may be some sort of optical interconnection requirement whereby networks must have the capability for competition in the cable local loop (by means of different service providers renting alternative wavelengths). In the long term, the main aim of regulators will be to ensure equitable sharing of infrastructure costs between services.

3.3.2 Specific Developments

Clear indications of the future regulatory path to be followed in Europe are given by present legislation or by processes already underway (as outlined below). This summary represents our general European-level regulatory projections, which reflect the Expansionist case move to the widespread introduction of competition. The projections are considered in a country-specific context in Annex B.

1990 End-of-year deadline for terminal equipment to be opened to EC-wide competition.

ONP Directive for leased lines submitted. Other service-specific ONP Directives and recommendations are likely to follow before 1995 (including ISDN, voice telephony, PSPDN, Broadband, IN, mobiles etc.).

Green Paper on satellite communications issued.

1991/1992 VSAT Directive issued – this will lead to downward pressure on trans-border leased-line tariffs over the following years.

European-wide equipment type-approval Directive notified.

Investigation by the European Commission into whether arrangements governing international telephone charges are incompatible with the competition rules of the Treaty of Rome.

Green Paper on mobile communications dealing with: Europe-wide operation; access of private systems to the public network; preservation of interoperability with many operators; safeguards on interworking (numbering, for example).

Move to cost-orientation of tariffs – intra-Community international call tariffs should reduce. CCITT will introduce changes in the accounting rates for international tariffs later in the year. Start of a review of the Services and ONP Framework Directives.

A Directive on personal data protection and privacy is likely to be notified at this stage.

1993 Single Market in force.

Separation of TOs' regulatory and operational functions; they will have to accept common interconnect and access obligations for cross-border service providers. The supply of terminal equipment will no longer be on an exclusive basis.

The Services Directive allows resale of datacommunications capacity (Member States with an undeveloped public data network may delay until January 1996).

Trans-border carriage of traffic – telecommunications 'cabotage'. A Directive is likely at this time to enable all carriers to widen the use of private networks.

Open procurement to bidders for telecoms equipment from other Member States.[11]

11 Implemented from 1 January 1993 in all Member States except those with transitional arrangements (Spain – 3 years; Portugal – 5 years; Greece – 5 years).

1994	ONP for Broadband issued.
	First licensing of pan-European telecommunications operators.
1996/1997	First competition under new regulations for networks and services.
	Rapid rebalancing of tariffs as international and national tariffs fall in response to competition.
1997/2000	It is likely that the Universal Service Obligation effectively ends in many Member States (once social objectives are achieved by direct government funding, or competition obviates the need for a Universal Service Obligation).
1995/2010	A transition towards more cost-oriented tariffs occurs during this time, although tariffs do not align exactly with costs and do reflect market-based pricing. It should be noted that since the exact period of adjustment is not known, we have found it necessary to make different assumptions for this particular development in the two cases; in the Minimum case we assume a ten-year transitional period (1995 to 2005) whilst in the Expansionist case we assume an expanded transitional period (1995 to 2010).

3.3.3 Country-by-Country Regulatory Projections

Country-specific regulatory projections (contained in Annex B) will include consideration of the following factors:

- the competitive structure of the industry; the number of telecoms providers, network operators and service suppliers and their respective market shares; whether these operate nationally, internationally, regionally or locally (e.g. if required to meet social objectives, whether these are afforded the opportunity to cross-subsidise)
- the extent of any monopoly; for example, in the case of a network provider, whether the monopoly is restricted (to the public network, basic telephony or specialised services, etc.)
- the restriction of licences (regarding the supply of other services or geographical coverage, etc.)
- resale of leased-line capacity

- third-party traffic restrictions, e.g. the use of leased lines by third parties for VADS
- interconnectivity of public/private networks (the conditions under which this is allowed, and any surcharges which may be levied)
- the level of freedom of user choice in equipment supply
- equipment standards (e.g. whether the public administration retains control over type approval for connection to the public network)
- separation of regulatory and operational responsibilities.

3.4 Regulation, Technology and Investment

In this section, we discuss the impact of regulation – both on telecommunications investment (3.4.1) and technological development (3.4.2).

3.4.1 Regulation and Investment

Direct and indirect regulatory forces may have a strong impact on network investment. In general terms, the regulatory impact on investment is reflected in the following issues:

- Firstly, who is allowed to put in the infrastructure or offer a service? For example, if this is restricted to TOs then they are committed to the expense of installing a vast fixed network; if new private companies are allowed, these generally have few assets and will be able to enter specific new markets more easily.
- Secondly, what investment is permitted, and what timescale (if any) is associated with this?
- Thirdly, how quickly will the national model break down (if at all)?

Investment will thus be affected by any regulatory change that:

- provides for the possibility of a larger market (such as co-operation and co-ordination of standards aimed at removing national boundaries).
- injects more dynamism into the sector and increases the opportunities for wider utilisation of the network.

- allows competition to flourish; competition generally supports investment, although if no strong network operators exist, this can act as deterrent to potential investors.
- allows new technology to deliver services to the market that cannot be provided by the TOs.

3.4.2 Regulation and Technology

The relationship between regulation and technology does not take the same form in every service area. In those service areas where the technology is new and demand less certain (such as ISDN), regulatory functions centre on risk reduction. In such cases, in addition to the issues of interconnectivity and compatibility, the setting of standards is important to encourage confidence in future market growth, in ensuring co-operation and co-ordinated introduction, and thereby providing cost savings.

In a service sector such as VSATs, where the technology is no longer very new and where there is clear evidence for the existence of pent-up demand, the regulatory environment acts as a dam, frustrating innovation and the take-up of new services.

Regulation that protects the position of terrestrial network operators and prevents the growth of two-way traffic compromises other policy goals, whether that regulation is imposed on political or economic grounds. Where such compromise can be identified, possible solutions lie in co-operation or competition. A reduction of tariffs may be achieved by co-operation with the TOs, who will exercise some control over the speed and extent of the regulatory changes. Alternatively, competition can be mobilised to undertake the same function. In this case the speed of change is dictated by the regulators and by the speed of innovation of the new service providers. The role of the regulators is then to foster competition by enforcing a timetable for the removal of obstacles to investment. Regulators must also apply principles such as ensuring equality of access to networks for service providers and users.

We consider that the regulation of voice telephony, leased lines and IN services will be driven by the capabilities of the basic network technology as it is to become the bearer for value-added services which rely on network functionality. This process has already begun with premium-rate services (which use the billing function in a non-standard way). With the implementation of intelligent networks, private service operators will in theory have access to many functional components from which innovative services may be built. The availability and rights of access to these are a major challenge for regulation, particularly for ONP.

3.5 THE SINGLE EUROPEAN MARKET

The completion of the Single European Market in 1992 will form the prelude to a major period of restructuring and reorganisation within Europe. As Europe recovers from the effects of the 1990 slow-down in world growth, many businesses will try to take early advantage of the opportunities offered by the Single Market.

Consider the following likely developments:

- Many business activities will become more dispersed geographically as they locate manufacturing, retailing, and research facilities in different countries.

- Many businesses will try to gain early advantages by locating branches in other countries, where they perceive the existence of gaps in the market.

- In some areas of business it may not be necessary to physically build a local branch. Instead, it might be possible to use an electronic medium to conduct business. A case in point is the retail banking industry and the use of electronic service points located on the premises of, for example, a chain of supermarkets.

As a direct result of such developments, the demand for trans-border communication flows and high transmission speeds will continue to grow. Indeed, there is evidence that this trend will escalate as 1993 draws closer. Furthermore, by 1995 there should be considerable economies of scale resulting from standardisation of the telecoms equipment market.

The potential for pan-European carriers in such an environment is immense. The incumbent TOs are faced with the challenge of harnessing some of this potential via their existing infrastructure. Their ability to perform well will be influenced by how well they make the transition from government department endowed with a monopoly to private sector commercially-minded organisations faced with aspiring new operators. Furthermore, the ownership and financial structures of the TOs will be of paramount importance. In the past, governments may have imposed rigid conditions on PTTs regarding profit retention and investment, but in the future 'conditions' are more likely to be dictated by shareholders and capital markets.

The establishment of the Single Market and the moves towards greater integration of the EC should bring substantial changes in total GDP and real disposable income. The Cecchini Report[12] predicts that total GDP growth for the 12 EC countries will be 0.9%

12 *1992 - The European Challenge*, The Cecchini Report (Wildwood House Ltd, 1988).

higher each year between 1993 and 1998 than it would otherwise have been. We envisage that, on average, real disposable income per head after 2000 could approach twice its current level within the Community. This (combined with falling costs due to technological advances) will be reflected in increased demand for products such as cable television, and even videophones in the home.

Convergence and the Single European Market

The completion of the Single European Market forms only a part of the move which is now taking place towards integration and convergence in the EC. The successful incorporation of Sterling into the Exchange Rate Mechanism of the European Monetary System (EMS) will reduce currency fluctuations in the EC and reduce the variance of interest rates and inflation within the EC. These trends will be accentuated by the (as yet tentative) moves towards monetary union of the 12 EC Member States.

The biggest challenge for policy makers in this area will be to ensure that the peripheral and less developed regions of the EC do converge with the other Member States. This will not be easy; although growth in Spain and Portugal exceeded 5% in real terms during the latter half of the 1980s, it then tailed off by the end of the decade. If there is to be some degree of convergence with the rest of the EC over the next two decades, growth in these countries must return to (and then remain at) its former high level. In the longer term we expect the EC to increase its output, at the expense of the world's other major trading powers; in particular, the gap in growth between Japan and the EC will be narrowed.

4/ Aggregate Quantitative Results for the EC

This chapter presents our aggregate assumptions for demand and competition, and aggregate quantitative modelling results for the 12 countries of the EC. Clearly, these aggregate EC results mask the wide range of results for individual countries; the corresponding assumptions and results for individual countries appear in Annex C.

Section 4.1 explains the layout and content of the input and results graphs. Section 4.2 includes commentary on the Expansionist case results, and the full set of input graphs and model results. Similarly, Section 4.3 provides commentary on the Minimum case results, and includes the full set of input graphs and model results.

The model results for each case are accompanied by print-outs of TO accounts and country accounts which detail the financial performance of the TOs and the EC countries as a whole.

4.1 Introduction

In this section we explain the layout and content of the input and results graphs. An explanation of financial terms used on the graphs and accounts print-outs appears towards the end of this volume.

Input graphs and model results relating to both the Expansionist and Minimum case models are presented, together with commentary on individual graphs from each case. The graphs for each model run are preceded by a summary table which includes data on demand, traffic and financial results.[1] All graphs and tables show time-series, indicating how demand and results will change over time. It should be noted that all data on traffic and connections represent the mid-point of the appropriate year.

1 The models have been run for the period 1990-2010, and summary data is given for the years 1990, 1995, 2000 and 2010.

The results are shown for the network as a whole and also for each service. These services are referred to as 'bearer services' on some Exhibits (since they are the services that 'bear' or carry the various applications), but they can also be thought of as 'connection types', since they are the various means by which applications are connected to the network.

A consistent numbering scheme has been adopted for the graphs from all model runs. The Exhibit number of each result graph takes the form EC.Z.N, where:

- EC denotes that the results are aggregate results for the 12 EC Member States
- Z is a character identifying the case: X for Expansionist, and M for Minimum case
- N is a number in the standard series of graphs, as listed below.

The standard input data graphs (Graphs 1 to 16) are described below. No detailed commentary is provided on the input graphs for each model; in many cases, the input graphs are self-explanatory.

4.1.1 Input Data Graphs

1: Total Network Traffic

Graph 1 shows the profile of Total Network Traffic (which drives the demand for bearer services) by application. Total Network Traffic is expressed in millions of Annual Call Minutes.

2: Customer Base

Graph 2 shows the Customer Base of the network, in terms of numbers of customers in each type of establishment (residential plus four types of business establishment).

3: Network Busy Hour Traffic

Graph 3 shows Network Busy Hour Traffic by the bearer service, expressed in millions of Busy Hour Erlangs. The graph represents the Busy Hour Traffic generated by the customers from Graph 2 using the applications shown in Graph 1.

4: Network Lines

Graph 4 shows network lines supplied by the different bearer services. Network lines are here expressed in millions of equivalent voice circuits, an equivalent voice circuit being the capacity required to carry one voice conversation. The number of lines is not necessarily identical to the number of connections shown in Graphs 5 to 8; this will depend on the applications carried by the service.

Graphs 5 to 8 show the number of network connections for the following bearer services:

- Basic Telephony, Basic-Rate ISDN, Mobiles (Graph 5)
- Primary-Rate ISDN, Narrowband Leased Lines, Broadband (Graph 6)
- Broadband Leased Lines (Graph 7)
- Telex, Packet-Switched Data Network, Public Payphones (Graph 8).

Graphs 9 to 12 show the relationship between the network busy-hour traffic in Graph 3 and the network lines in Graph 4, for certain bearer services:

9: Network Busy Hour Traffic per Business Line (Public Switched Services)

Graph 9 compares the Network Busy Hour Traffic per Line between business establishments of different sizes. Since different sizes of business establishment will use different bearer services, an aggregate Network Busy Hour Traffic per Line is calculated across all Public Switched Services – Business Telephony, Basic-Rate ISDN, Primary-Rate ISDN and Broadband. This aggregate is simply calculated as the total Network Busy Hour Traffic originating from an establishment divided by the total number of network lines connected to that establishment.

10: Network Busy Hour Traffic per Line (Basic Telephony and ISDN)

Graph 10 shows Network Busy Hour Traffic per Line for Business Telephony, Residential Telephony, Basic-Rate ISDN and Primary-Rate ISDN. Total Primary-Rate ISDN connections are shown in Graph 6, and total connections for the other bearer services shown here are indicated in Graph 5.

11: Network Busy Hour Traffic per Line (Mobiles)

Total mobiles connections are shown in Graph 5.

12: Network Busy Hour Traffic per Line (Broadband)

Total broadband connections are shown in Graph 6.

Graphs 13 to 15 (which show competitor market share for particular bearer services) are not shown for the EC as a whole.

16: Network Connections, Demand from Mobiles Operators

Graph 16 shows the number of leased-line connections which are used for transmission by mobiles operators (over and above the leased-line connections shown in Graphs 6 and 7).

4.1.2 Output Data Graphs

Graphs 17 to 47 are the standard output data graphs, which include graphs on installed equipment (17 to 23), capital outlay (24 to 28), service revenue and cost (29 to 40), tariffs (41 and 42), and financial performance (43 to 47).

All the output graphs relate to the 12 EC Member States as a whole, except for Graphs 45 to 47 (inclusive).[2]

Between Graphs 40 and 41, a set of summary accounts – Profit and Loss, Balance Sheet and Source and Application of Funds – are included for each year of the modelling period. Total network investment appears within the Source and Application of Funds under 'Net Expenditure on Tangible Fixed Assets'.

Two points should be noted:

- Two sets of summary accounts have been produced: one describing the TOs, and another for the EC countries as a whole. Each set of accounts comprises four pages, each covering five years of the modelling period.

- 1990 financial data have been taken from two different sources and it has not always been possible to reconcile these two sources exactly. Financial data in Graphs 1 to 42 come directly from the Investment Model itself, while data in the Summary Sheet (which appears immediately before the graphs), the Summary Accounts tables, and Graphs 43 to 47 come from the Financial Accounts which are produced as an adjunct to the Investment Model. For 1990 itself, therefore, the data are not necessarily exactly the same; the start data used in the model may not correspond

2 For the EC, Graph 46 relates to the countries' TOs, while Graphs 45 and 47 provide a comparison between the TOs and the countries as a whole.

completely to the start data shown in the Financial Accounts. This is because it has not always been possible to calibrate the model exactly on 1990 data shown in the accounts, as explained in Annex A of this Report, Section A2.3.4.

From 1991 onwards, however, the two sources (Investment Model and Financial Accounts) contain the same data: revenue, expenditure and cash streams resulting from the Investment Model are shown in the Financial Accounts and impact on balances existing at the previous year end.

INSTALLED EQUIPMENT

Note that in the graphs of installed equipment (Graphs 17 to 23) only the most significant types of installed equipment are shown; in particular, equipment used by the less significant services (telex, for example) is not shown.

17: Local Access Connections

Graph 17 shows the number of local access connections made using different access technologies; it shows only the most significant types of local access connection. Demand for local access connections arises from the demand for network lines shown in Graph 4.

18: Local Switch Connections

Graph 18 shows the number of connections made to local switches of different types; it shows only the most significant types of local access connection. Demand for connections to local switches arises from the demand for network lines shown in Graph 4.

Graphs 19 to 23 show the installed capacity of the switching and transmission elements at the higher levels of the network hierarchy:

- Junction Transmission (Graph 19)
- Transit Switching (Graph 20)
- Transit Transmission (Graph 21)
- International Switching (Graph 22)
- International Transmission (Graph 23).

CAPITAL OUTLAY

24: Network Capital Outlay

Graph 24 shows total network capital outlay, analysed according to the particular function performed by the equipment in the network. In this graph, CPE includes the capitalised value of CPE Sales Expenditure. Note that 1990 figures for total Network Capital Outlay (after the deduction of CPE Sales Expenditure) are not necessarily the same as the figures for Capital Outlay in Graph 43. As indicated above (page 98), the 1990 figures on these two graphs are derived from different sources.

25: CPE Expenditure

Graph 25 shows CPE Expenditure, both Sales and Rental. This is expenditure by the TO and other equipment retailers on CPE for resale and rental to customers. Note that expenditure on CPE for resale is not capitalised, since the equipment is only owned by the retailer whilst in stock.

26: Local Access Capital Outlay

Graph 26 shows the capital expenditure on local access to the network (from Graph 24) split according to the type of access mode used. 'Local Access – Basic' includes expenditure on all types of fixed access link, but does not include any access termination costs which are bearer-service-specific, such as 'Customer Termination – ISDN'. Expenditure on 'Local Access – Mobile' includes the cost of mobile base stations, but not the handsets which are included under CPE.

27: Local Switching Capital Outlay

Graph 27 shows the capital expenditure on local switching (from Graph 24) split according to the type of switch used. 'Local Switching – Basic' includes all types of local switch used to provide connections to the basic telephony services – Business Telephony, Residential Telephony and Public Payphones.

28: International Transmission Capital Outlay

Graph 28 shows the capital expenditure on international transmission (from Graph 24) split according to the transmission mode used.

SERVICE REVENUE AND COST

29: Revenue and Charge per Connection (Basic Telephony Business)

Graph 29 shows revenue and charge per connection for the Business Telephony bearer service.

30: Revenue and Charge per Connection (Basic Telephony Residential)

Graph 30 shows revenue and charge per connection for the Residential Telephony bearer service.

31: Revenue and Charge per Connection (Mobiles)

Graph 31 shows revenue and charge per connection for the Mobiles service.

32: Revenue and Charge per Connection (Leased Lines)

Graph 32 shows revenue and charge per connection for both Narrowband and Broadband Leased Line services.

33: Revenue and Charge per Connection (ISDN)

Graph 33 shows revenue and charge per connection for the Basic- and Primary-Rate ISDN services.

34: Revenue and Charge per Connection (Broadband)

Graph 34 shows revenue and charge per connection for switched Broadband.

35: CPE Revenue and Costs

Graph 35 shows total revenue from CPE rental and sales together with the capital charge arising from CPE rental equipment and the overall operating charge (which includes both this capital charge and the cost to the retailer of CPE sales equipment).

Graphs 36 to 40 show total service revenues and costs, measures which are illustrated per connection in Graphs 29 to 34.

36: Telephony Revenue and Costs

Graph 36 shows total revenue and costs for Value-Added Services, in addition to the basic telephony services (Business Telephony, Residential Telephony and Public Payphones).

37: Leased Lines Revenue and Costs

Graph 37 shows total revenue and costs for the Narrowband and Broadband Leased Lines services.

38: ISDN Revenue and Costs

Graph 38 shows total revenue and costs for the Basic- and Primary-Rate ISDN services.

The final graphs in this category show the total revenue and costs for the Mobiles service (Graph 39) and switched Broadband (Graph 40).

TARIFFS

41: Total Variation of Service Revenues from Costs

Graph 41 shows the aggregate (over all services) of the absolute amount by which Service Revenues vary from costs. It gives an indication of the progress of tariff rebalancing.

42: Index of Revenue per Call Minute

Graph 42 expresses revenue per call minute for residential and business subscribers as indices, where 1990 = 100. The index for residential subscribers is simply based upon the Residential Telephony Service; that for business subscribers includes Business Telephony, Basic and Primary Rate ISDN and Broadband, with total revenue from these services being divided by total call minutes to calculate the index.

FINANCIAL

43: Network Costs and Revenues

Graph 43 is a stacked bar chart consisting of the following items:

- *(Network) Capital Outlay.* This is identical to Net Expenditure on Tangible Fixed Assets shown in the accounts tables. It does not include the capitalised value of CPE Sales Expenditure, which is shown in Graph 24. Note that it may not be possible to reconcile 1990 data on this Graph with those on Graph 24, since they are derived from different sources (see page 98 above).

- *Running Costs.*

- *Indirect Costs.* These do not include Exceptional Charges, which are single non-recurring charges, such as redundancy costs associated with a restructuring of the organisation.

- *Funds from Operations.* These are calculated after deducting any Exceptional Charges.

The sum of these items plus any Exceptional Charge, equals Revenue, which is shown as a line in Graph 43. The line indicating Revenue normally passes through the top of the stacked bar, except when:

- There is an Exceptional Charge, in which case the revenue line passes above the top of the stacked bar.

- Any of the items in the stacked bar has a negative value, in which case the negative item is shown at the bottom of the stacked bar, below the horizontal axis. The stacked bar then rises above the revenue line by an amount equal to the negative item (so that the 'net' value of the stacked bar equals Revenue).

44: Network Cash Flow and Cash Balance — Graph 44 shows network cash flow and cash balance.

45: Profit Margin: Comparison of TO and Country — Graph 45 compares the profit margin for the TOs with the profit margin for the EC countries as a whole.

46: Analysis of TO's Net Assets — Graph 46 provides an analysis of the TOs' net assets.

47: TO's Comparative Performance in 1990 and 2010 — Graph 47 provides a comparison of the TOs' performance (in terms of shares of Turnover, Investment and Retained Profit) in 1990 with their performance in 2010.

4.2 Expansionist Case Results

Installed Equipment

Exhibits EC.X.17 and EC.X.18

Under the Expansionist case the number of copper-based connections will be 240 million at its peak, falling to about 170 million at the end of the period. This contrasts with a steep rise in the number of Basic fibre connections after 1995; these will total more than 70% of the total number of copper-based connections at the end of the period (Exhibit EC.X.17). Analogue switches will gradually decline from 105 million connections at the start of the period, but will still total 20 million connections in 2000. The installed capacity of digital switches will grow rapidly to a peak of nearly 190 million connections in 2001, and after this time the number of ATM switches will increase by more than 15 million connections per year. Basic-Rate ISDN and Mobile connections will also grow, though more slowly, at about 5 million connections per year (Exhibit EC.X.18).

Exhibits EC.X.19 and EC.X.21

The amount of installed fibre capacity in the junction and transmission networks will grow very significantly, to reach 90 million Erlangs and 23 million Erlangs of traffic respectively in 2010 (Exhibits EC.X.19 and EC.X.21). Meanwhile, copper in the junction transmission network will decrease, and will have almost disappeared by 2000, while microwave will increase slowly, to a capacity of 10 million Erlangs of traffic in 2010 (Exhibit EC.X.19). The total capacity in the junction transmission network at the end of the period will be over seven times its 1990 value.

The dominance of digital switches in the transit network will grow slowly, reaching a peak capacity of 9 million Erlangs of traffic in 2001. After 2001, however, digital switches in the transit network will decline, as the installed base of broadband transit switches increases. Broadband transit switches will represent a total capacity of 49 million Erlangs of traffic in 2010, which will carry 90% of transit traffic (Exhibit EC.X.20). In international switching, broadband switches will grow much less quickly, to provide around 15% of the total capacity of just under 6 million Erlangs of traffic in 2010 (Exhibit EC.X.22). *Exhibits EC.X.20 and EC.X.22*

For international transmission the increase in installed capacity will be very significant, and capacity at the end of the period will be nearly 12 times its 1990 value. Initially the growth will be mostly in satellites, but growth will slow down after 1998, and international cable capacity will increase and overtake that of satellites in 2005. The installed capacity of international satellites will start to increase significantly again after 2007 (Exhibit EC.X.23). *Exhibit EC.X.23*

Capital Outlay

The total of network capital outlay will increase markedly between 1990 and 2010, from about ECU 33 billion p.a. to about ECU 175 billion p.a. (Exhibit EC.X.24). However, its composition will change very little over the period. Local access will grow slightly more than local switching or CPE. The most significant part of local access capital outlay will be Basic Local Access, which will be about ECU 37 billion p.a. in 2010 (Exhibit EC.X.26). However, ISDN customer termination will also grow significantly, to comprise more than 25% of annual total access capital outlay at the end of the period. *Exhibits EC.X.24 and EC.X.26*

The most notable aspect of the CPE expenditure graph is the change in the composition of expenditure between rental and sales. Terminal rentals comprised 70% of the CPE expenditure in 1990, but by 2010 will have fallen to about 30% of the total of ECU 48 billion, CPE rental expenditure having temporarily fallen in absolute terms during the 1990s (Exhibit EC.X.25). In local switching, ISDN will take up the majority of annual capital expenditure from 2002, but capital expenditure on mobiles local switching will also display growth, comprising over ECU 3 billion in 2010, as against ECU 1 billion in 1990 (Exhibit EC.X.27). *Exhibits EC.X.25 and EC.X.27*

The most irregular profile in capital outlay is for international transmission, where annual expenditure will rise to a peak of ECU 1.6 billion in 1995, but then decline to the year 2000. After this, there will be a steep annual increase in expenditure to ECU 9.4 billion p.a. in 2010. Throughout the whole of the period international cable expenditure will grow steadily. The breaks in trend will be caused by the variability of international satellite expenditure (Exhibit EC.X.28). *Exhibit EC.X.28*

Revenue and Charge per Connection

Substantial profitability in the business segment of the basic telephony connection type of nearly ECU 600 per connection in 1990 will be eroded increasingly after 1994 as revenue per connection falls, but from 2005 the rate of reduction will slow. Profitability will remain broadly constant at around ECU 100 per connection from 2007 to the end of the period (Exhibit EC.X.29). By contrast, the residential basic telephony service was much less profitable at ECU 60 per connection in 1990, but this will increase marginally as unit costs fall (after 1991) and revenues per connection rise gradually (until 2001). By 2010 profitability will be about ECU 90 per connection (Exhibit EC.X.30). *Exhibits EC.X.29 and EC.X.30*

The mobiles service began the period with a profit of ECU 550 per connection, but falling unit revenues will gradually reduce this to ECU 100 per connection by 2010. *Exhibit EC.X.31*

The revenue per connection for the leased-line service will rise steadily until 1997 (when it will reach ECU 2400), and it will then decline before rising again from 2005. The overall charge per connection will follow a similar but less marked trend, and profitability will reach a maximum of ECU 1100 per connection in 1996, before finishing the period at about ECU 500 per connection (Exhibit EC.X.32). ISDN profits per connection will be gradually reduced from ECU 1400 in 1990 to only ECU 400 in 2010 (Exhibit EC.X.33), while Broadband unit revenues and charges will follow a similar pattern as for mobiles – rapidly falling revenues per connection (with the exception of 1998), and unit charges falling less rapidly than this (Exhibit EC.X.34). *Exhibits EC.X.32 to EC.X.34*

Service Financial Performance

The CPE market will be characterised by losses in the early years, but then move into profitability in the latter half of the 1990s, after which profits will gradually increase, reaching ECU 19 billion in 2010, with revenues of over ECU 80 billion (Exhibit EC.X.35). As the purchase of CPE becomes more economical and popular, the capital charge will represent a decreasing proportion of the total operating charge, and will actually be in decline until 1998. *Exhibit EC.X.35*

In the telephony service revenues will continue on a healthy upward path throughout the period, although there will be a slight slow-down in the late 1990s as cost-orientation of tariffs takes effect. However, because the operating charge will increase more or less in line with revenues, profits will remain broadly constant, standing at about ECU 34 billion in 2010 (Exhibit EC.X.36). It should be noted that the capital charge will increase only slightly between 1990 and 2005, after which it will begin to decline. *Exhibit EC.X.36*

Revenue from leased lines (Exhibit EC.X.37), mobiles (Exhibit EC.X.39) and Broadband (Exhibit EC.X.40) will only make a small contribution to overall revenue, compared with services already discussed. The strongest performance will be from mobiles; revenue in 2010 (nearly ECU 16 billion) will be over eight times the value for 1990. This is in marked contrast to the revenue per connection figures for mobiles in Exhibit EC.X.31, and indicates that the mobiles market will grow very significantly throughout the period (in terms of volume). *Exhibits EC.X.31, EC.X.37, EC.X.39 and EC.X.40*

Overall Financial Trends

Service revenues will gradually move towards costs from 1994 onwards (Exhibit EC.X.41), but will still vary from costs by over 30% at the end of the period. While business telephony revenues per call minute will fall continuously and steeply, residential revenues per call minute will fall less quickly, and will be 42% of their 1990 level at the end of the period, compared with 21% for business telephony (Exhibit EC.X.42). *Exhibits EC.X.41 and EC.X.42*

Indicators of overall financial trends for the telecoms industry in the EC as a whole will be favourable. However, this masks a wide variation between the individual EC countries. Consideration of network costs and revenues (Exhibit EC.X.43) shows that while funds from operations were negative in 1990 and 1991, they will then be positive until the closing years of the period. Network cash flow will turn negative in 2008 due to the large scale of investment under the Expansionist case (Exhibit EC.X.44). The positive cash flow in the earlier years of the period will result in a gradually increasing cash balance (from ECU 8 billion in 1990 to ECU 89 billion in 2007). The TOs will have nearly 87% of this accumulated cash balance in 2007, and so the TOs will still perform well under the Expansionist case, despite the increase in liberalisation measures. *Exhibits EC.X.43, EC.X.44 and EC.X.46*

On the assumption that the whole of network cash flow will feed directly into the cash balance in the balance sheet, the resultant change in the structure of the balance sheets of the European TOs as a whole is illustrated in Exhibit EC.X.46. This shows that net current assets will represent -1% of total net assets in 2010 – an improvement compared to the position in 1990, when net current assets were -7%.

Exhibit EC.X.45 shows that in the short to medium term the TOs in the 12 EC countries will gradually increase their profit margins, reaching 16.4% in 1999. This is nearly double the value for 1990. However, profit margins will then dip as a large increase in network capital outlay feeds through into depreciation costs. By the end of the period, however, profit margins will still be close to 13%. After 2003, the profit rate of the TOs will fall slightly below that of the EC as a whole, as the new operators win a greater share of markets. *Exhibit EC.X.45*

Operations' Financial Performance

In 1990 the TOs were already facing competition, and had less than a 100% market share of turnover and investment (Exhibit EC.X.47). By 2010, however, the TOs' share of turnover will have fallen to less than 74%, but their share of investment will only have declined to 79%. More marked is the decline in the TOs' share of retained profit – 72% in 2010, compared to 92% in 1990. The large growth in markets in the Expansionist case will of itself encourage competitive entry into the most profitable areas, and so boost the competitors' share of profits. *Exhibit EC.X.47*

4.3 Minimum Case Results

Installed Equipment

At the peak in 1998, over 220 million connections will be copper-based in the Minimum case, fewer than in the Expansionist case. Between 1999 and 2010 there will be a reduction in copper-based connections of around 30%, to about 150 million. This decline will take place alongside the advancement of fibre into the local loop. By 2010 there will be about two-thirds as much installed fibre as copper, a smaller proportion than in the Expansionist case (Exhibit EC.M.17). The peak of digital switching will be reached in 2001 (at over 160 million connections), and by this time the number of ATM switches will be increasing rapidly, by about 10 million connections p.a. Basic-Rate ISDN and mobile switch connections will also grow significantly, by about 3 million connections and 2 million connections per year respectively (Exhibit EC.M.18), although this is less rapid growth than in the Expansionist case. *Exhibits EC.M.17 and EC.M.18*

Fibre-transmission capacity in the junction network will increase significantly throughout the period, with substantial increases after 2000. By 2010 the fibre capacity in the junction transmission network will be more than 50 million Erlangs of traffic, compared to a little over 5 million Erlangs at the start of the period, but the 2010 figure will still be only slightly more than half that for the Expansionist case (Exhibit EC.M.19).

Broadband transit switches will be introduced in 1996, and their installed capacity will grow rapidly to a capacity of over 25 million Erlangs by 2010, about 90% of total transit switch capacity (Exhibit EC.M.20). However, this total transit capacity is only slightly more than half that of the Expansionist case in the same year. *Exhibit EC.M.20*

Transit transmission will follow a similar profile to junction transmission, except that the growth of fibre will initially be rather slower in transit transmission. However, fibre will still grow from less than 2 million Erlangs of traffic in 1990 to 13 million Erlangs by the end of the period (Exhibit EC.M.21), although this is significantly lower than the corresponding figure in the Expansionist case. *Exhibits EC.M.19 to EC.M.21*

In the area of international traffic the switching capacity will increase gradually throughout the period, but after 2000 the capacity of basic switches will grow markedly, while broadband switches will begin to become important. Even so, the capacity of broadband switches will only be 500 000 Erlangs of traffic in 2010, less than one-sixth of the total capacity in that year (Exhibit EC.M.22). While the total international switching capacity will grow sevenfold during the period, the installed capacity of international transmission will grow by a factor of nine, though this is less of an increase than in the Expansionist case (Exhibit EC.M.23). *Exhibits EC.M.22 and EC.M.23*

Capital Outlay

The growth in total network capital outlay will be significant, the 2010 figure being nearly three times that for 1990 (Exhibit EC.M.24). However, this will only be about 50% of the Expansionist case figure. Unlike the Expansionist case, local access capital outlay will not increase steadily in the early years of the period; in fact it will be broadly static between 1995 and 2000 (Exhibit EC.M.26). Similarly, there will be no growth in local access capital outlay between 1995 and 2000 (Exhibit EC.M.26), while in the Expansionist case there will be a small increase. The result is that CPE expenditure (where growth continues) will assume a larger proportion of total network capital outlay at the end of the period than it will under the Expansionist case (Exhibit EC.M.25). *Exhibits EC.M.24 to EC.M.27*

In local access, annual expenditure on ISDN customer terminations will become important after 2000, but by 2010 it will only amount to about 30% of total local access capital outlay (Exhibit EC.M.26). In local switching the picture will be very different, with ISDN becoming the largest part of annual capital outlay on local switching by the end of the period (Exhibit EC.M.27).

Capital outlay on international transmission will follow a very similar pattern to that in the Expansionist case. This will lead to total outlay of ECU 4.7 billion in 2010, about 60% of which will be composed of expenditure on international satellites (Exhibit EC.M.28). *Exhibit EC.M.28*

Revenue and Charge per Connection

In the Minimum case, tariffs will be oriented to costs at a slightly faster pace than in the Expansionist case, and the process of readjustment will therefore slow down earlier (in 2004), as can be seen from the Basic Telephony Business graph (Exhibit EC.M.29). In the residential market there will be lower revenue per connection than in the Expansionist case after 1995; this will have an effect on profitability, which will be about ECU 70 per connection from 2000 onwards, as opposed to around ECU 100 in the Expansionist case during the same period (Exhibit EC.M.30). *Exhibits EC.M.29 and EC.M.30*

From the mid-1990s, revenue per connection for the mobiles service will be slightly lower than in the Expansionist case, and this will lead to slightly lower profitability to the end of the period.

Exhibit EC.M.31

Although the overall charges per connection for the leased-line and ISDN services will be very similar to the Expansionist case, the revenues per connection will be lower. The net result will be to reduce profit per connection slightly relative to the Expansionist case (Exhibits EC.M.32 and EC.M.33). Take-up of Broadband in the early years will be lower than in the Expansionist case, and so this will lead to revenue per connection between 1998 and 2004 being around ECU 500 lower than in the Expansionist case (Exhibit EC.M.34).

Exhibits EC.M.32 to EC.X.34

Service Financial Performance

CPE will take slightly longer to move into profit than in the Expansionist case. Profits will gradually increase, to reach ECU 10 billion in 2010 (Exhibit EC.M.35).

Exhibit EC.M.35

In the telephony service revenues will continue on an upward trend in the short term, but will then decline after 1996 as new services are introduced and tariffs fall. The total operating charge, however, will continue to rise until the early years of the 21st century. The end result is that revenue in 2010 (ECU 66 billion) will be slightly less than in 1990 (ECU 70 billion), while profits will be just ECU 15 billion, half of the 1990 figure (Exhibit EC.M.36). The poor performance of the telephony service compared to its performance in the Expansionist case is an important feature of the Minimum case results.

Exhibit EC.M.36

ISDN revenue will grow rapidly after the year 2000, and by 2010 will be as much as 70% of the telephony revenue. However, it should be noted that the capital charge for ISDN will be over twice that of the telephony service at the end of the period (ECU 25 billion compared to ECU 15 billion).

Exhibit EC.M.3[illegible]

The revenue from other services will be relatively insignificant compared to telephony and ISDN (Exhibits EC.M.37, EC.M.39 and EC.M.40). As in the Expansionist case the strongest performance will be from mobiles, and revenue will grow to reach nearly ECU 11 billion in 2010, over five times the 1990 value (Exhibit EC.M.39). However, revenues will be significantly lower than in the Expansionist case, where the mobiles service will expand considerably.

Exhibits EC.M.37, EC.M.39 and EC.M.40

Overall Financial Trends

The movement of tariffs toward costs will be much faster in the Minimum case than in the Expansionist case, and service revenues will vary from costs by only 27% in 2010, compared to 33% in the Expansionist case (Exhibit EC.M.41). The effect on revenues per call minute for the business market will be very similar to that in the Expansionist case, unlike the residential market. Residential revenues per call minute will fall by less than 15% between 1990 and 2010, compared with a reduction of nearly 60% in the Expansionist case (Exhibit EC.M.42). *Exhibits EC.M.41 and EC.M.42*

As in the Expansionist case funds from operations will generally be positive (Exhibit EC.M.43), but the positive network cash flow will persist almost to the end of the period in the Minimum case. It is only in 2010 that it will become negative (Exhibit EC.M.44), whereas cash flows in the Expansionist case turn negative in 2008. However, in the Minimum case the total network revenue and network capital outlay will be much lower than in the Expansionist case, especially after 2000. Total network turnover in the Minimum case for 2010 will be ECU 188 billion, compared to ECU 322 billion in the Expansionist case. Similarly, operating costs in 2010 will be ECU 152 billion in the Minimum case, but ECU 245 billion in the Expansionist case. *Exhibits EC.M.43, EC.M.44 and EC.M.46*

Exhibit EC.M.45 shows that in the short term the profit margin of the TOs in the 12 EC countries will increase sharply to 15%. Unlike the Expansionist case, however, this trend will be short-lived, and a decline in profit margins will be observed in the medium term when competitive forces and cost and tariff changes have an impact. Between 2004 and 2010, the profit margin will remain stable at just over 10%. Throughout this time the profit margins of the TOs and the total EC telecoms operations as a whole will remain very similar. Both the peak profit margin and the profit margin reached at the end of the period will be lower than in the Expansionist case. *Exhibit EC.M.45*

Operations' Financial Performance

In the Minimum case the TOs' share of retained profit and of turnover in 2010 will be higher than in the Expansionist case, but not significantly so. However, their share of investment in 2010 will be 83%, compared to 79% in the Expansionist case, where greater liberalisation will encourage new investment by competitors to the TOs. *Exhibit EC.M.47*

Analysys

EC Total
Summary Results

Expansionist Case

EC Total TO Company Accounts

MECU — Year	1990	1995	2000	2005	2010
			All figures real at 1990		
Turnover	84,948	109,149	133,277	167,118	236,944
Operating Costs	62,085	74,409	91,938	123,995	181,070
Operating Profit before Interest	22,863	34,740	41,340	43,122	55,874
Net Interest Paid	7,963	6,281	4,964	3,606	4,958
Profit on Ordinary Activities after Interest and Tax	7,161	16,424	21,613	23,718	30,642
Total Dividends	1,529	4,178	5,320	5,718	7,330
Retained Profit for the Financial Year	5,632	12,245	16,293	17,999	23,312
Fixed Assets	179,894	229,270	284,268	348,659	489,116
Items not Involving Cash Movement: Depreciation	21,107	24,913	31,967	45,762	72,603
Net Expenditure on Tangible Fixed Assets	31,289	35,368	43,198	60,801	111,610
Net Cash Outflow from Operations	(4,052)	3,428	5,964	5,704	(9,564)

EC Total Country Accounts

MECU — Year	1990	1995	2000	2005	2010
			All figures real at 1990		
Turnover	90,472	120,237	153,810	206,176	321,729
Operating Costs	66,640	83,027	107,055	153,077	244,570
Operating Profit before Interest	23,832	37,210	46,755	53,100	77,158
Net Interest Paid	7,994	6,651	5,336	3,571	5,078
Profit on Ordinary Activities after Interest and Tax	7,970	17,867	24,581	29,491	42,768
Total Dividends	1,840	4,630	6,114	7,155	10,297
Retained Profit for the Financial Year	6,130	13,237	18,467	22,336	32,471
Fixed Assets	180,327	235,493	297,044	375,989	565,345
Items not Involving Cash Movement: Depreciation	22,456	27,273	35,629	51,979	86,469
Net Expenditure on Tangible Fixed Assets	33,071	39,511	48,121	71,133	141,996
Net Cash Outflow from Operations	(3,546)	3,255	7,466	6,981	(13,604)

EC Total TO Financial Ratios

Year	1990	1995	2000	2005	2010
Interest Cover	5.5	9.5	14.8	24.6	25.9
Net Profit Margin	8.4%	15.0%	16.2%	14.2%	12.9%
Return on Total Assets	3.5%	6.1%	6.1%	5.2%	5.1%
Investment in relation to Turnover	37%	32%	32%	36%	47%

EC Total Telecoms Markets

Year	1990	1995	2000	2005	2010
Connections (Thousands):					
Basic Telephony - Residential	105,389	125,224	142,327	154,126	159,433
Basic Telephony - Business	35,689	49,475	66,043	80,694	81,535
ISDN - Basic Rate	17	711	3,731	11,897	31,476
ISDN - Primary Rate	2	103	629	2,301	6,663
Broadband - Switched	0	0	81	502	2,119
Mobiles	1,862	5,200	11,513	24,649	42,438
Narrowband Leased Lines	1,586	1,974	2,407	2,537	2,287
Broadband Leased Lines	21	70	141	257	451
Originating Traffic (Millions of Busy Hour Erlangs):					
Telephony	6.91	9.67	14.86	21.97	26.05
ISDN	0.01	0.57	4.00	16.72	53.76
Broadband - Switched	0	0	0.48	3.43	16.20
Mobiles	0.04	0.12	0.36	1.26	2.73
Total	6.96	10.36	19.70	43.38	98.73

*** is a value of no significance

EC Total Expansionist Case

EXHIBIT EC.X.1: Total Network Traffic

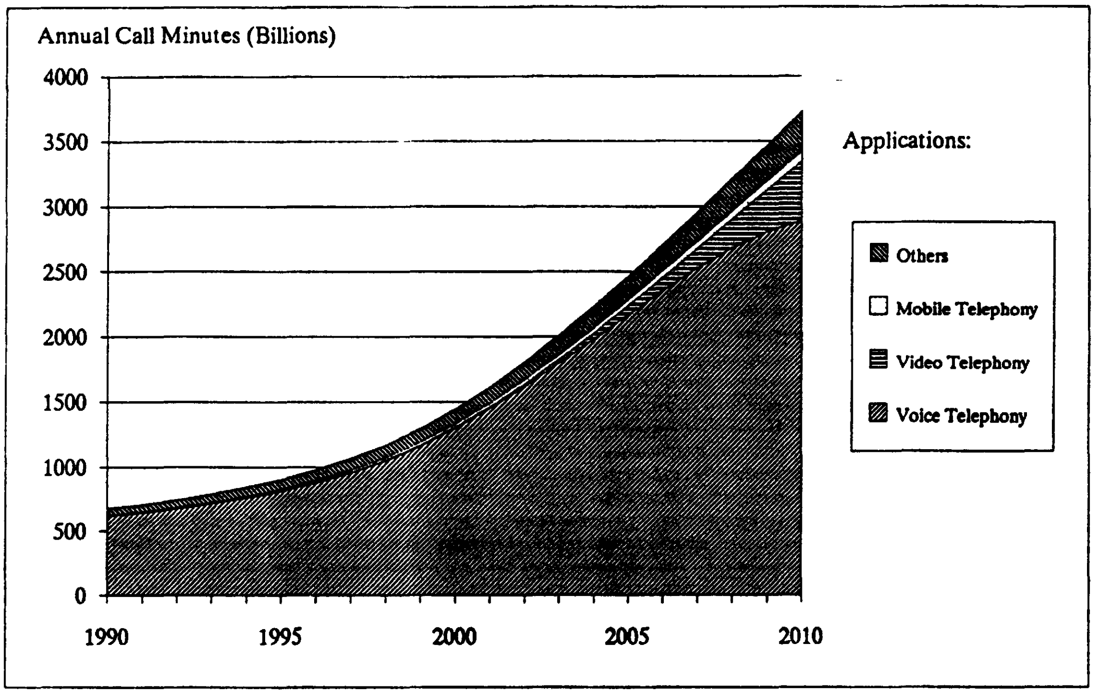
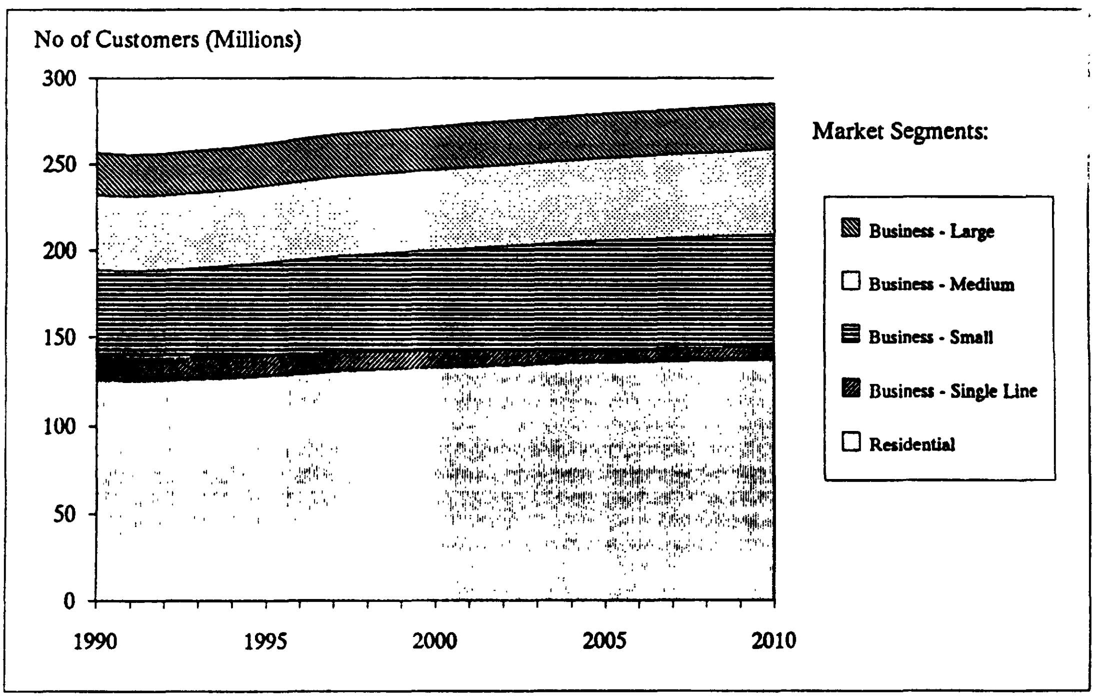


EXHIBIT EC.X.2: Customer Base



EC Total Expansionist Case

EXHIBIT EC.X.3: Network Busy Hour Traffic

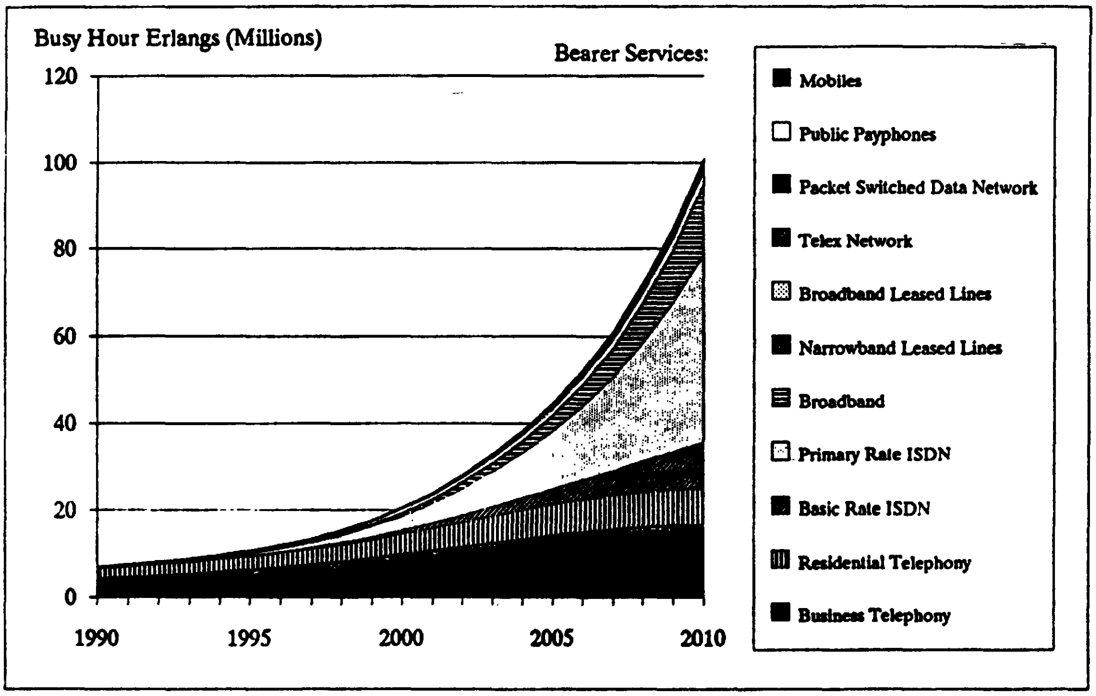
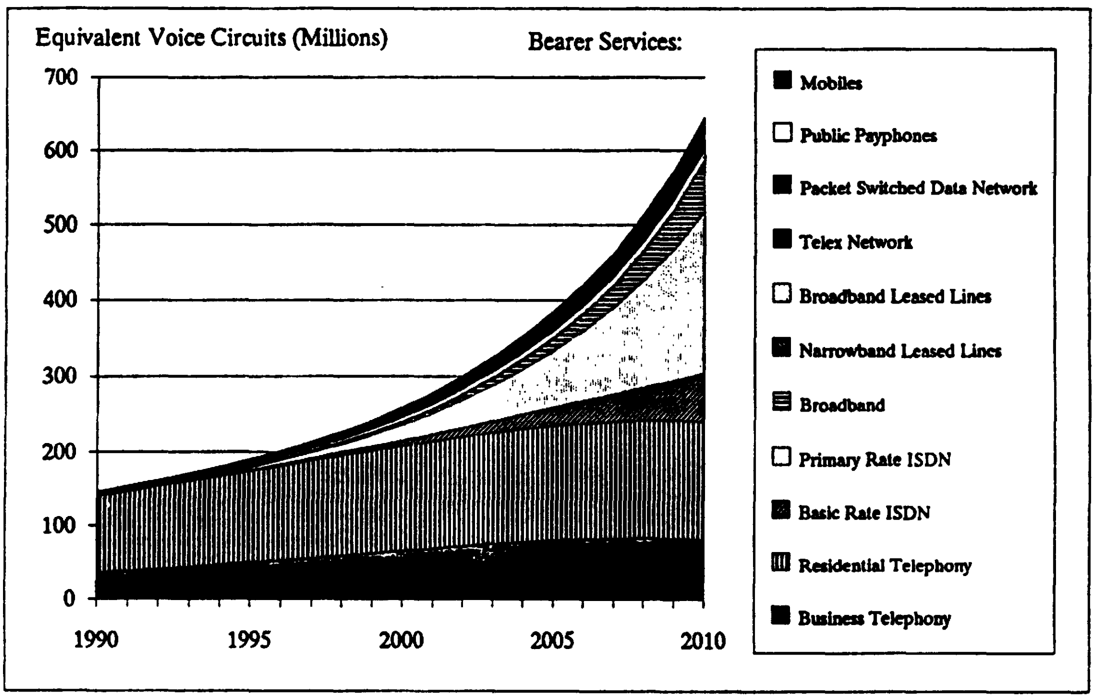


