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the department for Enterprise

Study of the International Competitiveness of the UK Telecommunications Infrastructure

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EXECUTIVE SUMMARY

1. Introduction

Telecommunications is of growing importance to the economic prosperity and competitiveness of nations. In recognition of this the UK Department of Trade and Industry commissioned a study to compare the state of development of the telecommunications infrastructure in the UK with that in a number of other leading industrial countries. This Executive Summary provides an overview of the more significant findings of the study, full details of which are contained in the following report.

The report provides an up-to-date comparison of the state of development of the telecommunications infrastructure and services in the UK with that of France, Germany, Japan, the Netherlands, Sweden and the United States, and identifies the major development trends. It provides a view of expected developments in both the short to medium term and in the longer term. The report covers switched two way networks, leased two way networks, cable TV networks, and mobile radio networks and in addition looks at the degree of liberalisation, and the cost and quality of services.

2. Regulation

There is a general trend away from monopoly provision of telecommunications services by a single national operator in all countries covered by the study, but the degree of liberalisation and the extent of competition varies considerably from country to country and service to service. Coupled with these changes is a trend for the separation of the operators from government and to a lesser extent a trend towards private ownership. Figure 1 summarises the current situation.

Country	Fixed n/w	Cable TV	Mobile	Leased Lines
France		LM	D	R
Germany			C	R
Japan	C	LM	C	R
Netherlands		LM		R
Sweden	C	C	C	U
USA	LM/C	LM	LD	U
UK	C	LM	C	U

Key: M: Monopoly L: Local D: Duopoly R: Restricted C: Competition U: Unrestricted

Figure 1. Degree of Liberalisation

Japan, Sweden, the USA, and the UK all permit competition in a wide variety of services. The remaining three countries are moving in the same direction, with the encouragement of the European Commission. The UK has generated competition in more areas than any of the other countries, although Sweden is in theory more liberalised.

3. Investment

The price paid by telecommunications operators for equipment varies from country to country, with some paying over three times the international price level. As a result the sums invested by operators can give a misleading indication of the quantity of equipment purchased. Figure 2 shows the actual investment in 1990, together with the equivalent investment if all equipment had been purchased at international prices.

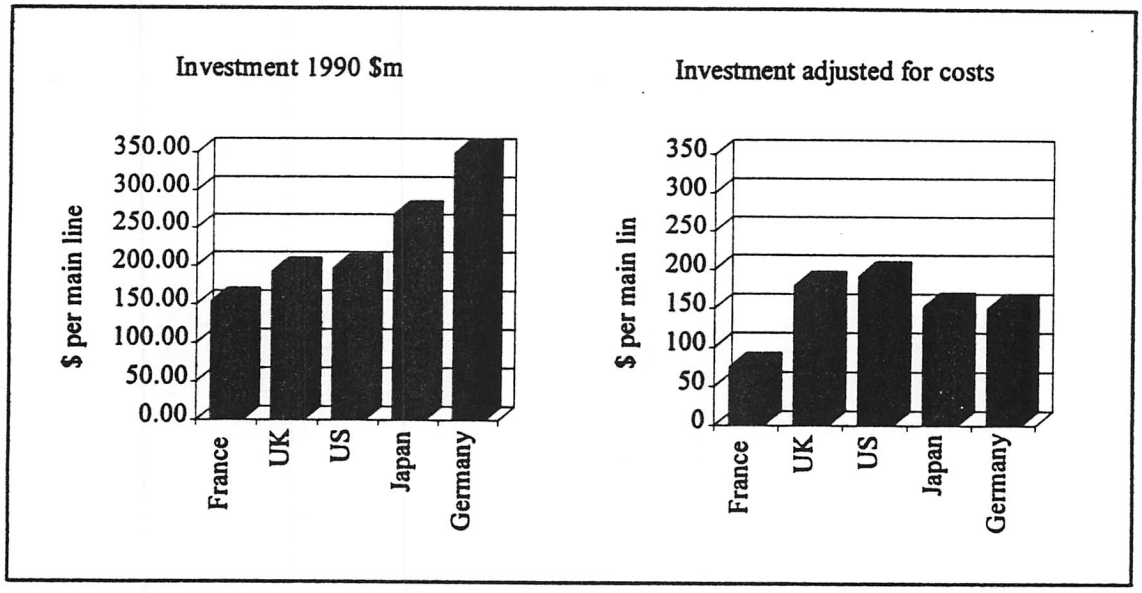

Figure 2. Investment adjusted to reflect cost of equipment

It should be noted that as markets become more open, prices in all countries are moving towards international levels.