EXHIBIT EC.X.4: Network Lines



EC Total Expansionist Case

EXHIBIT EC.X.5: Network Connections (1)

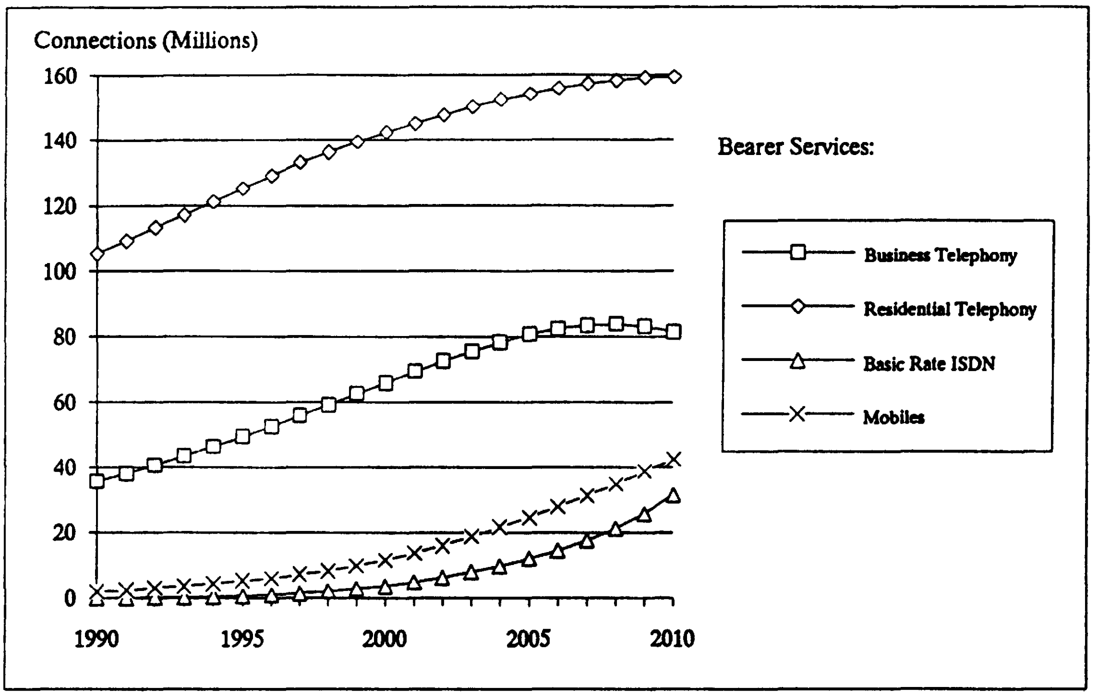
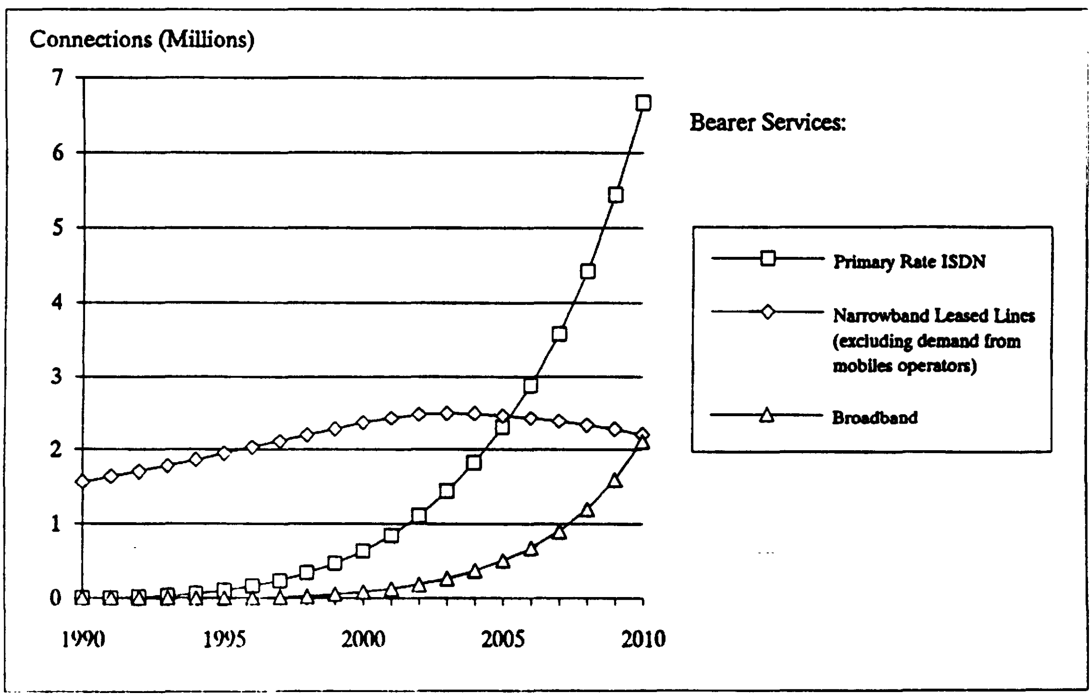


EXHIBIT EC.X.6: Network Connections (2)



EC Total Expansionist Case

EXHIBIT EC.X.7: Network Connections (3)

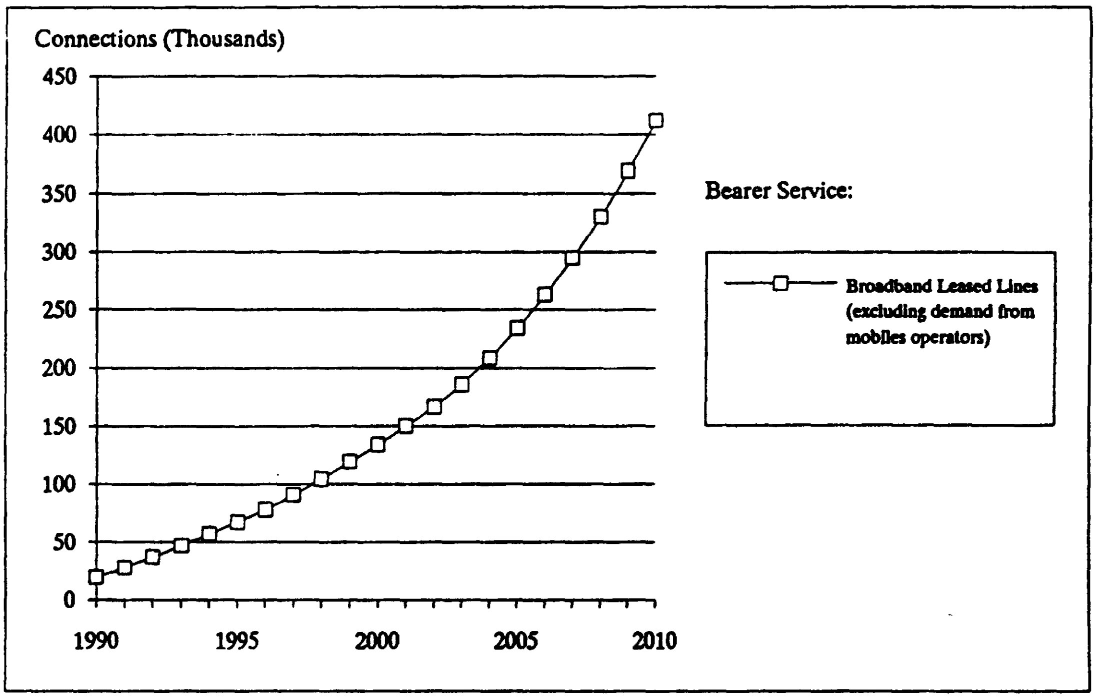
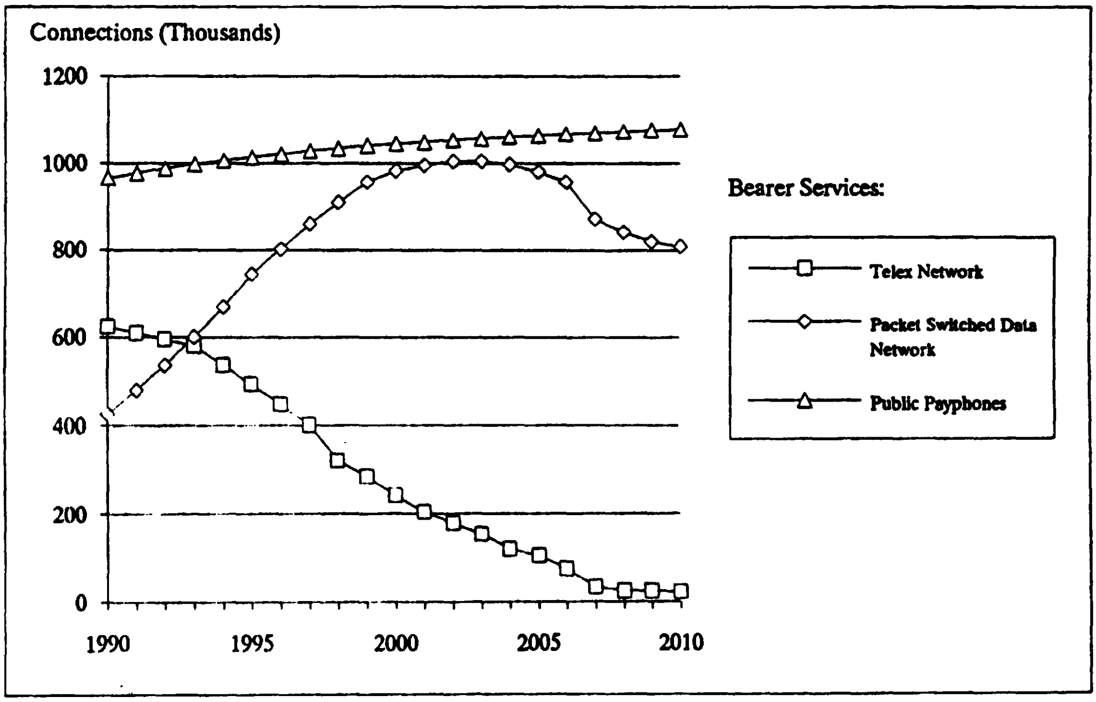


EXHIBIT EC.X.8: Network Connections (4)



EC Total Expansionist Case

EXHIBIT EC.X.9: Network Busy Hour Traffic per Business Line for Public Switched Services

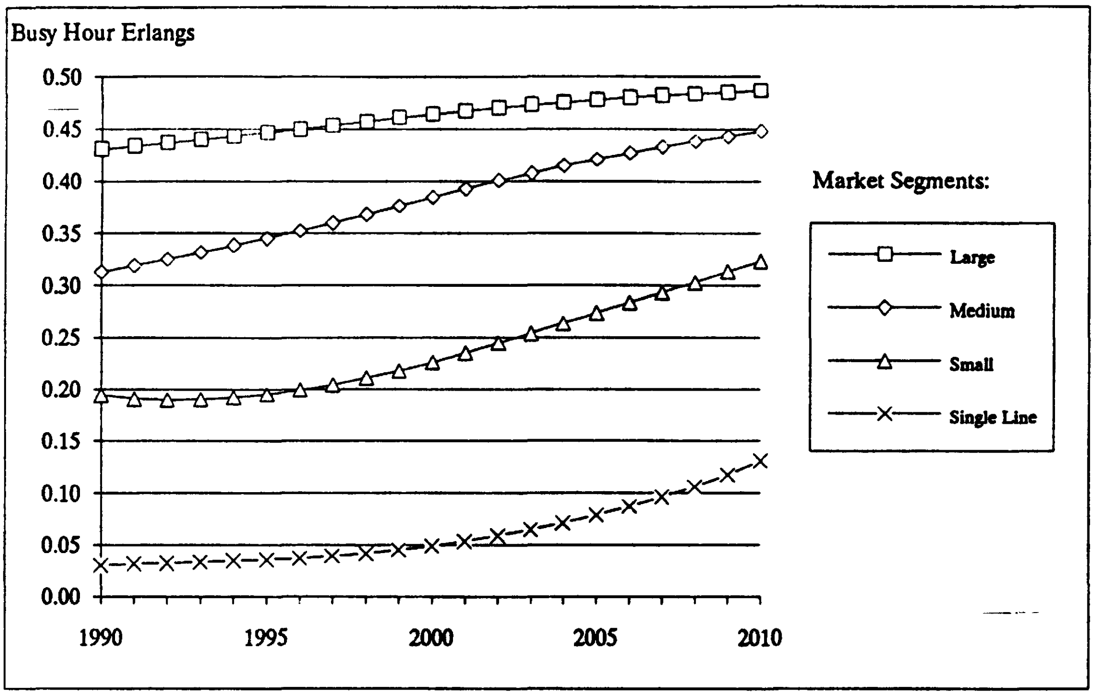
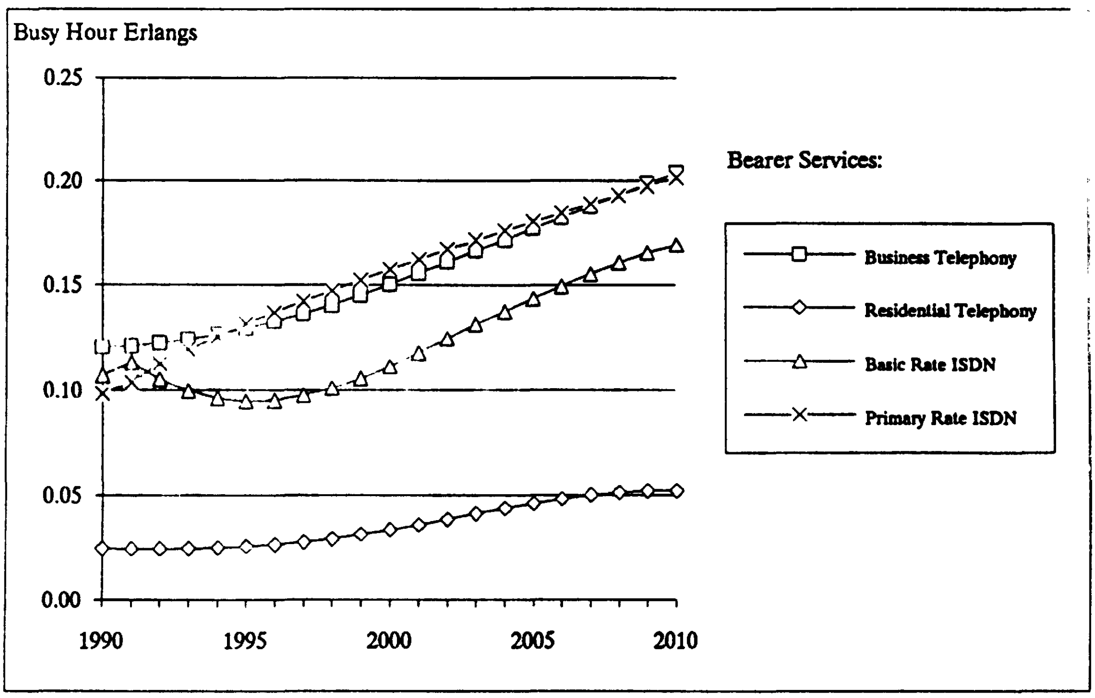


EXHIBIT EC.X.10: Network Busy Hour Traffic per Line for Basic Telephony and ISDN



EC Total Expansionist Case

EXHIBIT EC.X.11: Network Busy Hour Traffic per Line for Mobiles

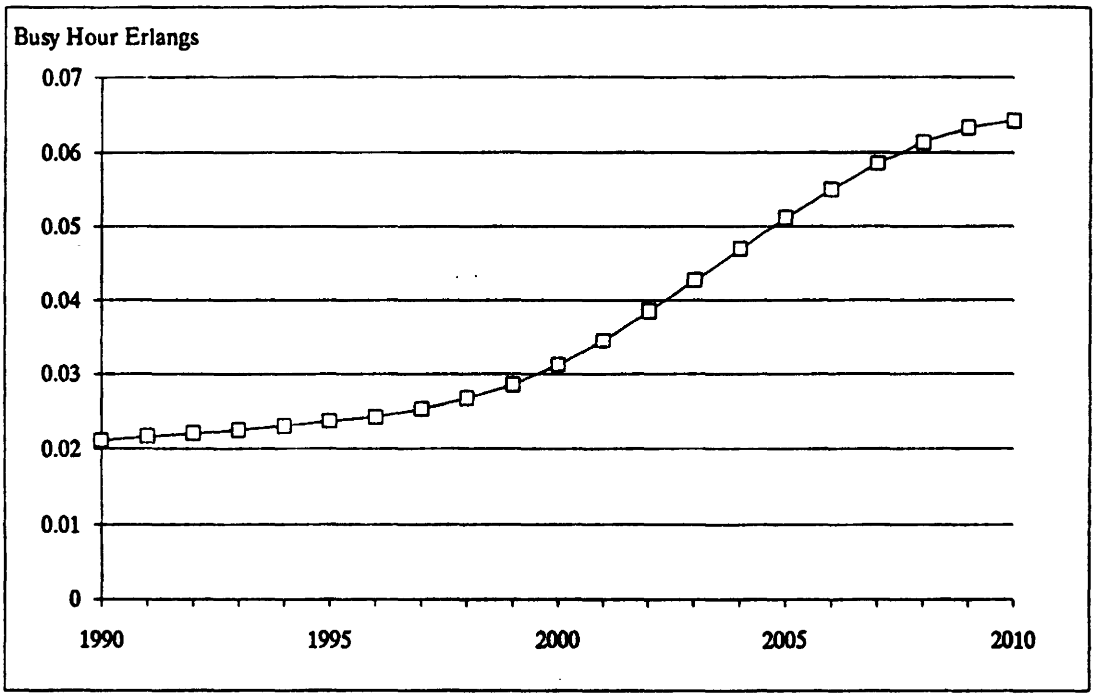
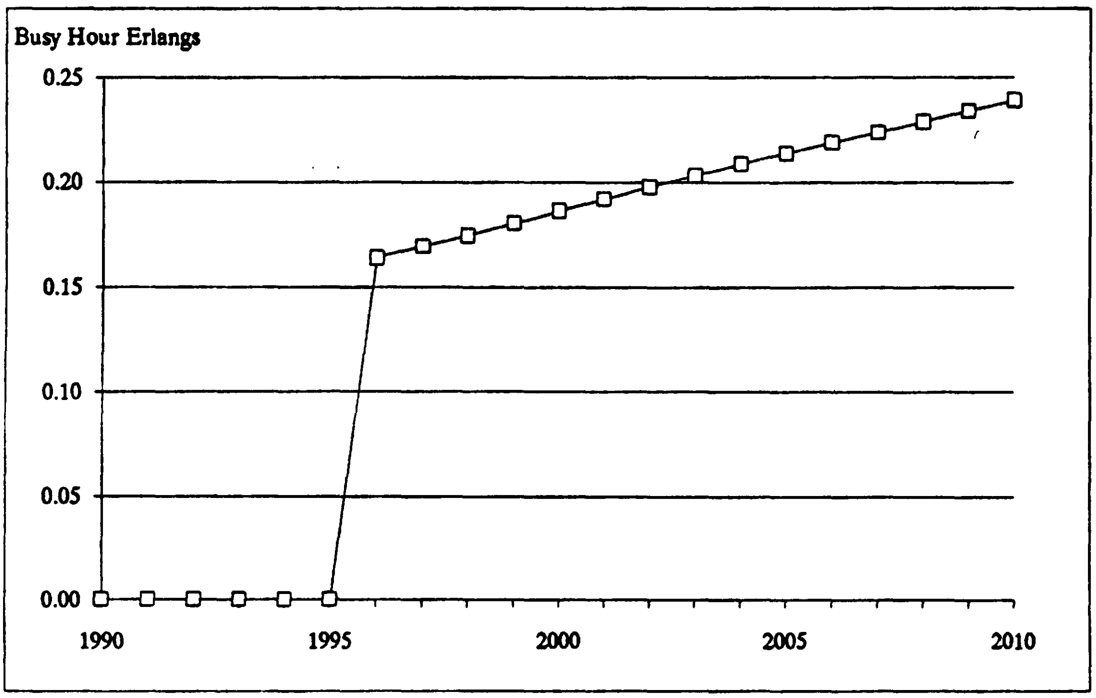
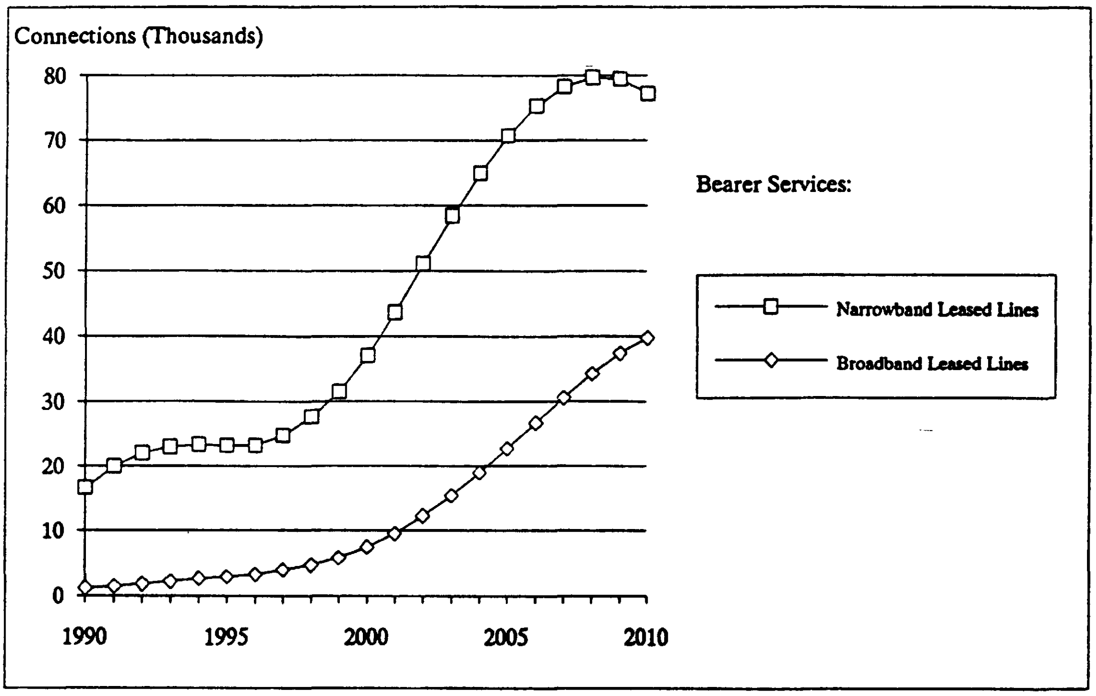


EXHIBIT EC.X.12: Network Busy Hour Traffic per Line for Broadband



EC Total Expansionist Case

EXHIBIT EC.X.16: Network Connections, Demand from Mobiles Operators



EC Total Expansionist Case

EXHIBIT EC.X.17: Local Access Connections

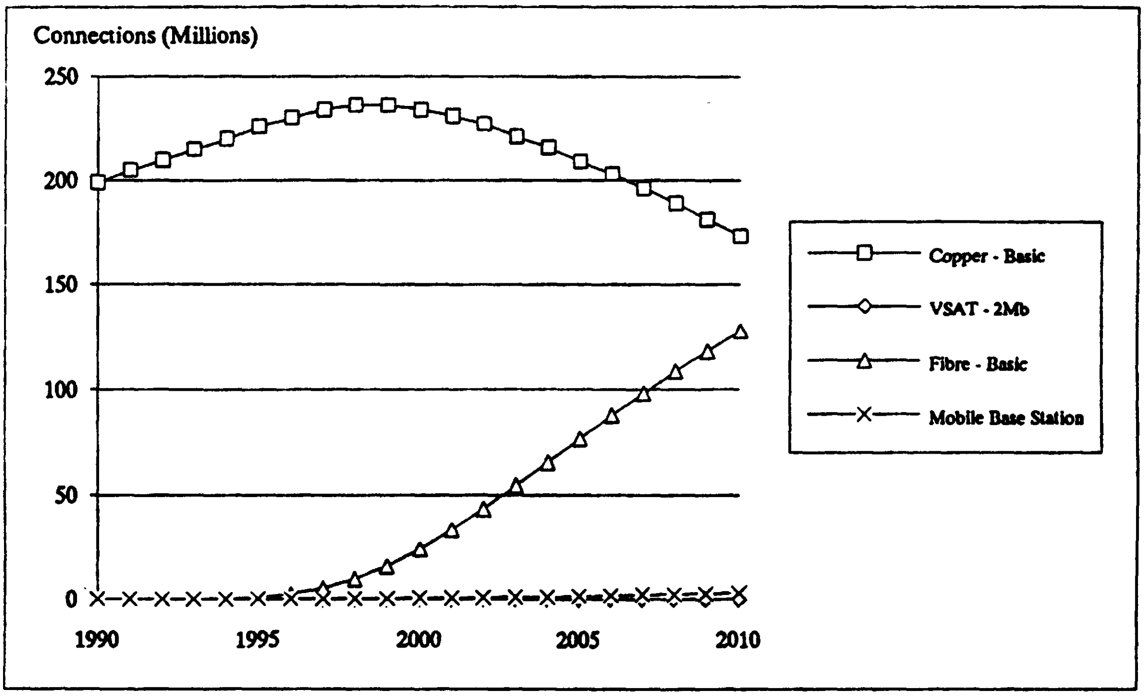
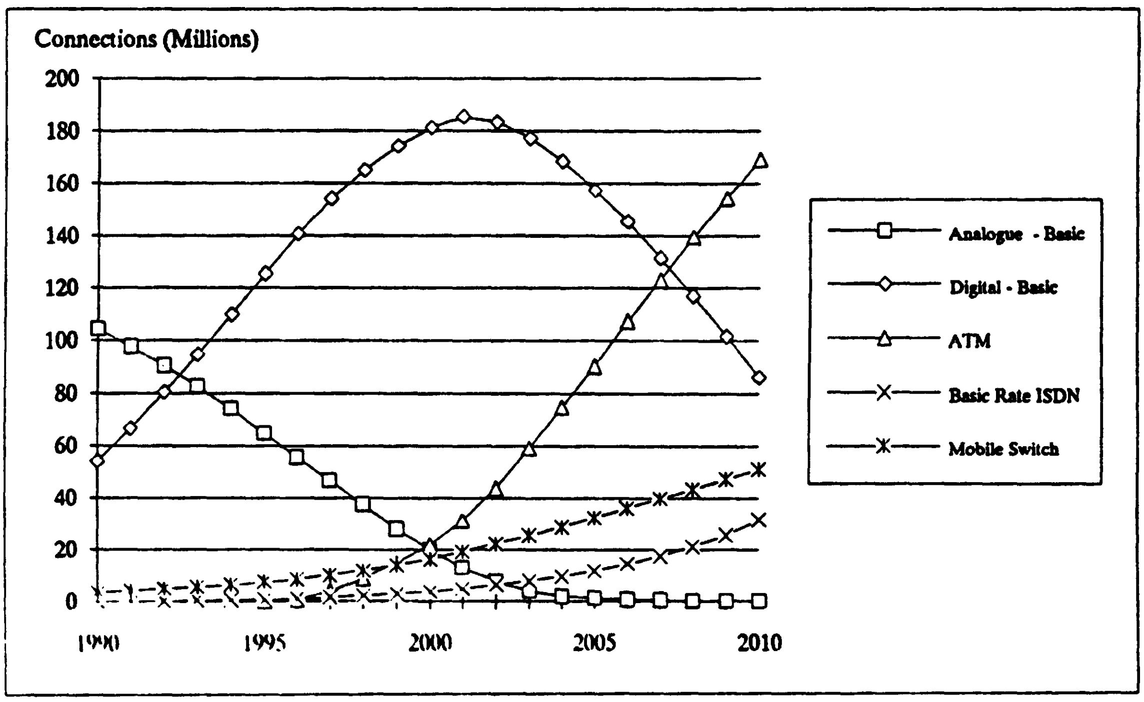


EXHIBIT EC.X.18: Local Switch Connections



EC Total Expansionist Case

EXHIBIT EC.X.19: Junction Transmission Installed Capacity

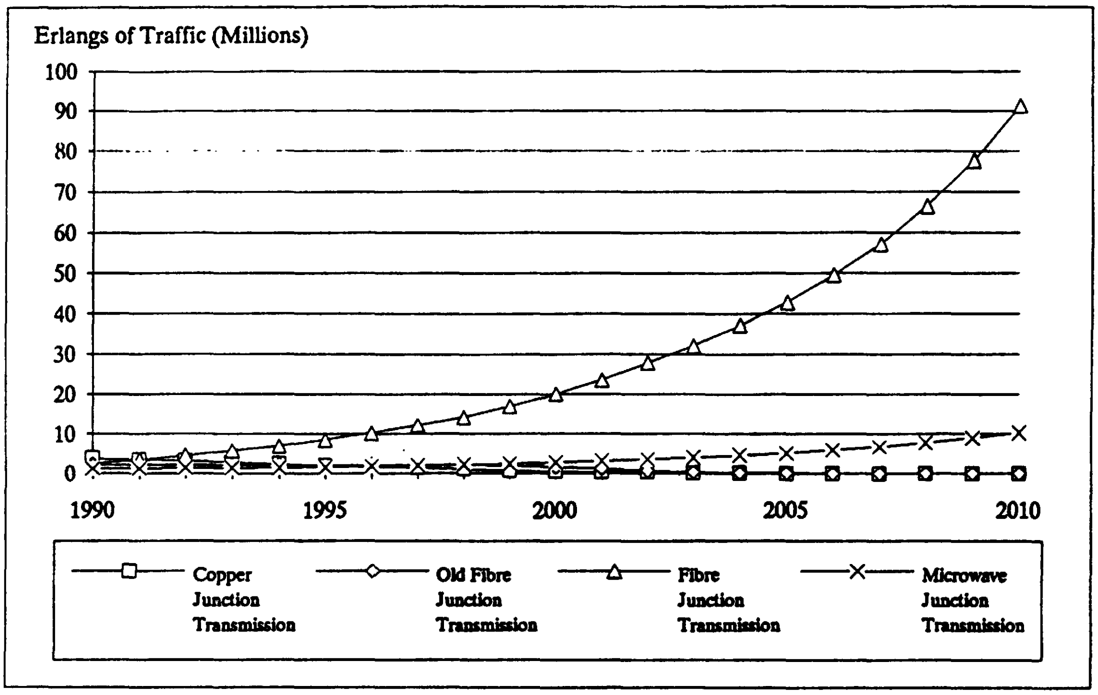
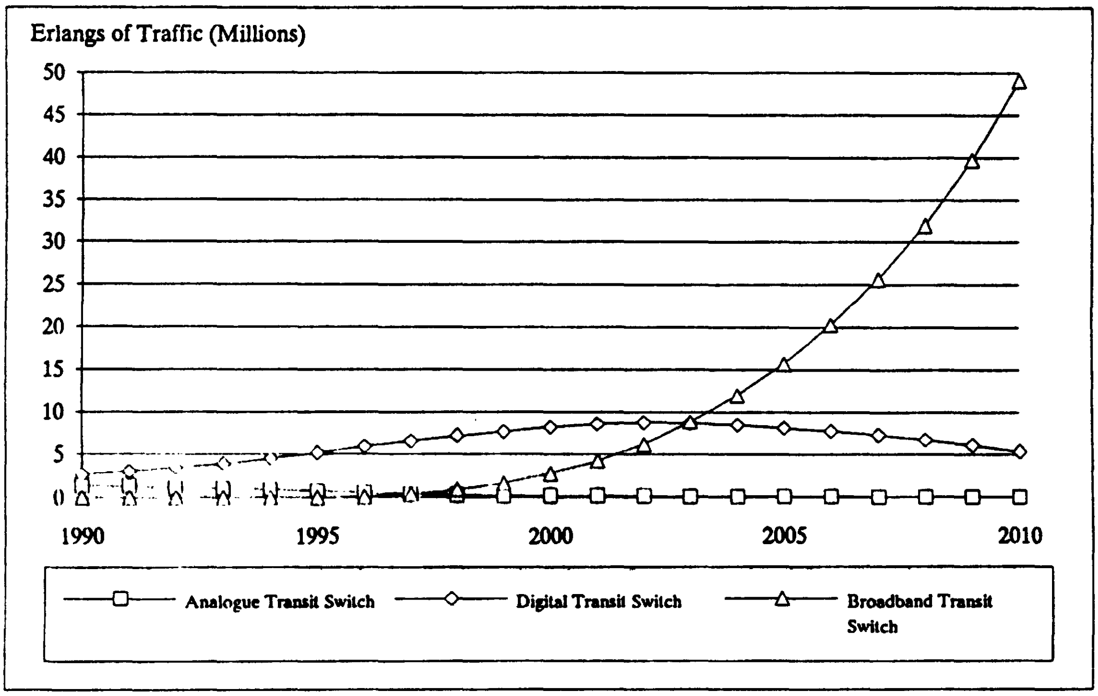


EXHIBIT EC.X.20: Transit Switch Installed Capacity



EC Total Expansionist Case

EXHIBIT EC.X.21: Transit Transmission Installed Capacity

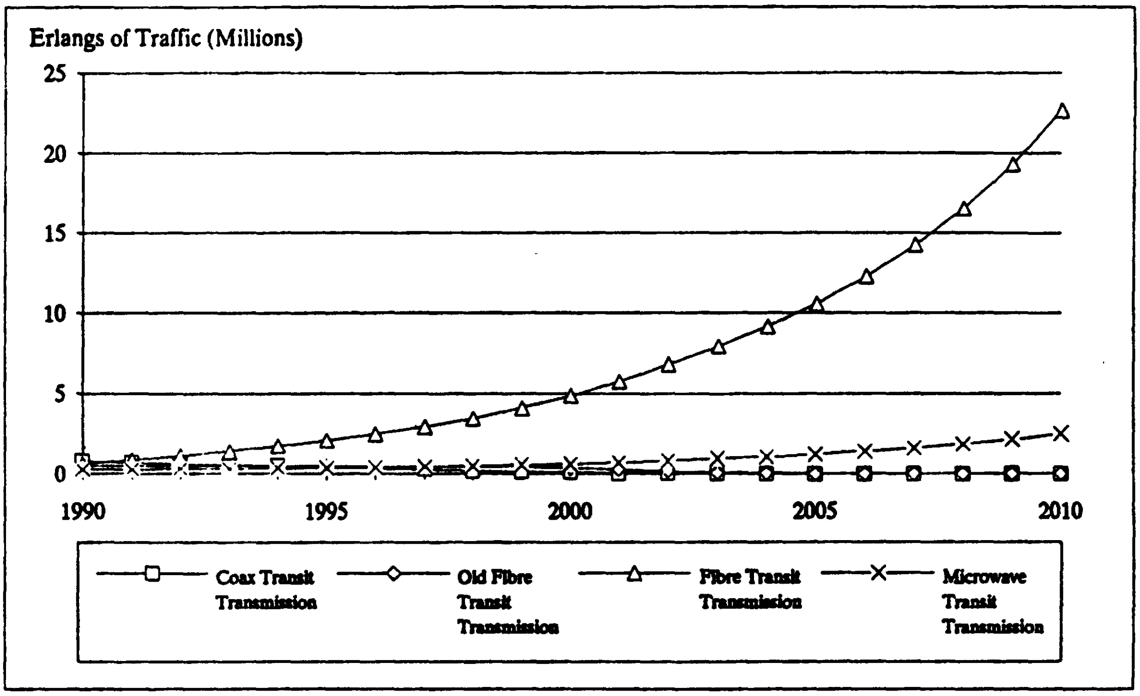
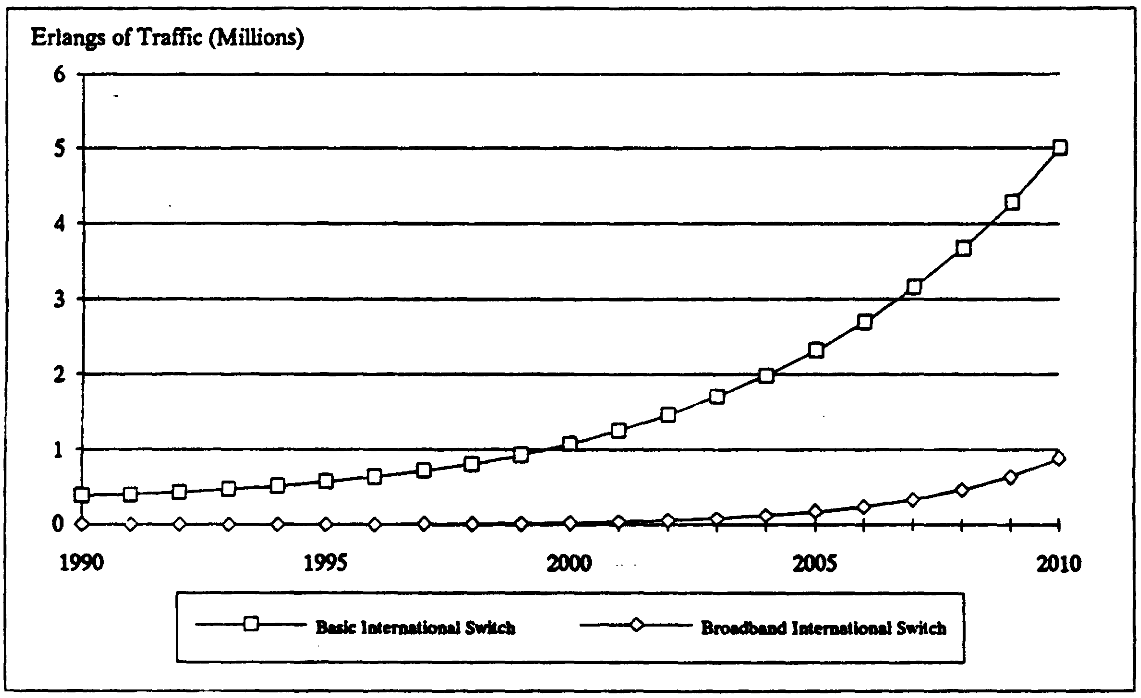


EXHIBIT EC.X.22: International Switch Installed Capacity



EC Total Expansionist Case

EXHIBIT EC.X.23: International Transmission Installed Capacity

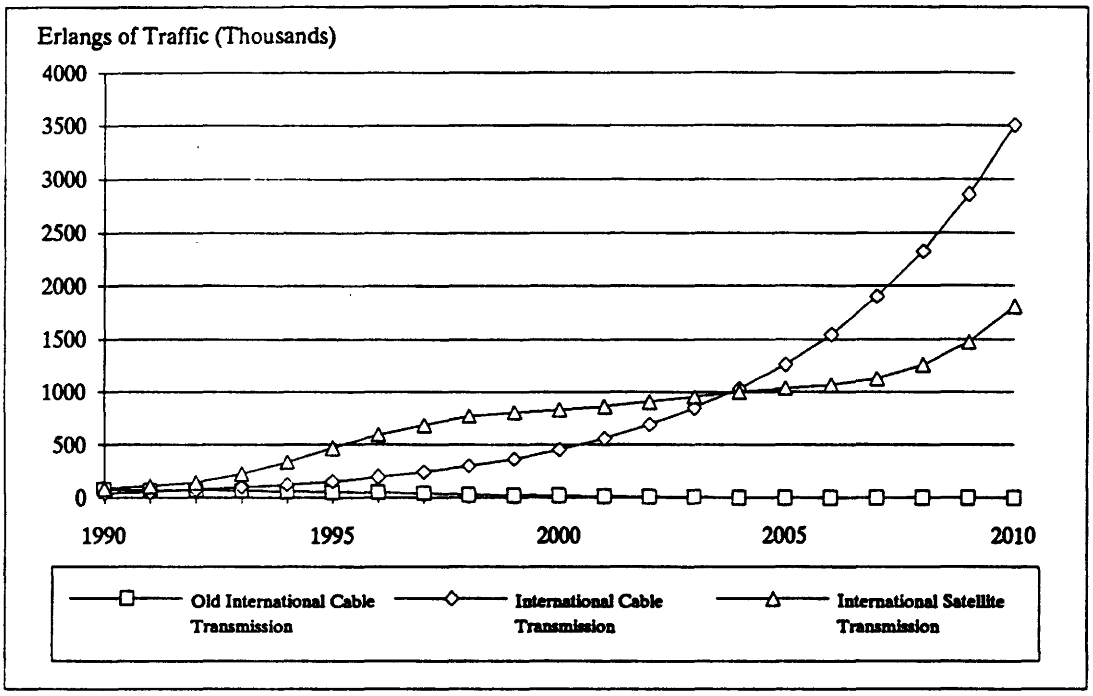
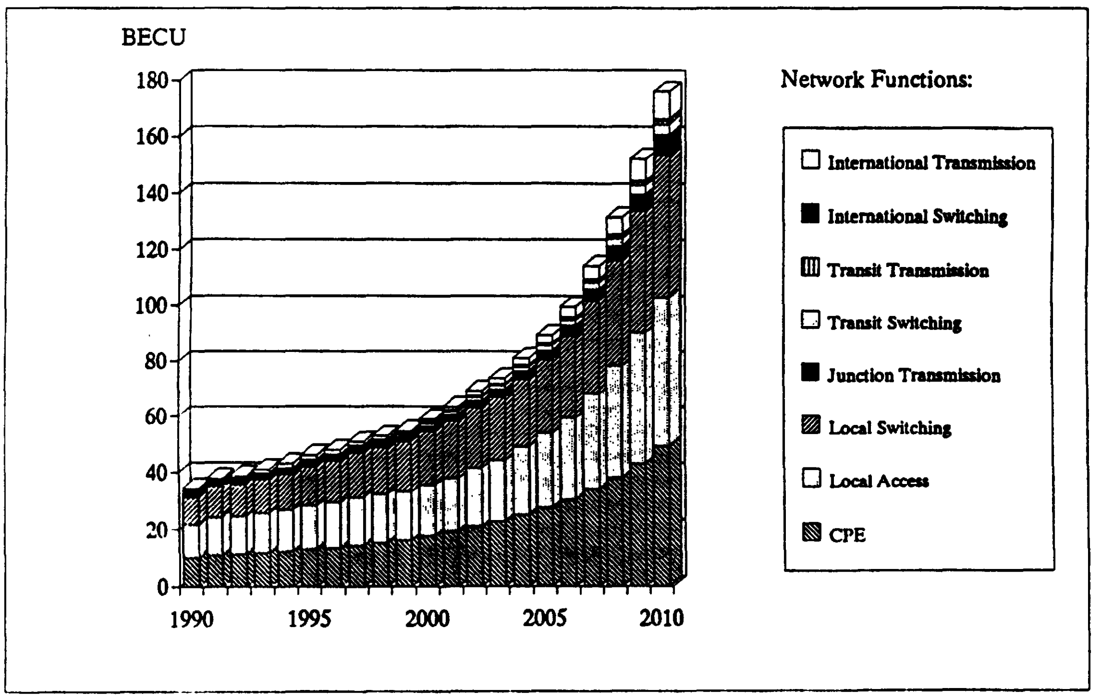


EXHIBIT EC.X.24: Network Capital Outlay



EC Total Expansionist Case

EXHIBIT EC.X.25: CPE Expenditure

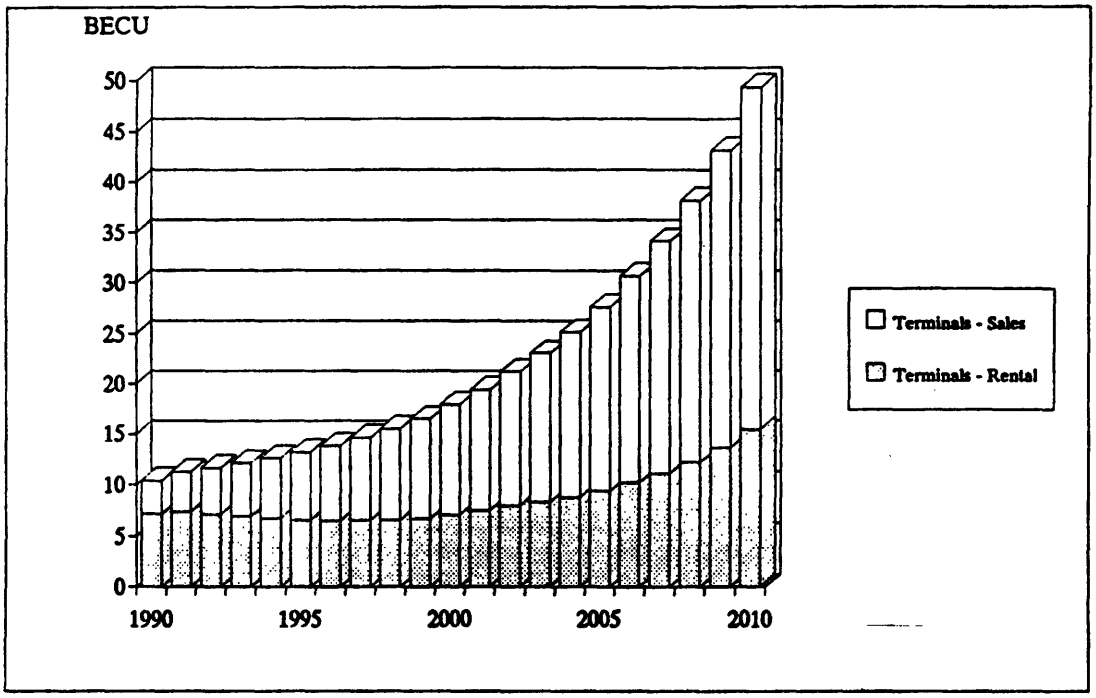
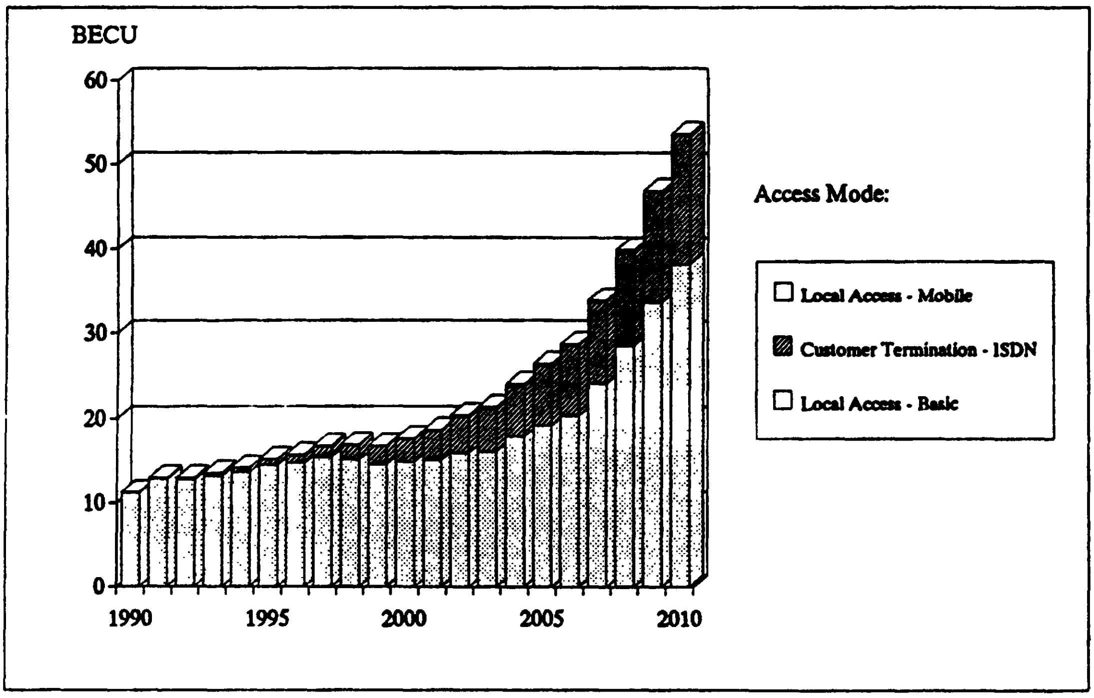


EXHIBIT EC.X.26: Local Access Capital Outlay



EC Total Expansionist Case

EXHIBIT EC.X.27: Local Switching Capital Outlay

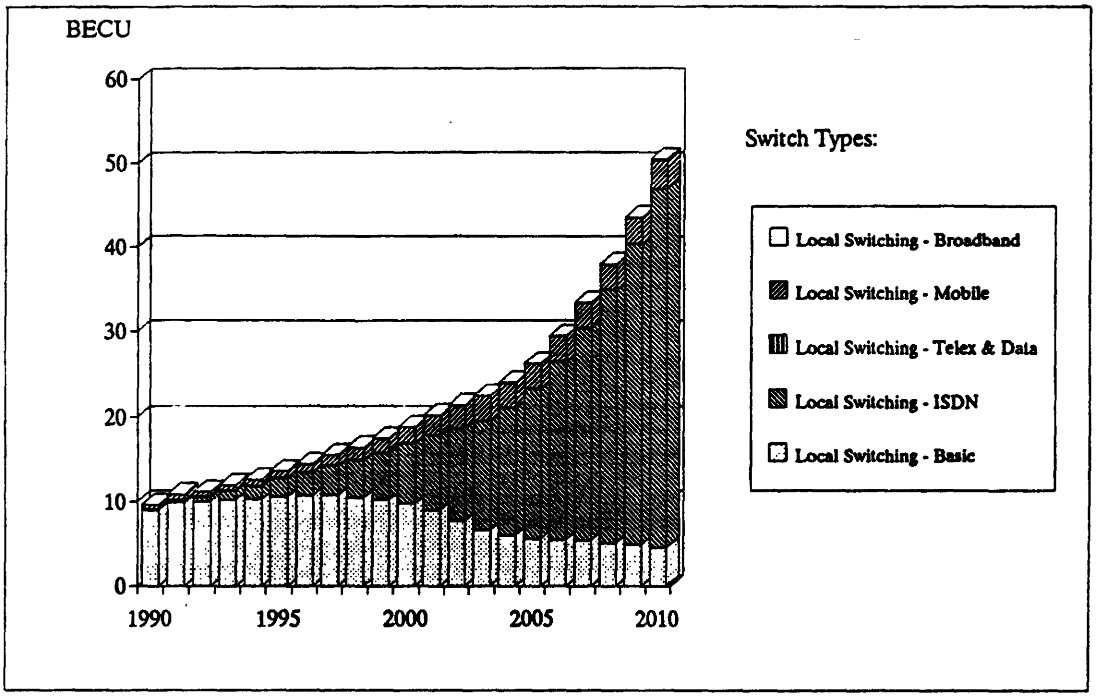
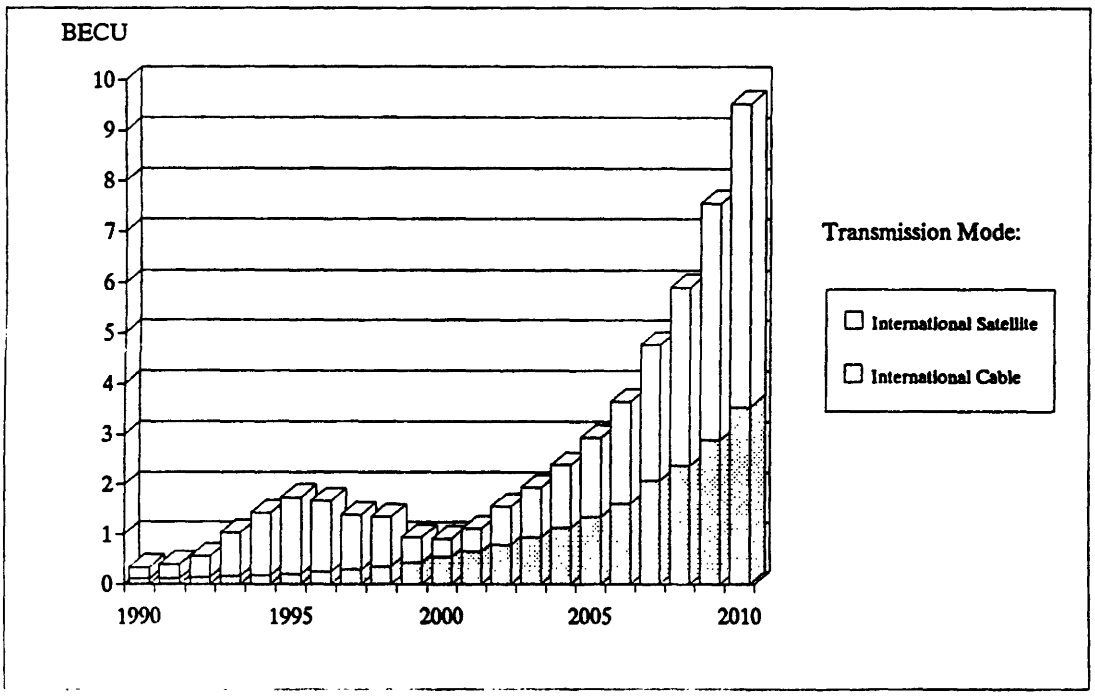


EXHIBIT EC.X.28: International Transmission Capital Outlay



EC Total Expansionist Case

EXHIBIT EC.X.29: Revenue and Charge per Connection: Basic Telephony Business

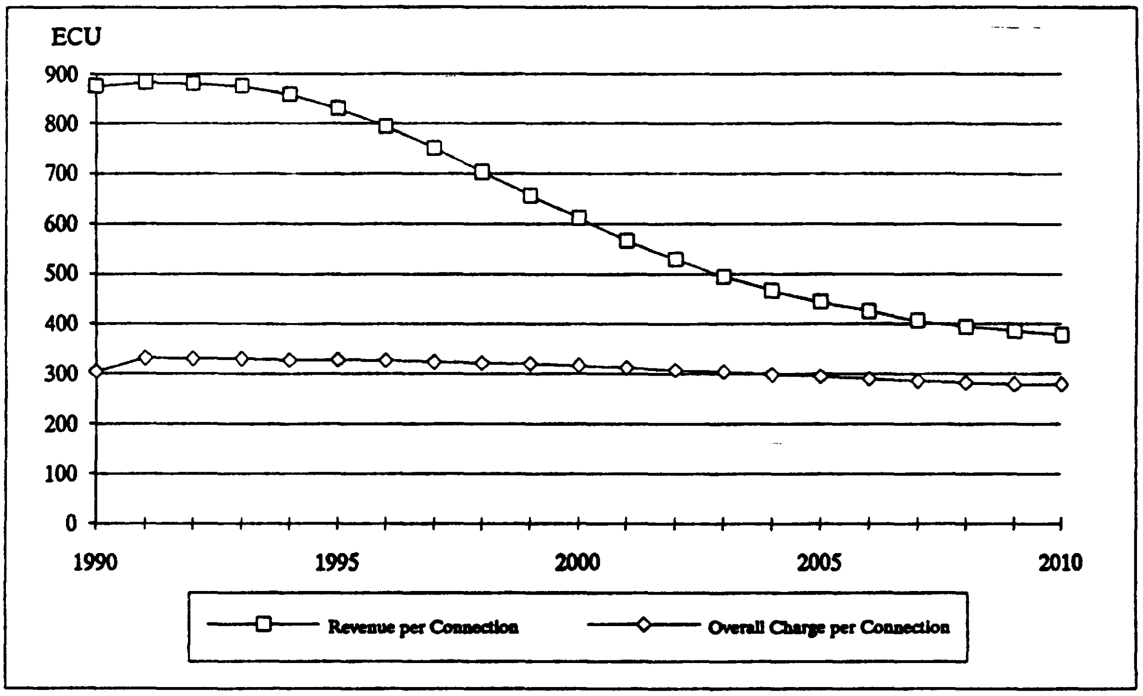
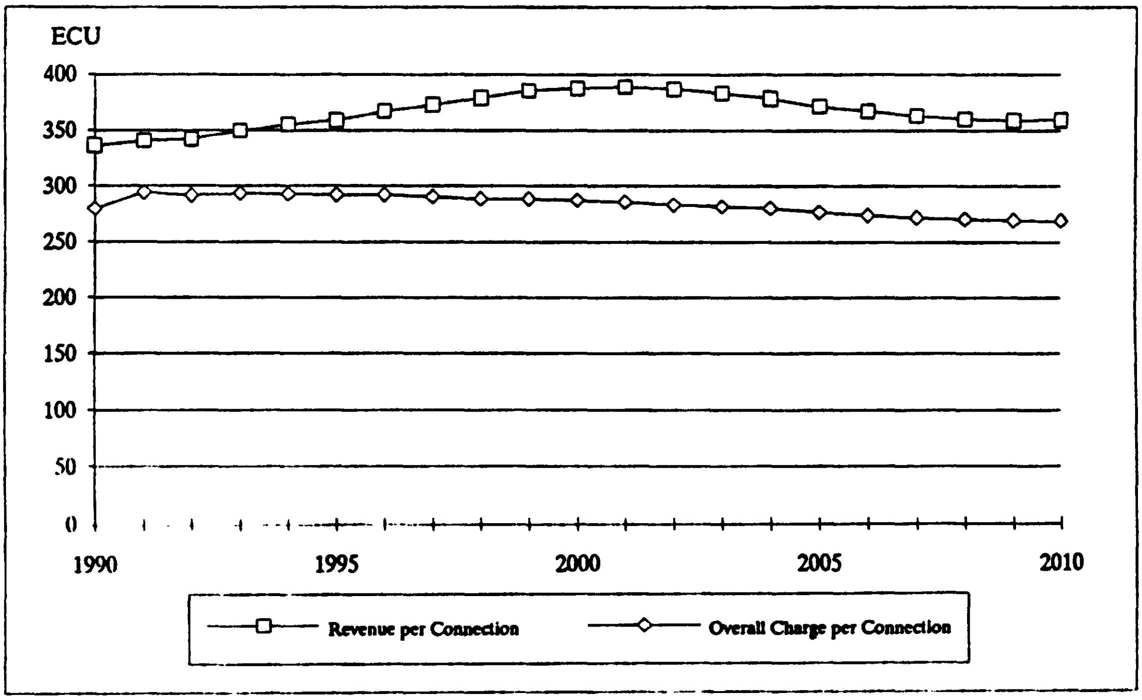


EXHIBIT EC.X.30: Revenue and Charge per Connection: Basic Telephony Residential



EC Total Expansionist Case

EXHIBIT EC.X.31: Revenue and Charge per Connection: Mobiles

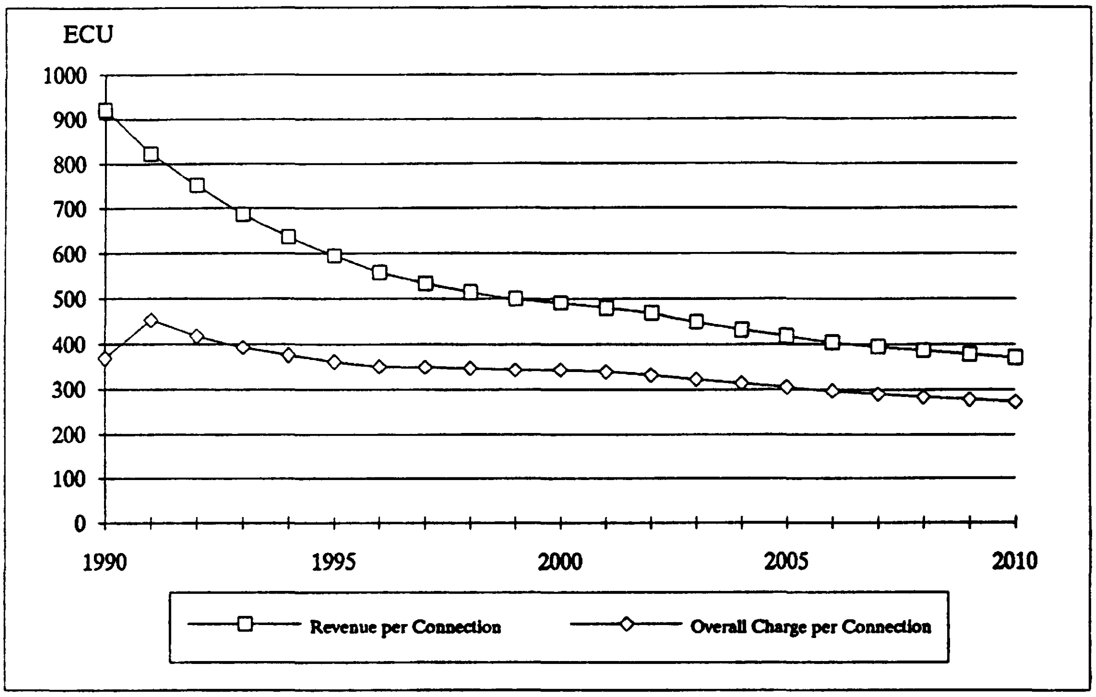
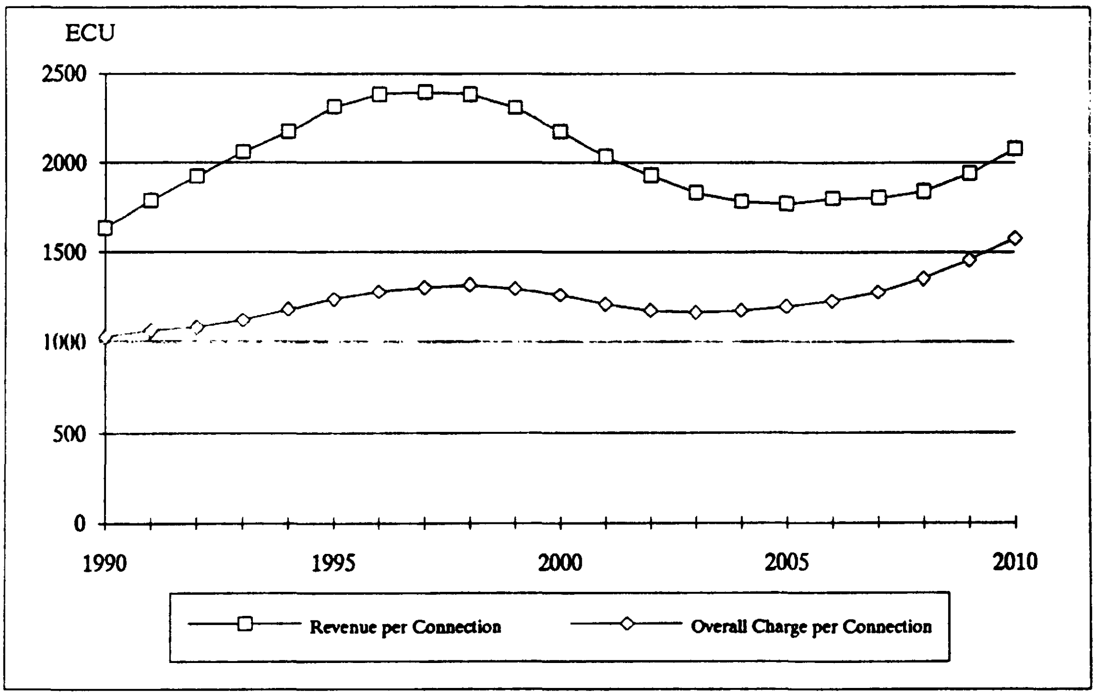


EXHIBIT EC.X.32: Revenue and Charge per Connection: Leased Lines



EC Total Expansionist Case

EXHIBIT EC.X.33: Revenue and Charge per Connection: ISDN

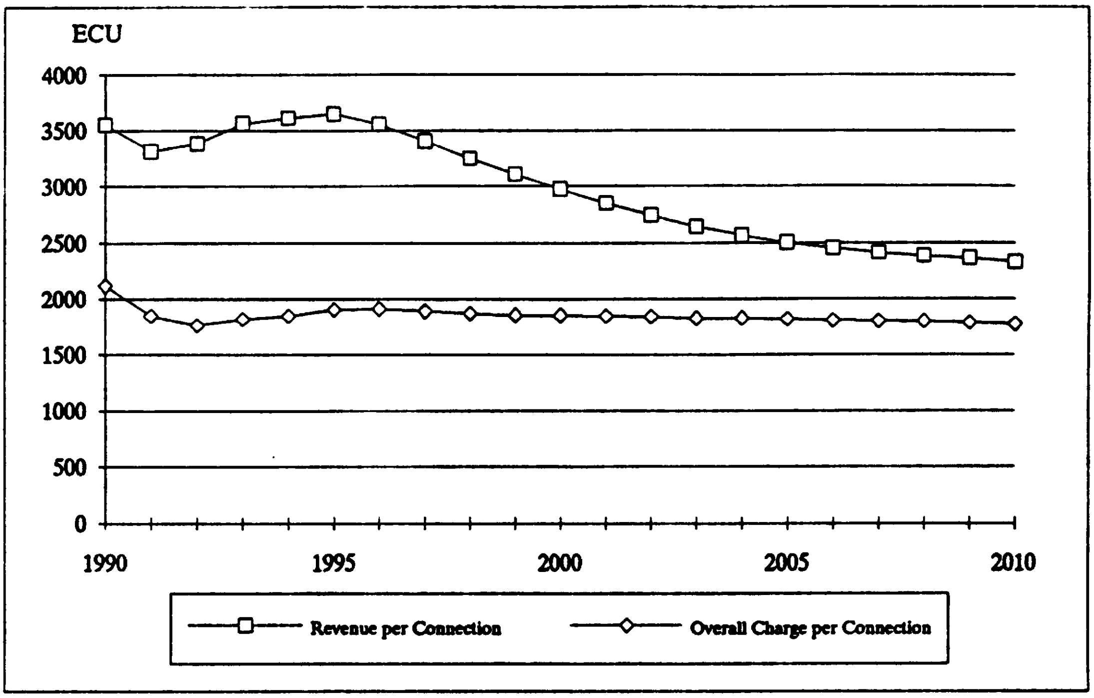
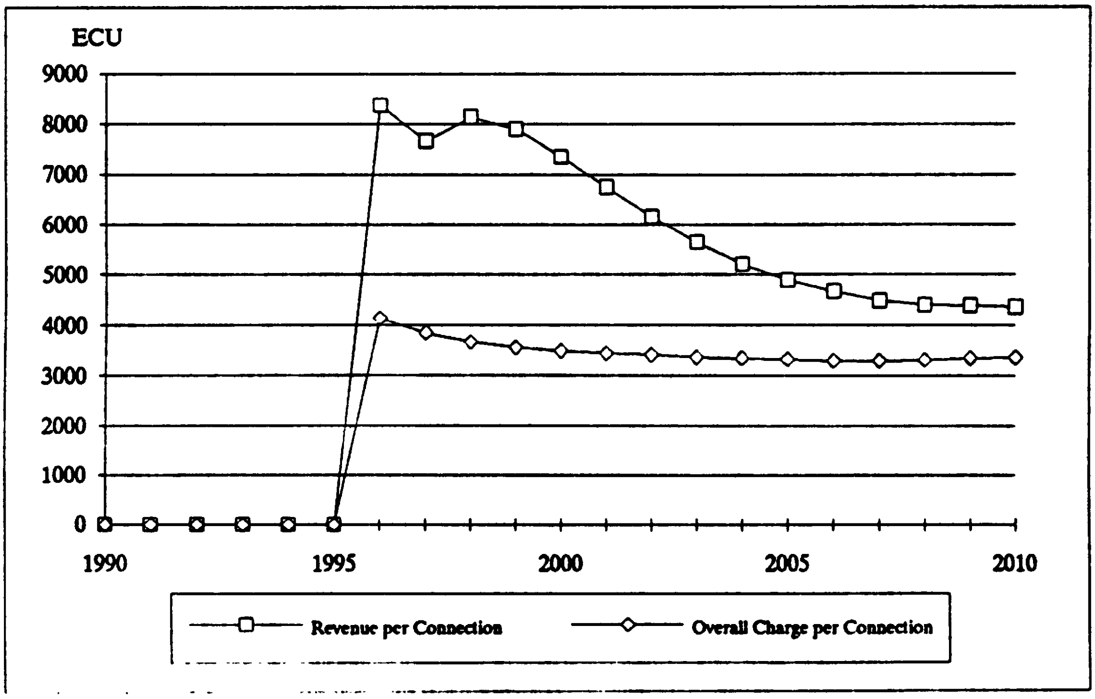


EXHIBIT EC.X.34: Revenue and Charge per Connection: Broadband



EC Total Expansionist Case

EXHIBIT EC.X.35: CPE Revenue & Costs

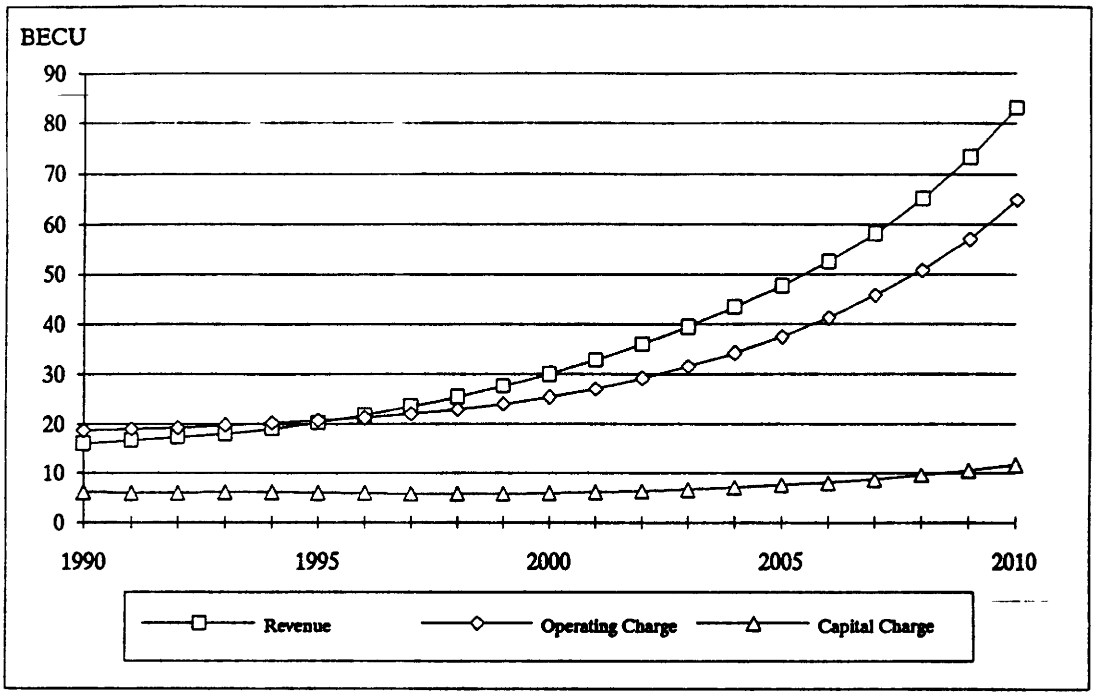
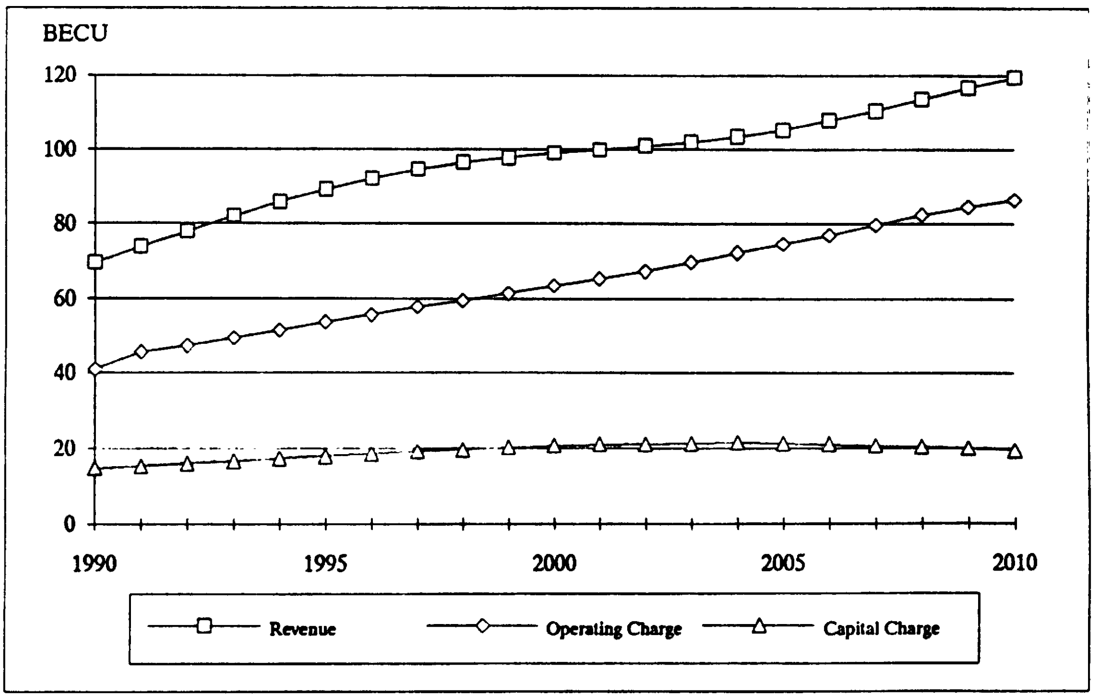


EXHIBIT EC.X.36: Telephony Revenue & Costs



EC Total Expansionist Case

EXHIBIT EC.X.37: Leased Lines Revenue & Costs

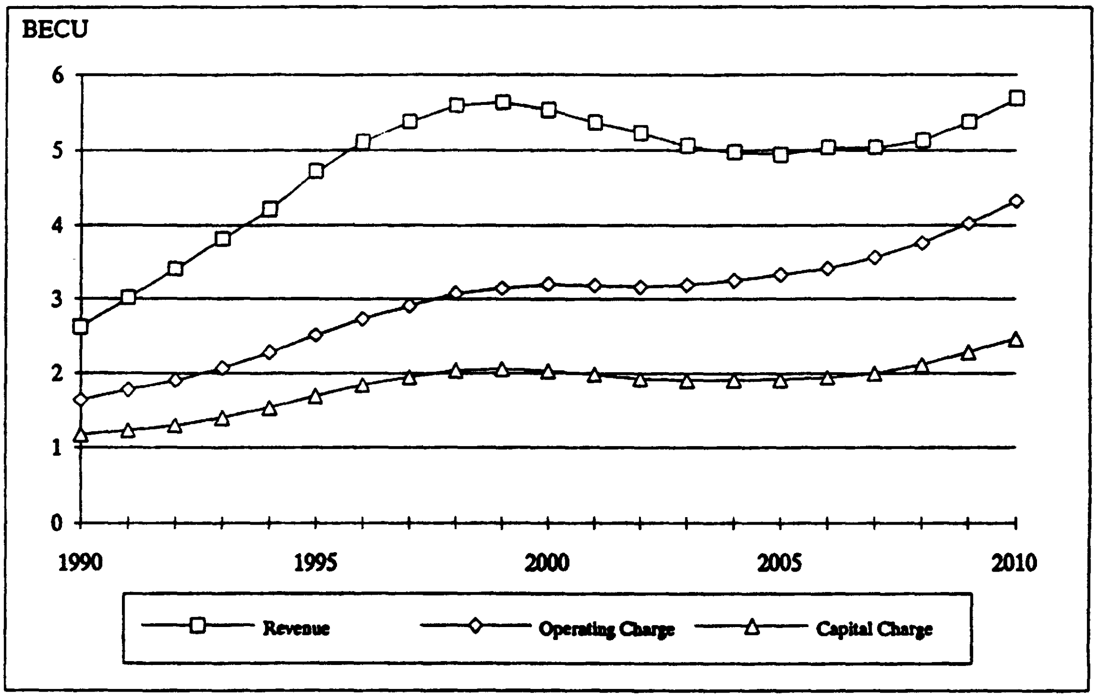
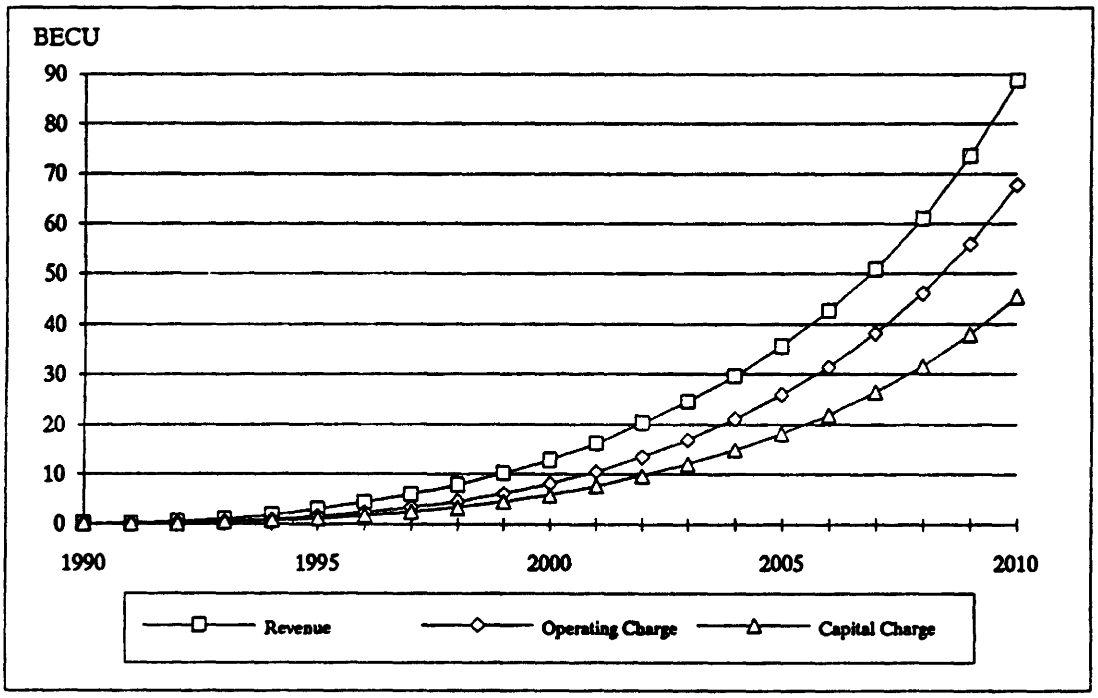


EXHIBIT EC.X.38: ISDN Revenue & Costs



EC Total Expansionist Case

EXHIBIT EC.X.39: Mobiles Revenue & Costs

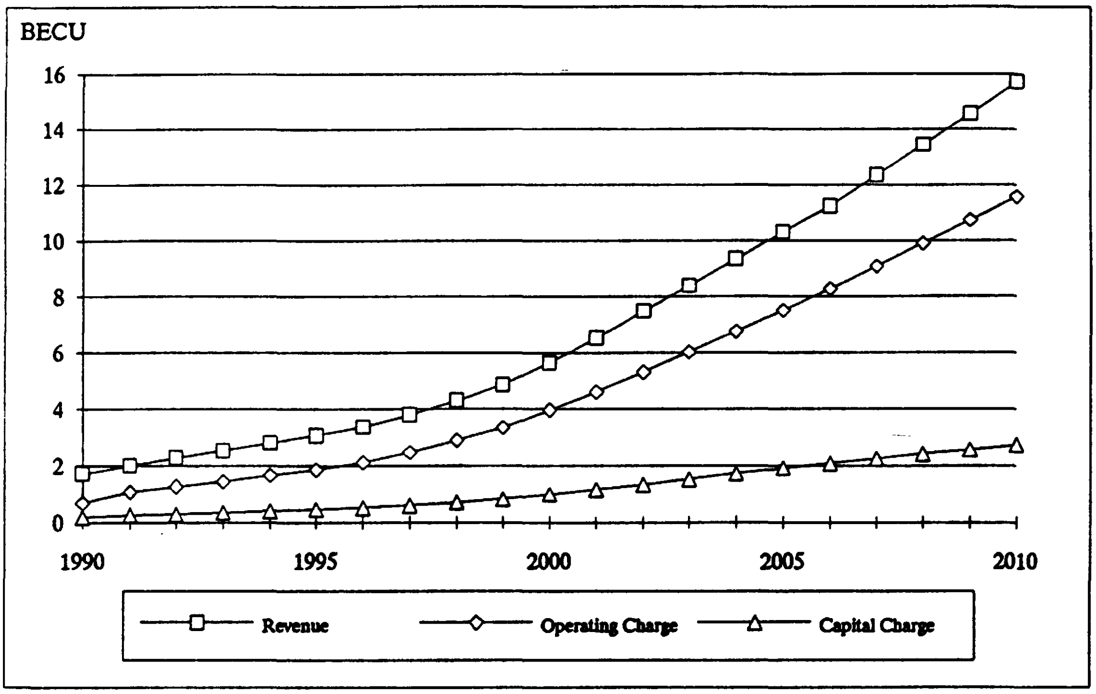
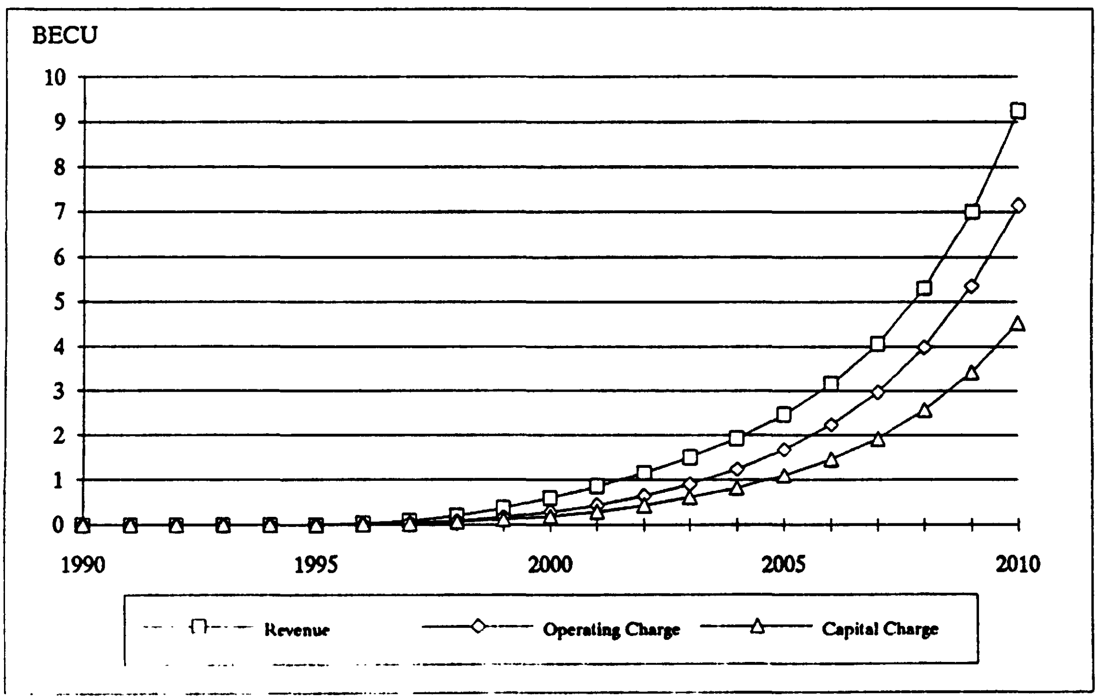


EXHIBIT EC.X.40: Broadband Revenue & Costs



EC Total TO
Company Accounts

Expansionist Case

Analysys Ltd
STEM Accounts
Version 1.1

MECU	Year	1990	1991	1992	1993	1994	1995
	(1990 refers to financial year 1989/90)		Network Operation — All figures real at 1990				
Profit and Loss Account							
	Turnover	84,948	89,235	94,016	99,248	104,240	109,149
	Operating Costs	62,085	64,802	66,764	69,027	71,644	74,409
	Operating Profit before Interest	22,863	24,433	27,253	30,221	32,595	34,740
	Exceptional Charge	1,183	0	0	0	0	0
	Net Interest Paid	7,963	7,672	7,469	7,112	6,702	6,281
	Profit on Ordinary Activities before Tax	13,717	16,761	19,784	23,109	25,894	28,459
	Tax on the Profit of Ordinary Activities	6,556	7,316	8,596	9,980	11,090	12,035
	Profit on Ordinary Activities after Tax	7,161	9,445	11,187	13,129	14,804	16,424
	Profit Attributable to Ordinary Shareholders	7,161	9,445	11,187	13,129	14,804	16,424
	Ordinary Dividends	1,529	2,197	2,720	3,255	3,714	4,178
	Retained Profit for the Financial Year	5,632	7,247	8,467	9,873	11,090	12,245
	Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
	Earnings per Share (ECU)	0.253	0.334	0.395	0.464	0.523	0.580
	Profit Margin (%)	8.43%	10.58%	11.90%	13.23%	14.20%	15.05%
Movement in Reserves:							
	Restated Reserves at Beginning of the Year	74,221	79,853	87,100	95,567	105,440	116,531
	Retained Profit for the Year	5,632	7,247	8,467	9,873	11,090	12,245
	Reserves at the Year end	79,853	87,100	95,567	105,440	116,531	128,776
Balance Sheet							
Assets:							
	Fixed Assets	179,894	189,942	199,558	209,263	218,814	229,270
Current Assets:							
	Stock	2,359	2,359	2,359	2,359	2,359	2,359
	Debtors	17,243	18,596	19,865	21,163	22,374	23,592
	Cash	7,342	5,696	5,271	6,995	10,155	13,583
	Creditors (tax and dividends payable)	8,085	9,514	11,317	13,236	14,803	16,214
	Creditors (other)	30,518	31,597	31,787	32,722	33,987	35,432
	Net Current Assets	(11,659)	(14,460)	(15,609)	(15,441)	(13,902)	(12,111)
	Fixed Assets plus Net Current Assets	168,235	175,482	183,949	193,822	204,913	217,158
Liabilities:							
Creditors (amounts falling due after more than one year		82,393	82,393	82,393	82,393	82,393	82,393
	Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
	Minority Interests	762	762	762	762	762	762
	Capital and Reserves	79,853	87,100	95,567	105,440	116,531	128,776
	Total	168,235	175,482	183,949	193,822	204,913	217,158
Source and Application of Funds							
Source of Funds:							
	Profit on Ordinary Activities before Tax	13,717	16,761	19,784	23,109	25,894	28,459
	Items not Involving Cash Movement: Depreciation	21,107	21,699	22,389	23,190	24,077	24,913
	Total Funds Generated from Operations before Tax	34,824	38,460	42,173	46,299	49,971	53,372
	Taxation Paid	6,967	6,556	7,316	8,596	9,980	11,090
	Total Sources of Funds Net of Taxation	27,857	31,904	34,857	37,703	39,991	42,282
Application of Funds:							
	Net Expenditure on Tangible Fixed Assets	31,289	31,747	32,005	32,896	33,629	35,368
	Dividends Paid	2,207	1,529	2,197	2,720	3,255	3,714
	Increase in Working Capital	(1,587)	274	1,079	363	(53)	(227)
	Total Application of Funds	31,909	33,550	35,282	35,979	36,831	38,854
	Net Cash Outflow from Operations	(4,052)	(1,646)	(425)	1,724	3,160	3,428

EC Total TO
Company Accounts

Expansionist Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU — Year (1990 refers to financial year 1989/90)	1990	1996	1997	1998	1999	2000
Profit and Loss Account						
Turnover	84,948	114,117	118,923	123,490	128,152	133,277
Operating Costs	62,085	77,130	80,393	83,616	87,422	91,938
Operating Profit before Interest	22,863	36,987	38,530	39,873	40,730	41,340
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,963	5,885	5,713	5,526	5,259	4,964
Profit on Ordinary Activities before Tax	13,717	31,102	32,817	34,348	35,470	36,375
Tax on the Profit of Ordinary Activities	6,556	13,016	13,592	14,120	14,480	14,763
Profit on Ordinary Activities after Tax	7,161	18,086	19,225	20,228	20,991	21,613
Profit Attributable to Ordinary Shareholders	7,161	18,086	19,225	20,228	20,991	21,613
Ordinary Dividends	1,529	4,595	4,853	5,040	5,196	5,320
Retained Profit for the Financial Year	5,632	13,492	14,371	15,188	15,795	16,293
Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
Earnings per Share (ECU)	0.253	0.639	0.679	0.714	0.741	0.763
Profit Margin (%)	8.43%	15.85%	16.17%	16.38%	16.38%	16.22%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	128,776	142,268	156,639	171,827	187,622
Retained Profit for the Year	5,632	13,492	14,371	15,188	15,795	16,293
Reserves at the Year end	79,853	142,268	156,639	171,827	187,622	203,915
Balance Sheet						
Assets:						
Fixed Assets	179,894	239,935	251,487	262,504	273,037	284,268
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	24,797	25,844	26,837	27,794	28,762
Cash	7,342	17,803	22,072	27,520	33,190	39,153
Creditors (tax and dividends payable)	8,085	17,611	18,446	19,160	19,676	20,082
Creditors (other)	30,518	36,633	38,295	39,850	40,700	42,164
Net Current Assets	(11,659)	(9,285)	(6,466)	(2,295)	2,967	8,028
Fixed Assets plus Net Current Assets	168,235	230,650	245,021	260,209	276,004	292,297
Liabilities:						
Creditors (amounts falling due after more than one year	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	79,853	142,268	156,639	171,827	187,622	203,915
Total	168,235	230,650	245,021	260,209	276,004	292,297
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	13,717	31,102	32,817	34,348	35,470	36,375
Items not Involving Cash Movement: Depreciation	21,107	25,915	27,146	28,511	30,091	31,967
Total Funds Generated from Operations before Tax	34,824	57,017	59,963	62,859	65,562	68,342
Taxation Paid	6,967	12,035	13,016	13,592	14,120	14,480
Total Sources of Funds Net of Taxation	27,857	44,982	46,947	49,267	51,442	53,863
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	31,289	36,580	38,698	39,528	40,625	43,198
Dividends Paid	2,207	4,178	4,595	4,853	5,040	5,196
Increase in Working Capital	(1,587)	4	(615)	(563)	108	(495)
Total Application of Funds	31,909	40,762	42,678	43,818	45,772	47,899
Net Cash Outflow from Operations	(4,052)	4,220	4,269	5,448	5,670	5,964

EC Total TO
Company Accounts

Expansionist Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU Year (1990 refers to financial year 1989/90)	1990	2006	2007	2008	2009	2010
Profit and Loss Account						
Turnover	84,948	177,486	189,280	203,336	219,354	236,944
Operating Costs	62,085	132,855	143,010	154,423	167,094	181,070
Operating Profit before Interest	22,863	44,632	46,270	48,913	52,260	55,874
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,963	3,432	3,419	3,675	4,194	4,958
Profit on Ordinary Activities before Tax	13,717	41,200	42,850	45,238	48,067	50,916
Tax on the Profit of Ordinary Activities	6,556	16,441	17,103	18,038	19,143	20,274
Profit on Ordinary Activities after Tax	7,161	24,760	25,747	27,200	28,924	30,642
Profit Attributable to Ordinary Shareholders	7,161	24,760	25,747	27,200	28,924	30,642
Ordinary Dividends	1,529	5,966	6,179	6,526	6,940	7,330
Retained Profit for the Financial Year	5,632	18,794	19,569	20,674	21,984	23,312
Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
Earnings per Share (ECU)	0.253	0.874	0.909	0.961	1.021	1.082
Profit Margin (%)	8.43%	13.95%	13.60%	13.38%	13.19%	12.93%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	290,036	308,830	328,399	349,073	371,057
Retained Profit for the Year	5,632	18,794	19,569	20,674	21,984	23,312
Reserves at the Year end	79,853	308,830	328,399	349,073	371,057	394,369
Balance Sheet						
Assets:						
Fixed Assets	179,894	365,951	388,423	416,261	450,109	489,116
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	37,572	39,982	42,972	46,425	50,186
Cash	7,342	74,623	77,290	75,364	69,084	59,521
Creditors (tax and dividends payable)	8,085	22,407	23,282	24,565	26,082	27,604
Creditors (other)	30,518	60,886	67,992	74,937	82,456	90,827
Net Current Assets	(11,659)	31,261	28,358	21,194	9,330	(6,365)
Fixed Assets plus Net Current Assets	168,235	397,212	416,781	437,455	459,439	482,751
Liabilities:						
Creditors (amounts falling due after more than one year	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	79,853	308,830	328,399	349,073	371,057	394,369
Total	168,235	397,212	416,781	437,455	459,439	482,751
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	13,717	41,200	42,850	45,238	48,067	50,916
Items not Involving Cash Movement: Depreciation	21,107	49,514	53,967	59,224	65,428	72,603
Total Funds Generated from Operations before Tax	34,824	90,714	96,818	104,463	113,495	123,519
Taxation Paid	6,967	15,799	16,441	17,103	18,038	19,143
Total Sources of Funds Net of Taxation	27,857	74,916	80,377	87,360	95,456	104,376
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	31,289	66,806	76,439	87,062	99,277	111,610
Dividends Paid	2,207	5,718	5,966	6,179	6,526	6,940
Increase in Working Capital	(1,587)	(1,782)	(4,695)	(3,955)	(4,067)	(4,610)
Total Application of Funds	31,909	70,742	77,710	89,286	101,736	113,940
Net Cash Outflow from Operations	(4,052)	4,173	2,667	(1,926)	(6,280)	(9,564)

EC Total
Country Accounts

Expansionist Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU — Year (1990 refers to financial year 1989/90)	1990	1991	1992	1993	1994	1995
Profit and Loss Account						
Turnover	90,472	95,604	101,252	107,541	113,743	120,237
Operating Costs	66,640	70,038	72,639	75,714	79,265	83,027
Operating Profit before Interest	23,832	25,567	28,613	31,827	34,478	37,210
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,994	7,757	7,600	7,294	6,969	6,651
Profit on Ordinary Activities before Tax	14,656	17,809	21,014	24,533	27,508	30,559
Tax on the Profit of Ordinary Activities	6,686	7,473	8,821	10,297	11,506	12,693
Profit on Ordinary Activities after Tax	7,970	10,337	12,193	14,236	16,003	17,867
Profit Attributable to Ordinary Shareholders	7,970	10,337	12,193	14,236	16,003	17,867
Ordinary Dividends	1,840	2,446	3,018	3,598	4,099	4,630
Retained Profit for the Financial Year	6,130	7,891	9,174	10,637	11,904	13,237
Number of Ordinary Shares (millions)	30,157	30,157	30,157	30,157	30,157	30,157
Earnings per Share (ECU)	0.264	0.343	0.404	0.472	0.531	0.592
Profit Margin (%)	8.81%	10.81%	12.04%	13.24%	14.07%	14.86%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	80,351	88,242	97,416	108,053	119,957
Retained Profit for the Year	6,130	7,891	9,174	10,637	11,904	13,237
Reserves at the Year end	80,351	88,242	97,416	108,053	119,957	133,194
Balance Sheet						
Assets:						
Fixed Assets	180,327	191,164	201,451	212,248	223,254	235,493
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	18,652	19,983	21,373	22,711	24,143
Cash	7,848	6,155	5,995	7,860	10,794	14,049
Creditors (tax and dividends payable)	8,526	9,919	11,839	13,895	15,605	17,322
Creditors (other)	30,518	31,788	32,151	33,510	35,175	37,146
Net Current Assets	(11,594)	(14,541)	(15,653)	(15,813)	(14,915)	(13,917)
Fixed Assets plus Net Current Assets	168,733	176,624	185,798	196,435	208,339	221,576
Liabilities:						
reditors (amounts falling due after more than one year)	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	80,351	88,242	97,416	108,053	119,957	133,194
Total	168,733	176,624	185,798	196,435	208,339	221,576
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	14,656	17,809	21,014	24,533	27,508	30,559
Items not Involving Cash Movement: Depreciation	22,456	23,190	24,028	25,036	26,189	27,273
Total Funds Generated from Operations before Tax	37,112	41,000	45,042	49,568	53,697	57,832
Taxation Paid	6,967	6,686	7,473	8,821	10,297	11,506
Total Sources of Funds Net of Taxation	30,145	34,313	37,569	40,747	43,400	46,327
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	33,071	34,028	34,315	35,832	37,195	39,511
Dividends Paid	2,207	1,840	2,446	3,018	3,598	4,099
Increase in Working Capital	(1,587)	139	968	32	(328)	(539)
Total Application of Funds	33,691	36,007	37,729	38,882	40,466	43,072
Net Cash Outflow from Operations	(3,546)	(1,693)	(160)	1,865	2,934	3,255

EC Total Expansionist Case

EXHIBIT EC.X.41: Total Variation of Service Revenues from Costs

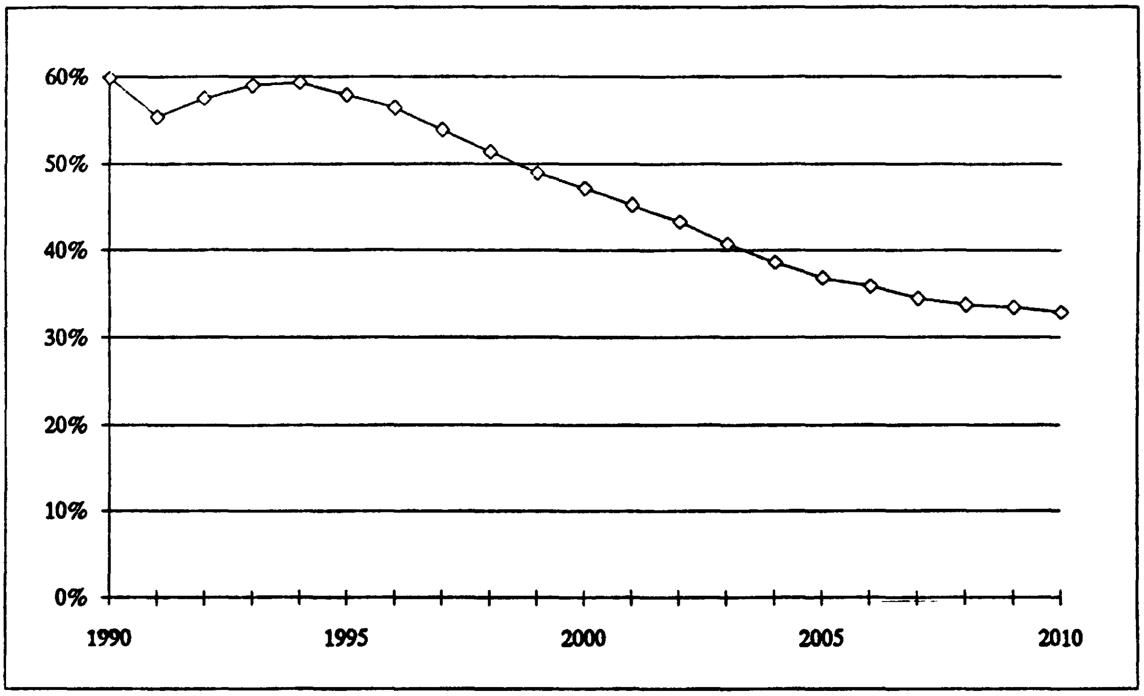
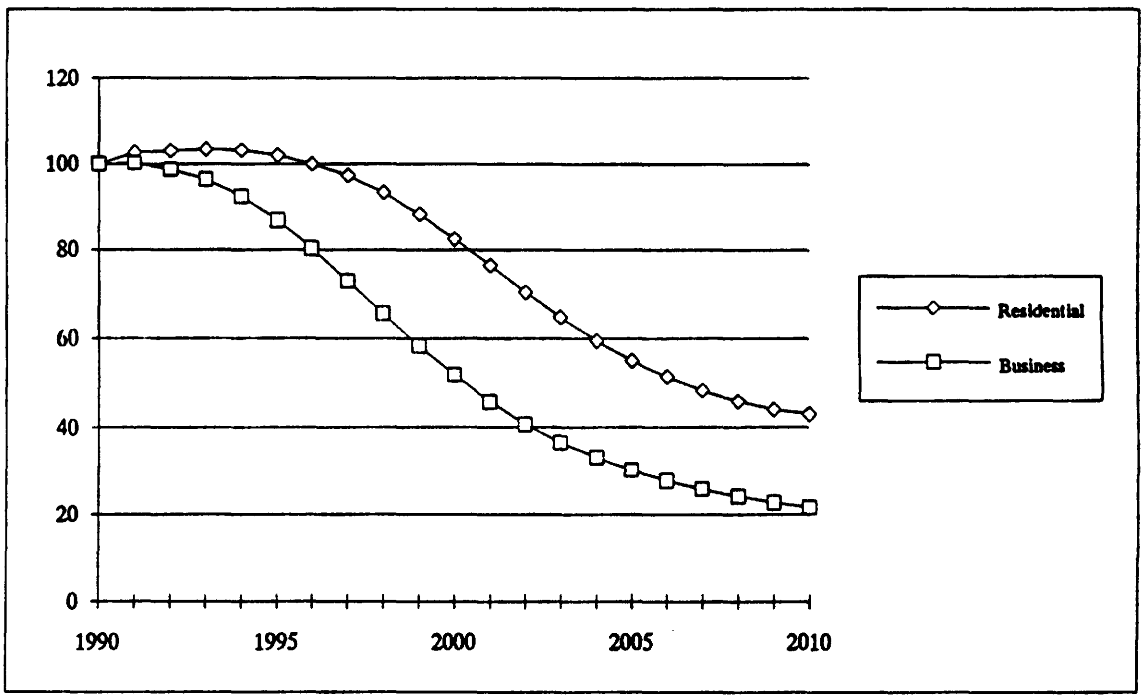