4. Digitalisation

Digital telecommunications equipment offers superior reliability, more consistent performance and is less expensive than analogue equipment. In addition it forms the basis for provision of digital service at multiples of 64kb/s in the form of ISDN (Integrated Services Digital Network). The extent of digitalisation is a useful measure of the ability of a network to meet today's needs. Figure 3 shows the proportion of main lines in each country attached to a digital switch, together with the proportion that have access to ISDN.

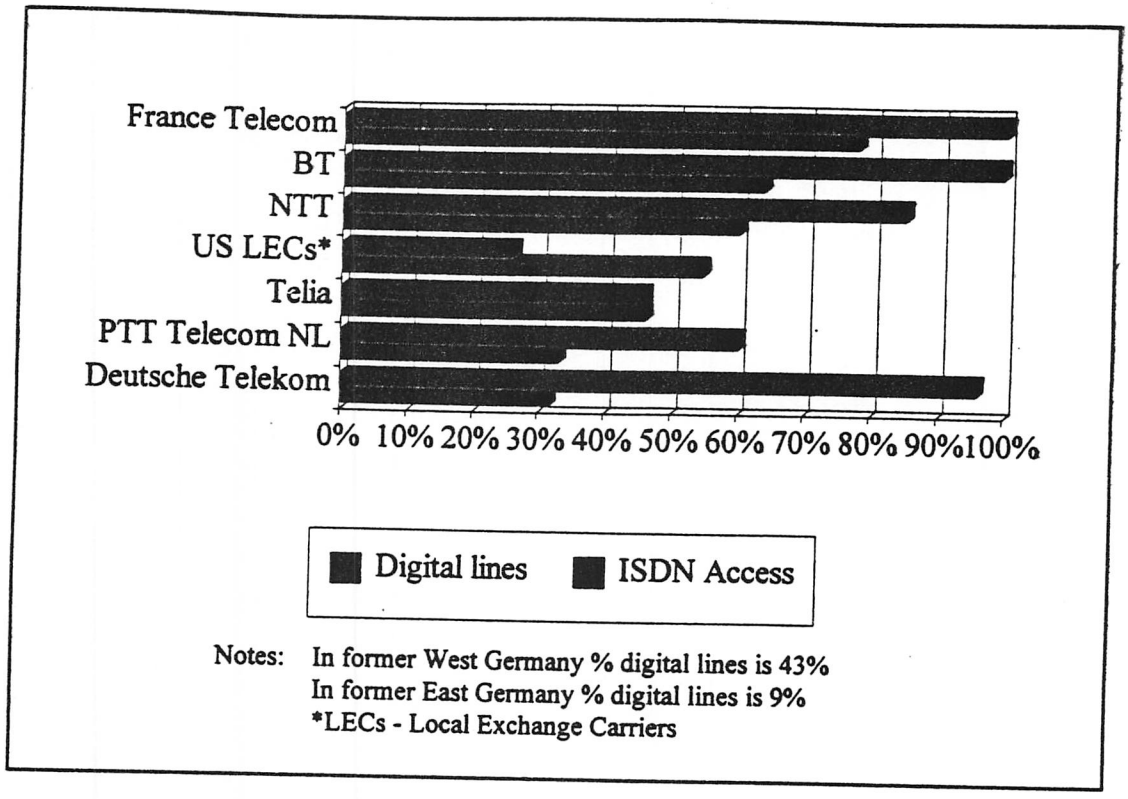

Figure 3. Main lines with access to digital exchanges and ISDN

The UK has the second highest proportion of subscribers connected to digital exchanges, and can provide access to ISDN for almost all users.

5. National Broadband Initiatives

The provision of a broadband telecommunications infrastructure is a necessary prerequisite for the development and use of many networked multimedia applications for both the business and residential user. The extent to which national networks support broadband can therefore be regarded as a measure of their ability to support innovative and future applications.

Two of the seven countries, the USA and Japan, have a government inspired national plan or concept to upgrade their telecommunications infrastructure with particular regard to the need to establish a national broadband network. The US government has promoted the idea of an Information Superhighway (now known as the National Information Infrastructure (NII)) as a "network of networks" constructed by the operators. At its core is the National Research and Education Network (NREN). US government funding will be limited to around $200m - $300m pa over five years, primarily for demonstration projects and connections to the NII. In Japan, the Ministry of Posts and Telecommunications (MPT) is working with industry to establish a framework for introducing a new broadband infrastructure. The UK and France are constructing national broadband research networks, Super JANET and Renater respectively.

Deutsche Telekom has embarked on the most extensive deployment of wideband technology in Europe, driven primarily by the need to create a new infrastructure in the former East German states. PTT Telecom of the Netherlands has developed a national scheme to deploy fibre in the access network from 1995 to carry telephony, GSM[1], and Cable TV services. The European Commission is actively promoting a broadband initiative under its TENs[2] programme which is primarily aimed at the development and trial of new applications. In advance of this many of the Western European operators have signed a Memorandum of Understanding to establish a trial overlay broadband ATM[3] network between the participating countries.