EXHIBIT EC.X.42: Index of Revenue per Call Minute



EC Total Expansionist Case

EXHIBIT EC.X.43: Network Costs and Revenues

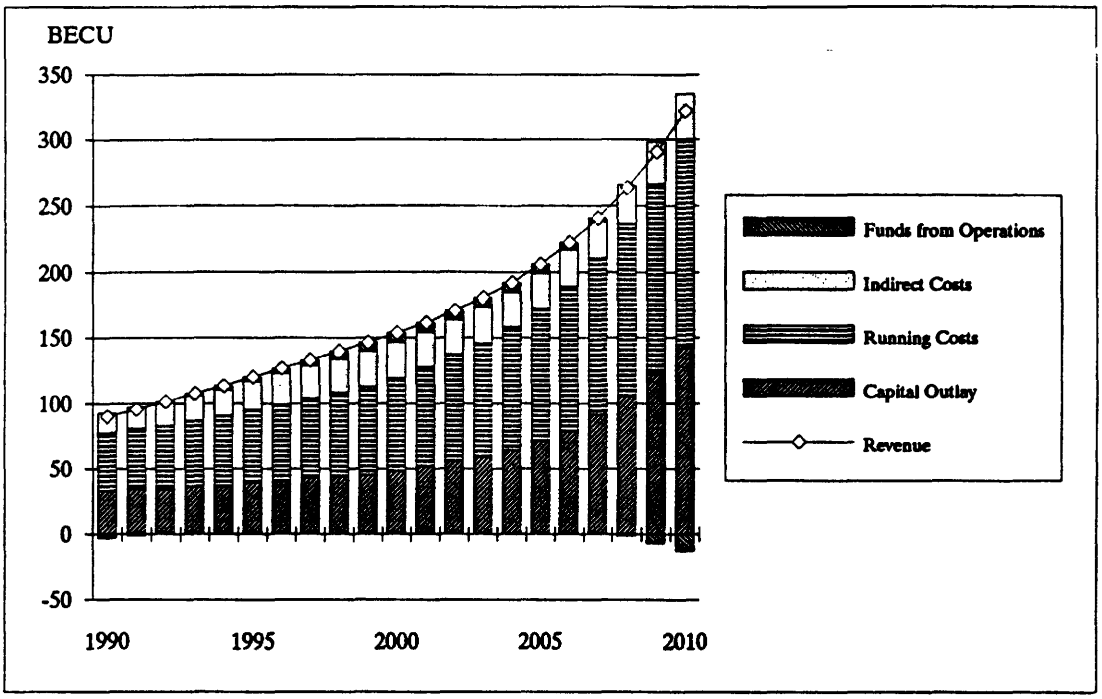
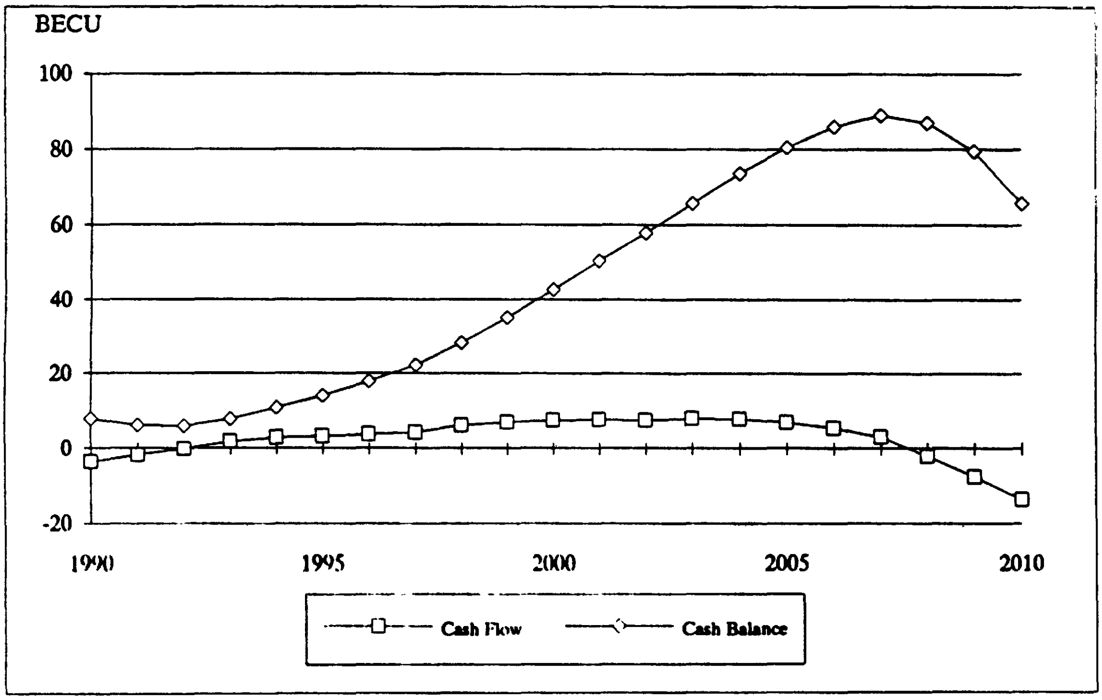


EXHIBIT EC.X.44: Network Cash Flow and Cash Balance



EC Total Expansionist Case

EXHIBIT EC.X.45: Profit Margin: Comparison of TO and Country

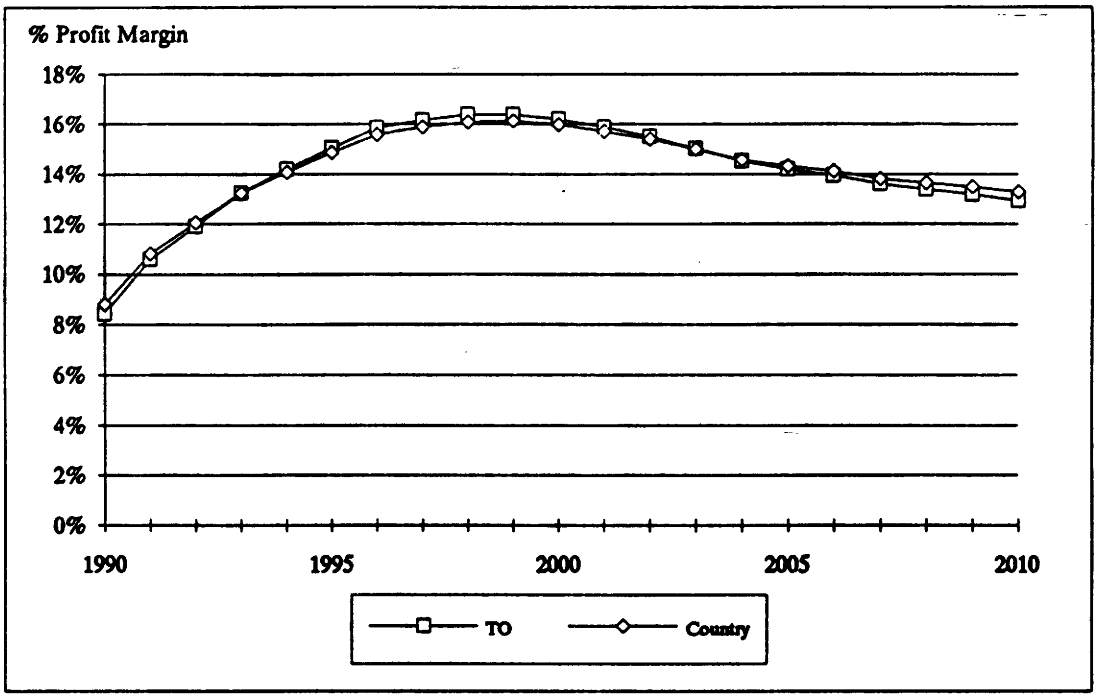
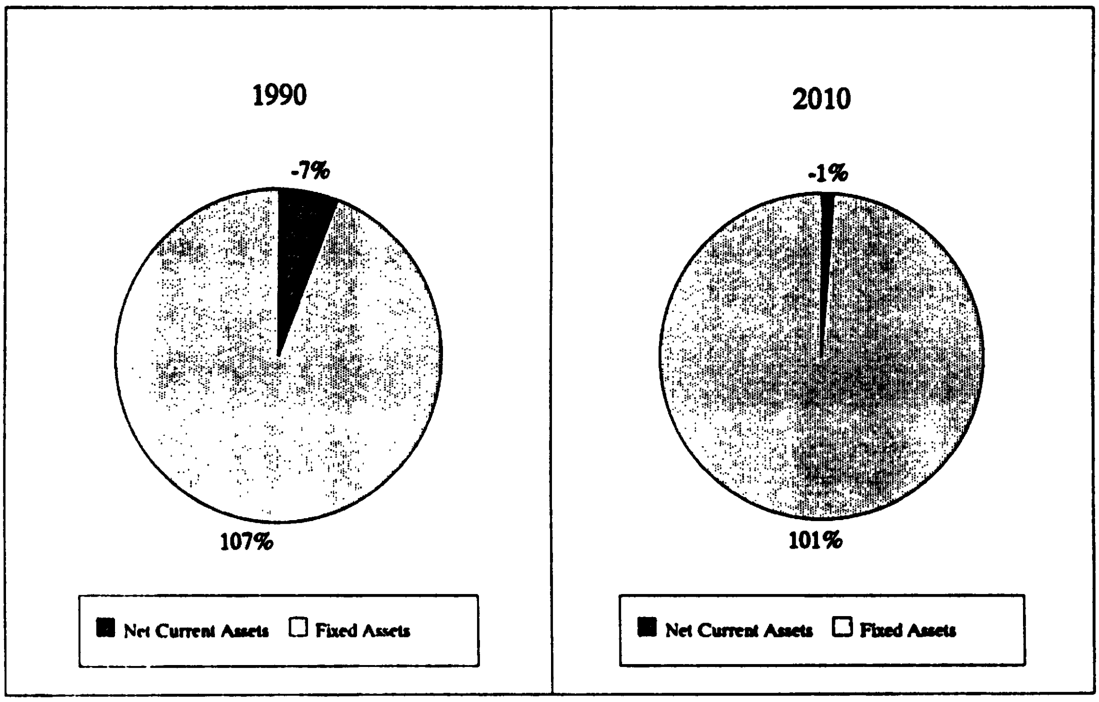
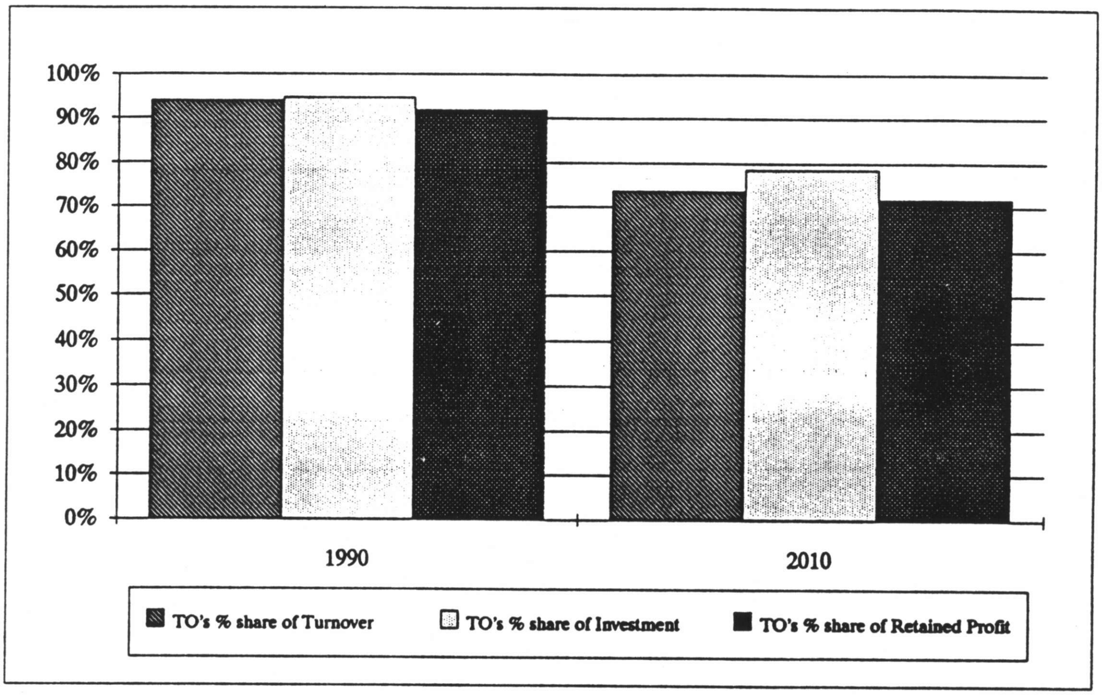


EXHIBIT EC.X.46: Analysis of TO's Net Assets



EC Total Expansionist Case

EXHIBIT EC.X.47: TO's Comparative Performance in 1990 and 2010 (TO as % of Total Telecoms Operation)



Analysys

EC Total
Summary Results

Minimum Case

EC Total TO Company Accounts

MECU Year	1990	1995	2000	2005	2010
			All figures real at 1990		
Turnover	84,948	103,583	107,075	115,999	141,041
Operating Costs	62,085	71,366	80,383	93,004	114,229
Operating Profit before Interest	22,863	32,218	26,692	22,995	26,812
Net Interest Paid	7,963	5,638	4,162	3,125	3,275
Profit on Ordinary Activities after Interest and Tax	7,161	15,291	13,374	11,916	14,193
Total Dividends	1,529	3,873	3,371	2,776	3,169
Retained Profit for the Financial Year	5,632	11,418	10,003	9,140	11,024
Fixed Assets	179,894	219,287	247,612	267,880	320,912
Items not Involving Cash Movement: Depreciation	21,107	23,974	28,230	35,337	47,288
Net Expenditure on Tangible Fixed Assets	31,289	31,726	32,939	39,787	63,590
Net Cash Outflow from Operations	(4,052)	4,574	4,309	6,884	(2,625)

EC Total Country Accounts

MECU Year	1990	1995	2000	2005	2010
			All figures real at 1990		
Turnover	90,472	113,747	122,906	142,720	188,305
Operating Costs	66,640	79,279	93,058	114,260	151,627
Operating Profit before Interest	23,832	34,469	29,848	28,460	36,678
Net Interest Paid	7,994	5,949	4,508	3,230	3,296
Profit on Ordinary Activities after Interest and Tax	7,970	16,642	15,029	15,021	19,839
Total Dividends	1,840	4,325	3,858	3,589	4,622
Retained Profit for the Financial Year	6,130	12,317	11,171	11,432	15,216
Fixed Assets	180,327	224,381	257,200	285,681	356,811
Items not Involving Cash Movement: Depreciation	22,456	26,179	31,339	39,911	55,185
Net Expenditure on Tangible Fixed Assets	33,071	35,309	36,855	46,526	76,447
Net Cash Outflow from Operations	(3,546)	4,542	5,059	7,564	(2,256)

EC Total TO Financial Ratios

Year	1990	1995	2000	2005	2010
Interest Cover	5.5	10.0	13.2	18.7	22.6
Net Profit Margin	8.4%	14.8%	12.5%	10.3%	10.1%
Return on Total Assets	3.5%	5.8%	4.2%	3.2%	3.3%
Investment in relation to Turnover	37%	31%	31%	34%	45%

EC Total Telecoms Markets

Year	1990	1995	2000	2005	2010
Connections (Thousands):					
Basic Telephony - Residential	105,389	120,851	133,421	141,433	144,689
Basic Telephony - Business	35,689	47,600	54,949	52,844	43,968
ISDN - Basic Rate	17	646	2,973	9,006	22,285
ISDN - Primary Rate	2	99	530	1,631	3,771
Broadband - Switched	0	0	63	343	1,209
Mobiles	1,862	4,804	8,922	18,226	31,220
Narrowband Leased Lines	1,586	1,920	2,172	2,099	1,709
Broadband Leased Lines	21	69	131	208	325
Originating Traffic (Millions of Busy Hour Erlangs):					
Telephony	6.91	9.08	11.16	12.15	11.91
ISDN	0.01	0.53	3.11	10.63	27.52
Broadband - Switched	0	0	0.35	2.12	8.24
Mobiles	0.04	0.11	0.25	0.65	1.21
Total	6.96	9.72	14.88	25.55	48.88

*** is a value of no significance

EC Total Minimum Case

EXHIBIT EC.M.1: Total Network Traffic

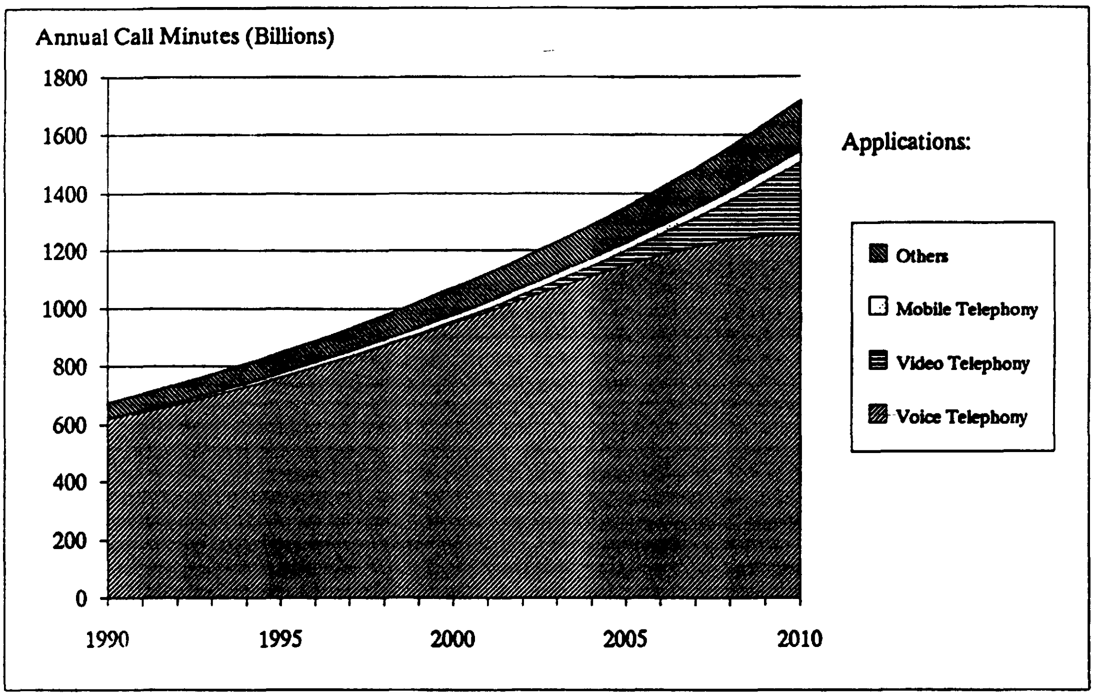
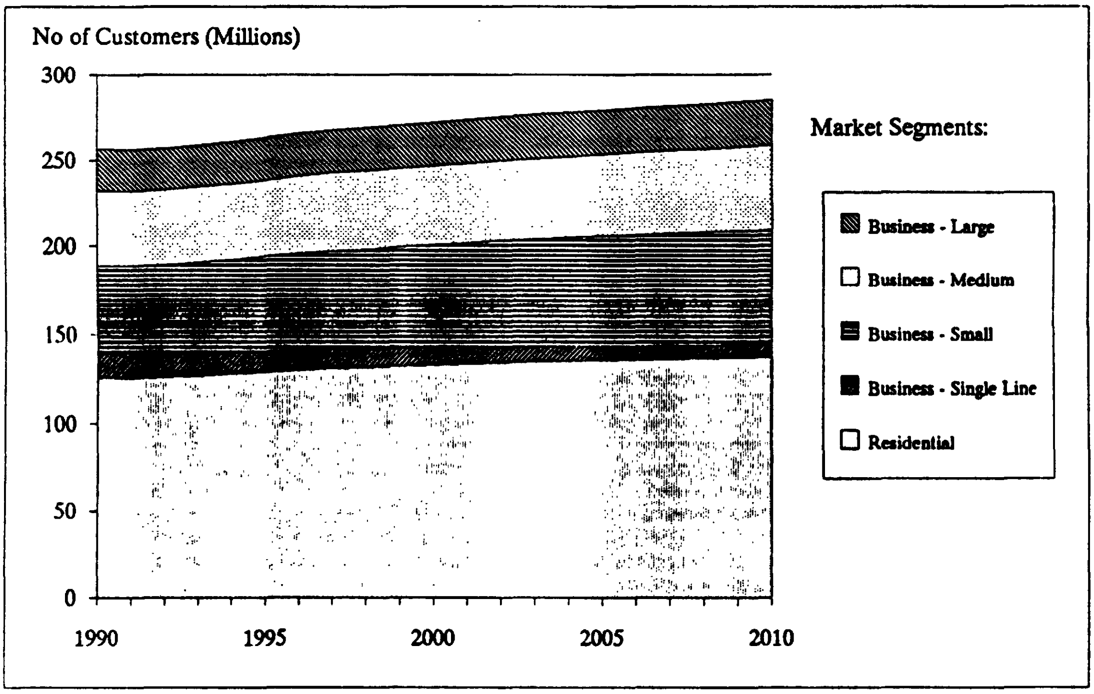


EXHIBIT EC.M.2: Customer Base



EC Total Minimum Case

EXHIBIT EC.M.3: Network Busy Hour Traffic

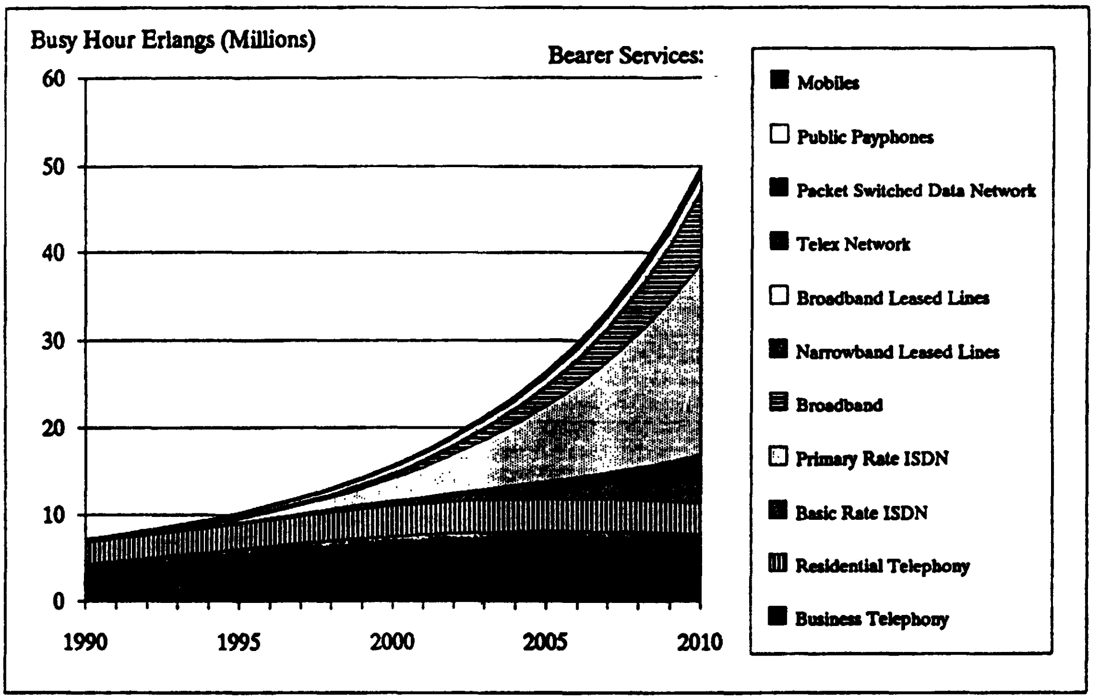
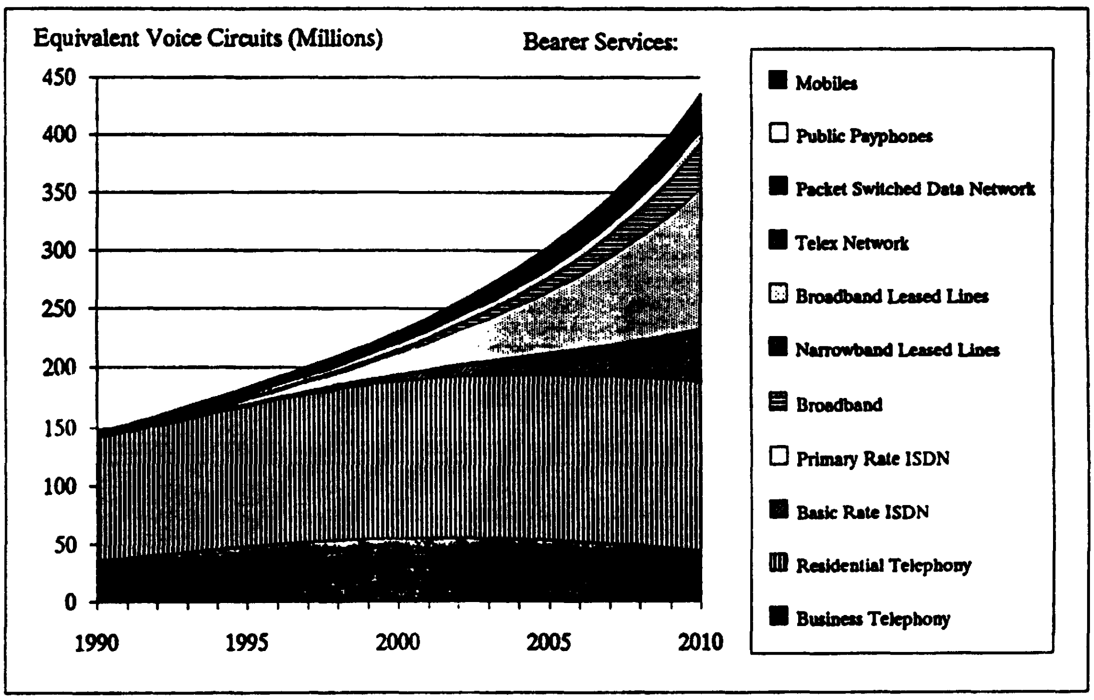


EXHIBIT EC.M.4: Network Lines



EC Total Minimum Case

EXHIBIT EC.M.5: Network Connections (1)

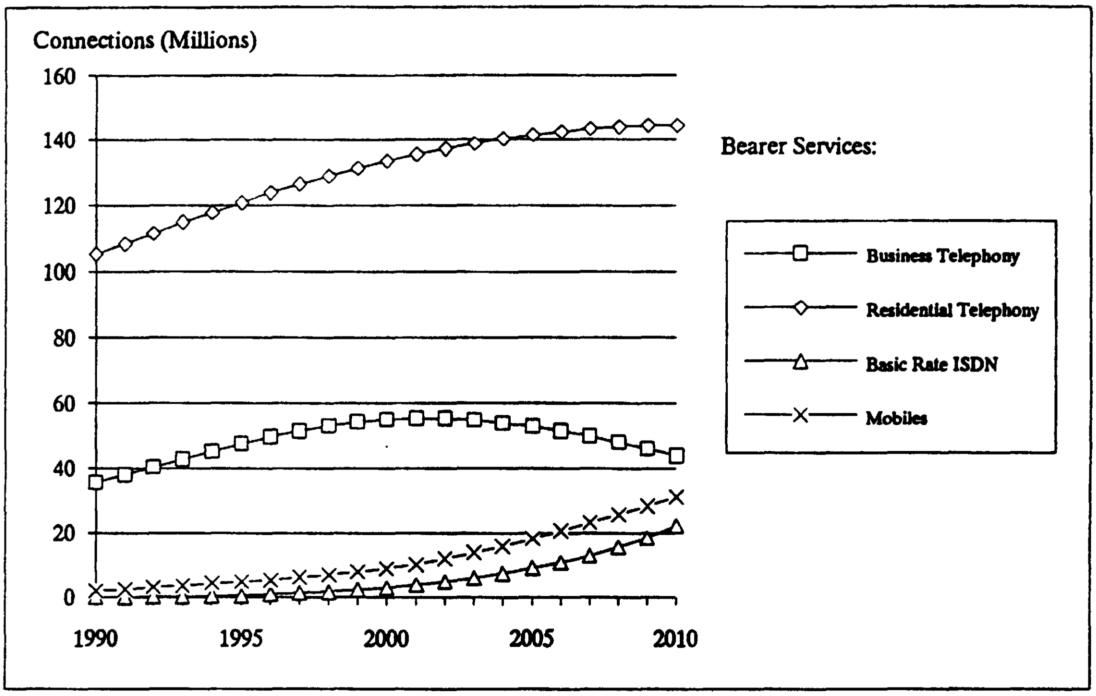
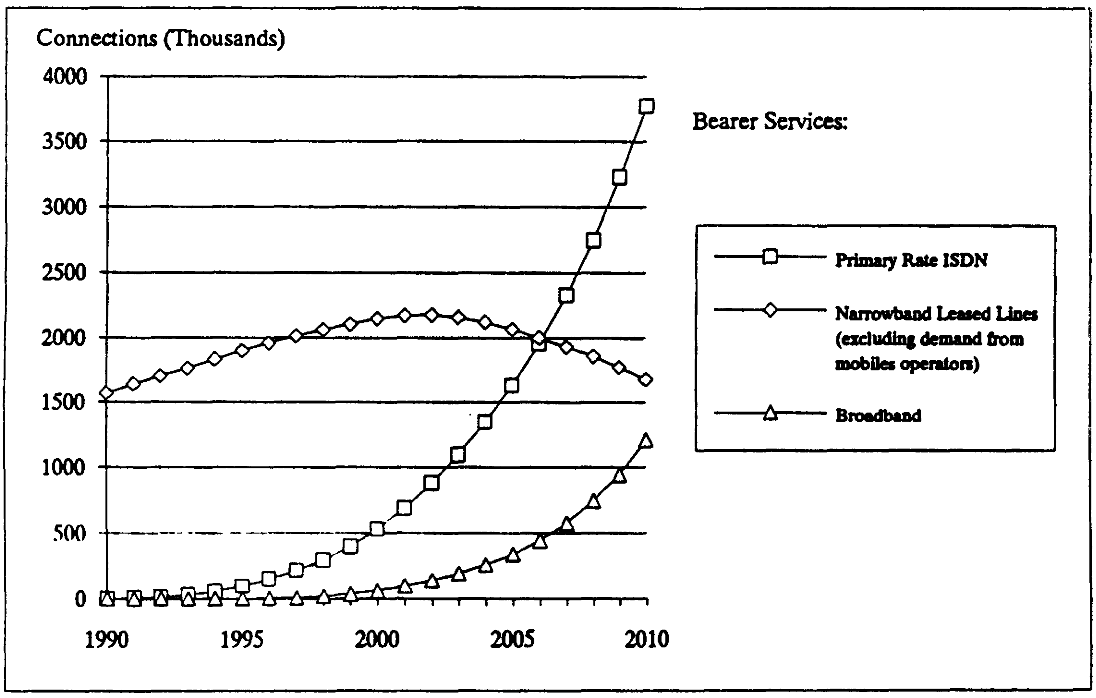


EXHIBIT EC.M.6: Network Connections (2)



EC Total Minimum Case

EXHIBIT EC.M.7: Network Connections (3)

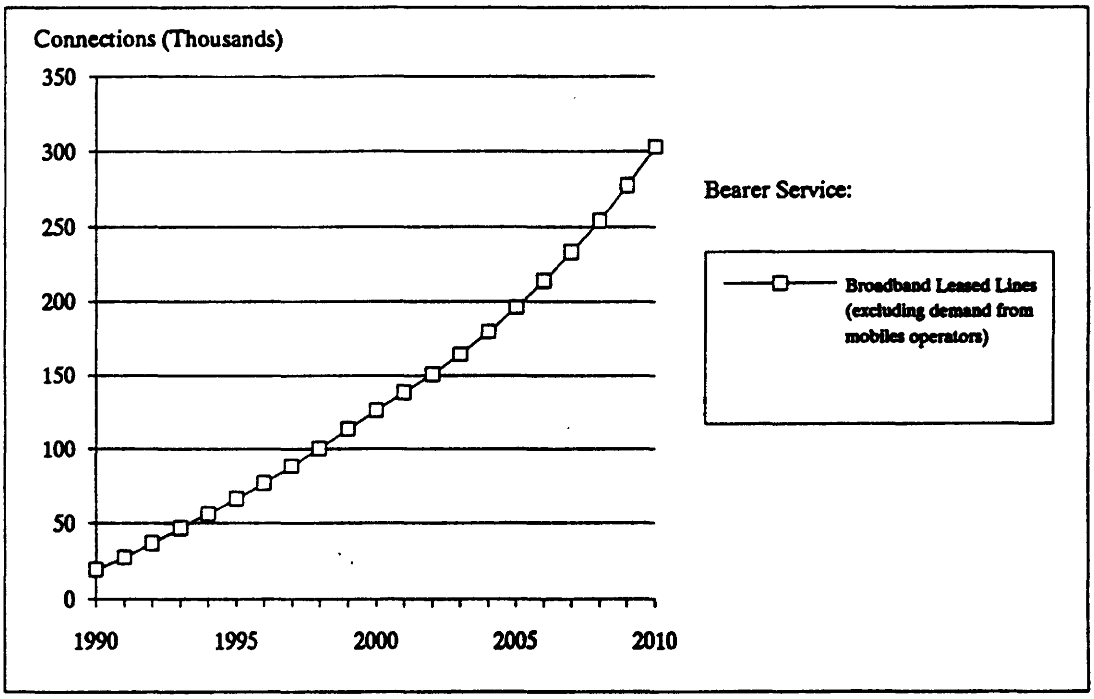
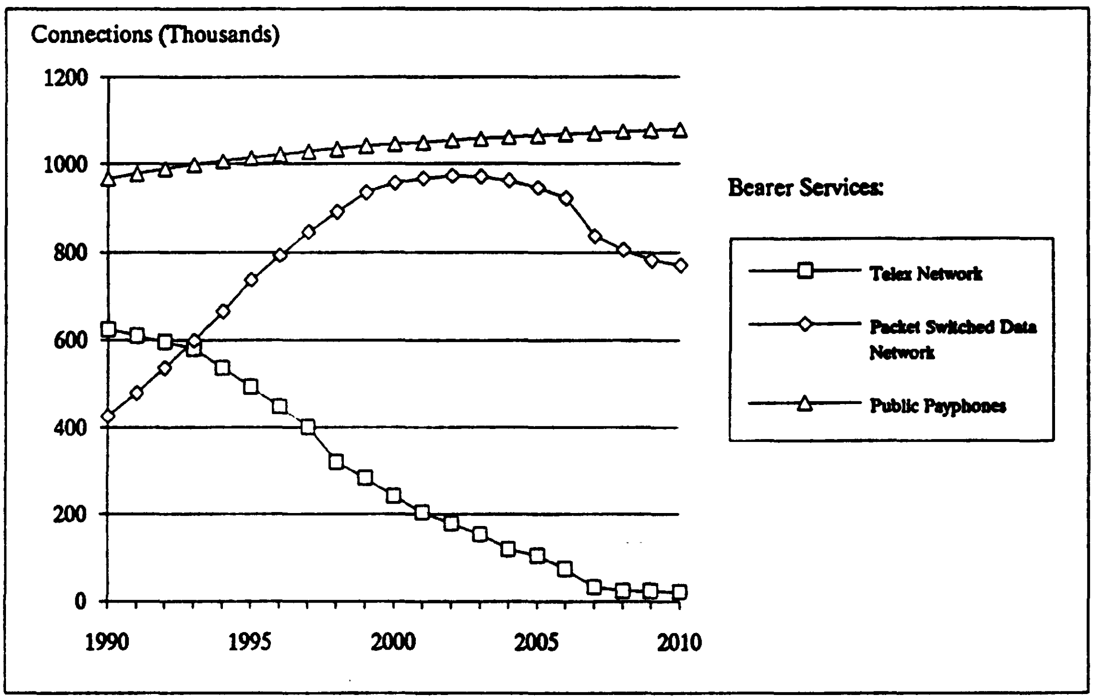


EXHIBIT EC.M.8: Network Connections (4)



EC Total Minimum Case

EXHIBIT EC.M.9: Network Busy Hour Traffic per Business Line for Public Switched Services

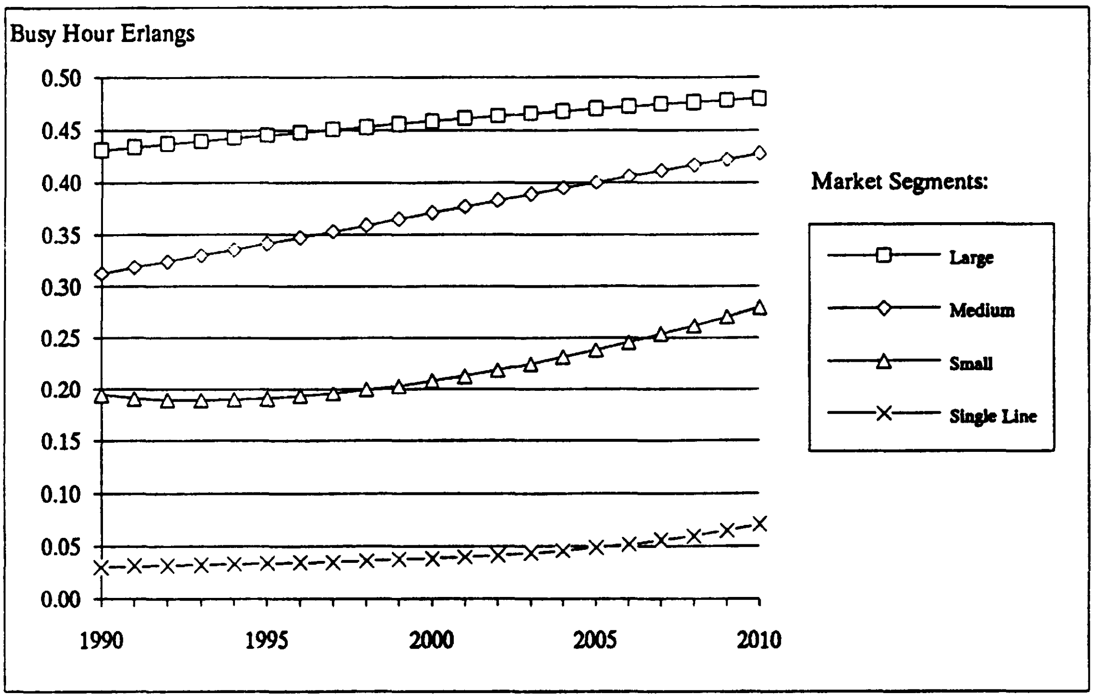
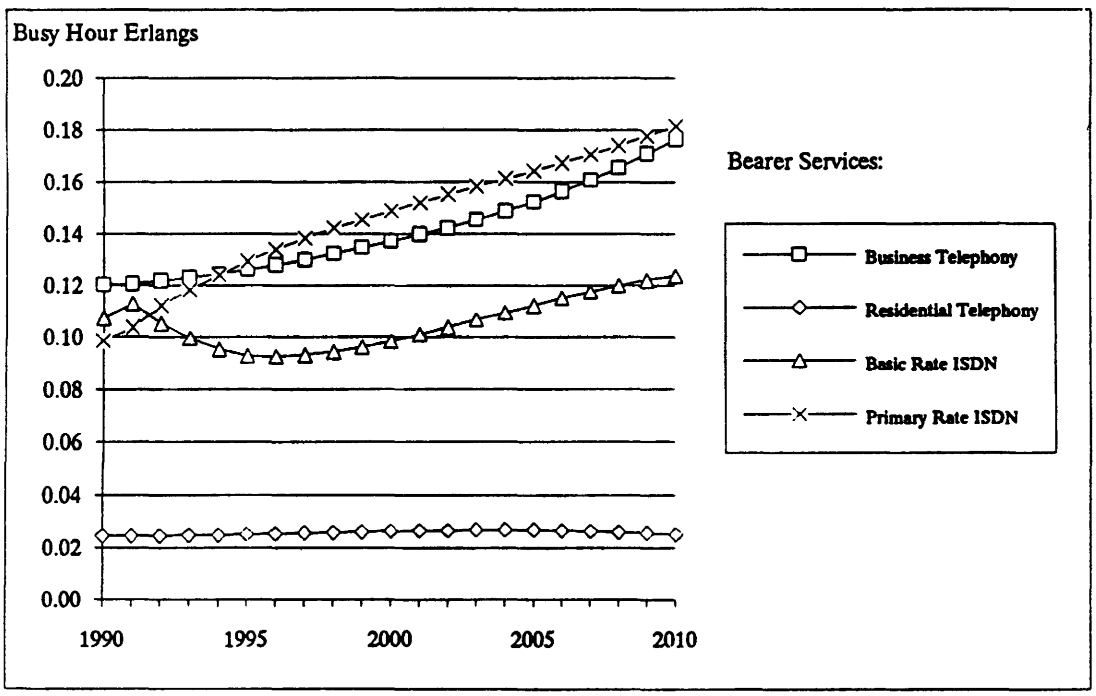


EXHIBIT EC.M.10: Network Busy Hour Traffic per Line for Basic Telephony and ISDN



EC Total Minimum Case

EXHIBIT EC.M.11: Network Busy Hour Traffic per Line for Mobiles

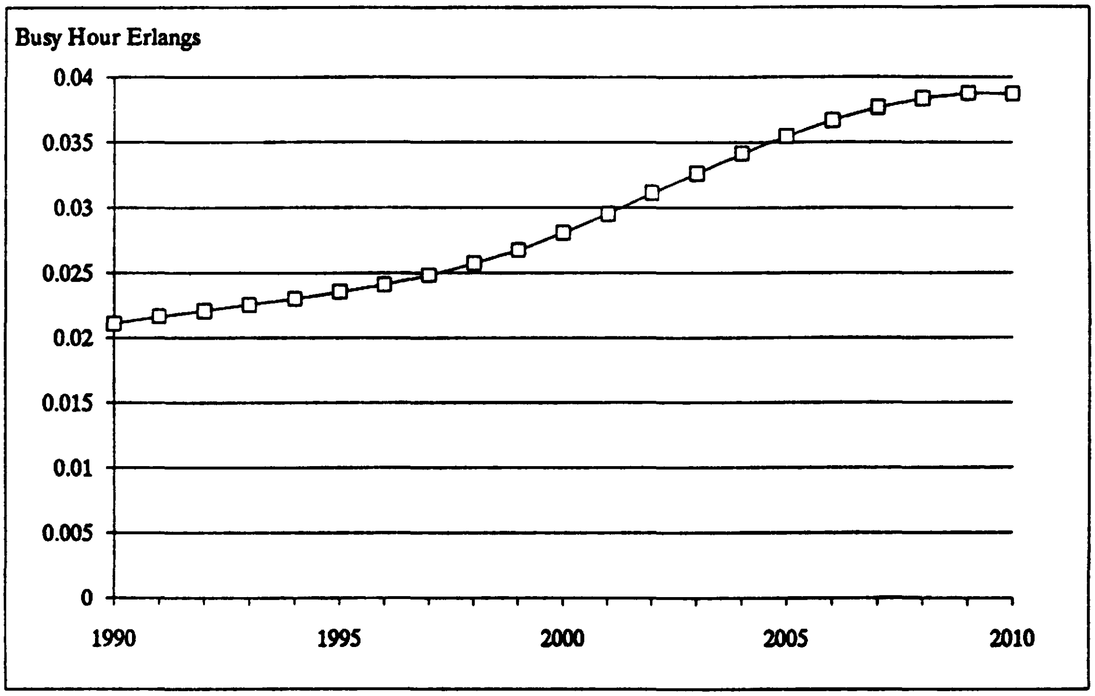
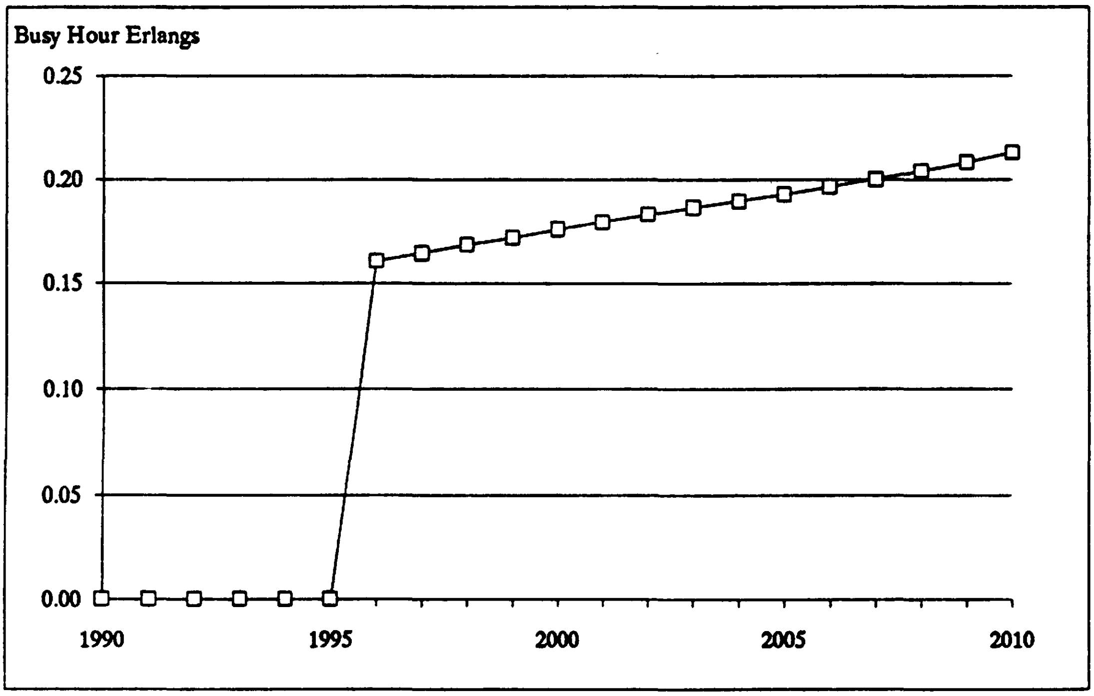
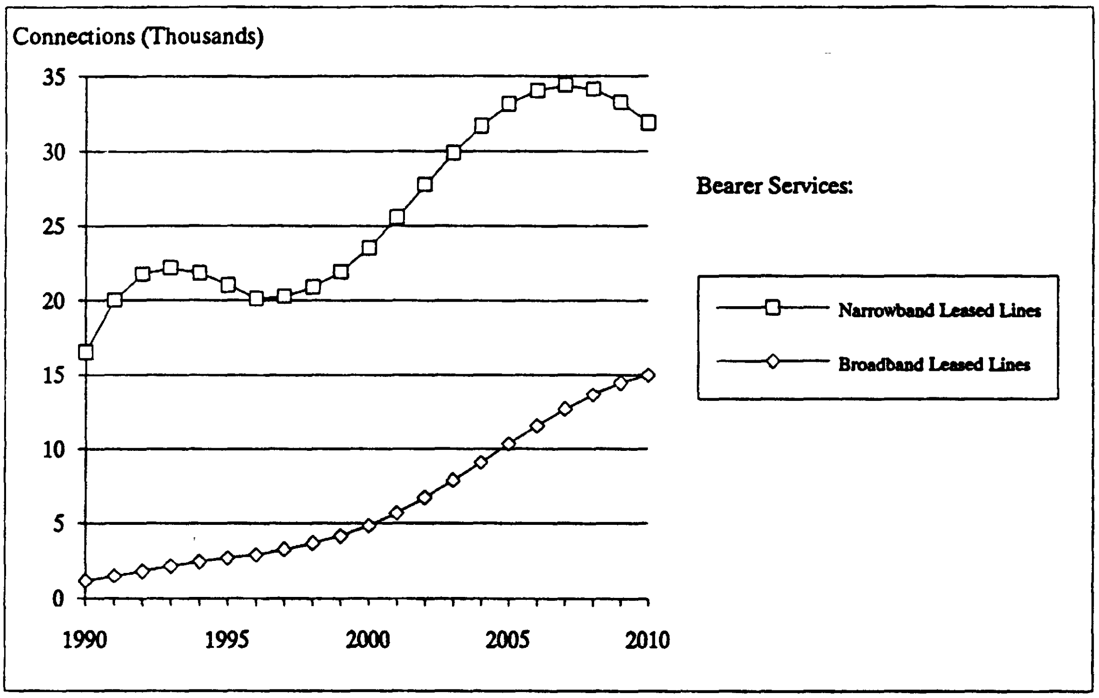