6. Broadband Infrastructure

The provision of broadband capability in modern telecommunications networks centres around the deployment of optical fibre cable and associated electronic systems in the core network. All operators in the seven countries make use of fibre for their inter-exchange networks, and fibre has become established as an economic means of connecting business users with multiple lines. Figure 4 shows the length of fibre installed per subscriber in the interexchange network in each country.

To take account of the differences in the population densities of the different countries, the installed base of fibre shown in Figure 4 may also be adjusted for the difference in the sizes of the countries. As might be expected the figures for the USA and Sweden fall to levels equal to or lower than the UK, and that for the Netherlands increases. However comparison based directly on the land areas is not meaningful owing to the uneven distribution of the populations.

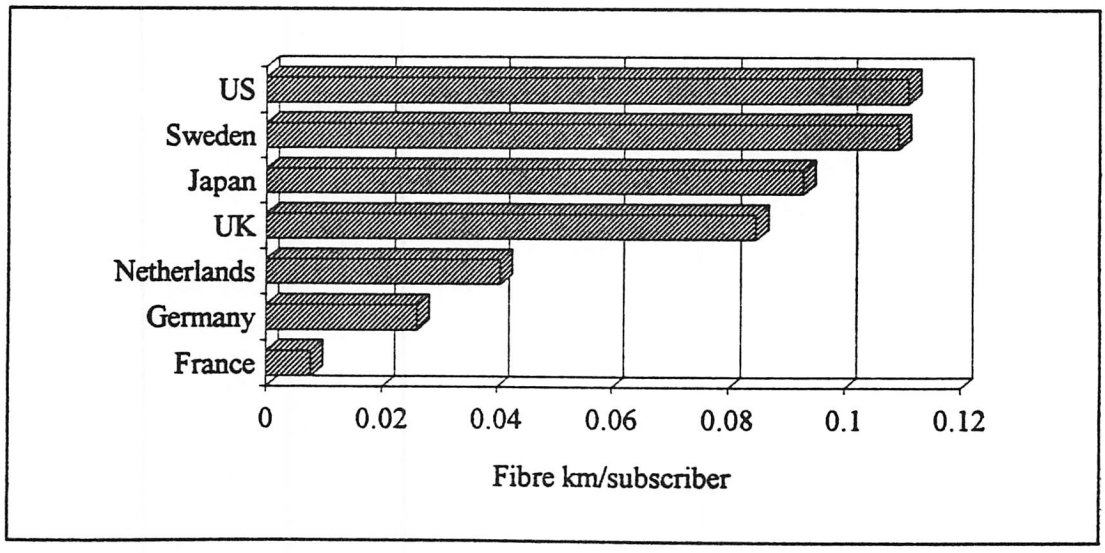

Figure 4. Installed fibre per subscriber in the interexchange network

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1 Global System for Mobile Communications. The scheme will carry traffic to the fixed base stations.

2 Trans European Networks

3 Asynchronous Transfer Mode. A broadband switching technology.

At present the consensus amongst all operators covered by the study is that the cost of the terminal electronics will make fibre to the home uneconomic for new installations until at least 1995-7, and for replacement of existing copper until early in the next century. However deployment of fibre to the kerb, or to multi-occupancy buildings can often be justified at today's costs for new installations. Operators in the USA, Germany and the UK are installing fibre in the loop commercially for residential users. France Telecom, NTT, and Telia all plan to conduct further trials before embarking on major deployment. The number of telephone subscribers served by networks using fibre in the loop is shown in figure 5a. together with forecasts for 1995.

Most of the connections to residential users in the UK are being provided by the cable TV operators. Figure 5b shows the number of telephone subscribers in the UK served by fibre in the loop systems compared to the number of homes passed by such systems. Inclusion of fibre based cable TV networks in France and the USA, which do not at present carry telephony, would increase the penetration in both those countries.