EXHIBIT EC.M.12: Network Busy Hour Traffic per Line for Broadband



EC Total Minimum Case

EXHIBIT EC.M.16: Network Connections, Demand from Mobiles Operators



EC Total Minimum Case

EXHIBIT EC.M.17: Local Access Connections

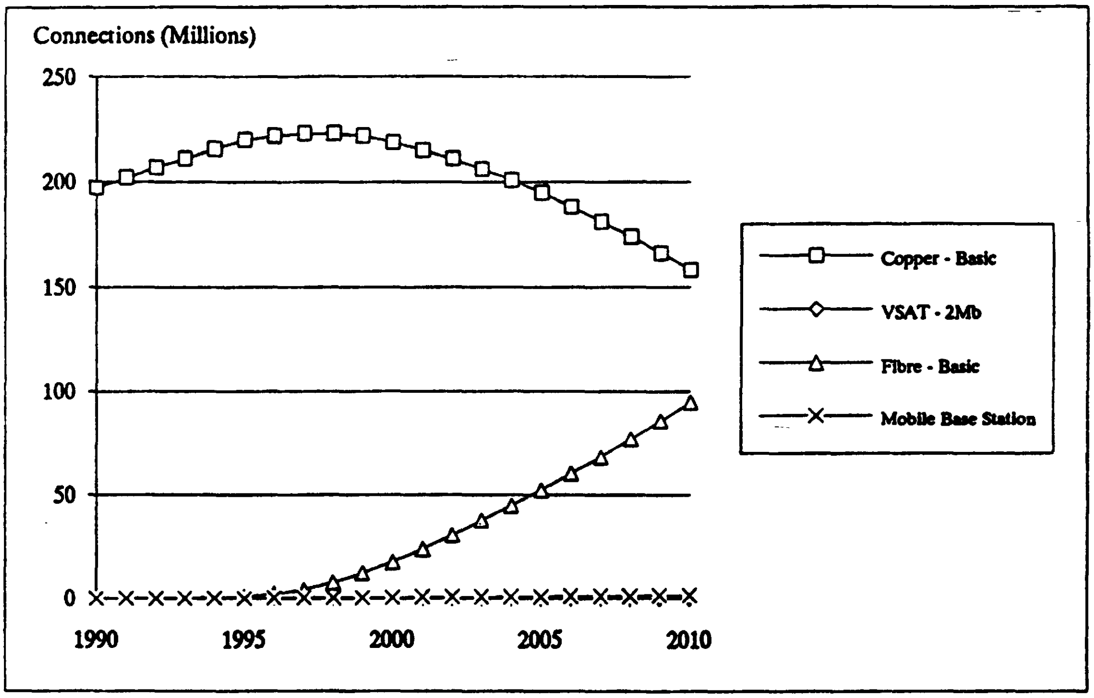
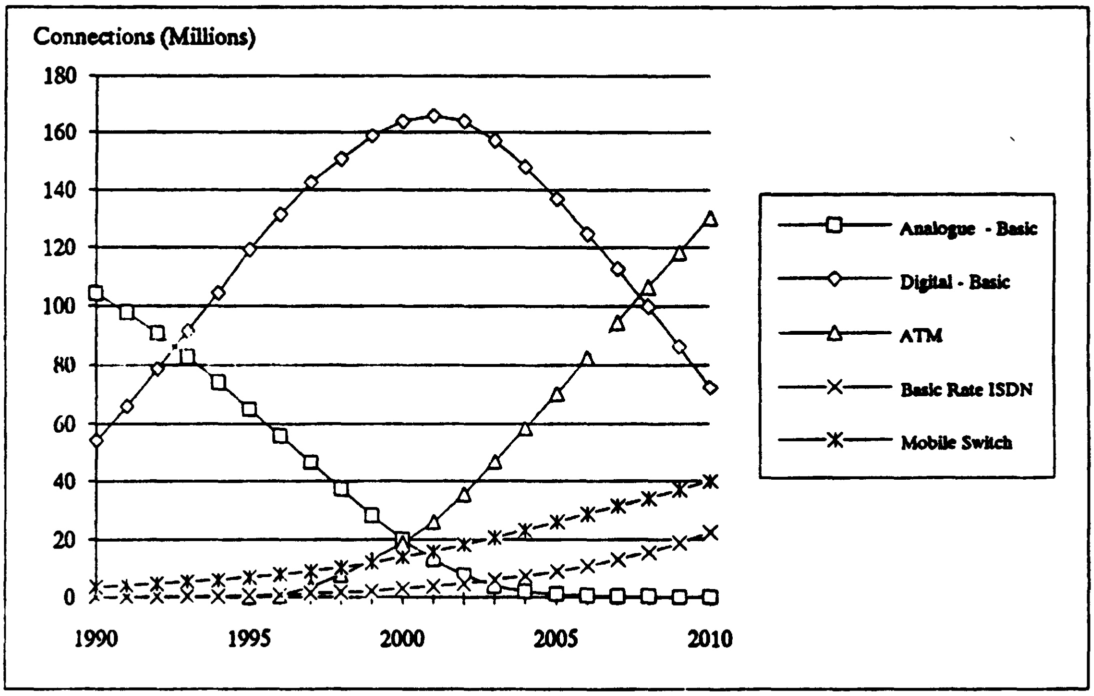


EXHIBIT EC.M.18: Local Switch Connections



13

EC Total Minimum Case

EXHIBIT EC.M.19: Junction Transmission Installed Capacity

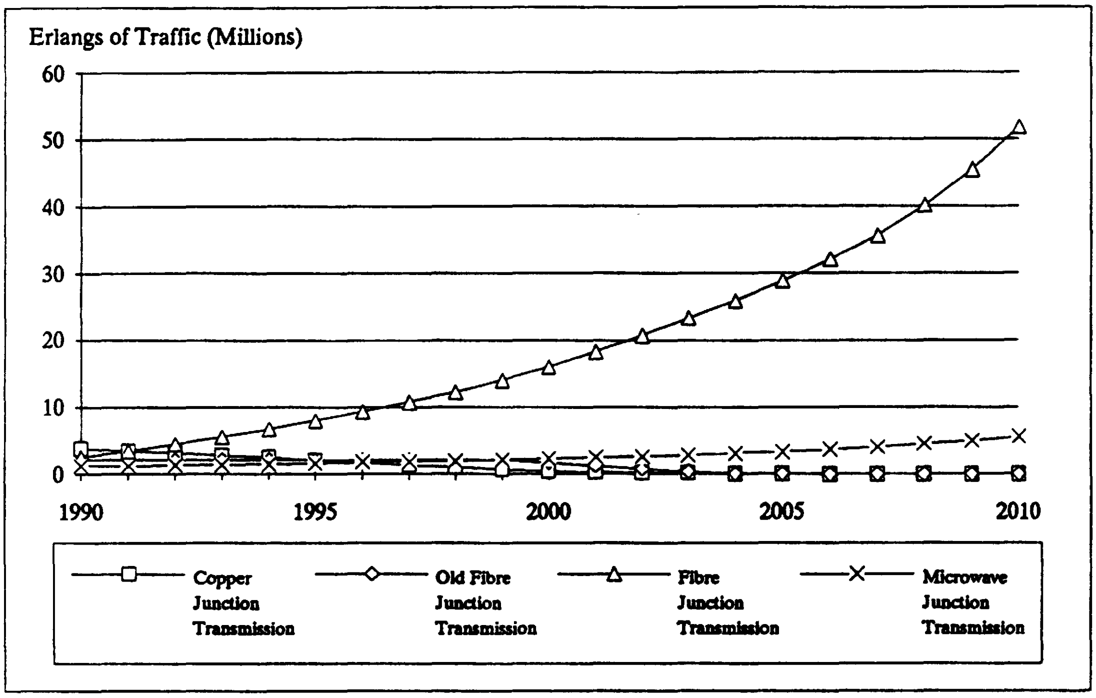
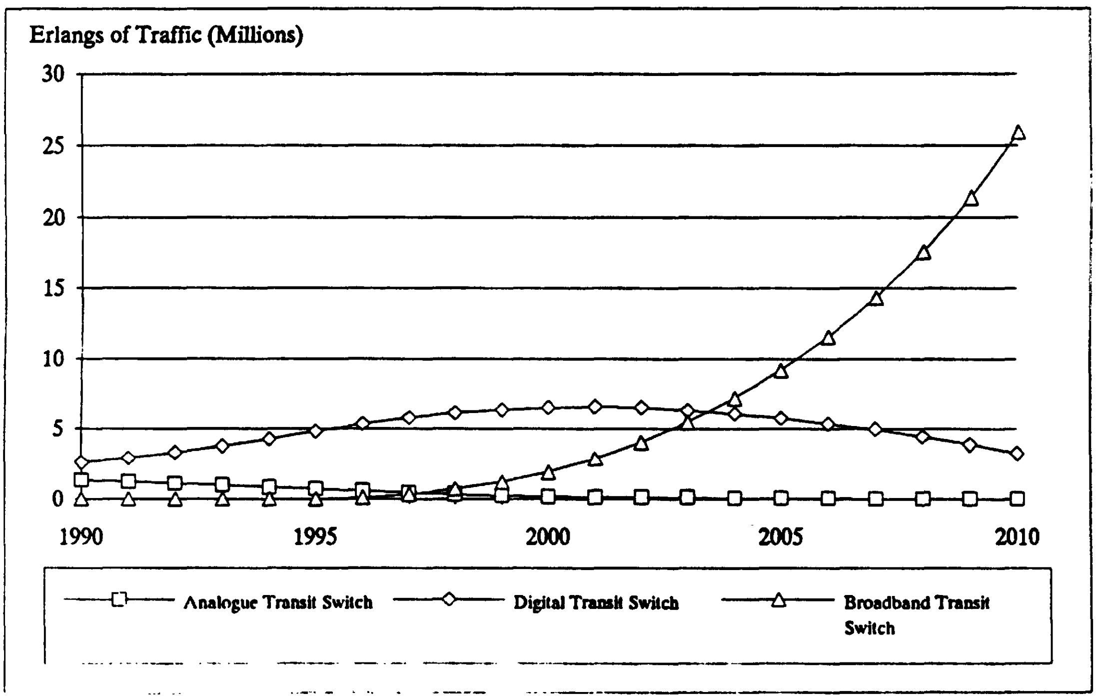


EXHIBIT EC.M.20: Transit Switch Installed Capacity



EC Total Minimum Case

EXHIBIT EC.M.21: Transit Transmission Installed Capacity

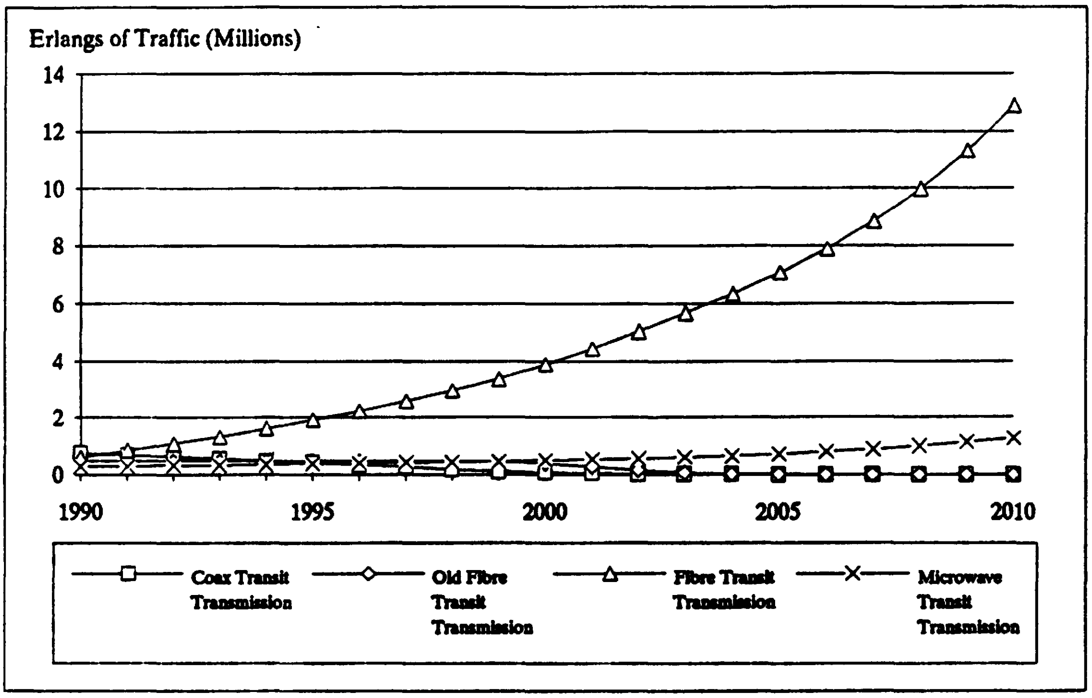
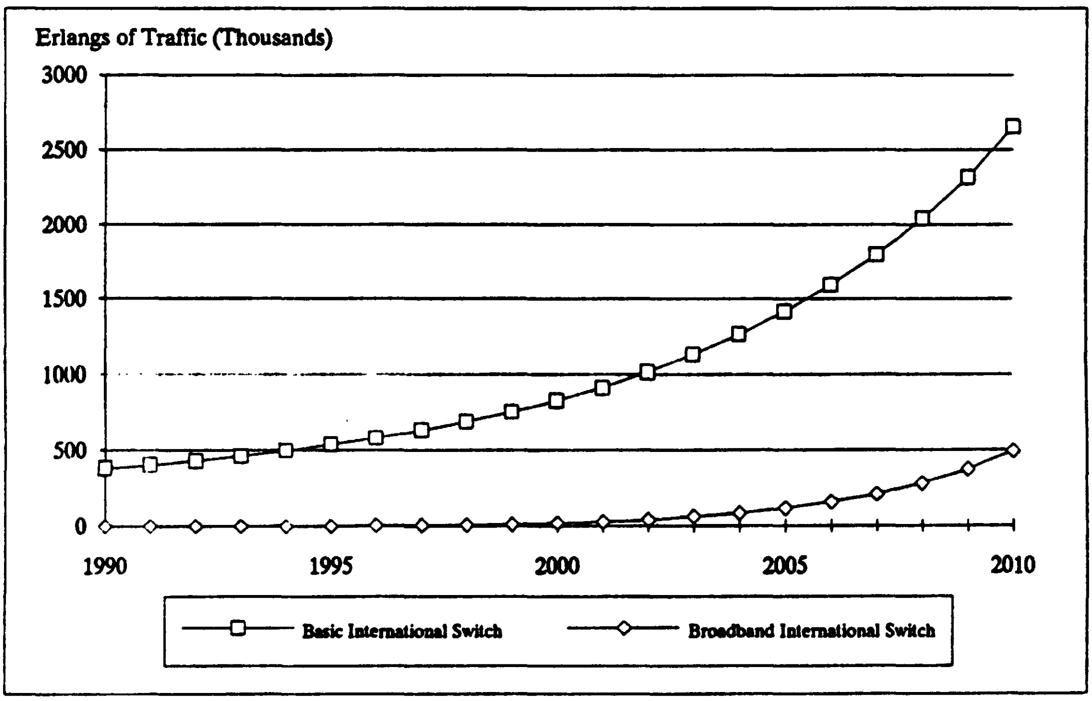


EXHIBIT EC.M.22: International Switch Installed Capacity



155

EC Total Minimum Case

EXHIBIT EC.M.23: International Transmission Installed Capacity

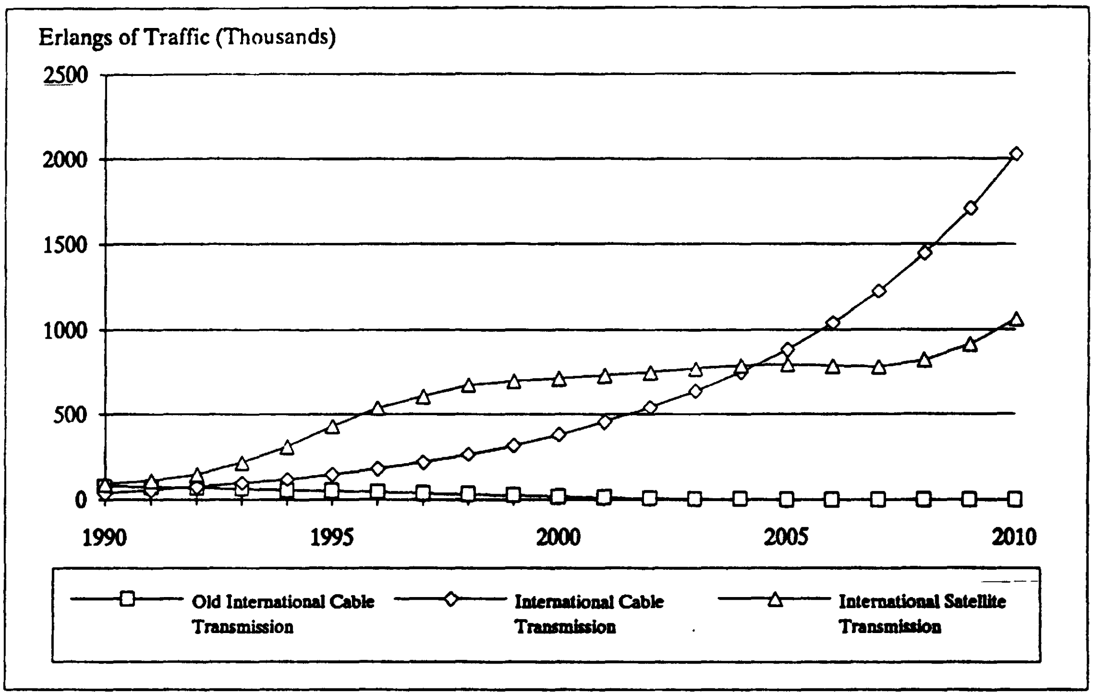
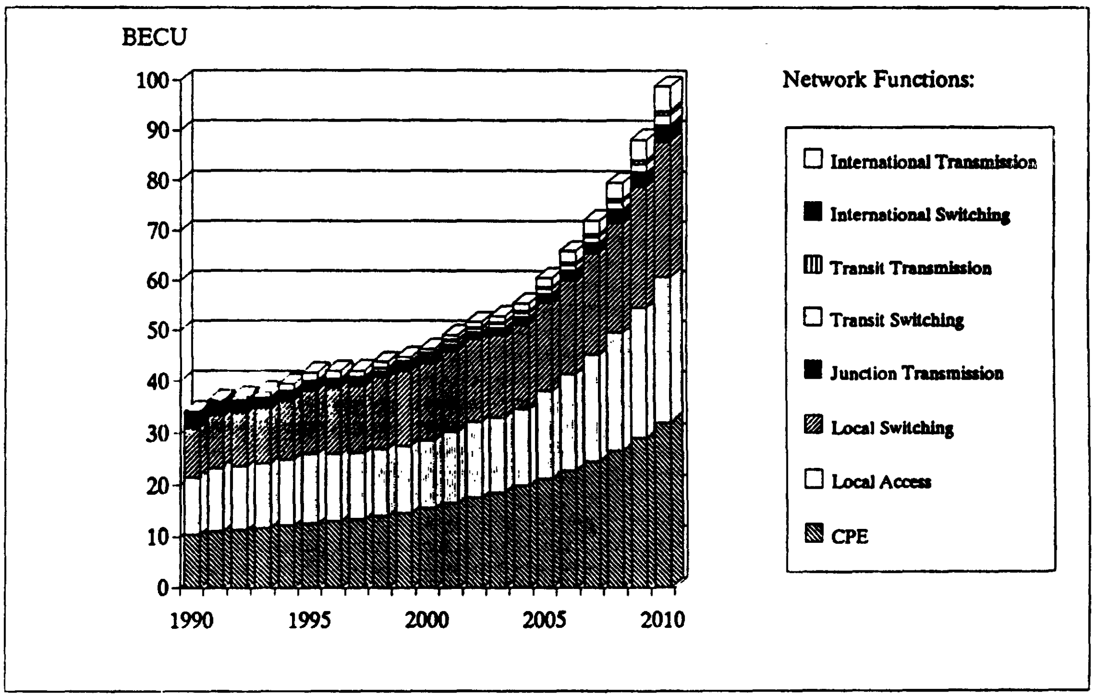


EXHIBIT EC.M.24: Network Capital Outlay



EC Total Minimum Case

EXHIBIT EC.M.25: CPE Expenditure

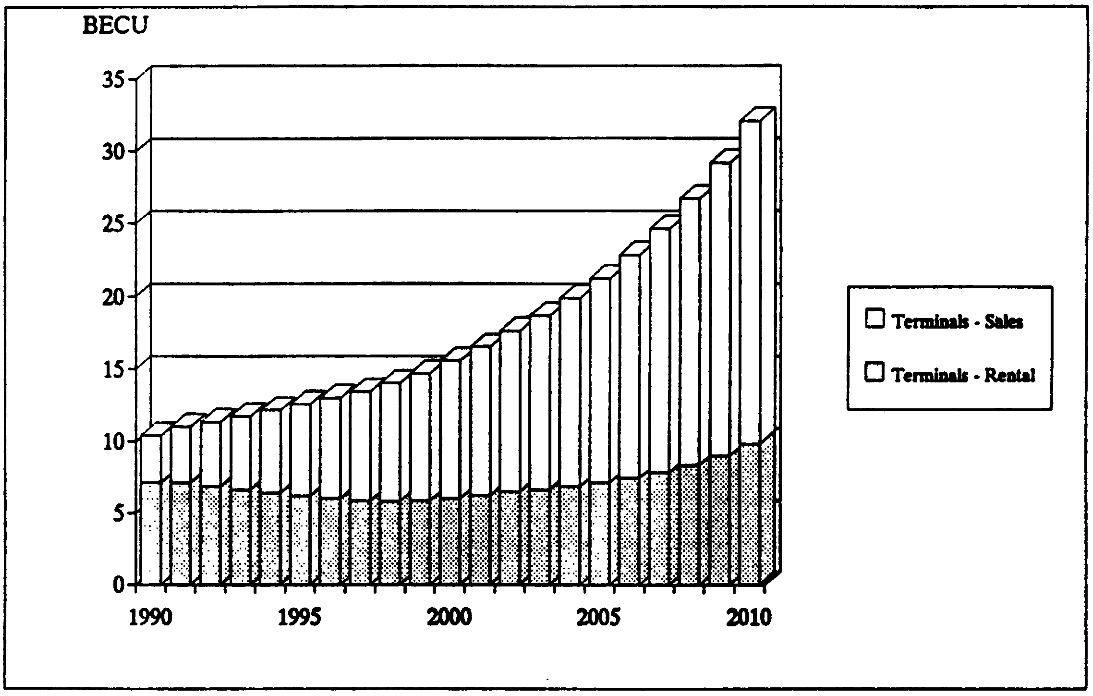
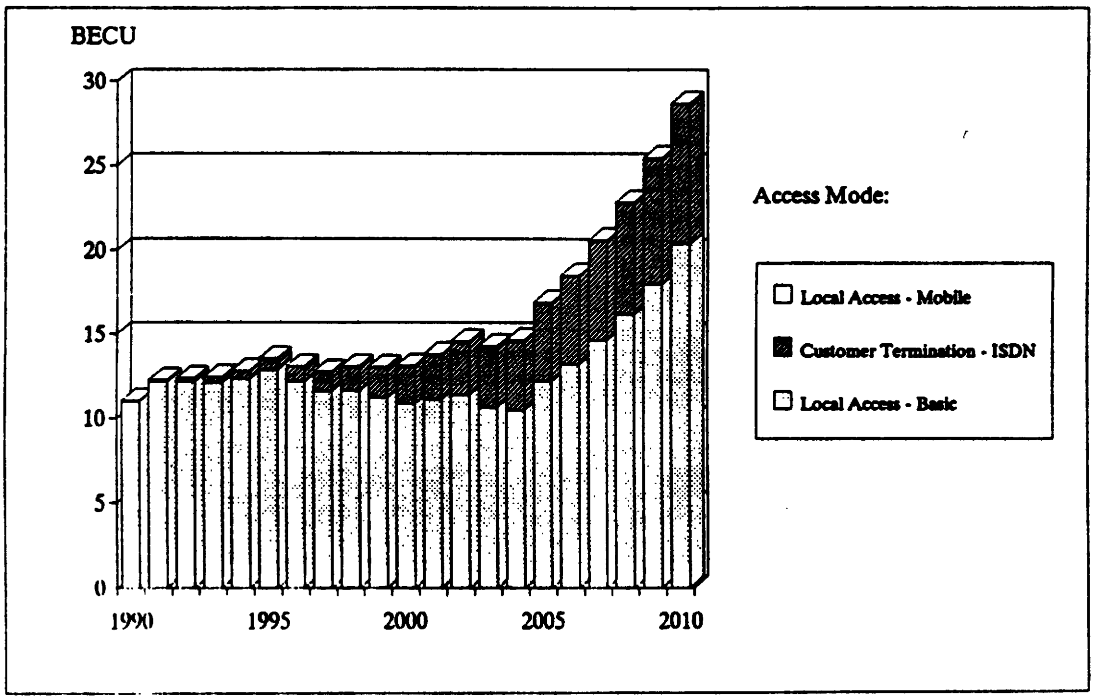


EXHIBIT EC.M.26: Local Access Capital Outlay



EC Total Minimum Case

EXHIBIT EC.M.27: Local Switching Capital Outlay

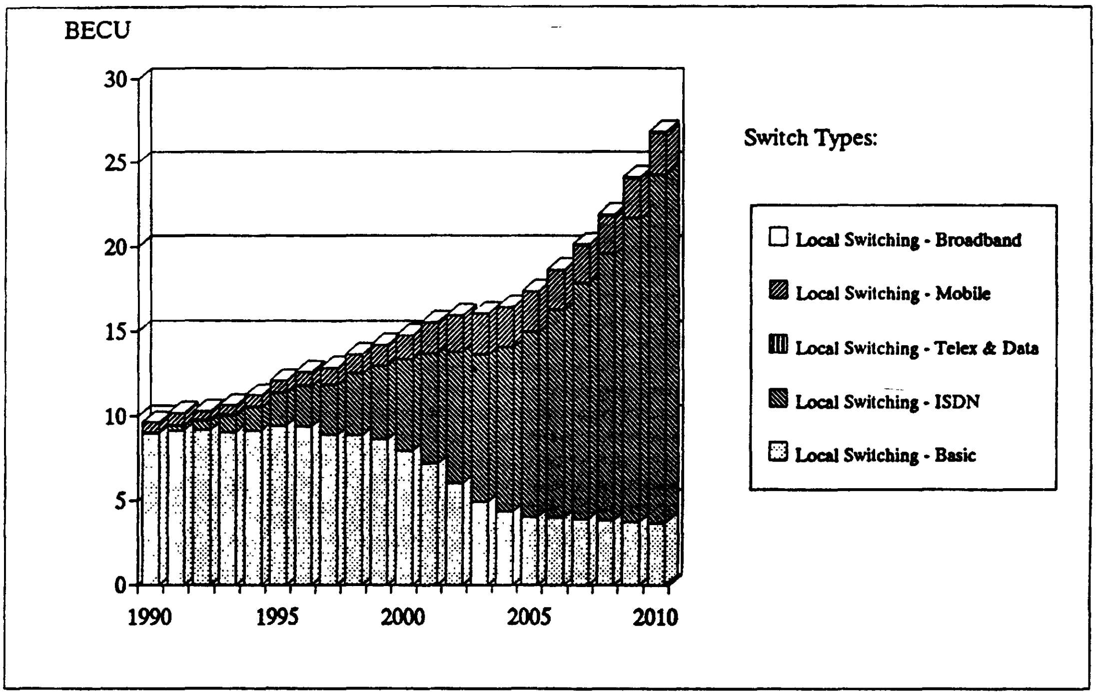
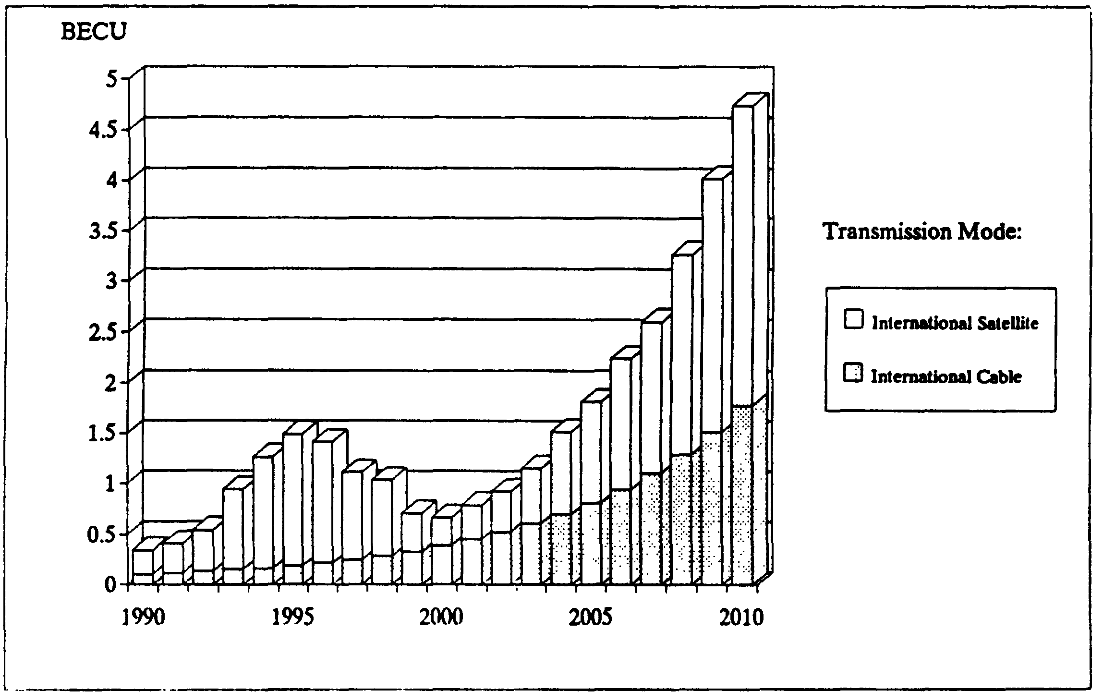


EXHIBIT EC.M.28: International Transmission Capital Outlay



EC Total Minimum Case

EXHIBIT EC.M.29: Revenue and Charge per Connection: Basic Telephony Business

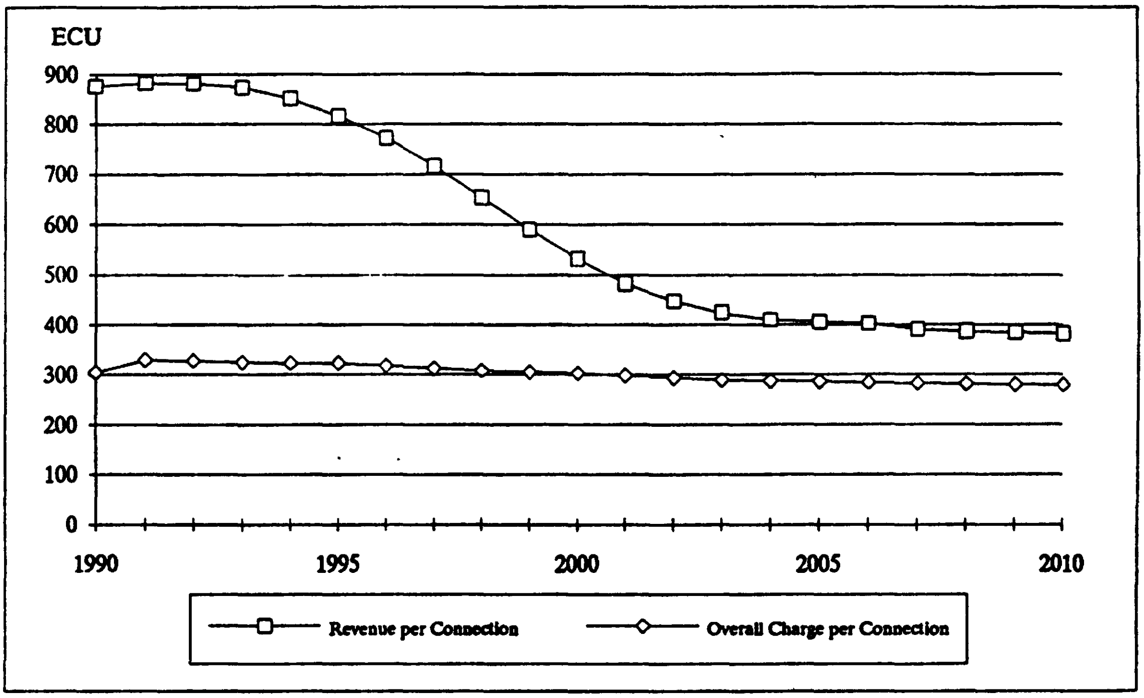
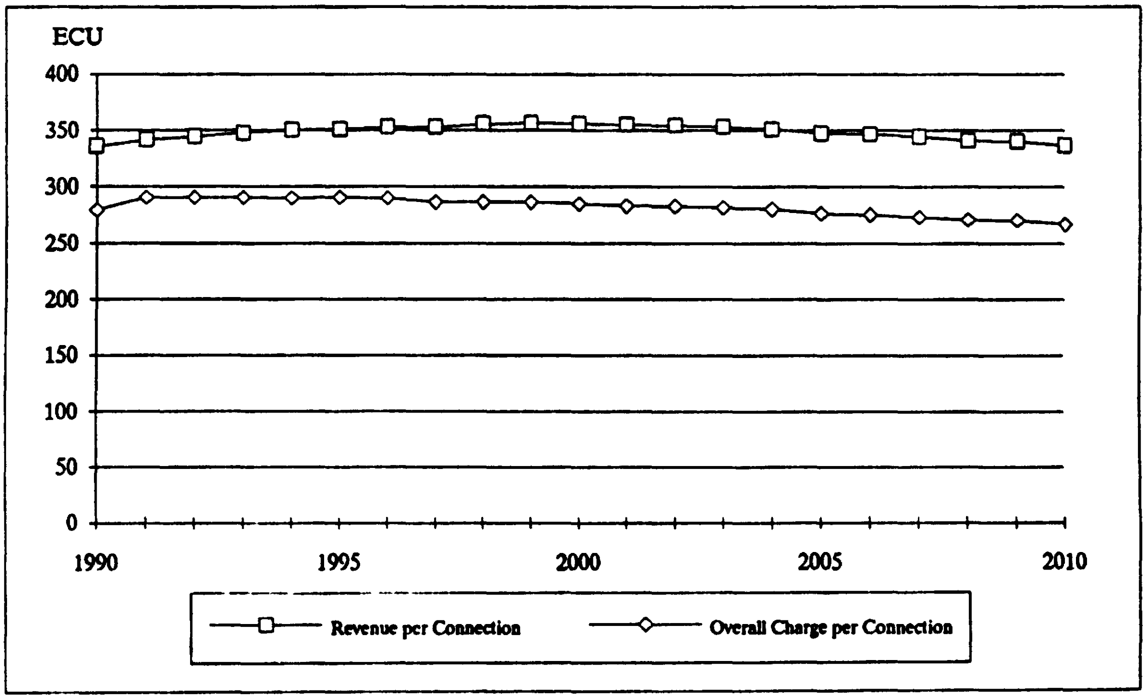


EXHIBIT EC.M.30: Revenue and Charge per Connection: Basic Telephony Residential



EC Total Minimum Case

EXHIBIT EC.M.31: Revenue and Charge per Connection: Mobiles

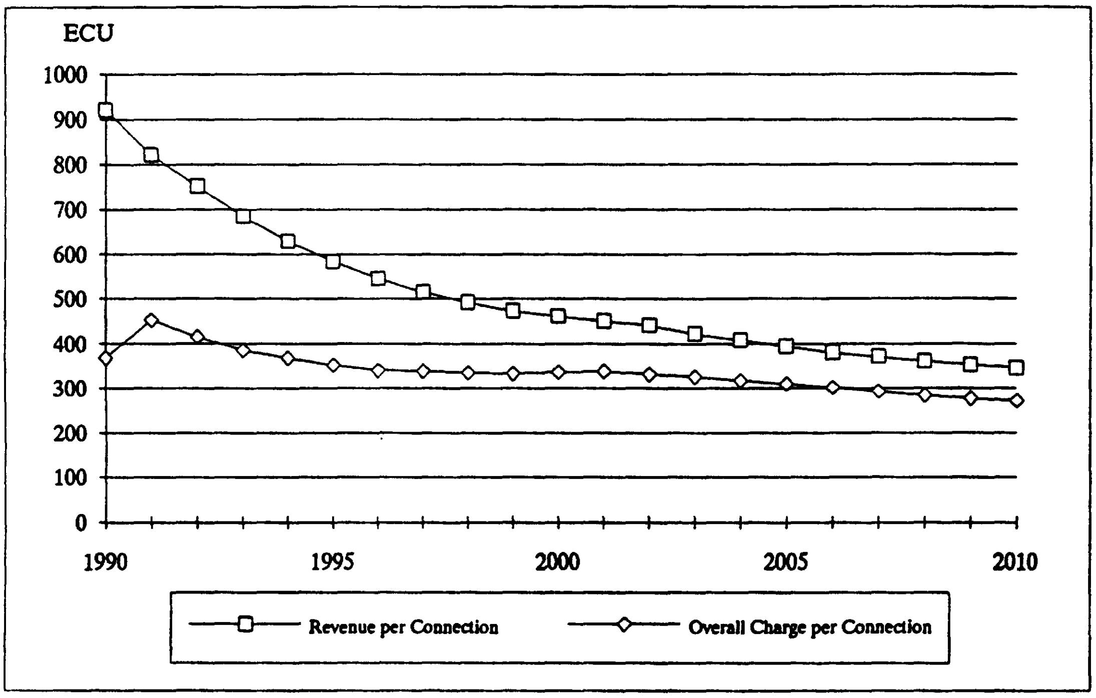
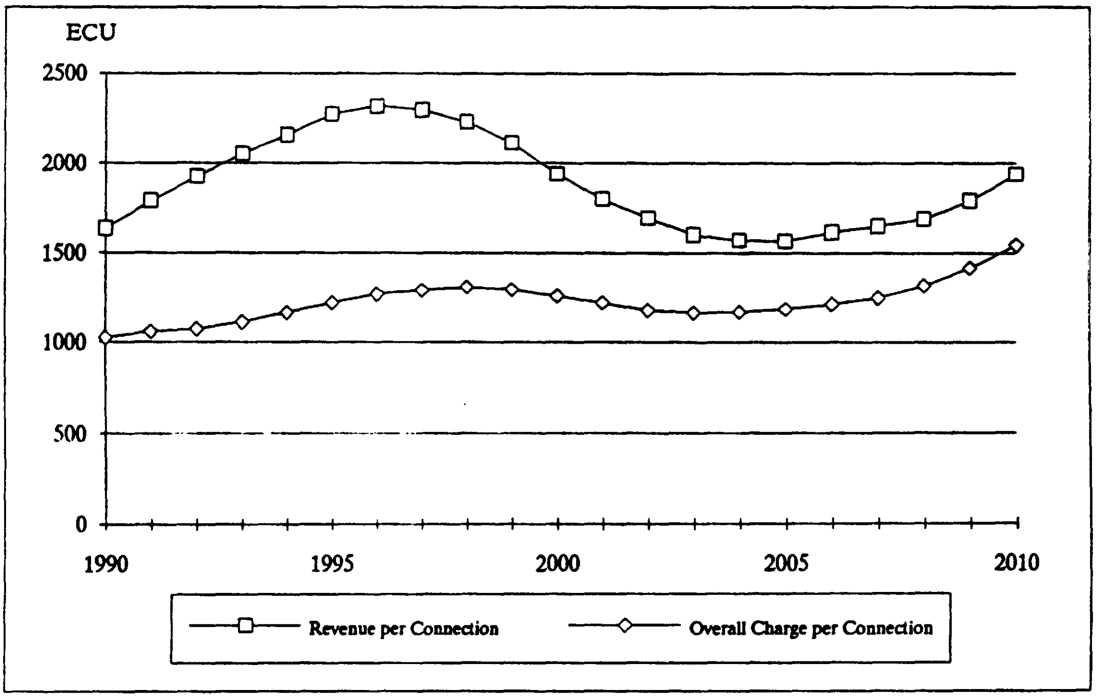


EXHIBIT EC.M.32: Revenue and Charge per Connection: Leased Lines



EC Total Minimum Case

EXHIBIT EC.M.33: Revenue and Charge per Connection: ISDN

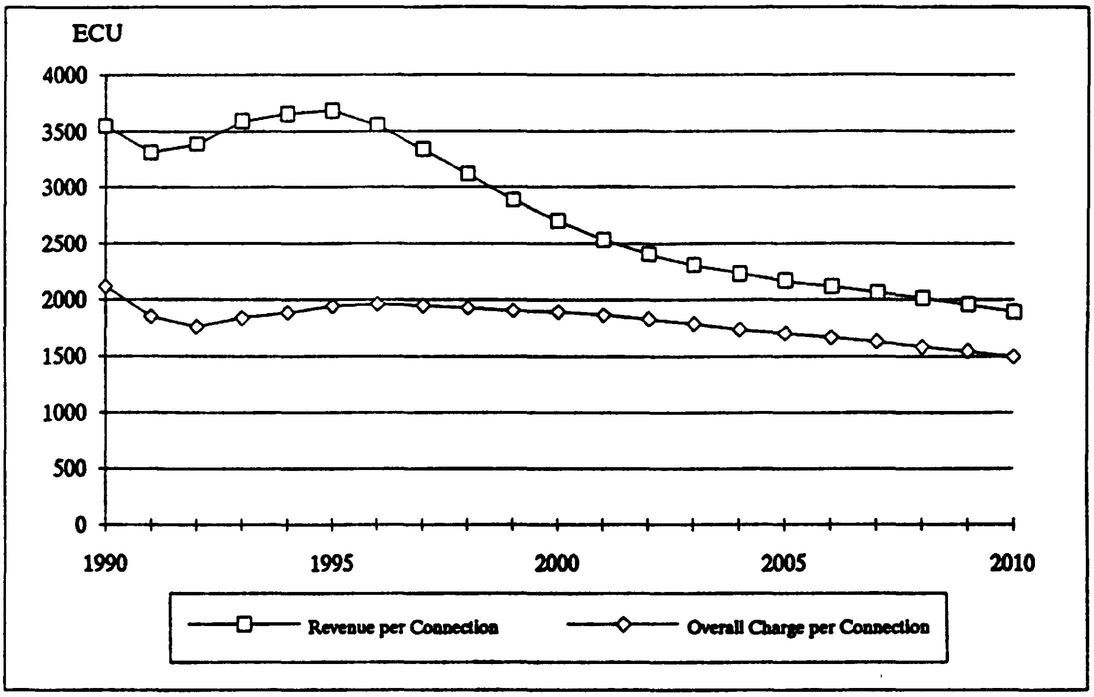
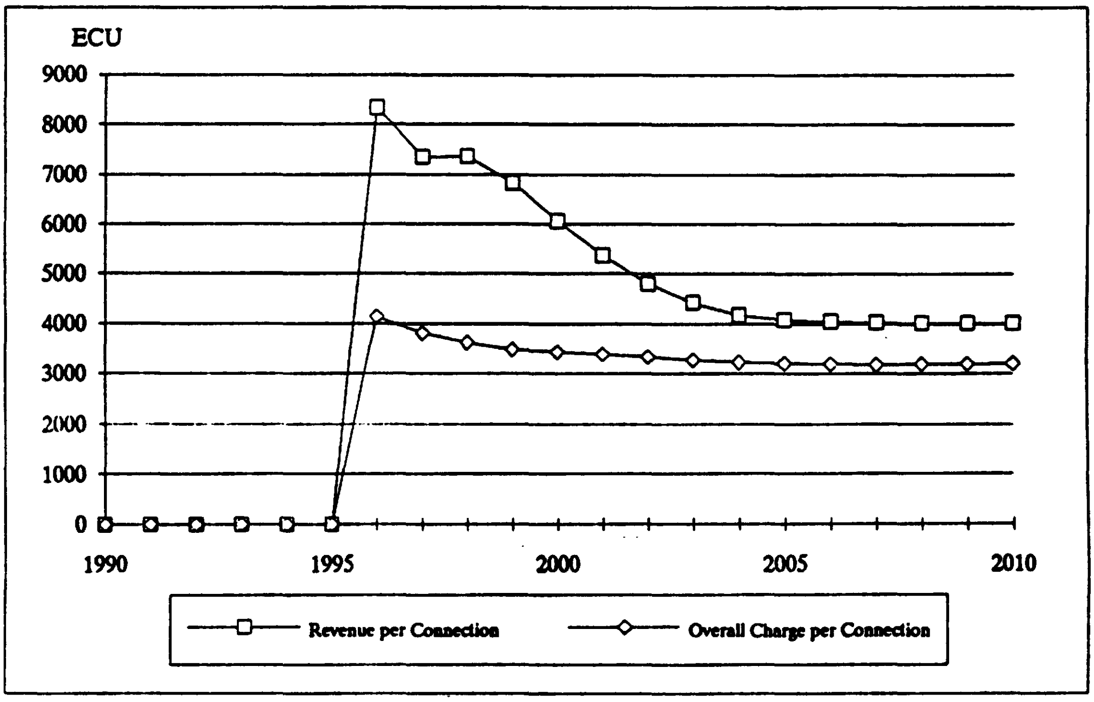


EXHIBIT EC.M.34: Revenue and Charge per Connection: Broadband



EC Total Minimum Case

EXHIBIT EC.M.35: CPE Revenue & Costs

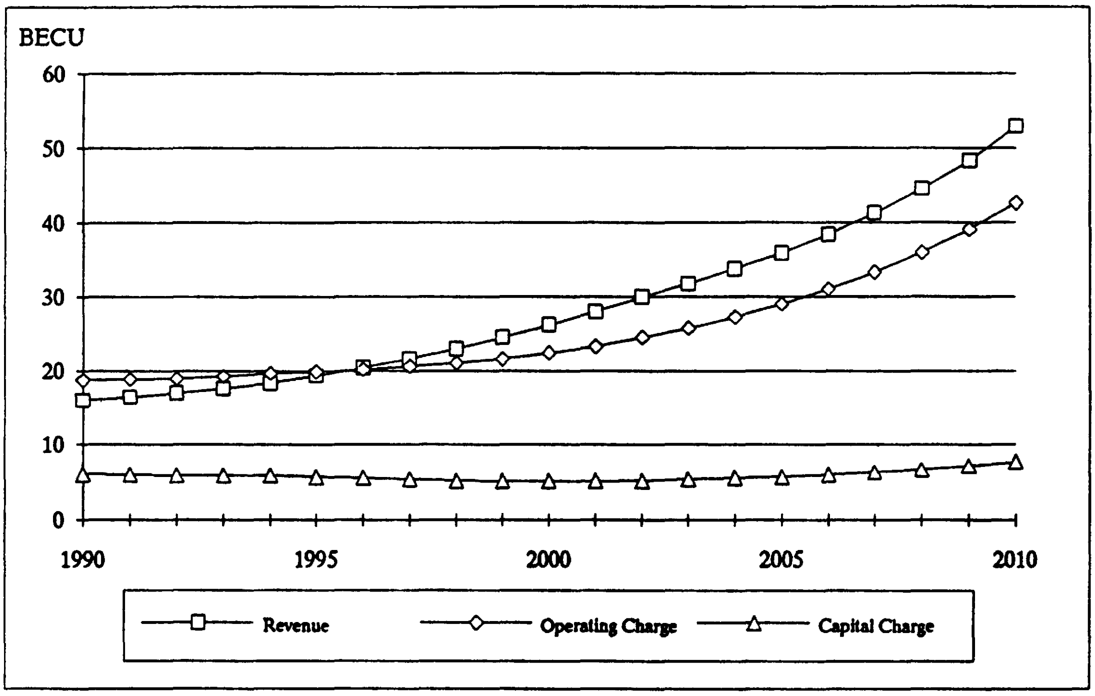
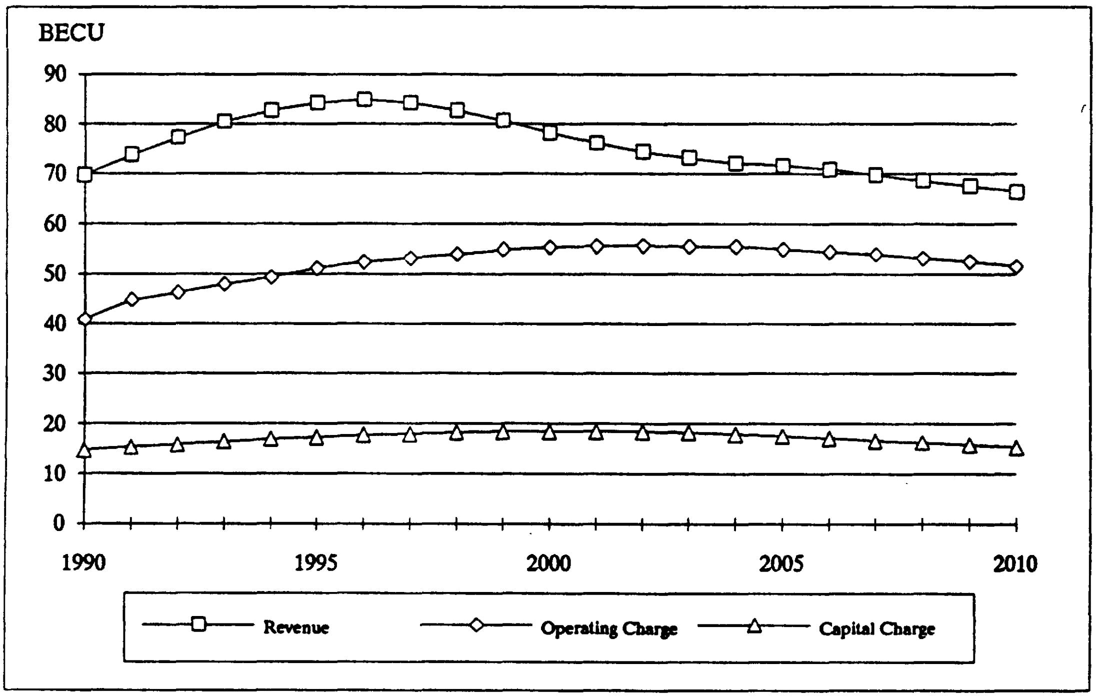


EXHIBIT EC.M.36: Telephony Revenue & Costs



EC Total Minimum Case

EXHIBIT EC.M.37: Leased Lines Revenue & Costs

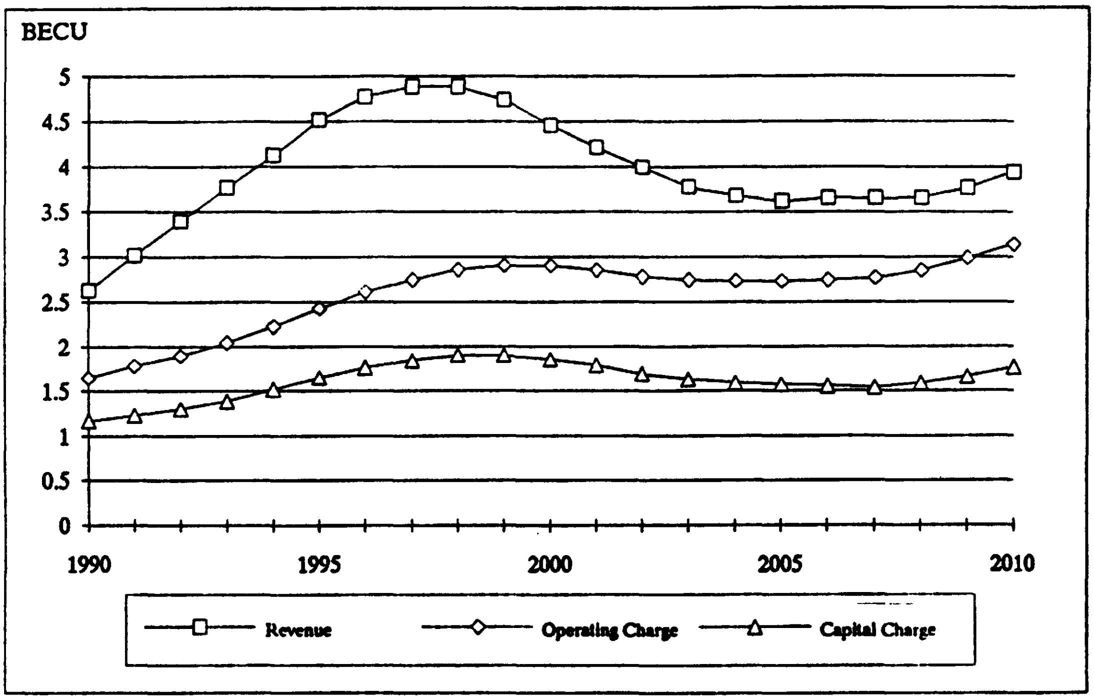
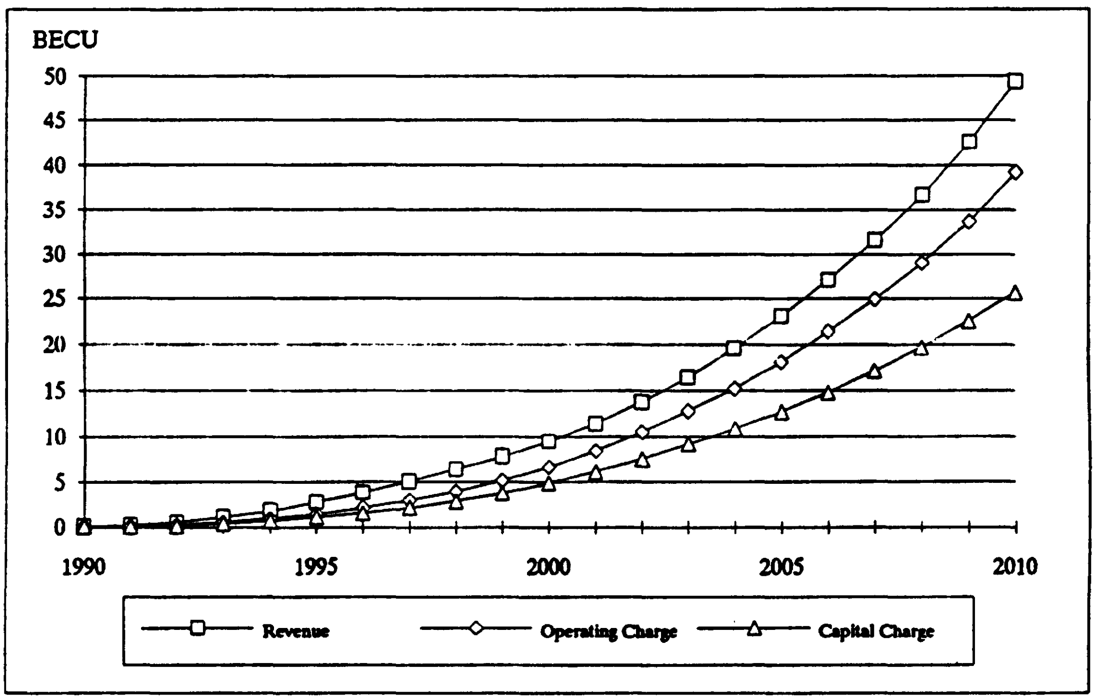


EXHIBIT EC.M.38: ISDN Revenue & Costs



EC Total Minimum Case

EXHIBIT EC.M.39: Mobiles Revenue & Costs

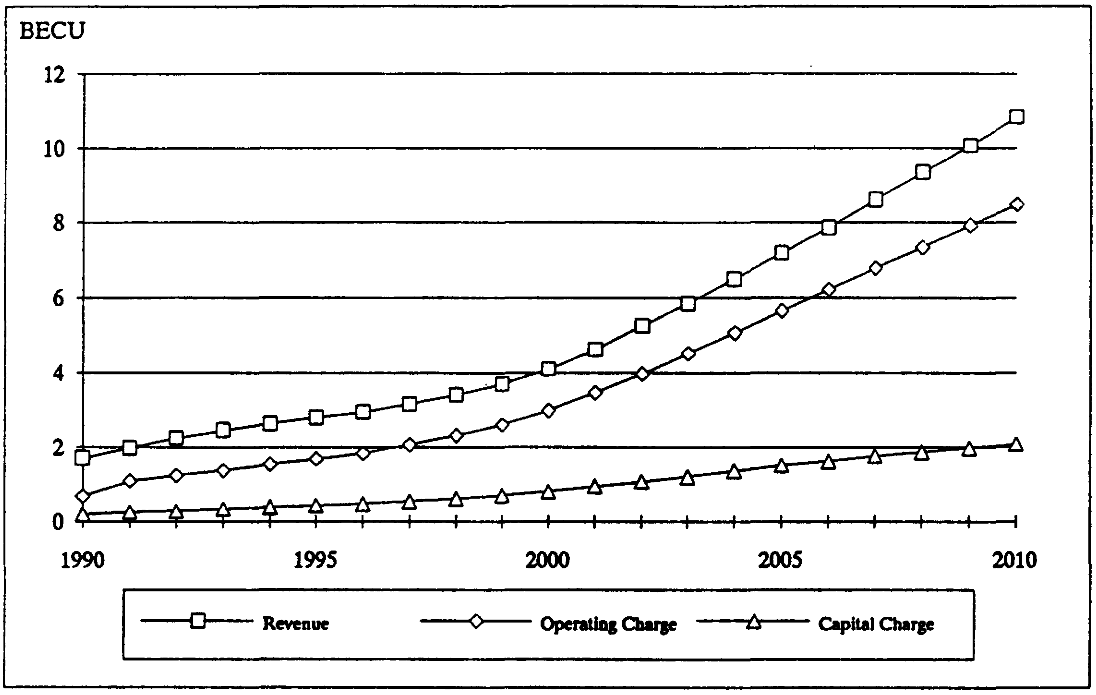
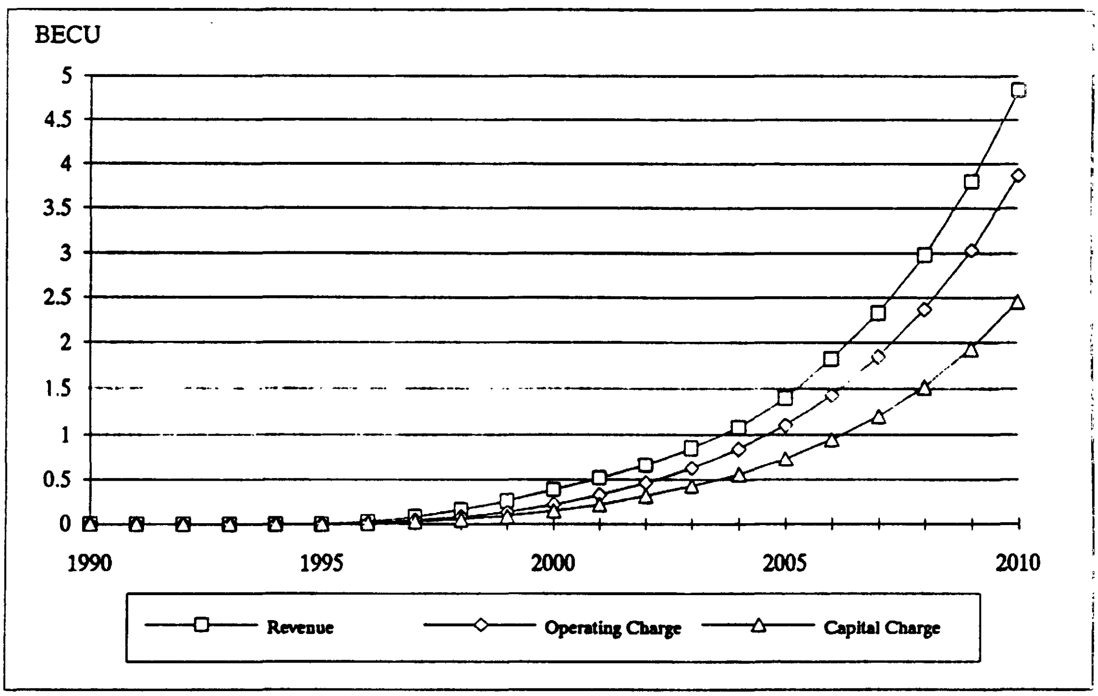


EXHIBIT EC.M.40: Broadband Revenue & Costs



EC Total TO
Company Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU Year (1990 refers to financial year 1989/90)	1990	1991	1992	1993	1994	1995
Profit and Loss Account						
Turnover	84,948	89,109	93,223	97,326	100,629	103,583
Operating Costs	62,085	64,069	65,657	67,414	69,312	71,366
Operating Profit before Interest	22,863	25,040	27,566	29,912	31,318	32,218
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,963	7,537	7,188	6,708	6,166	5,638
Profit on Ordinary Activities before Tax	13,717	17,502	20,378	23,204	25,151	26,579
Tax on the Profit of Ordinary Activities	6,556	7,656	8,883	10,064	10,812	11,288
Profit on Ordinary Activities after Tax	7,161	9,847	11,495	13,140	14,339	15,291
Profit Attributable to Ordinary Shareholders	7,161	9,847	11,495	13,140	14,339	15,291
Ordinary Dividends	1,529	2,344	2,830	3,264	3,587	3,873
Retained Profit for the Financial Year	5,632	7,502	8,665	9,876	10,752	11,418
Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
Earnings per Share (ECU)	0.253	0.348	0.406	0.464	0.506	0.540
Profit Margin (%)	8.43%	11.05%	12.33%	13.50%	14.25%	14.76%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	79,853	87,355	96,020	105,896	116,648
Retained Profit for the Year	5,632	7,502	8,665	9,876	10,752	11,418
Reserves at the Year end	79,853	87,355	96,020	105,896	116,648	128,066
Balance Sheet						
Assets:						
Fixed Assets	179,894	188,671	196,871	204,351	211,534	219,287
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	18,552	19,678	20,733	21,581	22,361
Cash	7,342	6,891	8,118	11,714	16,208	20,782
Creditors (tax and dividends payable)	8,085	10,000	11,712	13,329	14,399	15,161
Creditors (other)	30,518	30,736	30,913	31,550	32,253	33,179
Net Current Assets	(11,659)	(12,934)	(12,469)	(10,073)	(6,504)	(2,838)
Fixed Assets plus Net Current Assets	168,235	175,737	184,402	194,278	205,030	216,448
Liabilities:						
Creditors (amounts falling due after more than one year	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	79,853	87,355	96,020	105,896	116,648	128,066
Total	168,235	175,737	184,402	194,278	205,030	216,448
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	13,717	17,502	20,378	23,204	25,151	26,579
Items not Involving Cash Movement: Depreciation	21,107	21,527	22,094	22,713	23,392	23,974
Total Funds Generated from Operations before Tax	34,824	39,030	42,471	45,917	48,543	50,553
Taxation Paid	6,967	6,556	7,656	8,883	10,064	10,812
Total Sources of Funds Net of Taxation	27,857	32,474	34,816	37,035	38,479	39,741
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	31,289	30,304	30,294	30,193	30,575	31,726
Dividends Paid	2,207	1,529	2,344	2,830	3,264	3,587
Increase in Working Capital	(1,587)	1,091	950	417	146	(146)
Total Application of Funds	31,909	32,924	33,588	33,439	33,984	35,168
Net Cash Outflow from Operations	(4,052)	(451)	1,227	3,596	4,494	4,574

EC Total TO
Company Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU — Year (1990 refers to financial year 1989/90)	1990	1996	1997	1998	1999	2000
Profit and Loss Account						
Turnover	84,948	105,821	106,860	107,172	107,154	107,075
Operating Costs	62,085	73,122	74,640	76,381	78,370	80,383
Operating Profit before Interest	22,863	32,700	32,219	30,791	28,784	26,692
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,963	5,271	4,938	4,618	4,357	4,162
Profit on Ordinary Activities before Tax	13,717	27,429	27,281	26,174	24,428	22,531
Tax on the Profit of Ordinary Activities	6,556	11,513	11,347	10,787	9,987	9,156
Profit on Ordinary Activities after Tax	7,161	15,916	15,934	15,387	14,440	13,374
Profit Attributable to Ordinary Shareholders	7,161	15,916	15,934	15,387	14,440	13,374
Ordinary Dividends	1,529	4,051	4,034	3,890	3,650	3,371
Retained Profit for the Financial Year	5,632	11,865	11,899	11,496	10,790	10,003
Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
Earnings per Share (ECU)	0.253	0.562	0.563	0.543	0.510	0.472
Profit Margin (%)	8.43%	15.04%	14.91%	14.36%	13.48%	12.49%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	128,066	139,931	151,830	163,327	174,117
Retained Profit for the Year	5,632	11,865	11,899	11,496	10,790	10,003
Reserves at the Year end	79,853	139,931	151,830	163,327	174,117	184,120
Balance Sheet						
Assets:						
Fixed Assets	179,894	226,117	231,893	237,681	242,903	247,612
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	22,954	23,219	23,284	23,215	23,062
Cash	7,342	25,937	32,306	37,816	42,566	46,875
Creditors (tax and dividends payable)	8,085	15,564	15,382	14,677	13,637	12,528
Creditors (other)	30,518	33,491	34,183	34,754	34,907	34,879
Net Current Assets	(11,659)	2,196	8,319	14,028	19,595	24,890
Fixed Assets plus Net Current Assets	168,235	228,313	240,212	251,709	262,499	272,502
Liabilities:						
Creditors (amounts falling due after more than one year	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	79,853	139,931	151,830	163,327	174,117	184,120
Total	168,235	228,313	240,212	251,709	262,499	272,502
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	13,717	27,429	27,281	26,174	24,428	22,531
Items not Involving Cash Movement: Depreciation	21,107	24,649	25,377	26,197	27,157	28,230
Total Funds Generated from Operations before Tax	34,824	52,078	52,657	52,371	51,584	50,761
Taxation Paid	6,967	11,288	11,513	11,347	10,787	9,987
Total Sources of Funds Net of Taxation	27,857	40,789	41,145	41,024	40,797	40,773
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	31,289	31,479	31,153	31,985	32,379	32,939
Dividends Paid	2,207	3,873	4,051	4,034	3,890	3,650
Increase in Working Capital	(1,587)	282	(428)	(506)	(222)	(125)
Total Application of Funds	31,909	35,633	34,776	35,514	36,047	36,464
Net Cash Outflow from Operations	(4,052)	5,156	6,369	5,510	4,750	4,309

EC Total TO
Company Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU						
Year (1990 refers to financial year 1989/90)	1990	2001	2002	2003	2004	2005
Profit and Loss Account						
Turnover	84,948	107,395	108,495	110,156	112,659	115,999
Operating Costs	62,085	82,617	84,966	87,376	90,105	93,004
Operating Profit before Interest	22,863	24,778	23,529	22,780	22,554	22,995
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,963	4,009	3,888	3,697	3,407	3,125
Profit on Ordinary Activities before Tax	13,717	20,769	19,641	19,083	19,147	19,870
Tax on the Profit of Ordinary Activities	6,556	8,410	7,928	7,677	7,675	7,954
Profit on Ordinary Activities after Tax	7,161	12,360	11,713	11,406	11,472	11,916
Profit Attributable to Ordinary Shareholders	7,161	12,360	11,713	11,406	11,472	11,916
Ordinary Dividends	1,529	3,080	2,880	2,754	2,722	2,776
Retained Profit for the Financial Year	5,632	9,279	8,833	8,652	8,750	9,140
Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
Earnings per Share (ECU)	0.253	0.436	0.414	0.403	0.405	0.421
Profit Margin (%)	8.43%	11.51%	10.80%	10.35%	10.18%	10.27%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	184,120	193,399	202,232	210,884	219,634
Retained Profit for the Year	5,632	9,279	8,833	8,652	8,750	9,140
Reserves at the Year end	79,853	193,399	202,232	210,884	219,634	228,775
Balance Sheet						
Assets:						
Fixed Assets	179,894	252,576	257,431	260,702	263,430	267,880
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	23,031	23,187	23,499	24,004	24,708
Cash	7,342	51,144	55,092	60,191	66,317	73,200
Creditors (tax and dividends payable)	8,085	11,490	10,808	10,431	10,397	10,730
Creditors (other)	30,518	35,839	36,647	37,054	37,696	40,260
Net Current Assets	(11,659)	29,205	33,183	38,564	44,587	49,277
Fixed Assets plus Net Current Assets	168,235	281,781	290,614	299,266	308,016	317,157
Liabilities:						
Creditors (amounts falling due after more than one year	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	79,853	193,399	202,232	210,884	219,634	228,775
Total	168,235	281,781	290,614	299,266	308,016	317,157
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	13,717	20,769	19,641	19,083	19,147	19,870
Items not Involving Cash Movement: Depreciation	21,107	29,455	30,753	32,164	33,731	35,337
Total Funds Generated from Operations before Tax	34,824	50,224	50,394	51,247	52,878	55,207
Taxation Paid	6,967	9,156	8,410	7,928	7,677	7,675
Total Sources of Funds Net of Taxation	27,857	41,068	41,984	43,319	45,201	47,532
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	31,289	34,419	35,608	35,435	36,459	39,787
Dividends Paid	2,207	3,371	3,080	2,880	2,754	2,722
Increase in Working Capital	(1,587)	(991)	(652)	(95)	(138)	(1,860)
Total Application of Funds	31,909	36,799	38,036	38,220	39,075	40,649
Net Cash Outflow from Operations	(4,052)	4,268	3,948	5,099	6,126	6,884

EC Total TO
Company Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU Year (1990 refers to financial year 1989/90)	1990	2006	2007	2008	2009	2010
Profit and Loss Account						
Turnover	84,948	119,686	123,556	128,450	134,256	141,041
Operating Costs	62,085	96,207	99,757	103,871	108,659	114,229
Operating Profit before Interest	22,863	23,478	23,799	24,579	25,597	26,812
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,963	2,930	2,834	2,851	2,987	3,275
Profit on Ordinary Activities before Tax	13,717	20,548	20,964	21,728	22,610	23,537
Tax on the Profit of Ordinary Activities	6,556	8,212	8,379	8,663	8,996	9,344
Profit on Ordinary Activities after Tax	7,161	12,337	12,586	13,065	13,615	14,193
Profit Attributable to Ordinary Shareholders	7,161	12,337	12,586	13,065	13,615	14,193
Ordinary Dividends	1,529	2,836	2,868	2,957	3,060	3,169
Retained Profit for the Financial Year	5,632	9,500	9,718	10,108	10,555	11,024
Number of Ordinary Shares (millions)	28,316	28,316	28,316	28,316	28,316	28,316
Earnings per Share (ECU)	0.253	0.436	0.444	0.461	0.481	0.501
Profit Margin (%)	8.43%	10.31%	10.19%	10.17%	10.14%	10.06%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	228,775	238,275	247,993	258,101	268,656
Retained Profit for the Year	5,632	9,500	9,718	10,108	10,555	11,024
Reserves at the Year end	79,853	238,275	247,993	258,101	268,656	279,680
Balance Sheet						
Assets:						
Fixed Assets	179,894	273,883	281,642	291,836	304,611	320,912
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	25,528	26,353	27,439	28,717	30,190
Cash	7,342	78,214	81,888	83,760	83,785	81,160
Creditors (tax and dividends payable)	8,085	11,048	11,246	11,620	12,056	12,513
Creditors (other)	30,518	42,279	44,620	47,291	50,379	54,047
Net Current Assets	(11,659)	52,774	54,733	54,647	52,427	47,149
Fixed Assets plus Net Current Assets	168,235	326,657	336,375	346,483	357,038	368,062
Liabilities:						
Creditors (amounts falling due after more than one year	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	79,853	238,275	247,993	258,101	268,656	279,680
Total	168,235	326,657	336,375	346,483	357,038	368,062
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	13,717	20,548	20,964	21,728	22,610	23,537
Items not Involving Cash Movement: Depreciation	21,107	37,126	39,143	41,483	44,173	47,288
Total Funds Generated from Operations before Tax	34,824	57,675	60,108	63,211	66,783	70,825
Taxation Paid	6,967	7,954	8,212	8,379	8,663	8,996
Total Sources of Funds Net of Taxation	27,857	49,721	51,896	54,832	58,120	61,829
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	31,289	43,130	46,902	51,677	56,948	63,590
Dividends Paid	2,207	2,776	2,836	2,868	2,957	3,060
Increase in Working Capital	(1,587)	(1,199)	(1,516)	(1,584)	(1,810)	(2,195)
Total Application of Funds	31,909	44,707	48,222	52,960	58,095	64,454
Net Cash Outflow from Operations	(4,052)	5,014	3,674	1,872	25	(2,625)

EC Total
Country Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU	1990	1991	1992	1993	1994	1995
Year (1990 refers to financial year 1989/90)	1990	1991	1992	1993	1994	1995
Profit and Loss Account						
Turnover	90,472	95,448	100,356	105,390	109,655	113,747
Operating Costs	66,640	69,250	71,381	73,818	76,456	79,279
Operating Profit before Interest	23,832	26,199	28,975	31,572	33,199	34,469
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,994	7,619	7,307	6,867	6,393	5,949
Profit on Ordinary Activities before Tax	14,656	18,580	21,667	24,705	26,806	28,520
Tax on the Profit of Ordinary Activities	6,686	7,821	9,126	10,406	11,242	11,878
Profit on Ordinary Activities after Tax	7,970	10,759	12,541	14,299	15,564	16,642
Profit Attributable to Ordinary Shareholders	7,970	10,759	12,541	14,299	15,564	16,642
Ordinary Dividends	1,840	2,604	3,147	3,634	3,997	4,325
Retained Profit for the Financial Year	6,130	8,155	9,394	10,664	11,568	12,317
Number of Ordinary Shares (millions)	30,157	30,157	30,157	30,157	30,157	30,157
Earnings per Share (ECU)	0.264	0.357	0.416	0.474	0.516	0.552
Profit Margin (%)	8.81%	11.27%	12.50%	13.57%	14.19%	14.63%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	80,351	88,506	97,900	108,564	120,132
Retained Profit for the Year	6,130	8,155	9,394	10,664	11,568	12,317
Reserves at the Year end	80,351	88,506	97,900	108,564	120,132	132,449
Balance Sheet						
Assets:						
Fixed Assets	180,327	189,825	198,574	206,937	215,251	224,381
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	18,606	19,791	20,933	21,895	22,849
Cash	7,848	7,451	9,063	12,983	17,519	22,061
Creditors (tax and dividends payable)	8,526	10,425	12,274	14,040	15,239	16,203
Creditors (other)	30,518	30,929	31,232	32,225	33,272	34,616
Net Current Assets	(11,594)	(12,937)	(12,292)	(9,991)	(6,737)	(3,551)
Fixed Assets plus Net Current Assets	168,733	176,888	186,282	196,946	208,514	220,831
Liabilities:						
reditors (amounts falling due after more than one year)	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	80,351	88,506	97,900	108,564	120,132	132,449
Total	168,733	176,888	186,282	196,946	208,514	220,831
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	14,656	18,580	21,667	24,705	26,806	28,520
Items not Involving Cash Movement: Depreciation	22,456	23,007	23,703	24,501	25,404	26,179
Total Funds Generated from Operations before Tax	37,112	41,587	45,370	49,206	52,210	54,699
Taxation Paid	6,967	6,686	7,821	9,126	10,406	11,242
Total Sources of Funds Net of Taxation	30,145	34,901	37,550	40,080	41,804	43,457
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	33,071	32,505	32,452	32,865	33,718	35,309
Dividends Paid	2,207	1,840	2,604	3,147	3,634	3,997
Increase in Working Capital	(1,587)	953	882	148	(84)	(391)
Total Application of Funds	33,691	35,298	35,937	36,160	37,268	38,915
Net Cash Outflow from Operations	(3,546)	(397)	1,612	3,920	4,536	4,542

EC Total
Country Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU — Year (1990 refers to financial year 1989/90)	1990	1996	1997	1998	1999	2000
Profit and Loss Account						
Turnover	90,472	117,030	119,068	120,464	121,592	122,906
Operating Costs	66,640	81,849	84,197	86,881	89,848	93,058
Operating Profit before Interest	23,832	35,182	34,871	33,583	31,744	29,848
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,994	5,649	5,344	5,021	4,737	4,508
Profit on Ordinary Activities before Tax	14,656	29,533	29,527	28,562	27,007	25,340
Tax on the Profit of Ordinary Activities	6,686	12,217	12,164	11,712	11,026	10,312
Profit on Ordinary Activities after Tax	7,970	17,315	17,363	16,850	15,981	15,029
Profit Attributable to Ordinary Shareholders	7,970	17,315	17,363	16,850	15,981	15,029
Ordinary Dividends	1,840	4,523	4,507	4,360	4,125	3,858
Retained Profit for the Financial Year	6,130	12,792	12,855	12,490	11,856	11,171
Number of Ordinary Shares (millions)	30,157	30,157	30,157	30,157	30,157	30,157
Earnings per Share (ECU)	0.264	0.574	0.576	0.559	0.530	0.498
Profit Margin (%)	8.81%	14.80%	14.58%	13.99%	13.14%	12.23%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	132,449	145,241	158,096	170,586	182,442
Retained Profit for the Year	6,130	12,792	12,855	12,490	11,856	11,171
Reserves at the Year end	80,351	145,241	158,096	170,586	182,442	193,614

	1990	1996	1997	1998	1999	2000
Balance Sheet						
Assets:						
Fixed Assets	180,327	232,447	239,104	245,790	251,684	257,200
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	23,607	24,031	24,286	24,432	24,546
Cash	7,848	26,877	33,184	38,895	44,216	49,275
Creditors (tax and dividends payable)	8,526	16,740	16,671	16,072	15,151	14,169
Creditors (other)	30,518	34,927	35,529	36,290	36,716	37,213
Net Current Assets	(11,594)	1,176	7,375	13,178	19,140	24,795
Fixed Assets plus Net Current Assets	168,733	233,623	246,478	258,968	270,824	281.996
Liabilities:						
reditors (amounts falling due after more than one year)	82,393	82,393	82,393	82,393	82,393	82,398
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	80,351	145,241	158,096	170,586	182,442	193,61[illegible]
Total	168,733	233,623	246,478	258,968	270,824	281,998

	1990	1996	1997	1998	1999	2000
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	14,656	29,533	29,527	28,562	27,007	25,340
Items not Involving Cash Movement: Depreciation	22,456	27,039	27,940	28,959	30,090	31,339
Total Funds Generated from Operations before Tax	37,112	56,572	57,466	57,522	57,097	56,680
Taxation Paid	6,967	11,878	12,217	12,164	11,712	11,026
Total Sources of Funds Net of Taxation	30,145	44,694	45,249	45,358	45,385	45,653
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	33,071	35,104	34,597	35,646	35,984	36,855
Dividends Paid	2,207	4,325	4,523	4,507	4,360	4,125
Increase in Working Capital	(1,587)	447	(178)	(506)	(281)	(386)
Total Application of Funds	33,691	39,877	38,942	39,647	40,064	40,594
Net Cash Outflow from Operations	(3,546)	4,817	6,307	5,710	5,322	5,059

EC Total
Country Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

Network Operation
All figures real at 1990

MECU Year (1990 refers to financial year 1989/90)	1990	2001	2002	2003	2004	2005
Profit and Loss Account						
Turnover	90,472	124,810	127,941	131,752	136,664	142,720
Operating Costs	66,640	96,544	100,423	104,542	109,186	114,260
Operating Profit before Interest	23,832	28,267	27,518	27,209	27,478	28,460
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,994	4,318	4,154	3,914	3,569	3,230
Profit on Ordinary Activities before Tax	14,656	23,948	23,363	23,295	23,909	25,231
Tax on the Profit of Ordinary Activities	6,686	9,726	9,477	9,436	9,675	10,210
Profit on Ordinary Activities after Tax	7,970	14,223	13,887	13,859	14,234	15,021
Profit Attributable to Ordinary Shareholders	7,970	14,223	13,887	13,859	14,234	15,021
Ordinary Dividends	1,840	3,610	3,479	3,417	3,453	3,589
Retained Profit for the Financial Year	6,130	10,613	10,408	10,441	10,781	11,432
Number of Ordinary Shares (millions)	30,157	30,157	30,157	30,157	30,157	30,157
Earnings per Share (ECU)	0.264	0.472	0.460	0.460	0.472	0.498
Profit Margin (%)	8.81%	11.40%	10.85%	10.52%	10.42%	10.52%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	193,614	204,227	214,635	225,076	235,857
Retained Profit for the Year	6,130	10,613	10,408	10,441	10,781	11,432
Reserves at the Year end	80,351	204,227	214,635	225,076	235,857	247,289
Balance Sheet						
Assets:						
Fixed Assets	180,327	263,249	269,571	274,499	279,065	285,681
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	24,756	25,230	25,868	26,735	27,848
Cash	7,848	54,078	58,651	64,391	71,279	78,842
Creditors (tax and dividends payable)	8,526	13,335	12,955	12,854	13,128	13,798
Creditors (other)	30,518	38,498	39,839	40,805	42,071	45,260
Net Current Assets	(11,594)	29,359	33,446	38,959	45,174	49,991
Fixed Assets plus Net Current Assets	168,733	292,609	303,017	313,458	324,239	335,671
Liabilities:						
reditors (amounts falling due after more than one year)	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	80,351	204,227	214,635	225,076	235,857	247,289
Total	168,733	292,609	303,017	313,458	324,239	335,671
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	14,656	23,948	23,363	23,295	23,909	25,231
Items not Involving Cash Movement: Depreciation	22,456	32,766	34,300	36,006	37,907	39,911
Total Funds Generated from Operations before Tax	37,112	56,715	57,663	59,302	61,816	65,141
Taxation Paid	6,967	10,312	9,726	9,477	9,436	9,675
Total Sources of Funds Net of Taxation	30,145	46,403	47,937	49,825	52,379	55,466
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	33,071	38,815	40,622	40,934	42,473	46,526
Dividends Paid	2,207	3,858	3,610	3,479	3,417	3,453
Increase in Working Capital	(1,587)	(1,073)	(867)	(328)	(399)	(2,076)
Total Application of Funds	33,691	41,600	43,365	44,085	45,492	47,903
Net Cash Outflow from Operations	(3,546)	4,803	4,573	5,740	6,888	7,564

EC Total
Country Accounts

Minimum Case

Analysys Ltd
STEM Accounts
Version 1.1

MECU				Network Operation All figures real at 1990		
Year (1990 refers to financial year 1989/90)	1990	2006	2007	2008	2009	2010
Profit and Loss Account						
Turnover	90,472	149,555	156,948	165,820	176,162	188,305
Operating Costs	66,640	119,886	126,174	133,447	141,827	151,627
Operating Profit before Interest	23,832	29,669	30,774	32,372	34,334	36,678
Exceptional Charge	1,183	0	0	0	0	0
Net Interest Paid	7,994	2,980	2,829	2,821	2,973	3,296
Profit on Ordinary Activities before Tax	14,656	26,689	27,946	29,552	31,361	33,383
Tax on the Profit of Ordinary Activities	6,686	10,797	11,329	11,984	12,720	13,544
Profit on Ordinary Activities after Tax	7,970	15,891	16,616	17,568	18,641	19,839
Profit Attributable to Ordinary Shareholders	7,970	15,891	16,616	17,568	18,641	19,839
Ordinary Dividends	1,840	3,759	3,909	4,119	4,354	4,622
Retained Profit for the Financial Year	6,130	12,133	12,708	13,450	14,286	15,216
Number of Ordinary Shares (millions)	30,157	30,157	30,157	30,157	30,157	30,157
Earnings per Share (ECU)	0.264	0.527	0.551	0.583	0.618	0.658
Profit Margin (%)	8.81%	10.63%	10.59%	10.59%	10.58%	10.54%
Movement in Reserves:						
Restated Reserves at Beginning of the Year	74,221	247,289	259,422	272,129	285,579	299,865
Retained Profit for the Year	6,130	12,133	12,708	13,450	14,286	15,216
Reserves at the Year end	80,351	259,422	272,129	285,579	299,865	315,082
Balance Sheet						
Assets:						
Fixed Assets	180,327	294,187	304,857	318,552	335,549	356,811
Current Assets:						
Stock	2,359	2,359	2,359	2,359	2,359	2,359
Debtors	17,243	29,172	30,541	32,237	34,239	36,579
Cash	7,848	84,712	89,218	91,912	92,465	90,210
Creditors (tax and dividends payable)	8,526	14,556	15,238	16,102	17,075	18,166
Creditors (other)	30,518	48,071	51,226	54,997	59,291	64,329
Net Current Assets	(11,594)	53,617	55,654	55,409	52,698	46,652
Fixed Assets plus Net Current Assets	168,733	347,804	360,511	373,961	388,247	403,464
Liabilities:						
reditors (amounts falling due after more than one year)	82,393	82,393	82,393	82,393	82,393	82,393
Provisions for Liabilities and Charges	5,227	5,227	5,227	5,227	5,227	5,227
Minority Interests	762	762	762	762	762	762
Capital and Reserves	80,351	259,422	272,129	285,579	299,865	315,083
Total	168,733	347,804	360,511	373,961	388,247	403,464
Source and Application of Funds						
Source of Funds:						
Profit on Ordinary Activities before Tax	14,656	26,689	27,946	29,552	31,361	33,383
Items not Involving Cash Movement: Depreciation	22,456	42,139	44,674	47,648	51,130	55,185
Total Funds Generated from Operations before Tax	37,112	68,828	72,619	77,200	82,491	88,567
Taxation Paid	6,967	10,210	10,797	11,329	11,984	12,720
Total Sources of Funds Net of Taxation	30,145	58,618	61,822	65,871	70,508	75,847
Application of Funds:						
Net Expenditure on Tangible Fixed Assets	33,071	50,646	55,344	61,343	68,128	76,447
Dividends Paid	2,207	3,589	3,759	3,909	4,119	4,354
Increase in Working Capital	(1,587)	(1,486)	(1,787)	(2,075)	(2,292)	(2,698)
Total Application of Funds	33,691	52,748	57,316	63,177	69,954	78,102
Net Cash Outflow from Operations	(3,546)	5,870	4,506	2,694	554	(2,256)

EC Total Minimum Case

EXHIBIT EC.M.41: Total Variation of Service Revenues from Costs

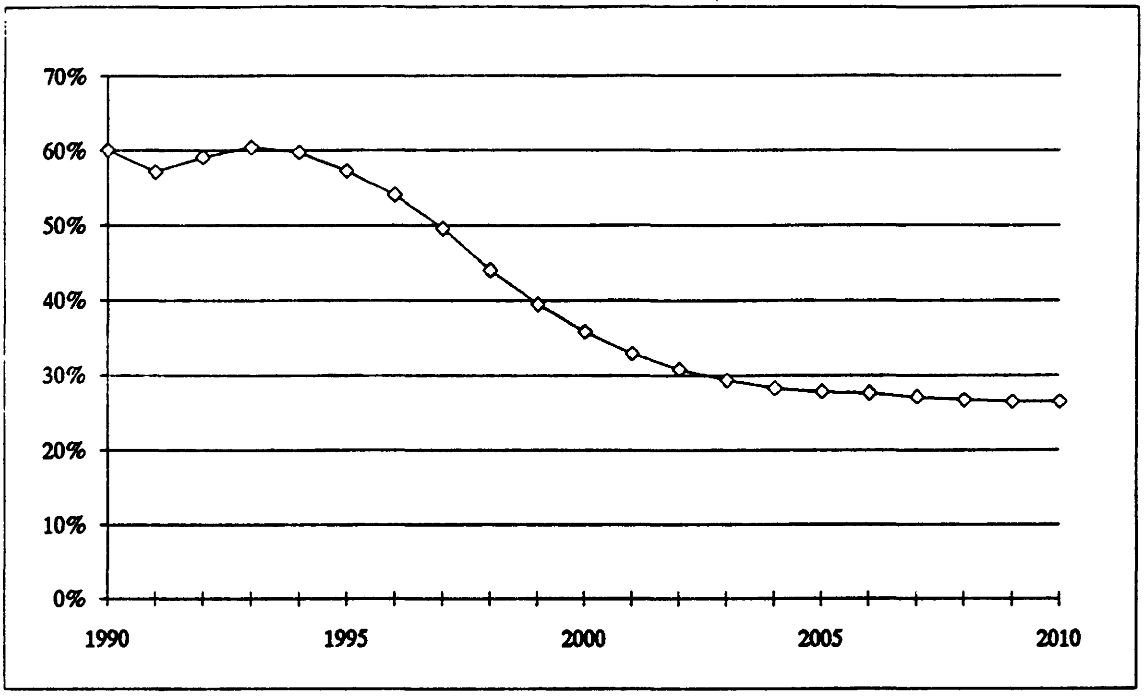
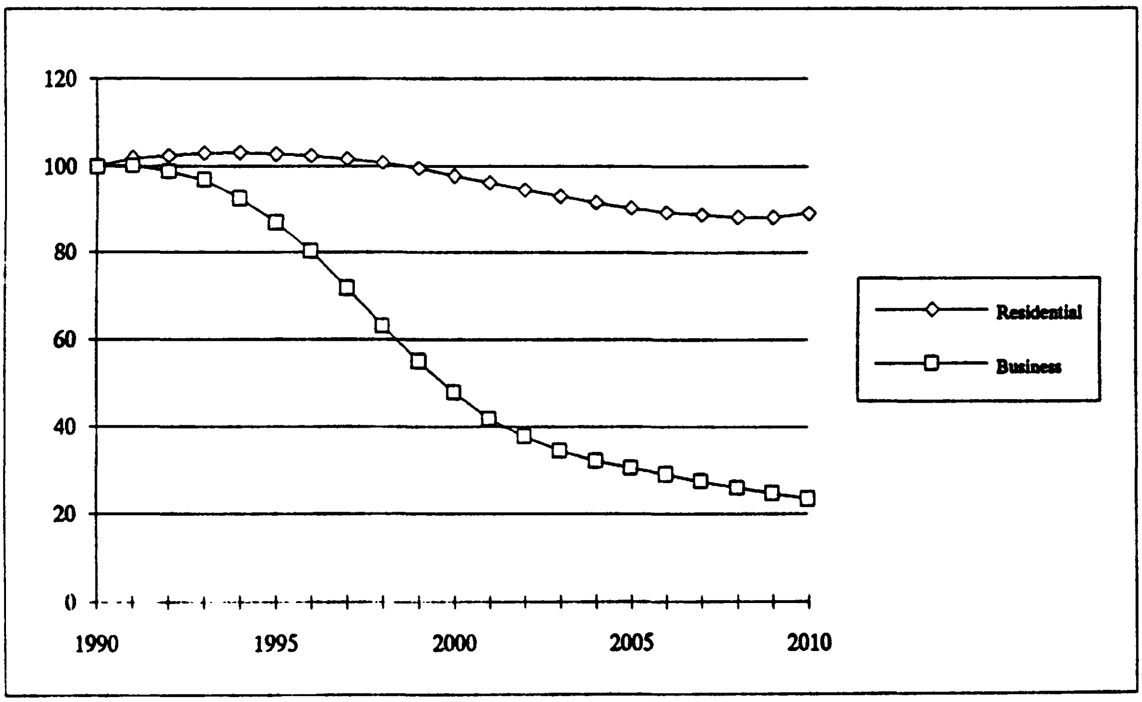


EXHIBIT EC.M.42: Index of Revenue per Call Minute



EC Total Minimum Case

EXHIBIT EC.M.43: Network Costs and Revenues

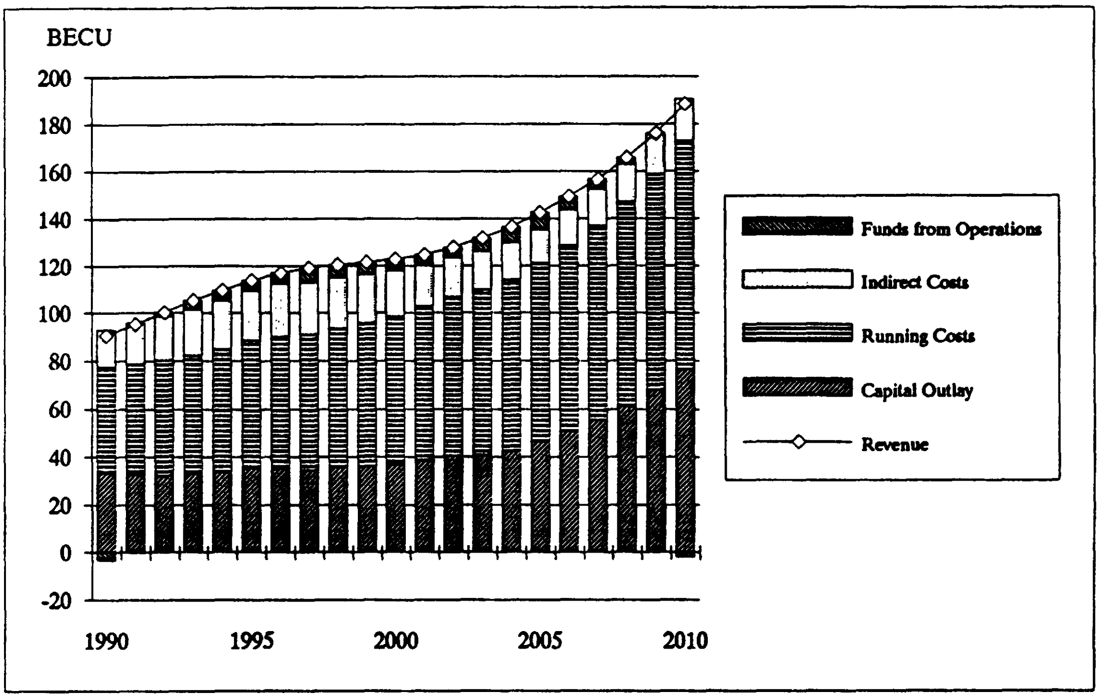
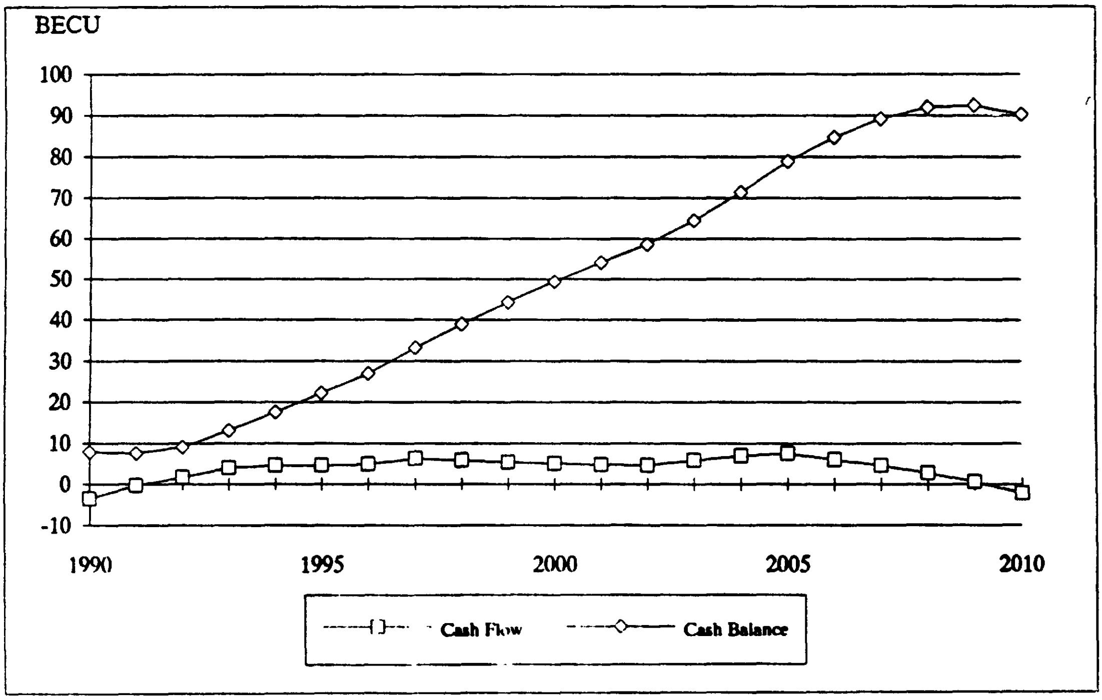


EXHIBIT EC.M.44: Network Cash Flow and Cash Balance



EC Total Minimum Case

EXHIBIT EC.M.45: Profit Margin: Comparison of TO and Country

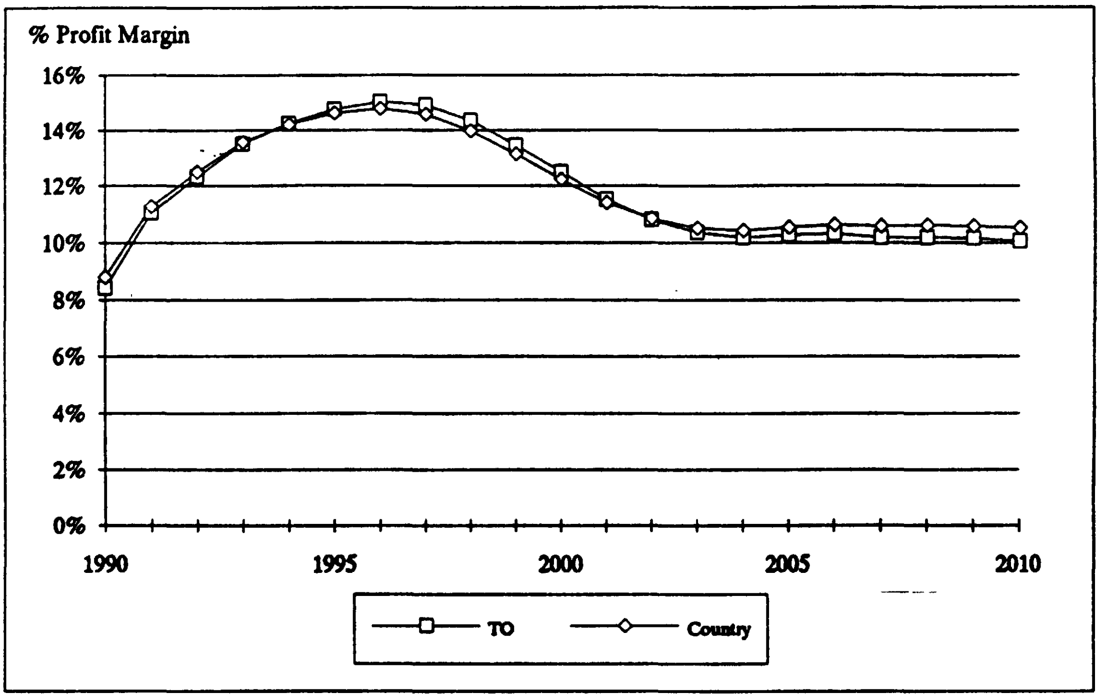
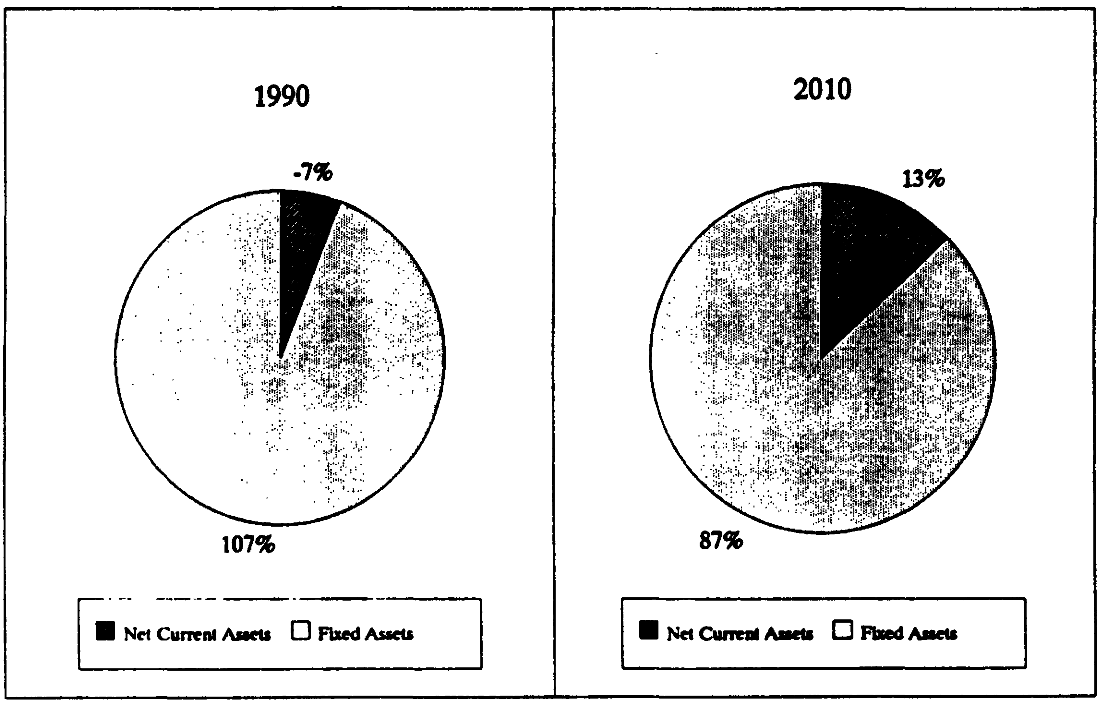
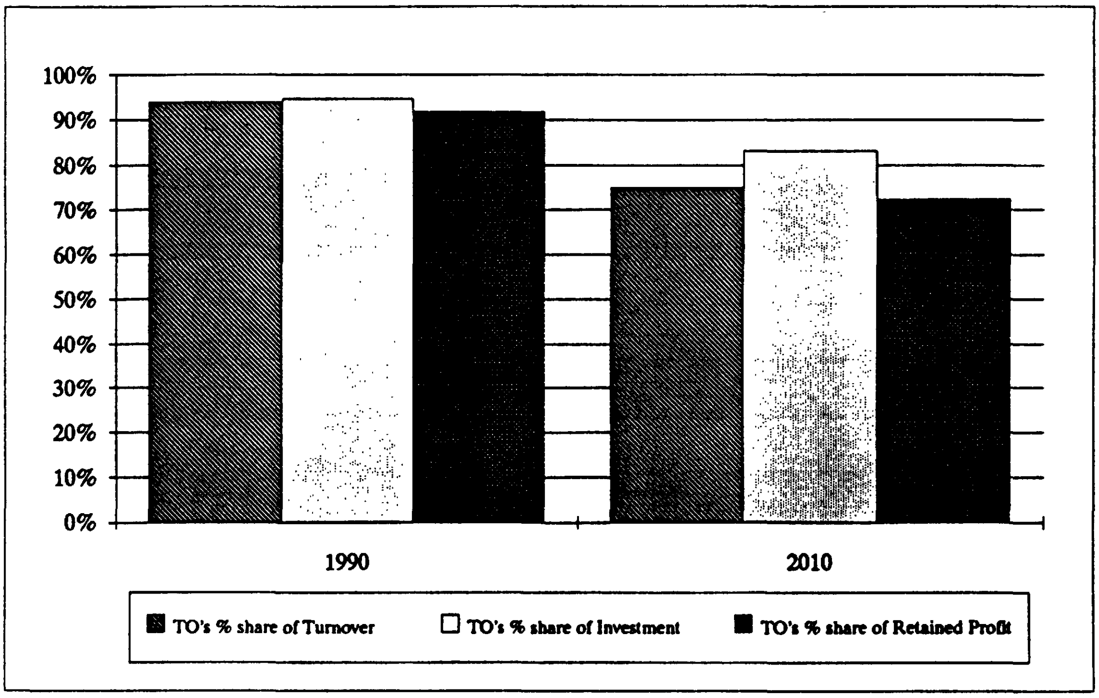


EXHIBIT EC.M.46: Analysis of TO's Net Assets



EC Total Minimum Case

EXHIBIT EC.M.47: TO's Comparative Performance in 1990 and 2010 (TO as % of Total Telecoms Operation)



Analysys

5/ Summary Quantitative Results for EFTA and Eastern Europe

In this chapter aggregate results for EFTA[1] and Eastern Europe are discussed, and compared and contrasted with those for the EC.[2] Note that the results relate to the period 1990 to 1995 only. Section 5.1 explains why the aggregate EFTA and Eastern Europe results are important for the CEC (Section 5.1). A number of key results are then presented and analysed:

- penetration (Section 5.2)
- projected investment (Section 5.3)
- revenue per connection and profitability (Section 5.4)
- financial requirements (Section 5.5).