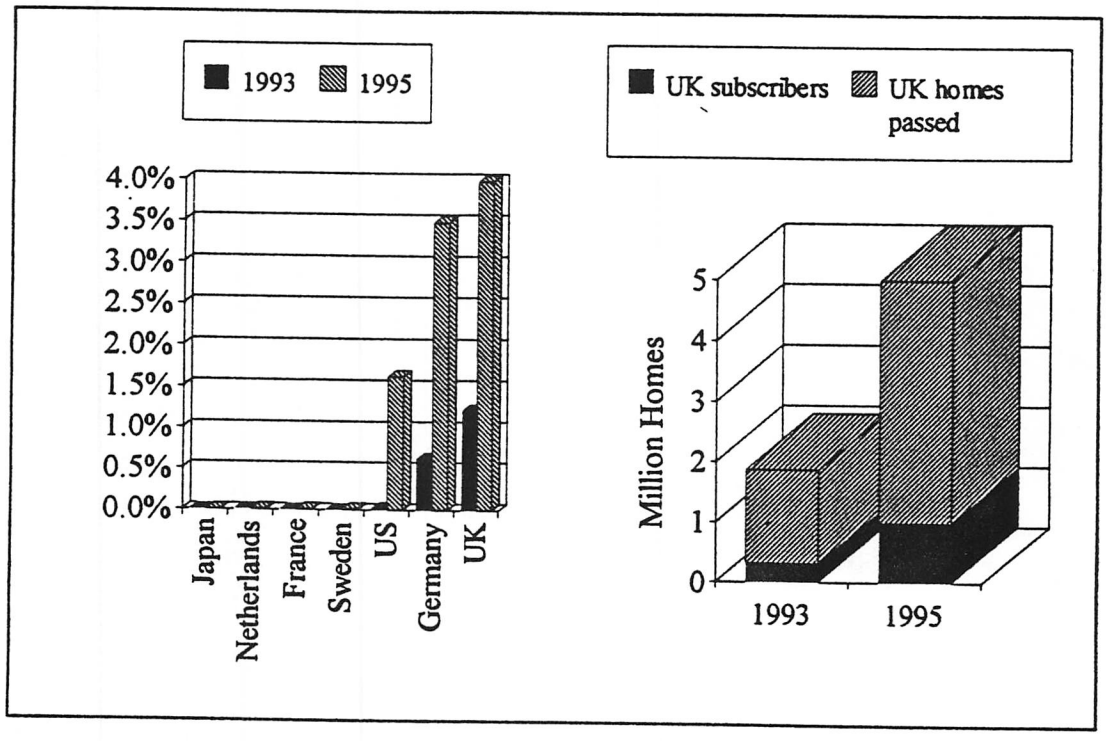

Figure 5a.
Proportion of residential and small business telephone subscribers served by fibre in the loop

Figure 5b.
Number of UK homes passed by fibre in the loop vs number of telephone subscribers served by fibre in the loop

Fibre rings are now becoming established as a means of providing resilient broadband access for business users, particularly in areas of high business concentration. The USA has the largest installed base, with rings in service in over 150 metropolitan areas. In the UK, rings are being installed in London by

several operators for service in 1994. Deutsche Telekom has a programme for rolling out rings in 38 cities by 1997. NTT plans to deploy fibre to all business subscribers in Tokyo by 1995 and in other metropolitan areas by the year 2000. The other national operators are conducting trials of fibre rings.

7. Mobile Services

All countries in the study have established cellular analogue networks providing widespread coverage in the country, and all are now in the process of introducing digital cellular services which provide improved signal quality, security, and use of spectrum. All European countries, and many elsewhere in the world, use the GSM standard for digital cellular radio networks which operates at 900MHz, and in some cases also use DCS1800, a variation of GSM for use at 1800MHz. GSM was specifically developed, with the encouragement of the European Commission, to provide Europe with a mobile radio system to a single standard which would allow users to roam freely from country to country without interruption of the service.

The USA and Japan use different standards, and introduction of digital cellular radio is running behind Europe. In the USA licences are to be issued for new PCS[4] services at around 2GHz which will allow up to seven new operators in any given area. The concept is that PCS services will address user needs over small areas. Other PCS-type implementations include the Japanese Personal Handy Phone system and Telepoint.