Finally, Section 5.6 draws some conclusions from this examination of aggregate results for EFTA and Eastern Europe.

5.1 Expansion of the Membership of the European Community

Pressure is building up in non-EC European countries to apply for EC membership. For example, the Austrian government has already applied for full membership of the Community, and the Swedish government has resolved to apply in the near future, with the aim of profiting from the Single Market and gaining monetary stability. Other EFTA countries are likely to follow, and membership could have increased to 18 by the end of the century.

There is also a growing demand for the criteria for membership to be relaxed, or for an additional tier of membership to be created (which would permit the developing nations

1 Excluding Iceland.

2 Country-by-country quantitative results for EFTA are presented in Annex C13-C17 of this report; those for Eastern Europe are presented in Annex C18-C21.

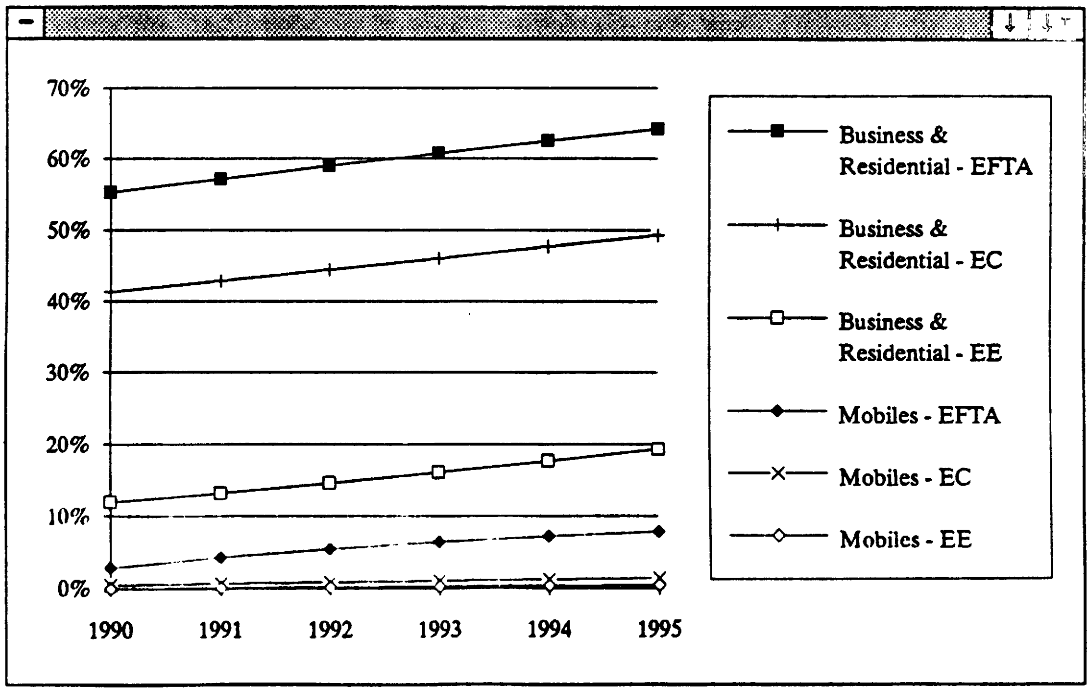
of Eastern Europe to join). It is unlikely that a wider concept of the EC will emerge before 2000, given the risks associated with diverting attention from the essential tasks of managing the integration of existing EC members. Nevertheless, it seems certain that the EC's links with EFTA and with Eastern Europe will grow, and that the convergence of the telecommunications networks of west, central and east Europe will continue.

5.2 Total Penetration

In 1990 total penetration in EFTA of public switched services (excluding mobile) was more than 55%, rather higher than that for the EC, as shown in Exhibit 5.1. Penetration will increase slightly to reach 64% by 1995, still higher than the EC figure. Mobile penetration will be considerably higher for EFTA than for the EC throughout the 1990-95 period – more than 2% in 1990, and reaching almost 8% by 1995.

In Eastern Europe penetration in 1990 (under 15%) was considerably lower than for the EC, as shown in Exhibit 5.1. Whilst the number of connections will increase quite rapidly over the next five years, penetration will still be less than 20% in 1995, well below the EC level. Similarly, mobile penetration will increase throughout this period, but will still not have reached 1% by 1995. Whilst there are considerable differences in penetration rates between individual East European countries, these differences are insignificant compared with the overall difference from the EC.

EXHIBIT 5.1: Total Penetration for EC, EFTA and Eastern Europe



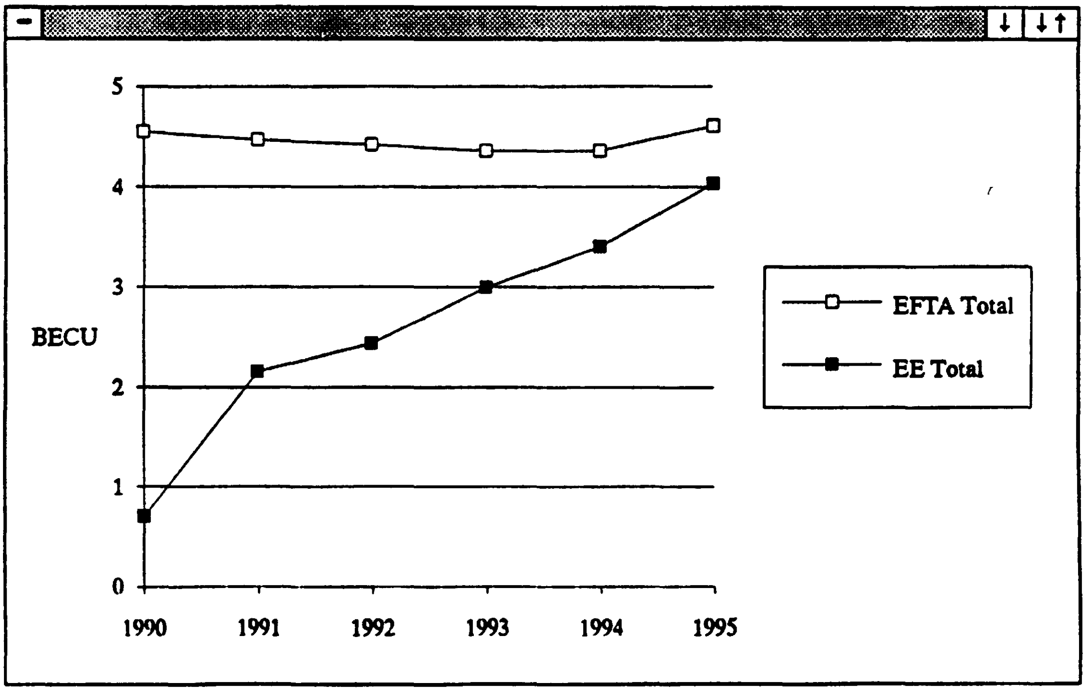
5.3 Projected Investment

The large difference in penetration rates between EFTA and Eastern Europe is the result of large historic differences in investment, which also continued through to 1990. However, projected capital outlay for the EFTA and East European countries is also very different in the short term, as the Eastern European countries seek to upgrade and extend their networks.

In 1990, total capital outlay in EFTA[3] was slightly more than ECU 4.5 billion. It is expected that this will decrease slowly in the short term, before increasing slightly in 1995 to ECU 4.6 billion (as shown in Exhibit 5.2). The state of development of networks in the EFTA countries is, on average, slightly ahead of those in the EC. The composition of network capital outlay is therefore expected to be similar to that for the advanced networks in the EC.

Network capital outlay in Eastern Europe in 1990 was less than ECU 1 billion. The need for massive investment (both to increase penetration and replace outdated equipment), combined with the need to purchase Western technology at much higher cost, will result in network capital outlay increasing to more than ECU 2 billion in 1991 and more than ECU 4 billion by 1995 (see Exhibit 5.2).

EXHIBIT 5.2: Network Capital Outlay for EFTA and Eastern Europe



3 Excluding Iceland.

The current dilapidated condition of networks in Eastern Europe, together with the low penetration, mean that most network capital outlay will be devoted to modernising and extending the basic network. As a result, the breakdown of capital outlay in Eastern Europe will be similar to that for the less advanced EC countries.

5.4 Revenue per Connection and Profitability

While the increases in investment in both the EFTA and East European countries will result in revenue growth (particularly in Eastern Europe), the changes in revenue per connection will not be nearly so significant. In 1990, revenue per connection in EFTA for both public switched services (ECU 600) and mobile telephony (ECU 1020) was slightly higher than for the EC (see Exhibit 5.3). This situation will continue for public switched services, but revenue per connection for mobile telephony will fall below the EC level by 1995 as the generally high level of penetration brings tariff reductions.

At between 30% and 35%, operating profit margins for the total of all services in EFTA as a whole will be largely comparable with, if a little higher than, those for the EC (see Exhibit 5.4).

In Eastern Europe in 1990 revenue per connection for public switched services (ECU 190) was considerably below the levels in the EC and EFTA (Exhibit 5.3), although operating profit margins were relatively high at more than 65% (Exhibit 5.4). Whilst early tariff realignment will have an impact on the proportion of revenue coming from different sources, it will have little impact on the overall level of revenue per connection over this short period. Hence, revenue per connection will remain almost constant throughout the period at just below ECU 200.

Operating profit margins will fall quite considerably over the period but will remain higher than those for the EC and EFTA, falling just below 40% by 1995.

For mobile telephony the situation is different. Mobile telephony is only now being introduced into Eastern Europe and a premium tariff is to be charged. The mobile telephony revenue per connection will therefore be comparable with EC and EFTA levels throughout the 1990 to 1995 period.

EXHIBIT 5.3: Revenue per Connection for all Public Switched Services and Mobiles for the EC, EFTA and Eastern Europe

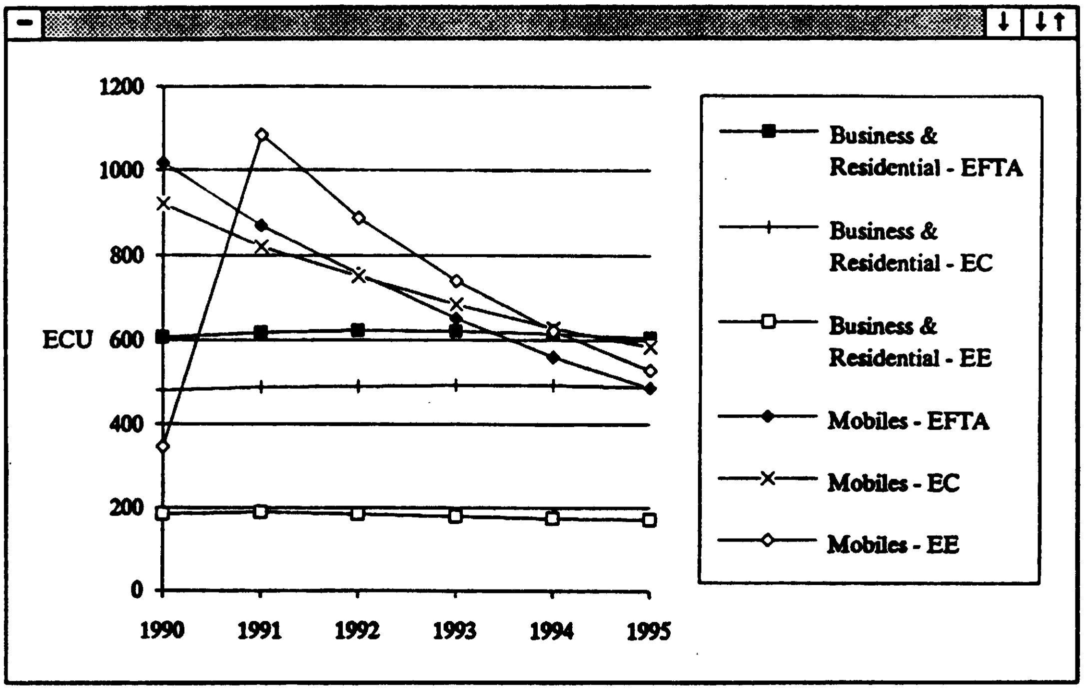
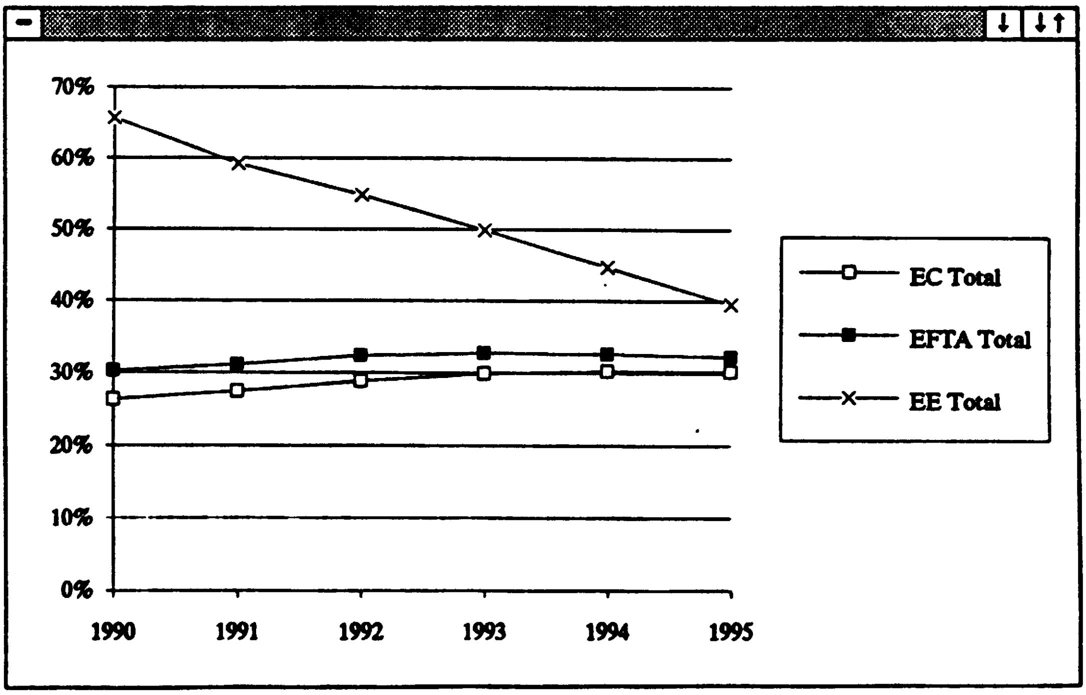


EXHIBIT 5.4: Operating Profit Margin for the EC, EFTA and Eastern Europe



5.5 FINANCIAL REQUIREMENTS

As mentioned in Section 5.3 above, the investment requirements for EFTA countries are fairly similar to those of the advanced EC countries, and hence the ratio of annual investment to turnover will follow a similar pattern, decreasing slightly from its 1990 level of 31% to 26% by 1995 (Exhibit 5.5). Cash outflow from operations will be positive throughout the period, at between ECU 1.5 billion and ECU 3.5 billion (Exhibit 5.6), so EFTA will face no difficulties in financing this level of investment.

In Eastern Europe, as previously discussed, a considerable increase in investment in 1991 is expected, continuing throughout the period to 1995. This is reflected in Exhibit 5.6, where it can be seen that the 1990 ratio of annual investment to turnover of 20% will increase to 51% in 1991 and 64% by 1995. This will have serious implications for the cash-flow situation in these countries. As can be seen in Exhibit 5.6, overall Eastern European cash flows will decrease significantly from an outflow of ECU 490 million in 1990 to ECU 240 million in 1991. They will become negative in 1992 (when the cash requirement will be ECU 620 million), and become increasingly negative during the rest of the period – the cash requirement will reach ECU 1.3 billion by 1995.

EXHIBIT 5.5: Ratio of Annual Investment to Turnover for the EC, EFTA and Eastern Europe

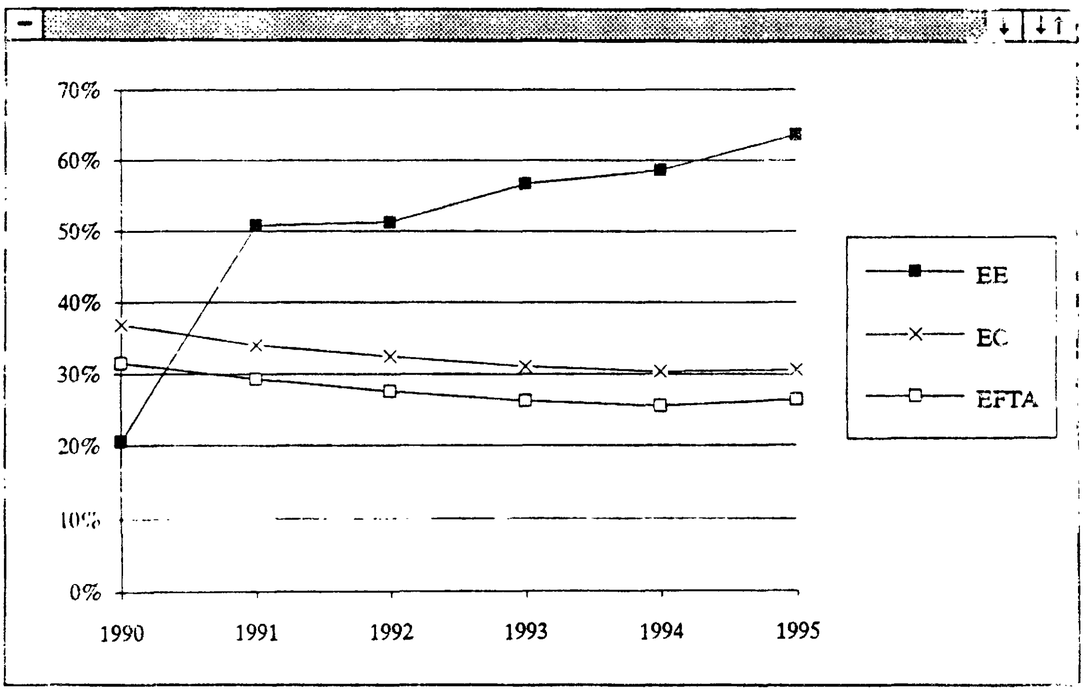
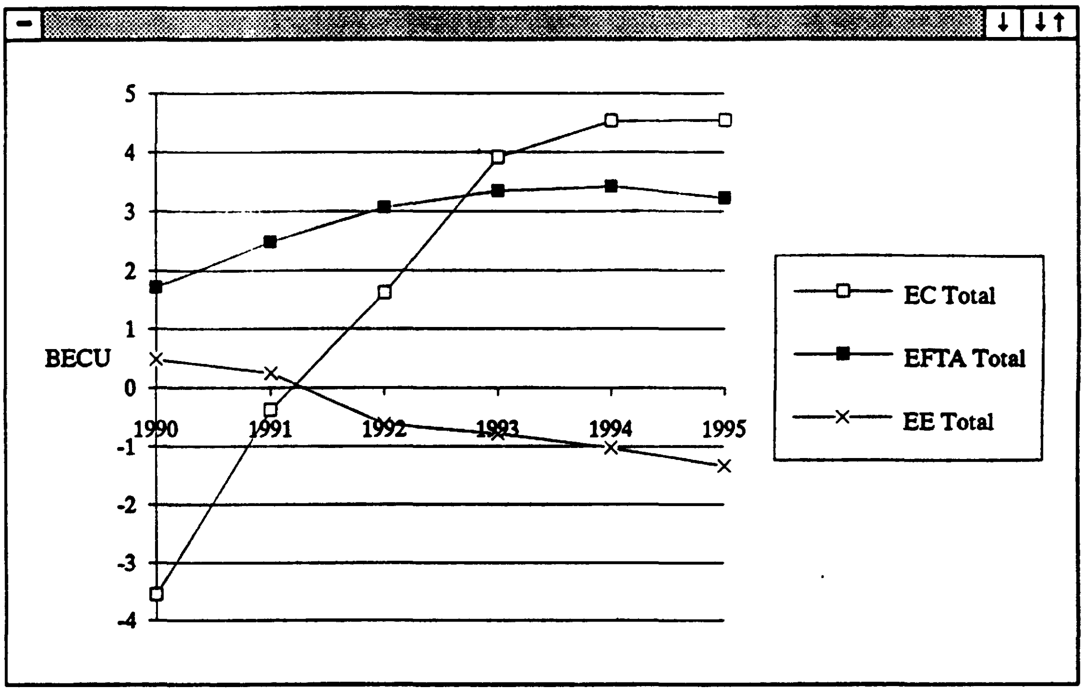


EXHIBIT 5.6: *Cash Flow for the EC, EFTA and Eastern Europe*



5.6 Conclusions

In many ways the EFTA and East European blocs are more homogenous than the EC in terms of their telecommunications development; the EC has large differences between countries in terms of intensity of usage, technology and financial well-being. However, EFTA and Eastern Europe are radically different from each other, and will display different development paths.

On average, the **EFTA countries** are slightly ahead of the EC in terms of demand (although the gap can be expected to narrow over the next five years). Their financial results will also be healthier than the EC average in the period to 1995. Lower levels of investment in EFTA countries compared to the EC will result in better cash flows; capital outlay will be only ECU 26.8 billion (less than 13% of the EC total); and as a proportion of turnover, capital outlay will be 28% (compared to 34% in the EC). This will result in an average Self Financing Ratio of 165% for EFTA, compared to 101% in the EC. Similarly, cash flow as a percentage of turnover will be 18% for EFTA over this period, whereas in the EC it will be less than 1%.

By contrast, although the **East European countries** are undertaking network expansion and improvement, the development of their telecommunications will continue to lag well behind the EC. Capital outlay will be ECU 15.7 billion over the period to 1995 – over 50% of turnover (which will be just under ECU 30 billion) for the same period. The effect on cash flow will be very significant, with a cumulative negative cash flow of over ECU 3 billion by the end of the period. Whilst the Self Financing Ratio in 1990 was very high at 170%, it will drop markedly to 67% in 1995; the average Self Financing Ratio for the whole period will be 94%.

Two tables of individual country results appear for EFTA and Eastern Europe appear in Exhibit 5.7.

EXHIBIT 5.7a: Selected Data for EFTA Countries

	Austria		Finland		Norway		Sweden		Switzerland	
	1990	1995	1990	1995	1990	1995	1990	1995	1990	1995
Penetration, public switched services[4]	42.9%	55.6%	54.9%	64.7%	50.1%	60.8%	71.3%	77.2%	60.6%	69.3%
Penetration (mobiles)	0.9%	6.2%	3.4%	8.2%	4.2%	8.8%	5.0%	9.4%	1.1%	6.3%
Network capital outlay, MECU	472.0	535.1	665.9	703.9	622.5	828.9	1241.8	1145.0	1548.5	1395.1
Rev./connec'n, public switched services,[4] ECU	559.3	548.2	419.2	420.5	799.7	789.2	486.0	483.3	769.8	772.8
Rev./connec'n (mobiles), ECU	545.6	310.2	475.8	386.2	886.3	534.3	1309.2	572.7	1351.0	577.0
Operating profit margin	45.5%	55.7%	28.5%	33.6%	24.4%	25.8%	19.8%	17.1%	37.8%	35.6%
Annual investm't as % of turnover	22.8%	18.2%	37.6%	30.4%	26.5%	29.1%	29.1%	25.0%	38.8%	29.3%
Cash outflow from ops, MECU	1075.6	1228.9	324.9	463.4	348.4	337.4	1.6	390.4	-35.9	801.2

EXHIBIT 5.7b: Selected Data for East European Countries

	Czechoslovakia		Hungary		Poland		Other East[5]	
	1990	1995	1990	1995	1990	1995	1990	1995
Penetration, public switched services[4]	14.7%	22.2%	9.0%	17.7%	8.8%	16.4%	14.3%	22.1%
Penetration (mobiles)	0.0%	0.4%	0.0%	0.4%	0.0%	0.5%	0.0%	0.4%
Network capital outlay, MECU	93.0	508.6	229.0	380.7	107.0	1227.5	272.0	1915.5
Rev. per connec'n, public switched services,[4] ECU	162.3	173.6	249.1	238.9	84.6	111.3	217.2	180.1
Rev. per connec'n (mobiles), ECU	0	313.5	346.4	702.8	0	315.1	0	760.0
Operating profit margin	75.0%	39.6%	38.9%	40.9%	33.9%	29.6%	75.6%	43.7%
Annual investment as % of turnover	15.1%	55.3%	69.0%	46.1%	21.0%	85.4%	13.9%	60.7%
Cash outflow from ops, MECU	84.0	-183.1	-81.0	-74.9	145.8	-565.4	339.0	-517.8

4 Excluding mobiles.

5 This group comprises Bulgaria, Romania and Yugoslavia; the three countries are covered in a single aggregate model.

Appendix/ The Methodology

The purpose of this appendix is to provide an overview of the procedures involved in the production of our country investment projections. This appendix is a summary of Annex A, 'Technical Reference', which provides a more detailed description of our methodology. We have established a framework – the General Reference Model – within which the impact of technological, regulatory, demand and economic factors may be assessed systematically. In Section X1 we provide an overview of the General Reference Model, and the main modules of the system are described in further detail in the remaining sections:

- the investment model is presented in Section X2
- the demand methodology is presented in Section X3
- the tariff methodology is presented in Section X4.

X1 Overview of the General Reference Model

The purpose of the General Reference Model is to provide a consistent framework from which the telecommunications investment requirements of all countries in Europe may be evaluated on a country-by-country basis. A copy of the General Reference Model has been made for each country modelled in the study,[1] and each copy contains country-specific input relating to demand, tariffs, finance, costs and technology. Each country-specific model is known as a Country Reference Model.

For the countries of EFTA and Eastern Europe, the models represent the combined operation of the TO and competitors. For each EC country, on the other hand, separate models have been produced for the national TO and its competitors, to enable a distinction to be made between the financial health of the incumbent TO and that of the country's telecoms operations as a whole.

1 Except for the group of 'other East European' countries (Bulgaria, Romania and Yugoslavia), for which a single copy has been made.

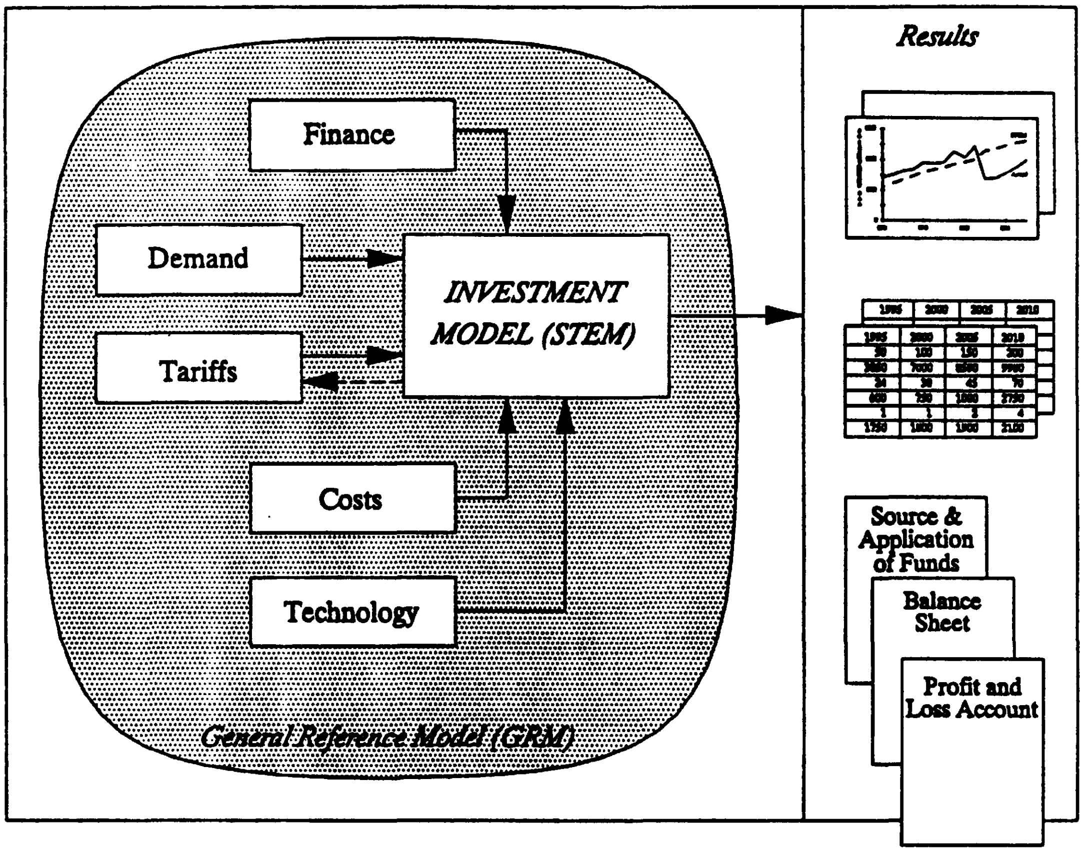
In order to examine the effects of different growth scenarios, for each EC country and model we use an *Expansionist* and a *Minimum* case based on different assumptions in the areas of demand, tariffs and regulation. Four models are thus generated for each EC country, and one model is generated for each of the other countries in the study. Exhibit X1.1 shows which models have been produced for each country in the study:

EXHIBIT X1.1: Models Produced for Each Country in the Study

Study Period >>>	*20-year period*				*5-year period*
Scenario >>>	*Expansionist case*		*Minimum case*		*Standard Short-Term Projection*
Operators >>>	*TO*	*Compet'n*	*TO*	*Compet'n*	*All*
Belgium	√	√	√	√	
Denmark	√	√	√	√	
France	√	√	√	√	
Germany	√	√	√	√	
Greece	√	√	√	√	
Rep. of Ireland	√	√	√	√	
Italy	√	√	√	√	
Luxembourg	√	√	√	√	
Netherlands	√	√	√	√	
Portugal	√	√	√	√	
Spain	√	√	√	√	
UK	√	√	√	√	
Austria					√
Finland					√
Norway					√
Sweden					√
Switzerland					√
Czechoslovakia					√
Hungary					√
Poland					√
Bulgaria/Romania/Yugoslavia					√

The logical structure of the General Reference Model, including the main modules, is outlined in Exhibit X1.2:

EXHIBIT X1.2: Structure of the General Reference Model



Below, we provide a brief description of each aspect of the General Reference Model:

- *Finance* – specifies the initial financial position for all the operators in the country (as well as the current and future tax and interest rates). This includes information about the profit and loss accounts, tax and interest rates, movements in reserves, the balance sheet and source and applications of funds. For some countries, the information relating to telecommunications operations has been extracted from accounts for the PTT as a whole, where these also include postal operations.

- *Demand projections* – a very complex part of the model structure, based on our demand methodology (demand in terms of connections and traffic per connection for each service). For those countries where we model competition, the methodology also provides the demand projections for each service and for each operator.[2] Furthermore, for those countries where we model two cases, a demand

2 We group the operators into two groups: one for the incumbent national TO and associated operators, and the other for competing operators.

projection is generated for each case. The methodology underpinning the demand projections is described in greater detail in Section X3 below.

- *Tariff projections* – based on our tariff methodology. The tariff methodology uses feedback from the investment model[3] containing information about the cost of providing services to customers, and generates annual installation tariffs, rental tariffs and usage charges for each service and for each year of the study period. For those countries where we model both an Expansionist and a Minimum case, separate tariff projections are generated for each scenario. The methodology underpinning the tariff projections is described in greater detail in Section X4 below.

- *Costs* – including projections of capital, operational and maintenance costs for the main elements of the telecommunications network (such as analogue local exchange, ISDN digital exchange, cable international transmission and satellite international transmission). The costs for the elements are projected over time, based on evolving technology cost trends and trends for associated costs such as labour unit costs. The costs of offering services are also taken into account; these include administration costs (such as billing) and the costs of adding a new customer to the network.

- *Technology* – including information on current and future requirements for the network, and the capacities and lifetimes of equipment installed in it. The type of equipment currently installed in the network is provided by 1990 data, whilst future equipment choices are determined by the technological and regulatory projections.

The *Investment Model* (based on the Analysys STEM modelling system[4]) performs calculations using input data from the modules described above, and generates output relating to:

- the costs and quantities of equipment in the network
- the capital investment required
- cash flow, revenue and profitability
- the cost of providing services to customers (this is then fed back to the tariff calculations)
- financial information (summarised in the form of profit and loss account, balance sheet and source and application of funds).

The investment model is described further in Section X2 below.

3 As described in Section X2.

4 The calculation cycle used in the STEM modelling system is described in Annex A, Appendix 2.

X2 THE INVESTMENT MODEL

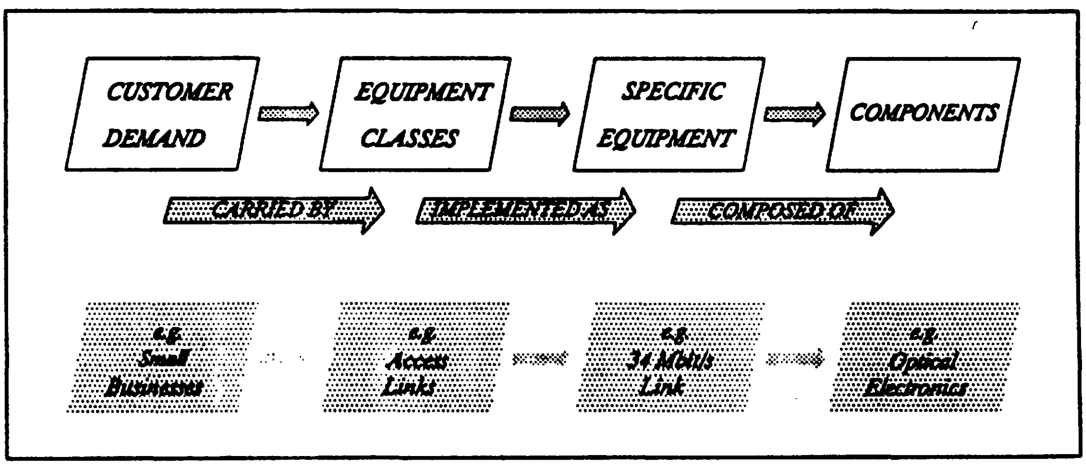
In this section we describe the investment model developed for this study, based on the Analysys STEM modelling system. We begin in Section X2.1 by introducing a number of terms used in Analysys STEM, and outline the inputs and outputs of the investment model. This is followed in Section X2.2 by a description of the overall investment model structure, and in Section X2.3 by a discussion of how the choice of technology impinges on the investment model. Finally, in Section X2.4 we summarise the calculation cycle of the modelling system.

X2.1 STEM Terminology

The four key conceptual elements in all STEM models are *Demand*, *Classes*, *Specifics*, and *Components*. These key concepts and their connection are illustrated in Exhibit X2.1.

As this diagram shows, the demand which drives the model[5] is met by a network comprising a number of **Classes** of equipment. These Classes are the *parts* or functional blocks which make up the network architecture (e.g. local access links). A Class may include several kinds of equipment (e.g. narrowband and broadband links), each of which is implemented by a **Specific** technology. Finally, the parts of which Specifics are composed are modelled as **Components** (e.g. opto-electronics or signal-processing software) for which price trends are set.

EXHIBIT X2.1: Key Conceptual Elements of STEM Models



5 This is described in Chapter A4 of Annex A.

X2.2 Structure of Investment Model

In this section we briefly describe the overall model structure in general terms. In essence, the telecoms investment requirements of an operator are evaluated by forecasting user population (in terms of population, employees, numbers of business establishments and households) and from this projecting *Demand for Applications*. This demand is mapped, within the demand methodology (but outside the investment model itself), onto connection types ('bearer services' in the model terminology) and expressed there in the form of connections and traffic. This bearer service demand is then input to the investment model and within this is again mapped (or 'loaded') onto network functions such as Local Access, Local Switch and Junction Transmission via *Supply Ratios*[6] (which specify the amount of an equipment Specific[7] required to satisfy one unit of demand).

Whilst the loading of services on different parts of the network is of primary importance in the investment process, decisions on the particular technology employed also have a significant impact; for instance, whether to install digital or ATM local switches. Country-specific input to this process consists of *Equipment Mappings* – technology input data describing the specific equipment (from within each Class of network function) to be used by each service when additional investment is required. It should be emphasised that these Equipment Mappings only determine what type of equipment is to be used for new investment (whether satisfying new demand or replacing old equipment); they do not force the replacement of previously installed equipment directly.

The Classes of network function, and the Specifics within those classes are organised in the Investment Model in a network architecture. This is shown in Exhibit X2.2:

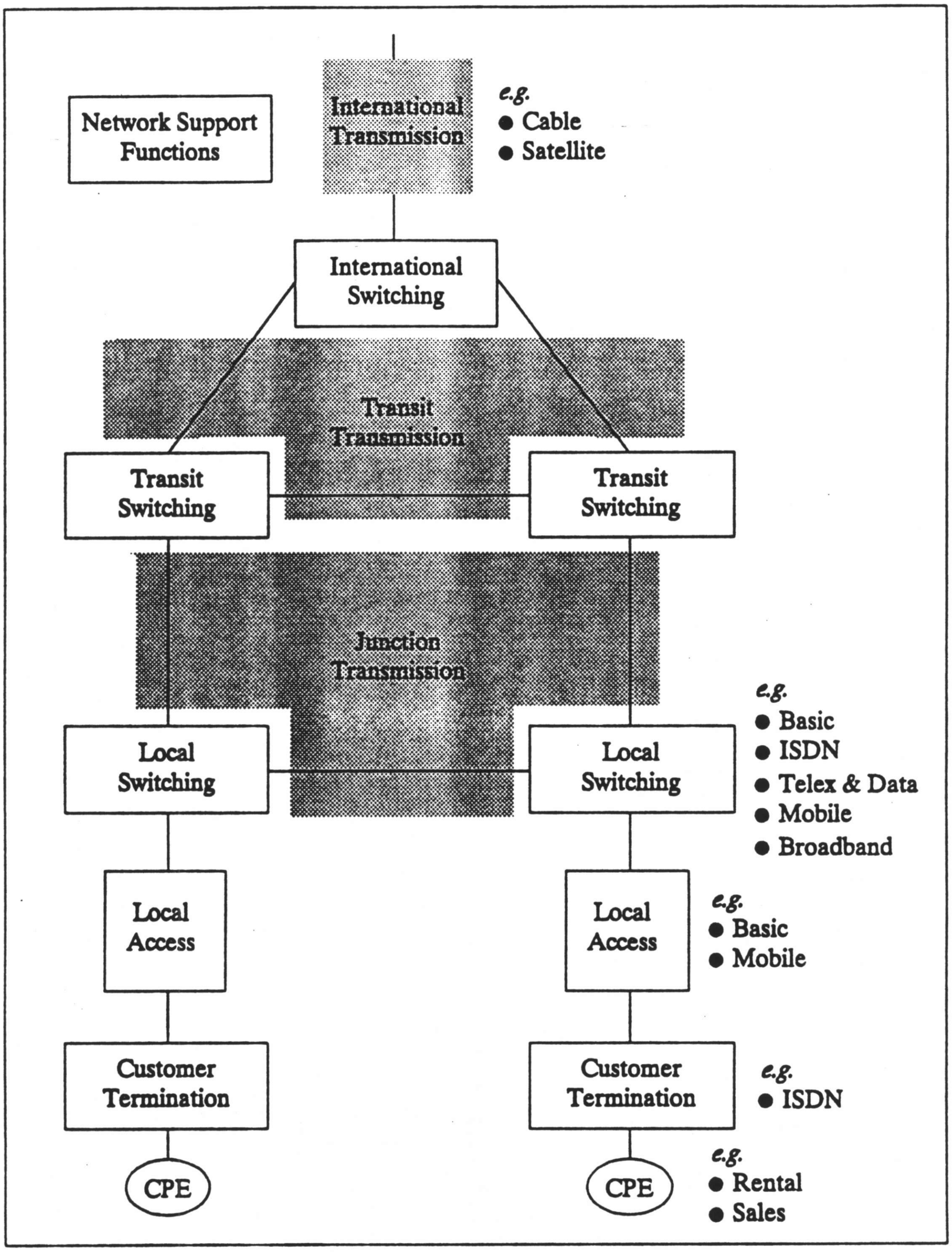
This Exhibit identifies the range of Classes (network functions) in the model and examples of associated Specifics (particular items of equipment). All Services make use of the transmission network (including the Junction, Transit and International networks), and they are all taken into account in the dimensioning of the transmission network; in the case of Local Access and Switching, however, Services with distinct technical characteristics – such as Basic Telephony, Mobiles and Broadband – each require their own facilities until ATM and optical-fibre systems become widely deployed.

It would be possible to define the network architecture in much greater detail than we have done (by breaking down Local Access into cabinets and cables, for example), and even within the current Class structure it would be possible to have many more Specific

6 See Section A7.1 of Chapter A7.

7 As defined in Section X2.1.

EXHIBIT X2.2: Schematic of Network Architecture



items of equipment. However, our aim is to model the investment in important structural elements of the network, and the significant technological changes that have an impact upon that investment, and therefore the list of Classes and Specifics has been kept to a minimum.

A number of country-specific input data items are required for each Specific:

- cost inputs, consisting of capital costs for each year of the model run, together with a financial lifetime and initial running costs
- an overall running cost trend
- the capacity and physical lifetime of each Specific, which come from the technology input and do not change between countries.

For each year of the model run the investment model tracks a number of financial quantities, including turnover, operating costs, net interest paid, tax and dividends owing, depreciation, capital outlay and cash balance. These measures, together with details of the initial financial position of the TO and competitors, are used to produce the summary accounts for the TO and country as a whole. The initial values for cash balance, tax and dividends owing, together with the interest, tax and dividend rates for the remaining years of the model run, are country-specific financial inputs.

X2.3 Choice of Technology

Supply ratios represent the loading of demand for a particular service onto different Classes of equipment. In order to determine the Supply Ratios for a service, two questions must be asked about each equipment Specific used by that service:

- **How should the equipment be dimensioned?** The alternatives are to dimension it according to the connections to the service, or to dimension it according to the traffic originating from the service.

- **What is the quantity of equipment required to support one unit of that service demand?**

The answers to these questions are determined by the way in which a particular service impinges on (or 'loads') a function of the network. This, in turn, depends on several factors, including:

- whether the service is loading the network function according to the level of service utilisation (traffic per connection) or the number of service connections

- how the traffic originated by a particular customer is routed through the network (where the service loads the network function according to the traffic per connection).

To illustrate the effect of the first factor, it is clear that the loading effect of a dedicated leased line on the junction transmission network will be full occupancy of a single channel, whereas the loading effect associated with traffic from a switched service will depend on the combined effect of the level of originating traffic per connection and the proportion of calls that are routed across the junction network.

In the investment model, the mapping of service demand onto items of equipment allows the loading effect to be defined in terms of either total traffic or the number of connections. Thus, a particular class of network function will be dimensioned according to the combined effect of, say, basic telephony demand and leased lines (as illustrated in Exhibit X2.3 below).

EXHIBIT X2.3: STEM Model Maps Demand for Connections and Traffic onto Dedicated and Shared Equipment

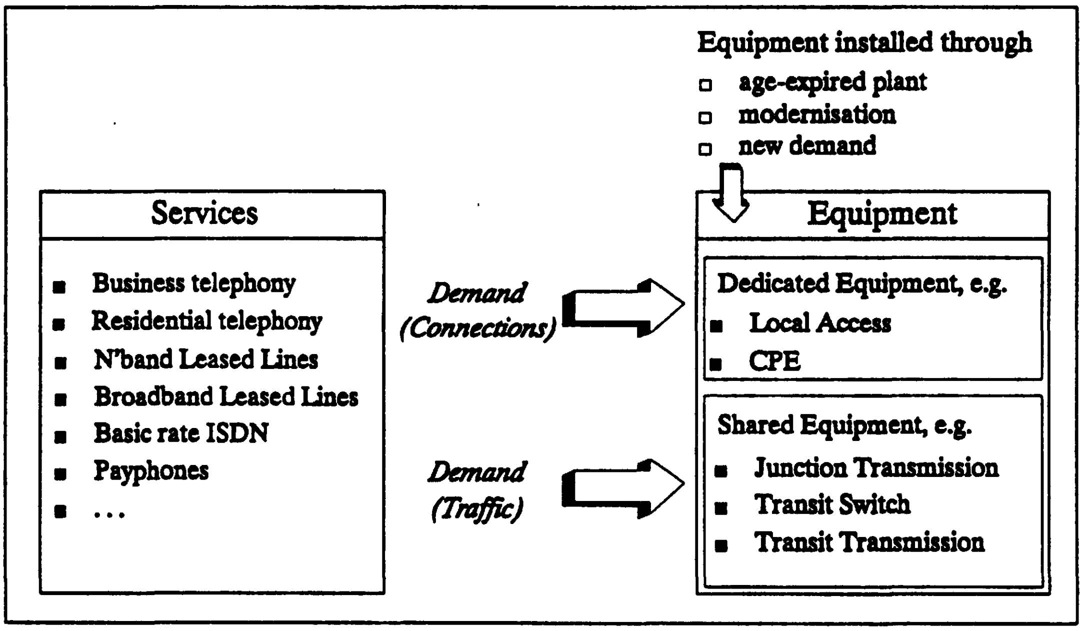
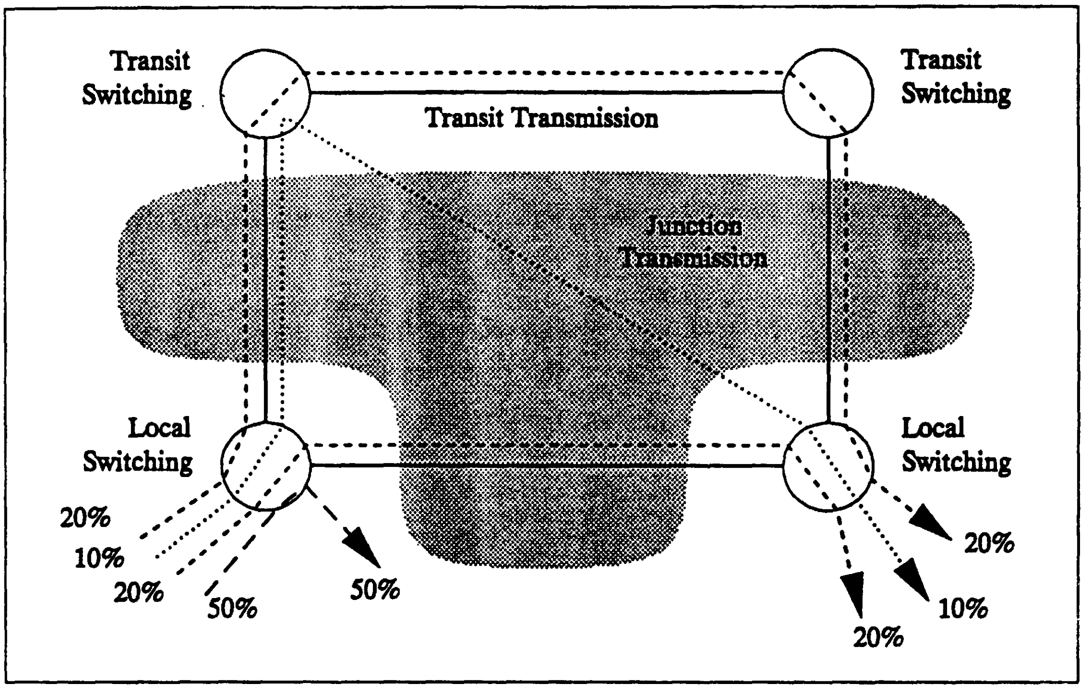


Exhibit X2.4 gives a simple illustration of how the calling behaviour of a particular service determines the routeing of traffic through the network, and hence how it results in the loading of the network. On the assumption that the calling pattern of the network is symmetrical – that is for every originated Erlang of traffic there is a received Erlang – we see that the loading of a network function such as the junction network is dependent on the calling pattern of subscribers and the absolute volume of traffic that they originate.