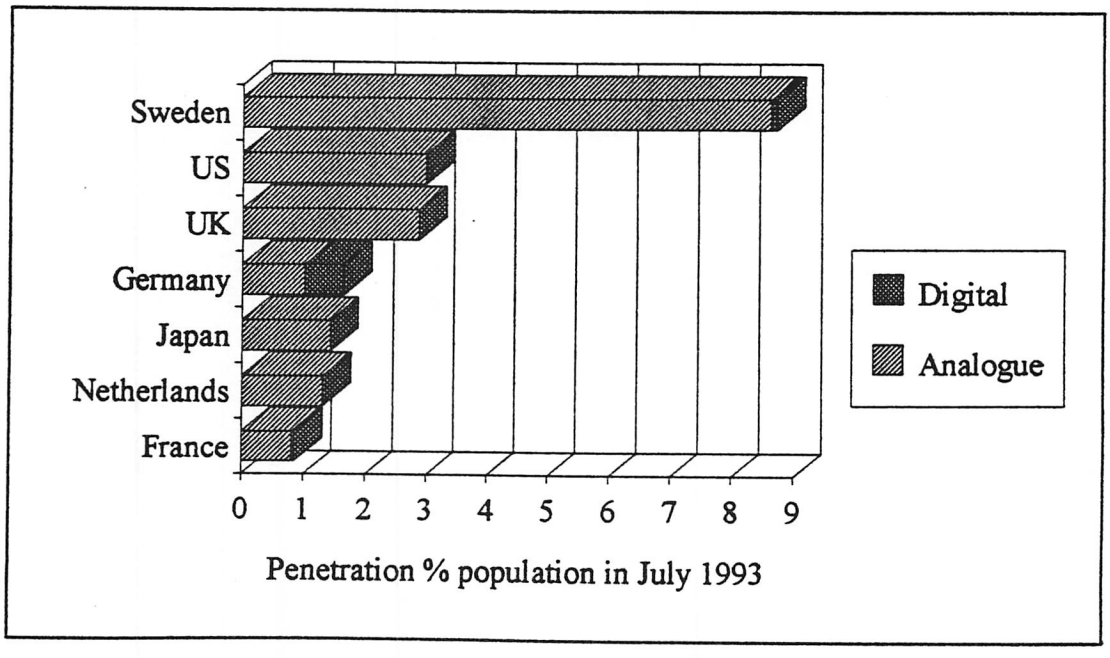

Figure 6. Penetration of Analogue and Digital Mobile Services

[4] Personal Communications System

Take up of the digital services already in operation has been highly dependent on the quality of the analogue service previously available, and the extent of roll-out provided by the digital operator. Penetration of analogue services was low in both France and Germany, but so far take up of GSM has been rapid only in Germany. Figure 5 shows penetration of analogue and digital services. The UK already has high penetration of its analogue services, so there was no pent up demand for the digital services to satisfy. Nevertheless take up of Mercury One-2-One has been high, and the market will be further stimulated by the launch of services by Cellnet and Hutchison in 1994.

8. Impact of Costs

A major factor influencing the use of broadband circuits is the high cost of national and international leased lines in Europe. Figure 7a compares costs for international leased lines within Europe with costs for national leased lines in Europe and the USA. Reuters, which has the largest private network in the world, has prepared a comparison of the costs it incurs in Europe for leased lines with the costs it would incur if its entire network were in the USA, which shows a saving of 90%. Such high costs not only increase the costs for business, but they also suppress business activity by making it uneconomic to offer certain types of service or to carry out some business activities.

Many business users think on a regional basis, and will frequently determine activities on a European, rather than national basis. Whilst the UK has relatively low tariff levels, the high costs elsewhere in Europe can lead to businesses deciding not to carry out a particular activity in any of the countries. The lower costs can, and do, serve as encouragement for businesses to locate in the UK.

As shown in figure 7b the ratio of costs for lines of different speeds is lowest in the USA. The proportionally low increase in cost for the higher speed circuit makes it very attractive for USA businesses to use them in preference to lower speed lines. This difference in tariffing policy between the USA and other countries means that users in the USA tend to regard bandwidth as an inexpensive commodity, and face a far lower cost penalty in experimenting with broadband applications. If maintained, such tariffing policies will act as a brake on the development and use of broadband applications in Europe when compared with the USA.

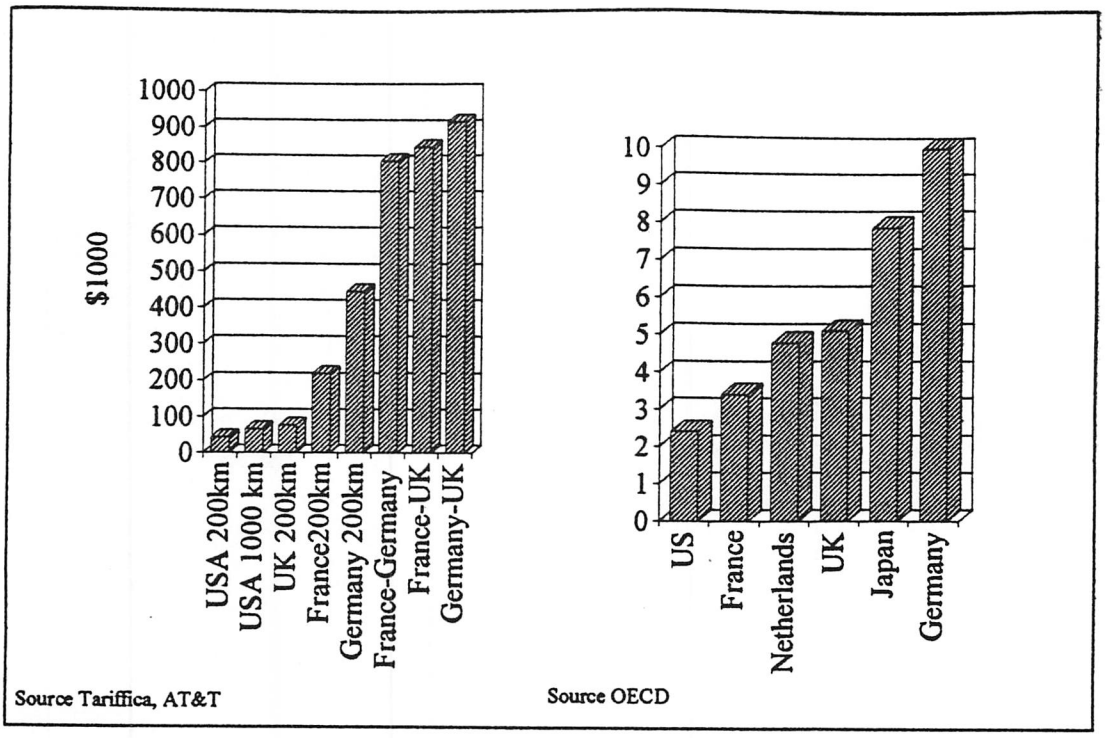

Figure 7a
Comparison of 1.5/2 Mbit/s Leased Line Costs:
National vs International within Europe

Figure 7b
Comparison of costs of leased lines of different speeds:
Ratio of costs of baskets of 1.5/2Mbit/s to 56/64kbit/s leased lines
(fixed and variable charges at Jan 1992)

9. Conclusions

The UK has competition in the supply of almost all telecommunications services. Only the cable TV operators do not face direct competition (in respect of their TV services), but they do compete with alternative means of receiving off-air combinations of terrestrial and satellite broadcasts. BT's planned video-on-demand service, if commercially deployed, can be expected to encourage innovation in interactive services.

Altogether the state of development of the UK telecommunications infrastructure and the range of services available to users compares well with the other countries covered by the study. The UK's position benefits from the number of new operators which are taking the opportunity to install up-to-date networks, and the competitive pressure this has introduced. But it would be misleading to imply that BT, as the major operator, is lagging in any significant respect. On the contrary BT's network is one of the most modern in the world.

Although never the most advanced in any one area, the UK is consistently a good second and does not lag significantly in any major respect. No one country is a consistent first, although in general the USA is also well advanced. Germany is putting particular emphasis on updating its infrastructure, especially in the East with broadband and digital cellular radio networks.

UK price levels are, by comparison with the other countries, generally reasonable for business, though they compare less favourably for residential users. High prices in some other European countries, however, act as a constraint on business activity throughout Europe.

In the medium term the plans of the operators suggest that UK infrastructure will continue to develop at a rate to keep it abreast of its competitors. In the longer term much will depend upon the rate of development and adoption of new broadband multimedia applications, together with the ability of the operators to continue to keep abreast of developments and provide the infrastructure and services required to support the applications and encourage their ongoing development. There is a view held by some in the industry that a clearer vision of the future shared with government would help ensure that the industry was able to do so.

This generally encouraging picture of the UK is not always reflected in the perceptions held by the community at large, particularly in respect of broadband infrastructure. Whilst there is no room for complacency, this must be a point of concern. It would be desirable if such perceptions could be altered to more accurately reflect the more positive position in fact currently held by the UK, and thus form a basis for informed discussion on the requirements for the future.

As the networks in the UK and the other countries continue to develop, a number of trends can be expected to emerge or continue. It will be worthwhile monitoring these as indicators of continuing positive developments in the UK telecommunications environment. They may be summarised as:

- Development of innovative tariff and service packages as a result of increased competition in both fixed and mobile networks.

- Development and uptake of business and residential broadband multimedia applications in the UK, together with resulting user demands for increasing bandwidth. Comparison with developments in the USA and elsewhere will provide useful reference points.

- Increased availability of low cost high bandwidth services and supporting infrastructure in UK *and* Europe to meet those needs.

- Ongoing development of the American and Japanese initiatives, with a particular regard to any significant changes in the rate of development in those countries that may result.

1. INTRODUCTION

1.1 Objectives and Scope

This report was prepared at the request of the UK Department of Trade and Industry in recognition of the increasing importance of telecommunications to the nation's economic prosperity and competitiveness. It provides an up-to-date comparison of the state of development of the telecommunications infrastructure and services in the UK with that of a number of other leading industrial nations. In addition it provides a view of expected developments in both the short to medium term and in the longer term.