Within the investment model, traffic per connection is defined for the busy hour. The number of required circuits is, in the first instance, determined by calculating the product of traffic per connection and the unit of loading depicted in Exhibit X2.4. A similar effect to traffic patterning is observed with leased lines, except that in this case the loading effect on the network arises from the proportion of leased lines which are routed across the junction network, for instance.

EXHIBIT X2.4: Example of Telephony Traffic Routeings



For each Erlang for originated traffic:
1.5E loading on Local Switching, 0.8E on Junction Transmission, 0.5E on Transit Switching, and 0.2E on Transit Transmission

The investment model allows different traffic loading patterns for each defined service. For example, it can accommodate differences between business and residential telephony subscribers in terms of the proportion of their calls which are international.

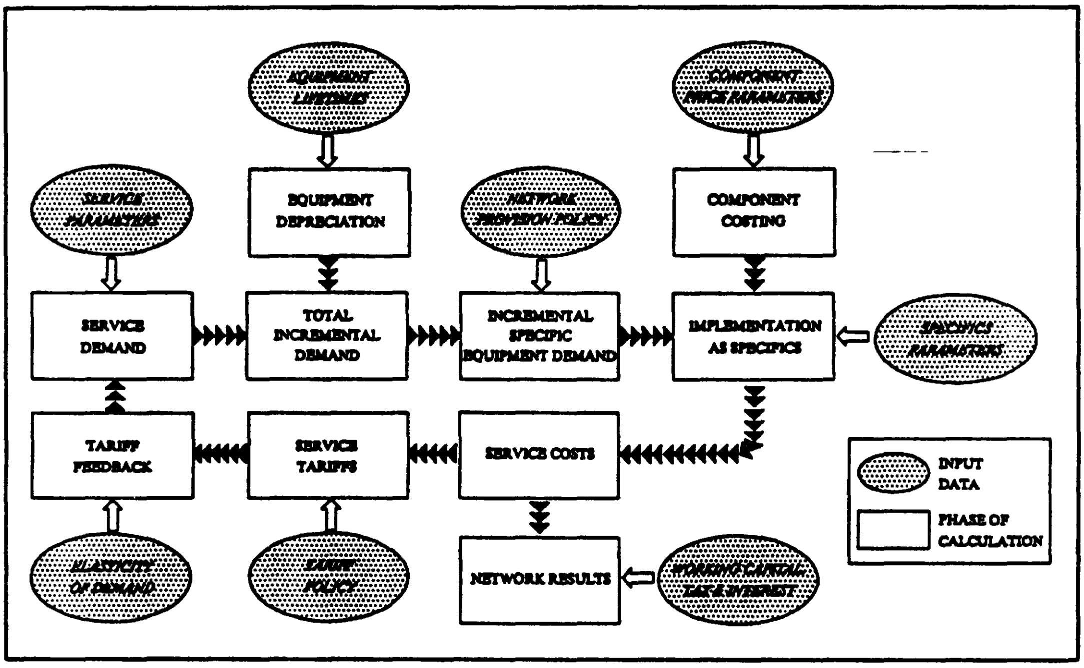
Having defined how the service loads a particular function of the network, the Supply Ratio can be calculated. This specifies the amount of the Specific required to satisfy one unit of demand (either a connection or an originating Erlang of traffic) from that service. It reflects *either* the requirement for one unit of capacity (for each item of connections-dimensioned equipment), *or* the routeing of traffic through the network (for traffic-dimensioned equipment).

Whilst the treatment of traffic loading described above is quite complex, it does not capture those dimensioning rules which aim to realise a given grade-of-service in the network; this aspect of investment dimensioning is handled by the investment model as an additional form of network capacity supply.

X2.4 Calculation Cycle

STEM models represent the dynamic changes to a telecommunications system using an annual cycle which is repeated for each year until a specified time horizon. The following diagram summarises the basic cycle:

EXHIBIT X2.5: Basic Calculation Cycle (Simplified)



This diagram shows how demand for Services is first mapped onto demand for equipment, which is met by installation of the additional Specifics required (if any), taking into account the existing network and depreciation of existing plant. Newly installed equipment is costed, and the various costs are allocated back to Services. These costs may influence tariffs in the following year. The service revenues together with the costs are aggregated to determine Network financial results, from which interest, tax and dividend payments are calculated. The key phases of the cycle are described below.

Service Demand

Demand for services, in terms of both connections and traffic, is determined by the demand inputs (from the demand methodology).

Equipment Depreciation and Total Incremental Demand

The incremental demand for equipment in any year is the total demand in that year less the equipment already installed in the network. This calculation takes into account the *physical* depreciation of equipment and its eventual replacement, controlled by the physical lifetimes of the equipment. Additional incremental equipment demand is required in order to maintain spare capacity, as specified by the pre-investment policy in terms of design periods and buffers.

Incremental Specific Equipment Demand

The choice of particular Specific equipment to fulfil incremental equipment demand is determined by the Equipment Mappings, which are part of the technology input.

Implementation as Specifics and Costing of Equipment

Demand for equipment is satisfied by the installation of Specifics, at which point the costs of the new equipment are calculated (as are the various running costs of the network). All the costs can change from year to year during the model run, as determined by the cost inputs.

Service Costs

Once demand for equipment has been met by its installation as Specifics, the costs of particular Services can be calculated, taking into account their use of equipment and the Service costs of administration and provision.

Service Tariffs

STEM also calculates tariffs for each Service. Initially these are entirely cost-independent, but during the model run a transition is made towards tariffs based on the Service costs. These effects are determined by the tariff inputs (from the tariff methodology).

Tariff Feedback

Service tariffs can alter demand for the service by means of demand elasticities. This process brings us back full circle to the Service Demand at the beginning of the calculation cycle. In the General Reference Model, demand elasticities are not within the STEM model, and so the demand elasticities within the calculation cycle are specified to ensure that demand for the service does not alter.

Network Results These costs and tariffs are used as the basis for calculating cash flow, revenue surplus, and various other measures of financial performance. Interest, tax and dividend payments are calculated from these based upon the rates specified in the financial input.

X3 DEMAND METHODOLOGY

In this section we describe the demand methodology developed for this study. We first define some key terms used in the demand methodology (Section X3.1), and then describe the demand methodology itself (Section X3.2).

The demand methodology summarised below has been used for all countries included in this study. As discussed earlier, for each of the 12 EC Member States we have studied two cases – Expansionist and Minimum. In order to capture the differences between the two cases, we have applied the demand methodology *separately* for each, using case-specific input data. In some areas of the methodology, however, we have used country-specific input data for both Expansionist and Minimum cases. In the detailed description given below, we indicate whether the input data are case- or country-specific.

X3.1 Definition of Key Terms in Demand Methodology

In this section we define the important terms used in the demand methodology. We have classified subscribers according to the type of establishment they correspond to:

- *Multi-line establishments* – organisations with more than one connection to a public switched network, including large organisations, medium-sized organisations and small organisations (except those with only one connection).

- *Single-line establishments* – organisations with only one connection to a public switched network.

- *Residential* – residential users. The number of residential establishments in a country is simply the number of homes in that country.

Furthermore, in the demand methodology we distinguish between *applications* and *bearer services*:

- An application indicates the type of communication
- A bearer service indicates the type of access used for the communication.

We have used the following applications in the demand methodology:

- voice telephony
- videotelephony
- mobile telephony
- telex
- videotex
- facsimile transmission
- high-speed facsimile transmission
- low-speed data transmission
- high-speed data transmission
- video conference
- video broadcast.

With the exception of the Mobile Telephony application, all *applications* are assumed to be based on fixed-link services, that is where all parties to a communication use a fixed link service. For Mobile Telephony, it is explicitly assumed that at least one party is not able to use a fixed link. Note that this does not preclude the use of cellular access technology by users of the other applications.

We have used the following bearer services in the demand methodology:

- public payphone
- business basic telephony
- residential basic telephony
- Basic-Rate ISDN
- Primary-Rate ISDN
- Broadband
- mobile telephony (access based on cellular radio technology)
- narrowband leased lines
- broadband leased lines
- telex
- packet switch data
- value-added services.[8]

To illustrate the distinction between *applications* and *bearer services* we use the voice telephony application as an example. The voice telephony application can be carried on a range of bearers, including (for instance) the basic telephony bearer service and the mobile telephony bearer service. Currently, nearly all voice telephony is carried on the

8 Value-added services should logically be specified as an application, as they can be carried on a variety of bearer services. We have, however, chosen to define value-added services as a bearer service in order to capture their special characteristics; value-added services generate significantly higher usage revenues, as well as imposing a greater load on the toll and trunk transmission network. By defining value-added services as a bearer service, we can allocate a proportion of the applications traffic to the value-added service, thus capturing the impact both on the revenue stream and on the network dimensioning. The allocation of applications traffic to bearer services is specified as a time series; we therefore capture situations where a growing proportion of calls is directed towards value-added services as the study period progresses.

basic telephony bearer service, but this situation may change in future, when advanced technologies make the mobile telephony service (radio accesses) cost-effective for this application. On the other hand, the mobile telephony *application* is already generating demand for the mobile bearer service, and we expect this application to continue to grow in popularity. However, substantial demand for the mobile bearer service (compared to basic telephony) will only arise once a large proportion of voice telephony is carried on the mobile bearer service.

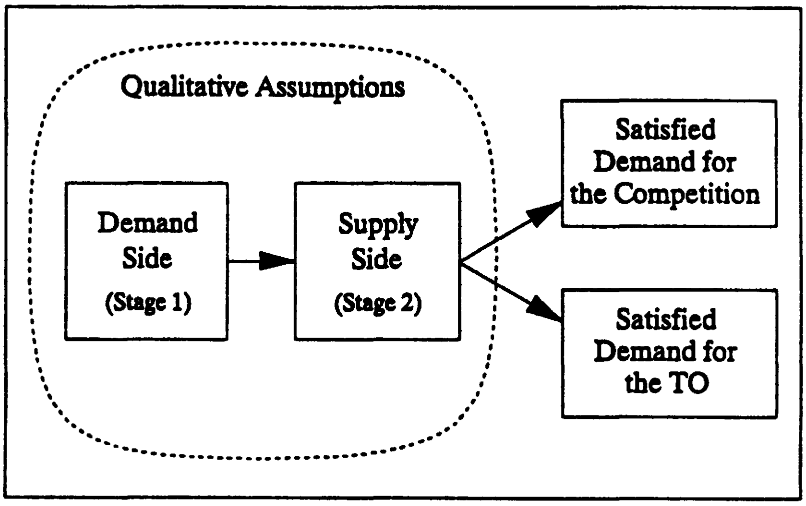
X3.2 Description of Demand Methodology

As can be seen in Exhibit X3.1, which illustrates the overall demand methodology, we have divided the process of quantifying satisfied demand into two stages:

- Stage 1 – the demand side
- Stage 2 – the supply side.

This split enables us to handle complicated situations where although demand exceeds supply in the short term (due to inadequate infrastructure), supply then exceeds demand in the medium to long term.

EXHIBIT X3.1: Overall Demand Methodology



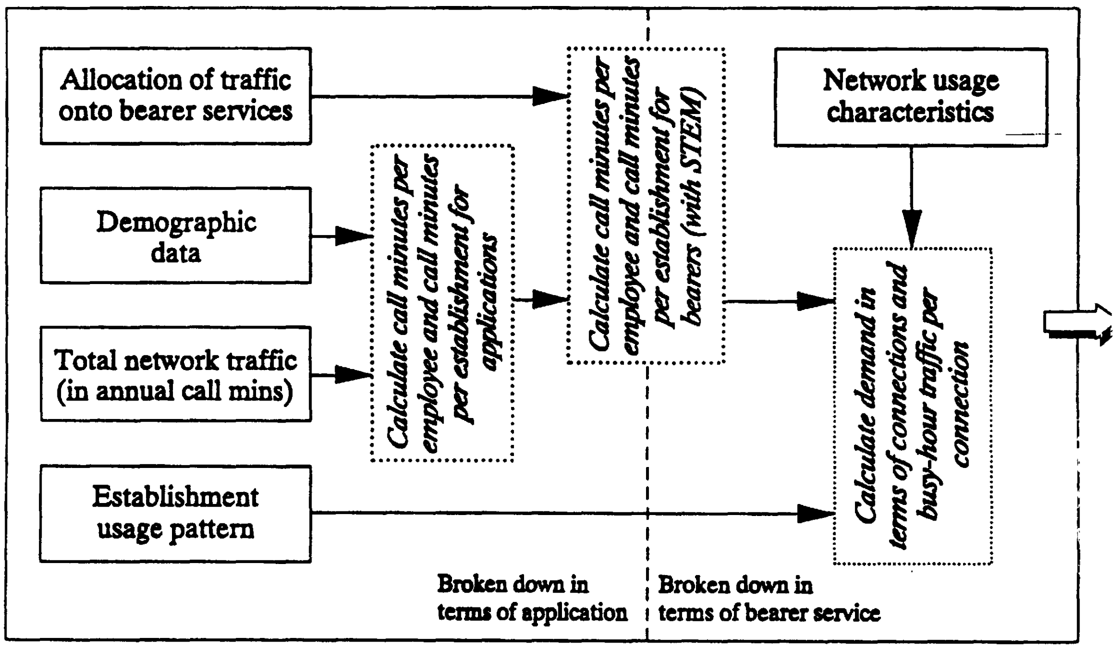
The outcome of Stage 1, the demand side, is total telecommunications demand in terms of connections and traffic per bearer service. The outcome of Stage 2, the supply side, is the satisfied demand in terms of connections and traffic per connection. Satisfied demand is specified for two investment models: the first captures financial flows for the incumbent national TO (referred to here as 'the TO'), and the second captures the financial flows for the other operators (here referred to as 'the competition'). Both stages of the demand methodology require quantitative input data, and these data are specified in highly structured types of input (each of which is described below). The input data have been derived from our qualitative assumptions regarding technology, regulation and demand, as outlined in Annex B.

In Subsections X3.2.1 and X3.2.2 below we look in more detail at the demand and supply sides of our demand methodology.

X3.2.1 Demand Side

The demand side is the first stage in the process of quantifying demand. The structure of the demand side of the demand methodology is illustrated in Exhibit X3.2.

EXHIBIT X3.2: Demand Methodology: Detail of Demand Side



The processes involved in the demand side are summarised below.

INPUT: Demographic Data The demographic data input includes information on the number of households over time, the average size of a household, the number of (business) establishments of each type, and the average number of employees for each establishment type. These input data are country-specific.

INPUT: Total Network Traffic (in annual call minutes)

The input for total network traffic includes data on demand (in annual call minutes) for each application. These input data allow different assumptions to be made about the growth rate for each application.

The demand methodology is based on the overall traffic loading (annual call minutes) rather than the busy-hour loading. The use of overall traffic loading makes it possible to capture the effect of changes in network usage characteristics; such changes cause busy-hour traffic to change relative to the overall traffic loading. The busy-hour traffic load is, however, calculated (as described on page 202 below), to enable the investment model to dimension the telecoms network in a realistic manner. These input data are country- and scenario-specific.

CALCULATION: Call Minutes per Employee and per Establishment for each Application

Data from the two areas of input set out above are used for the calculation of traffic (in annual call minutes) per employee and per establishment. At this stage these calculations are made on a per-application basis.

INPUT: Allocation of Traffic onto Bearer Services

This input specifies how the traffic in annual call minutes for a particular country (as specified for each application in the above calculation) is allocated year by year to bearer services. It also shows how this allocation varies over time and hence indicates the transition from one access mechanism to another. The allocation of traffic to bearer services differs according to the type of establishment and application.

CALCULATION: Call Minutes per Employee and per Establishment

This calculation is used to allocate traffic (per application) to bearer services in each year of the study period in one of two ways:

- on a per-employee basis for multi-line establishments
- on a per-establishment basis for single-line businesses and the residential market.

The end result is the specification of traffic (in annual call minutes) per bearer service and per establishment. Input to this process is the calculated traffic per employee and traffic per establishment for each application, as well as how the input on traffic per application is to be allocated to bearer services over time. Due to the complexity of the process, STEM has been used as the tool here. The general calculation process used by STEM is described in Section A2.4 of Annex A.

INPUT: Establishment Usage Pattern

Input relating to the establishment usage pattern includes information on the percentage of establishments connected, for each bearer service. It also includes data on the traffic generated by residential subscribers as a percentage of the total traffic generated; this is specified for each application. For single-line businesses, we specify the traffic per employee as a percentage of the traffic per employee for a multi-line business. These input data are country-specific.

INPUT: Network Usage Characteristics

The network usage characteristics input sets out the characteristics of the network loading, in the form of specification of grade-of-service, bearer service utilisation, the ratio of busy-hour to mean traffic, and the ratio of peak to mean traffic. These input data are country-specific.

CALCULATION: Demand for Connections and Busy-Hour Traffic per Connection

The third stage of calculation gives the required number of network connections for each bearer service, and the busy-hour traffic per connection. Information used in the calculation is data for traffic for each bearer service and assumptions for network usage characteristics. This calculation takes into account:

- assumptions regarding establishment usage pattern (that is, the number of establishments connected to the bearer service)
- the need to dimension access to the network in such a way that the assumed grade-of-service is maintained in accordance with Erlang's formula for the required traffic load.

This calculation converts total traffic loading to busy-hour traffic loading, to enable the network to be dimensioned correctly.

X3.2.2 Supply Side

The second stage of the demand methodology involves the quantification of satisfied demand for the current TO and for other operators outside the national TO's control (referred to as 'the competition'). The structure of the supply side of the demand methodology is illustrated in Exhibit X3.3.

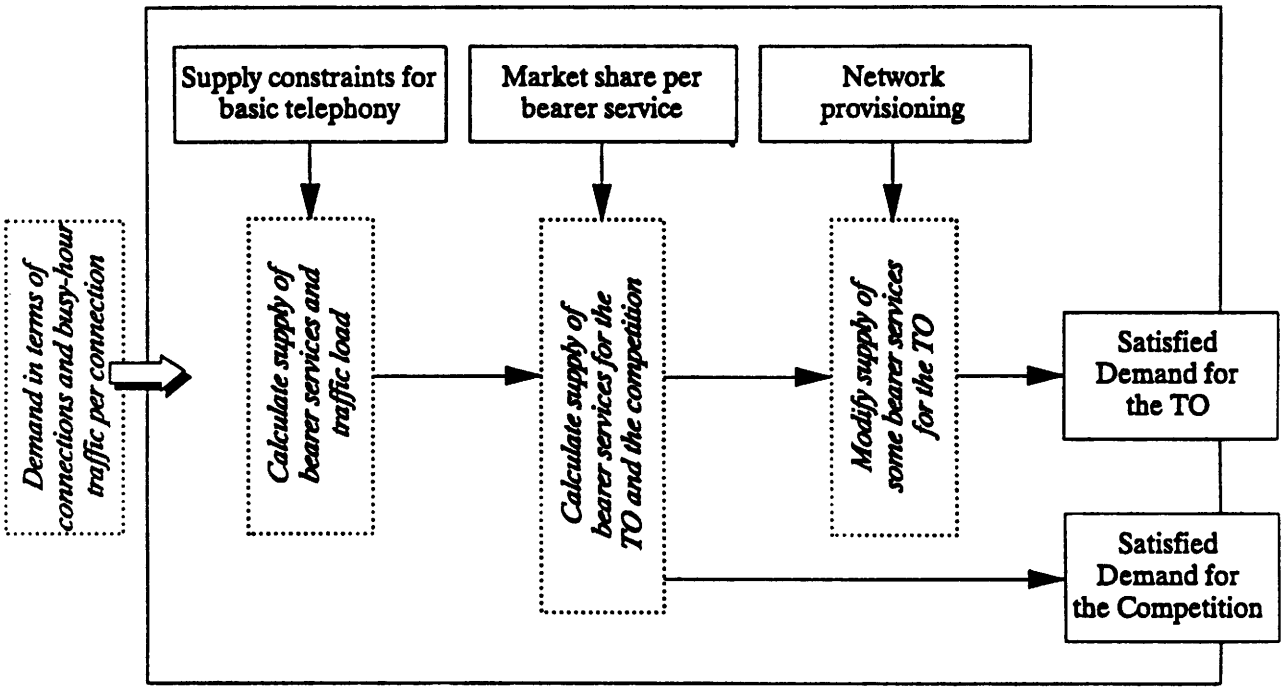
The processes involved in the supply side are summarised below.

INPUT: Supply Constraints for Basic Telephony

The first input on the supply side contains assumptions regarding network supply constraints. Only those supply constraints relating to basic telephony are considered, because this is where we envisage the greatest discrepancy between demand and supply. These input data are country-specific. Assumptions specified include:

- the satisfied demand for 1990
- the network supply limits over the study period
- the percentage of new connections which are allocated to the residential market

EXHIBIT X3.3: Demand Methodology: Detail of Supply Side



- the proportion of unsatisfied traffic demand carried on existing telephony connections. For example, when several households share one telephony connection because of supply limitations, part of their unsatisfied traffic demand is carried on the telephony network, causing a considerable increase in the traffic load per line. In a limited sense, therefore, parts of the unsatisfied demand becomes 'satisfied'.

CALCULATION: Supply of Bearer Services and Traffic Load

The supply of bearer services is calculated on the basis of assumptions from the input described above, and the results of the 'demand side' calculations. Also at this stage, the calculation of busy-hour traffic per connection is modified on the basis of data for unsatisfied traffic demand which is carried on existing connections. From this information, a waiting list for the basic telephony service can then be calculated.

INPUT: Market Share for each Bearer Service

The second input contains assumptions regarding the allocation of market share between the TO and the competition, for all bearer services and for the CPE market. For basic telephony and ISDN we expect the competition to develop differently in the access market and the transit traffic market; separate assumptions are therefore made regarding competition in these two markets. For the same reason, separate competition assumptions are made for the CPE sales and rentals markets. For the purposes of this study, VSAT is classified as a satellite-based broadband leased line, and so VSATs introduced by competitors are modelled as competition in the broadband leased-lines market. These input data are country- and scenario-specific.

CALCULATION: Supply of Bearer Services for the TO and for the Competition

The supply of bearer services for the TO and the competition is calculated from the assumptions regarding market share (as described in the previous paragraph). Calculations for the access network are done separately from those for the transit network, allowing us to represent situations where: a) there is competition in the local access, but all transit traffic is carried by the TO, or b) there is competition in the transit network, but the TO has a near monopoly in the local access network.

INPUT: Network Provisioning

The input for network provisioning contains assumptions regarding increases in the demand for leased lines to be used for interconnection with the mobile telephony network. Calculations concerning network provisioning are only carried out for the TO, not for the competition – we have assumed that the situation does not arise where a national TO leases lines from the competitors to operate its mobile telephony network. These input data are country- and scenario-specific.

Modification of the Supply of Some Bearer Services for the TO

The quantification of network provisioning effects (from the network provisioning input described in the previous paragraph) leads to a modification of demand for the TO's bearer services. The calculation of demand for leased lines for use by mobile telephony takes account of the bandwidth of the leased-line service, the bandwidth of mobile speech (which is assumed to decrease over time), and the split in usage between narrowband and broadband leased lines.

The results of these calculations – in the form of satisfied demand (number of connections and busy-hour traffic loading per connection) for each bearer service, for both the TO and its competitors – are passed on to the investment model.

X4 Tariff Methodology

In this section we describe the methodology we have used to project tariffs over the study period, for input to the investment model.

For each bearer service we calculate the following tariffs (known as 'derived' tariffs):

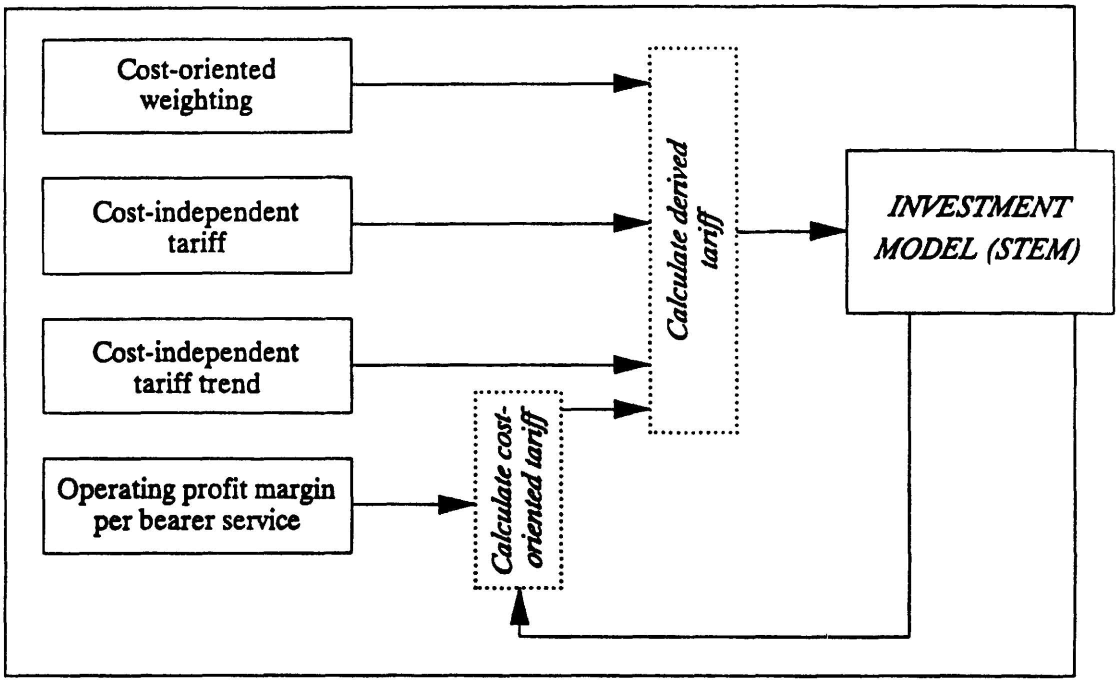
- *Installation Tariff* – the price paid by the customer for installing the connection
- *Rental Tariff* – the annual rental for the connection
- *Usage Charge* – the annual charge for usage of the bearer service (usage charge = usage tariff * volume of traffic).

Each of these derived tariffs is calculated using the following four parameters:

- *the cost-independent tariff* – the current tariff as specified by the TO. The label 'cost-independent tariff' signifies that this tariff is independent of the cost of offering the service as calculated by the investment model.
- *the cost-independent tariff trend* – an input assumption which drives change in the cost-independent tariff over time.
- *the cost-oriented tariff* – calculated by our investment model using information regarding network equipment costs, cost trends, depreciation periods and operating (gross) profit margins over time (specified on a country-by-country basis).
- *the cost-oriented weighting* – an input assumption which determines the extent to which the derived tariff is affected by the costs of providing the bearer service, and how this changes over time.

The process of determining each of these derived tariffs is summarised in Exhibit X4.1.

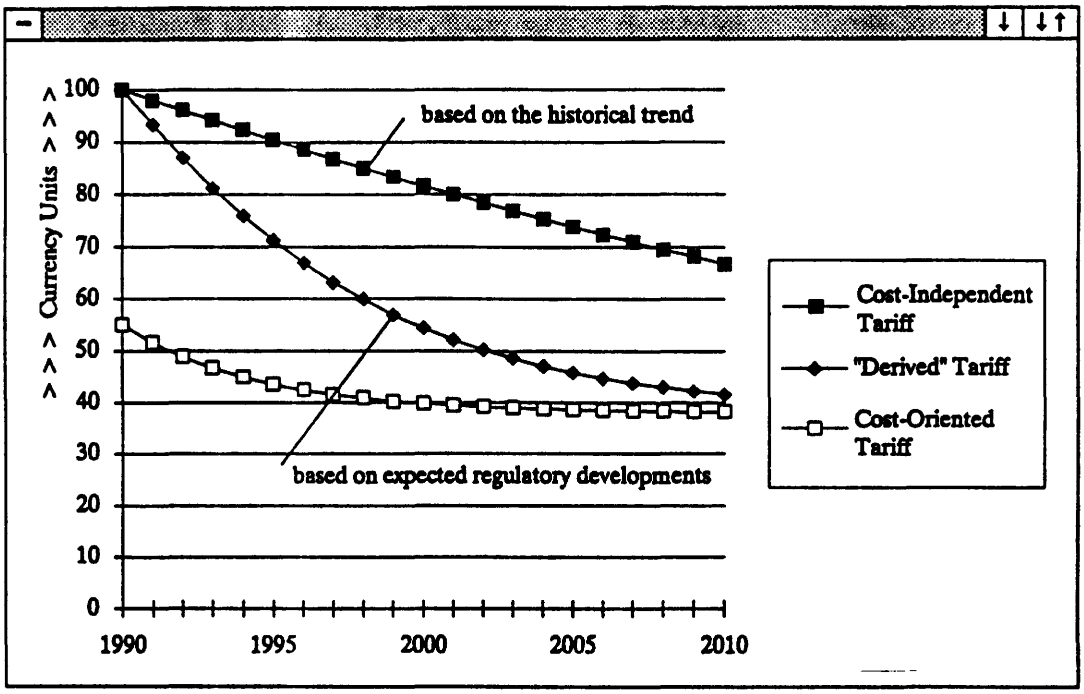
EXHIBIT X4.1: Summary of Tariff Methodology



For the first year of the study period, no cost data are available from the investment model. Therefore, the derived tariff for the first year is equal to the cost-independent tariff. For subsequent years of the study period, cost data are provided by the investment model, and so the derived tariff is calculated using the cost-oriented tariff, the cost-independent tariff, the cost-oriented weighting and the cost-independent trend.

Exhibit X4.2 gives an example of how the cost-independent tariff can develop over time, as determined by the cost-independent tariff trend. The Exhibit also illustrates the situation where the cost-oriented tariff is lower than the cost-independent tariff. As the model run progresses and the independence weighting changes, this causes a gradual transition of the derived tariff from the *cost-independent* to the *cost-oriented* tariff. In Exhibit X4.2, the weighting has not fallen to 0% by the end of the period; a weighting of 0% would imply that the derived tariff is wholly dependent on the cost-oriented tariff.

EXHIBIT X4.2: Sub-Components of a Derived Tariff



Explanation of Financial Terms

On the following pages we present an explanation of financial terms used in this report. In addition, the financial assumptions used in producing the accounts tables are also explained.

Capital Charge Capital Charge is Net Expenditure on Tangible Fixed Assets charged over the lifetime of the equipment – otherwise known as Depreciation. Capital Charge is *included* in Operating Charge.

Capital Outlay In Graph 24, Capital Outlay is defined as Net Expenditure on Tangible Fixed Assets plus CPE Sales Expenditure. In Graph 43, Capital Outlay is identical to Net Expenditure on Tangible Fixed Assets.

Cash For any one year, Cash is the sum of the Cash (balance) figure for the previous year and the Net Cash Outflow from Operations in the current year.

Note: it is assumed that the whole of Network Cash Flow resulting from the model run (as shown in Graph 44) feeds directly into this Cash balance. No assumptions have been made as to whether positive Network Cash Flows are used to pay off long-term debt or to invest in extra-national operations. In practice, therefore, the Cash balance shown in the accounts tables equates to the Network Cash Balance as shown in Graph 44.

Creditors (amounts falling due after more than one year) This term is taken to be equal to the operator's long-term debt in 1990.

Creditors (other)	'Creditors (other)' are all short-term creditors with the exception of tax payable and dividends payable. The figure for Creditors (other) in 1990 was taken from the 1990 accounts used as our starting-point, and represents the difference between total Short-Term Creditors and the sum of Tax and Dividends Payable. For subsequent years, the figure for Creditors (other) is adjusted according to changes in Turnover and Debtors.
Creditors (tax and dividends payable)	Creditors (tax and dividends payable) are equal to Tax on the Profit of Ordinary Activities in the current year plus Ordinary Dividends in the current year.
Debtors	The 1990 figures for Debtors were taken from the 1990 accounts used as our starting-point. For subsequent years, Debtors are assumed to vary from the base year in proportion to the level of turnover in the current year, and represent the amount of money that is owed to the operating company.
Depreciation	Depreciation is the sum of all capital charge payments from previous capital investments which fall due in the current year.
Dividends Paid	For any one year, Dividends Paid are the dividends which were declared due in the previous year.
Earnings per Share	Earnings per Share are calculated as Profit Attributable to Ordinary Shareholders divided by the Number of Ordinary Shares.
Exceptional Charge	Any Exceptional Charge[1] for 1990 is taken into account in that year, but for subsequent years there is assumed to be no Exceptional Charge.
Fixed Assets	Fixed Assets in the current year are calculated to be the sum of Fixed Assets in the previous year plus Net Expenditure on Tangible Fixed Assets less net Depreciation.
Funds from Operations (as used in Results Graphs)	In the results graphs, Funds from Operations are equal to Revenue less any Exceptional Charge, less the sum of all Running Costs, Indirect Costs and Net Expenditure on Tangible Fixed Assets. This is the same as Net Cash Outflow from Operations in the sets of accounts, but *different from* Total Funds Generated from Operations before Tax, as used in the sets of accounts.

1 Exceptional Charges are single non-recurring charges, such as redundancy costs associated with a restructuring of the organisation.

Increase in Working Capital	The 1990 figure for Increase in Working Capital has been taken from the 1990 accounts used as our starting-point. In subsequent years, Increase in Working Capital is defined as the difference between Debtors minus Creditors (Other) in the current year and Debtors minus Creditors (Other) in the previous year.
Indirect Costs	Indirect Costs are the sum of Net Interest Paid, Taxation Paid, Dividends Paid and Increase in Working Capital. Exceptional Charges are not included in Indirect Costs.
Interest Cover	Interest Cover is calculated as Operating Profit before Interest plus Depreciation, divided by Net Interest Paid. It indicates the multiple by which Operating Profit exceeds Net Interest Paid. Negative values indicate that Net Interest is negative.
Investment in Relation to Turnover	Investment in Relation to Turnover is Net Expenditure on Tangible Fixed Assets expressed as a proportion of Turnover (revenue).
Long-Term Creditors	See 'Creditors (amounts falling due after more than one year)'.
Minority Interests	The value for liability to Minority Interests in 1990 was taken from the 1990 accounts used as our starting-point, and remains unchanged for subsequent years of the model period.
Net Assets	Net Assets are calculated as Net Current Assets plus Fixed Assets.
Net Cash Outflow from Operations	Net Cash Outflow from Operations is the difference between Total Sources of Funds Net of Taxation and Total Application of Funds in the year.
Net Current Assets	Net Current Assets is the sum of Stock, Debtors and Cash, less Short-Term Creditors.
Net Expenditure on Tangible Fixed Assets	Net Expenditure on Tangible Fixed Assets is total capital expenditure in the year, excluding CPE Sales Expenditure.

Net Interest Paid

Net Interest Paid is calculated from the sum of Cash and Short-Term Creditors. A different interest rate is used depending on whether this total is positive or negative. However, the interest rate is gradually moved during the model period towards the European average, at a speed largely determined by the likely regulatory changes in the country.

Net Profit Margin

See 'Profit Margin'.

Network Cash Balance

This is illustrated in Graph 44 within each set of country results. It is the direct result of the pattern of network investment and operations modelled. For any year it is the sum of the Network Cash Balance for the previous year and the Network Cash Flow in the current year.

Because we have not undertaken detailed modelling of the means by which operators finance their capital expenditure, or of the uses to which network Cash Flows are put, the Cash figure shown in the Balance Sheet is identical to Network Cash Balance. In the Balance Sheets all debt (other than Short-Term Creditors) additional to the 1990 Long-Term Creditors figure is reflected in the Cash line. Similarly, we have not shown Network Cash Flow being used to reduce the amount of Long-Term Creditors. **Note:** if we had made different financing assumptions, the Cash figure in the accounts would not necessarily have been the same as the Network Cash Balance.

Network Cash Flow

The Network Cash Flow for each country is shown in Graph 44 of that country's results. The Network Cash Flow profile is the direct consequence of the pattern of network investment and operations modelled. It is conceptually different from Net Cash Outflow from Operations in the accounts sheets, since in theory the latter could be affected by cash movements which are not related to the network (for instance, the sale or purchase of financial assets). However, because we have not attempted to model financing in detail, and have instead assumed that cash is not used to pay off long-term debt or to purchase financial assets, in practice Net Cash Outflow from Operations shown in the accounts is the same as Network Cash Flow.

Number of Ordinary Shares	The Number of Ordinary Shares is taken to be equal to Turnover in 1990 divided by three. The purpose of calculating the number of shares in circumstances where operating companies are under government control is to see the equivalent earnings performance of the company, and to cater for the situation where a flotation occurs at some point during the model run.
Operating Charge	See 'Operating Costs'.
Operating Costs	Operating Costs are the sum of Depreciation charges occurring during the year and all Running Costs (all current account expenditure including operations and maintenance, administration, service provision and overheads) but not Interest, Tax or Dividends. Where we show figures for individual bearer services (as in Graphs 35 to 40), we refer to Operating Charge rather than Operating Cost, since this is a more appropriate term for the individual services where the total cost is allocated to each one.
Operating Profit before Interest	Operating Profit before Interest is calculated as Turnover less the sum of Operating Costs in the year.
Operating Profit Margin	Operating Profit Margin is calculated as the Profit on Ordinary Activities before Taxation divided by Turnover in the year.
Ordinary Dividends	The 1990 figure for Ordinary Dividends has been taken from the 1990 accounts used as our starting-point. In subsequent years, if there were dividends in 1990, the 1990 dividend rate (i.e. dividends as a percentage of Profit Attributable to Ordinary Shareholders) is used throughout. Where there were no dividends in 1990, dividends in subsequent years are also assumed to be zero. Within each country the same dividend rates have been used for both the TO and its competitors.
Overall Charge per Connection	Overall Charge per Connection is Operating Charge for the individual service divided by the number of connections.
Profit Attributable to Ordinary Shareholders	In practice, Profit Attributable to Ordinary Shareholders is equal to Profit on Ordinary Activities after Tax, since Minority Interests and Preference Dividends are assumed to be zero.

Profit Margin	Profit Margin is calculated as the Profit on Ordinary Activities after Taxation divided by Turnover in the year. It is also referred to as Net Profit Margin.
Profit on Ordinary Activities after Tax	Profit on Ordinary Activities after Tax is Profit on Ordinary Activities before Tax less Tax on the Profit of Ordinary Activities.
Profit on Ordinary Activities before Tax	Profit on Ordinary Activities before Tax is defined as Operating Profit before Interest less the sum of Exceptional Charge and Net Interest Paid.
Provisions for Liabilities and Charges	The Provision for Liabilities and Charges in 1990 has been taken from the 1990 accounts used as our starting-point, and this figure is used for all subsequent years.
Reserves at the Year End	Reserves at the Year End are Restated Reserves at Beginning of the Year plus Retained Profit for the Year.
Restated Reserves at the Beginning of the Year	Restated Reserves at the Beginning of the Year are equal to Reserves at the Year End for the previous year.
Retained Profit for the Financial Year	Retained Profit for the Financial Year is defined as Profit Attributable to Ordinary Shareholders less Ordinary Dividends.
Return on Total Assets	Return on Total Assets is defined as Profit on Ordinary Activities after Tax as a proportion of the sum of Stock, Debtors, Cash and Fixed Assets. As mentioned under 'Cash', we have assumed that Cash in the accounts is equal to Network Cash Balance. Since Cash (balance) is a part of Total Assets and, under our assumptions, Cash equates to Network Cash Balance, negative Network Cash Balances are reflected in the Balance Sheet as a reduction in Total Assets rather than as an increase in Total Liabilities. Return on Total Assets is therefore higher than if we had made different assumptions. Similarly, large positive Network Cash Balances result, under these assumptions, in increases in Total Assets compared to a situation where these large Network Cash Balances were used to reduce Total Liabilities.
Revenue per Call Minute	Revenue per Call Minute is total revenue for a particular service divided by number of call minutes for that service.

Revenue per Connection	Revenue per Connection is total revenue divided by the number of connections. Note that although a telephony connection in 1990 is usually a copper pair carrying one voice circuit, a connection not necessarily the same as a voice circuit. For instance, a Primary-Rate ISDN connection provides 30 voice circuits, but is still one connection. The sum of connections for Business Telephony, Residential Telephony, Mobiles, ISDN and Switched Broadband is described as the Total for Main Switched Services.
Running Costs	Running Costs are the sum of all current account charges including operations and maintenance, administration, service provision and overheads.
Short-Term Creditors	The sum of Creditors (tax and dividends payable) plus Creditors (other), in the Balance Sheet. Short-term Creditors are deducted from the total of Stock, Debtors and Cash to arrive at Net Current Assets.
Stock	The 1990 figure for Stock has been taken from the 1990 accounts used as our starting-point. In subsequent years, Stock varies in proportion to Net Expenditure on Tangible Fixed Assets.
Taxation Paid	Taxation Paid is taxation due on the Profit on Ordinary Activities in the previous year.
Tax on the Profit of Ordinary Activities	Tax on the Profit of Ordinary Activities is all tax due on the current year's activities. The tax rate is gradually moved during the model period to the European average, at a speed largely determined by likely regulatory changes in the country.
Total Application of Funds	Total Application of Funds is the sum of Net Expenditure on Tangible Fixed Assets, Dividends Paid and Increase in Working Capital.
Total Funds Generated from Operations before Tax (as used in the sets of accounts)	Total Funds Generated from Operations before Tax is the sum of Profit on Ordinary Activities before Tax, Depreciation and all other items not involving cash movement. Note: this is different from the Funds from Operations measure used in the results graphs (which is calculated after tax and after Net Expenditure on Tangible Fixed Assets).

Total Sources of Funds Net of Taxation	Total Sources of Funds Net of Taxation is calculated as Total Funds Generated from Operations before Tax, less Taxation Paid.
Turnover	Turnover is the sum of all revenues generated by the service and product sales during the year.

Analysys

Glossary and Abbreviations

3D	Three Dimensional
ANI	Automatic Number Identification
AON	Active Optical Network
Application	A task that a user performs using telecoms. A number of different attributes are used to distinguish applications – type of information to be communicated, mobility of user, speed of transmission, etc.
ASST	One of the three TOs in Italy, which is responsible for the long-distance national network between major cities, and the international (European and Mediterranean basin) telephony services
ATC	The Association of local Telephone Companies in Finland, representing the interests of the companies in dealings with the government and the TO
ATM	Asynchronous Transfer Mode
AV	Audio-Visual
BABT	British Approvals Board for Telecommunications, responsible for equipment type approval in the UK
Bearer Service	Types of connection either offered at present or expected to become significant in the future. They may also be referred to as 'connection types'
BECU	Billions of ECU
BeNeLux	Belgium, the Netherlands and Luxembourg
bn	Billion
BT	The trading name of British Telecommunications plc
BTN	Basic Telephony Network
BTS	Base Transceiver System (part of PCN)
CAA	Autocommutateur à Autonomie d'Acheminement, a primary level exchange in France
CATV	Cable Television
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CEC	Commission of the European Communities
Centrex	A service offering a user organisation the functionality of a PABX from the local telephone exchange
CL	A local switch in France
Class	In STEM, *Classes* are the functional blocks which make up the network architecture; each includes several kinds of equipment (modelled as *Specifics*)
CLI	Calling Line Identification
CO	Central Office

COCOM	The organisation responsible for determining the security export control system for NATO countries and Japan
Connection Type	The type of access to the network used for a communication (e.g. Public Payphone, Narrowband Leased Line,Basic-Rate ISDN)
CPE	Customer Premises Equipment
CPRM	Companhia Portuguesa Radio Marconi, which provides a satellite and continental cable service in Portugal
CSA	An independent commission in France which controls all TV and radio broadcasts
CSDN	Circuit-Switched Data Network
CT2	Cordless Telephony 2
CTP	A tertiary level exchange in France
CTS	A secondary level exchange in France
CTT	Correio e Telecomunicaceos de Portugal, the former name for Telecom Portugal
Cu	Copper
DCC	Digital Cross-Connect
DCS	A packet-switched service introduced by RTT, the Belgian TO
DCSR	Direzione Centrale Servizi Radioelettrici, a body in Italy responsible for radio services, particularly marine communications
DCST	Direzione Centrale Servizi Telegrafici, a body in Italy responsible for telex and telegram services and the Telex-dati data network
DDD	Direct Distance Dialling
DEC	Digital Equipment Corporation
DECT	Digital European Cordless Telephone (CEC standard for digital cordless telephones)
DEL	Direct Exchange Line
DOS	Disk Operating System
DRG	Direction de la Réglementation Générale (French regulatory body)
EBRD	European Bank for Reconstruction and Development
EC	European Community
ECU	European Currency Unit
EDI	Electronic Data Interchange (generic term for the electronic transfer of invoices and other commercial documents)
EFT	Electronic Funds Transfer
EFTA	European Free Trade Association
EFTPOS	Electronic Funds Transfer at Point of Sale
Email	Electronic mail
EMS	European Monetary System
ERM	Exchange Rate Mechanism
ETSI	European Telecommunications Standards Institute
FCC	US Federal Communications Commission
FDDI	Fibre Distributed Data Interchange
FT	France Telecom; also Fyns Telefon, one of the four regional operators in Denmark, responsible for the Funen area
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GNP	Gross National Product
GOS	Grade of Service
GPT	GEC Plessey Telecommunications
GSM	Groupe Spéciale Mobile (the CEC/CEPT-initiated future digital pan-European mobile telephone system)
HDTV	High-Definition Television

HRC	Hungarian Radiotelephone Company
HTC	Hungarian Telecommunications Company, the Hungarian TO
IBC	Integrated Broadband Communications
IBCN	IBC Network
IBT	The new Belgian Institute for Telecommunications
ICP	Instituto das Comunicacoes de Portugal, the independent regulatory body in Portugal
IFC	International Finance Corporation
IMF	International Monetary Fund
IN	Intelligent Network
INTUG	International Telecommunications Users Group
IPSS	BT's international data transmission network
ISDN	Integrated Services Digital Network
ISO	International Standards Organisation
ISPT	Instituto Superiore delle Poste e Telecommicazione, the body responsible for equipment type approval in Italy
IT	Information technology
ITU	International Telecommunication Union
IXC	Inter-Exchange Carrier in the USA
JTAS	Jyosk Telefon Aktie Selskab, one of the four regional operators in Denmark, responsible for Jutland
KDD	Japanese international carrier
KTAS	Københavns Telefon Aktie Selskab, one of the four regional operators in Denmark, responsible for Zealand, Lolland-Falster, Moen and Bornholm
LAN	Local Area Network
LATA	Local Access and Transport Area, in the USA
LEC	Local Exchange Carrier
LEX	Local Exchange
MAN	Metropolitan Area Network
MDNS	Managed Data Network Services
mE	milli-Erlang (1/1000th of an Erlang)
MECU	Millions of ECU
MES	Master Earth Station
MFJ	Modified Final Judgement
MS	Market Segment
Mux	Multiplexer
NB	Narrowband
NCC	New Common Carrier
NET	Norme Européenne de Télécommunications
NMS	Network Management System
NT	Network Termination
NTT	Japanese domestic carrier
NY	New York
O&M	Operations and Maintenance
OECD	Organisation for Economic Co-operation and Development
OF	Optical Fibre
OFTEL	Office of Telecommunications (UK regulatory body)
ONA	Open Network Architecture
ONP	Open Network Provision
OSI	Open Systems Interconnection
OTE	Hellenic Telecommunications Organisation, the Greek TO
PA	Primary Access
PBX	Private Branch Exchange
PC	Personal Computer
PCM	Pulse Code Modulation
PCN	Personal Communications Network

PNC	Personal Number Calling
PON	Passive Optical Network
POTS	'Plain Old Telephony Service'
PPTT	The Polish Post, Telegraph and Telephone Organisation
PSDN	Public Switched Data Network
PSO	Private Service Operator
PSTN	Public Switched Telephone Network
PTO	Public Telecommunications Operator
RACE	Research into Advanced Communications Technologies for Europe (CEC Programme)
RBHC	Regional Bell Holding Company
RBOC	Regional Bell Operating Company
RCU	Remote Concentrator Unit
RDSI	Red Digital Servicios Integrados, an integrated ISDN service being planned by Telefónica in Spain
RFD	Rete Fonia-Dati, the lower layer of the CSDN in Italy
RPI	Retail Price Index
RPT	Rom-Post-Telecom, an autonomous state-owned company in Romania, with a monopoly over the supply of basic services
RSS	Remote Subscriber Switch
RTT	Régie des Télégraphes et Téléphones, the Belgian TO
SDH	Synchronous Digital Hierarchy
SFR	Self Financing Ratio
SIP	One of the TOs in Italy, which is responsible for the local network and for some long-distance national networks
SLIC	Subscriber Line Interface Card
SONET	Synchronous Optical Network
Specific	In STEM, *Specifics* represent the various technological options for implementing the network function of a particular *Class*
SS7	CCITT Signalling System No. 7
STEM	Analysys STEM™ Strategic Telecommunications Evaluation Model
STF	Statens Teleforvaltning, a regulatory authority in Norway responsible for type approval and the award of operating licences
STORE	Analysys STORE™ database management and model annotation system
TEX	Transit Exchange
TLP	Telefones de Lisboa e Oporto, responsible for the telephone network of Lisbon and Oporto (Portugal)
TMN	Telecommunication Management Network
TO	Telecommunications Operator
TP	Telecom Portugal
TPON	Telephony Passive Optical Network
TS	Søndis Telefon, one of the four regional operators in Denmark, responsible for southern areas of Jutland
UK	United Kingdom
UMTS	Universal Mobile Telephony Service
UPT	Universal Personal Telecommunications
USO	Universal Service Obligation
VADS	Value-Added Data Service
VANS	Value-Added Network Service
VAS	Value-Added Service
VCR	Video Cassette Recorder
VLSI	Very Large-Scale Integration
VPN	Virtual Private Network
VSAT	Very-Small-Aperture Terminal (for satellite communications)
WAN	Wide Area Network
WDM	Wave-Division Multiplexing