Direct beneficiaries of development of the telecommunications infrastructure and of services offered over it, are users, independent service providers, and suppliers of products used in its construction. In preparing the report the role of telecommunications as a generator of economic activity for each of these groups has been taken into account. The business user requires high quality, affordable services that can carry the traffic that is generated by his business, and required for its successful operation. The requirements of the service provider are similar, but may include a need for higher bandwidths and other special facilities. For both of these groups a well developed infrastructure is a prerequisite for the availability of the required services at economic rates. The supplier of products looks for a continuous stream of investment in new plant and equipment. Use of telecommunications by the residential user is not at present a significant direct contributor to economic activity, because of the generally low usage level. As a result, operators are eager to identify new applications that will generate the additional revenue required to provide an economic return on their investment. These may in turn require updated infrastructure. The report is therefore directed at the status and development of telecommunications infrastructure serving all user communities, and at services primarily directed at business users and service providers. Although not a prime focus of the study, consideration is also given to the costs of services and the impact of costs on take up and business development.

The thrust of the report is forward looking, and is primarily concerned with trends and developments, rather than detailed analysis of the results of past actions, although it is recognised that these often play a significant role in determining future activities. In particular detailed comparisons of take up of services which have been determined primarily by previous pricing and regulatory policies are not provided. The report pays particular attention to new developments, including the provision of broadband services and supporting infrastructure, and the continuing developments in mobile radio. To put these in context, some discussion of user needs and take up is included.

A limited number of countries were chosen for comparison. The countries chosen were France, Germany, Japan, the Netherlands, Sweden and the United

States; all advanced industrial nations with well developed telecommunications infrastructures. The choice was influenced by a desire to include in the study countries that had a variety of regulatory and competitive environments, declared national programmes for investment in the infrastructure, and were economically competitive with the UK.

Investment plans and development and provision of new services are heavily influenced by competitive and regulatory pressures and constraints. The report therefore provides an overview of the competitive and regulatory environment in each of the countries covered.

To provide a reasonably comprehensive assessment of the comparative position of the UK the scope of the study covered:

Fixed and mobile public telecommunications networks, including:

- switched two way networks
- leased two way networks
- cable TV networks
- mobile radio networks

and five main topics:

- Degree of Liberalisation
- Network Modernisation
- Services
- Cost of use
- Quality of Services

To help reflect the needs and views of the user community, a small number of multinational users were asked to compare the availability, quality and costs of services provided by operators in the different countries.

A copy of the terms of reference is given in Appendix A

1.2 Structure and methodology

The main body of the report is divided into five Chapters, three of which, Chapters 3 to 5, are devoted to different aspects of the infrastructure and services offered over it. An overview of the industry structure and the regulatory environment in provided in Chapter 2, which also provides an analysis of major national initiatives including US Vice President Gore's 'Information Superhighway' initiative. Chapter 3 covers the digitalisation of networks, and the provision of ISDN[1], digital leased lines and intelligent network services. Chapter 4 looks at the emerging broadband infrastructure,

[1] Integrated Services Digital Network

and the emergence of new broadband services, and Chapter 5 covers the development of the mobile radio infrastructure and services, with particular emphasis on the introduction of digital radio services and their take-up. A comparison of the costs and quality of services is provided in Chapter 6, together with an analysis of their impact on business use. Conclusions are provided at the end of each chapter, and these are drawn together in Chapter 7 which summarises the main findings of the study.

The information presented in this report was gathered during the period July to November 1993. The primary sources of information were the operators themselves, and data was obtained through questionnaire and interview. All the major operators in the countries covered and several of the smaller operators were contacted during the course of the study. Their assistance in helping to provide a comprehensive picture of developments is gratefully acknowledged. In addition a number of multinational users were contacted to establish their views on the range of services provided by each operator, and the cost and quality of their services. Their assistance is also acknowledged with gratitude. In some cases operators were reluctant to divulge information they felt to be of a confidential nature.

The information gathered from the operators was supplemented from secondary sources, including government data, published reports, conference papers given by operators' staff, articles and news reports in the general and trade press, and other industry sources. Wherever possible these were cross-checked with information provided by the operators. The resulting analysis, and the conclusions presented in the report reflect the views of the author, and do not necessarily reflect those of the DTI.

2. STRUCTURE AND REGULATION OF INDUSTRY

2.1 Introduction

Provision of telecommunications services is subject to legislation and regulation in all countries covered by the study. There is a general trend away from monopoly provision of telecommunications services by a single national operator, but the degree of liberalisation and the extent of competition varies considerably from country to country and service to service. Policy is determined by the national governments, but in Europe the European Commission plays an increasingly important role in the regulation of telecommunications in the member states. Coupled with these changes is a trend for the separation of the operators from government and to a lesser extent a trend towards private ownership.

Underlying these moves are conflicting philosophical arguments. It is generally agreed by the governments that open competition will ultimately provide users of telecommunications services with a wider choice at lower prices and with improved quality. In a few countries, for example the Netherlands, the argument is made that the provision of multiple networks is a waste of national resources.

With increasing competition many of the established operators are finding their traditional revenue streams threatened and are seeking new areas of business to replace them. In consequence many operators are entering into joint ventures, mergers and alliances with companies in the same or related industries, both in their own country and abroad.

2.2 Progress of Liberalisation

The European Commission has continued to encourage increased liberalisation of the telecommunications markets within the European Community since the publication of the Green Paper in 1987. By issuing directives and through other measures the Commission has been instrumental in the introduction of competition in mobile services, in value added services (VAS), and in the liberalisation and increased availability of leased lines. The Commission has secured agreement that all countries in the Community will introduce competition for voice services over leased lines by 1998, or in some cases two to five years later; at the same time international simple resale within the Community will also be permitted. In 1994 the Commission will report to the Council on studies currently being carried out into the use of alternative infrastructures, such as those owned by the railways and utilities, and of cable TV networks. It will be issuing a new Green Paper on mobile radio by early 1994, and plans to issue one on infrastructure and cable TV by 1995. Through its actions the Commission is forcing the more conservative regimes to follow the liberal examples set by the UK, the US, Japan, and Sweden.

The degree of progress made varies considerably from country to country, reflecting the differing philosophies and constitutions of the governments. France, Germany and the Netherlands have all made moves towards the ultimate

privatisation of the national operator, although in France and Germany this may be slower than originally thought, and all three countries have opened most value added and mobile services to competition. These three countries have also moved ahead of the requirements of the European Commission, together with the UK, by establishing a one stop shopping procedure for licences for VSAT[1] and SNE[2] operation.

Japan, Sweden, the USA, and the UK all permit competition in a wide variety of services. The remaining three countries are moving in the same direction, with the encouragement of the EC, and competition for mobile services now exists in France and Germany. Figure 2.1 summarises the current situation.

Country	Fixed n/w	Cable TV	Mobile	Leased Lines
France	M	LM	D	R
Germany	M	M	C	R
Japan	C	LM	C	R
Netherlands	M	LM	M	R
Sweden	C	C	C	U
USA	LM/C	LM	LD	U
UK	C	LM	C	U

Key: M: Monopoly D: Duopoly C: Competition
L: Local R: Restricted U: Unrestricted

Figure 2.1 Degree of Liberalisation

For the time being France Telecom will retain its monopoly for basic public services including voice and telex, although the French regulator, the Direction Reglementation Generale, has recently announced that it will allow mobile radio operators to provide their own infrastructure. In general, mobile services and VAS in France are open to competition. Germany is proceeding steadily with the process of liberalisation, although progress is slower where it impacts directly on Deutsche Telekom's traditional activities. This point is illustrated by the fact that while Germany was one of the early countries in Europe to liberalise VSAT operation, it has taken pressure from the European Commission for it to permit operation of corporate voice networks. It is planned to privatise Telekom, and as a preliminary exercise the mobile (GSM[3]) operation has been formed into a separate business unit preparatory to privatisation. The Netherlands is even slower in implementing competition in PTT Telecom's traditional areas of business, although liberal in other respects. For example, while cellular radio and paging

[1] Very Small Aperture Terminal (satellite link)
[2] Satellite News Gathering
[3] Global System for Mobile Communication

remain a PTT Telecom monopoly (although competition is planned) all other mobile services are classed as value added services, and therefore do not need licences at all. (They do, of course, require allocation of frequencies). PTT Telecom is a public corporation, and is to be privatised.

In Japan regulatory authority resides with the Ministry of Posts and Telecommunications (MPT). Competition is allowed through the issue of two types of licence; a Type I licence for operators with their own infrastructure, and Type II licences for VAS. MPT retains far more direct control over NTT's operations than is the case with the Department of Trade and Industry and BT, and can delay the introduction of new services if it considers they would disadvantage the competing operators.

There are 76 Type I carriers in Japan, offering telephony, leased line, cellular radio and satellite services. The majority, 58, are cellular radio operators, which operate on a regional basis. MPT has not allowed NTT to rebalance its tariffs, and as a result NTT's local tariffs have remained too low to allow would be competitors to offer a profitable service. NTT has however been reducing its long distance tariffs, increasing the competitive pressure on the Type I carriers offering long distance services.

Until recently Sweden had a completely unregulated market, in which Televerket (now Telia) held a *de facto* monopoly for almost all services. There were in theory no restrictions on any service, but in practice would be operators had to negotiate interconnect with Televerket, which also controlled the allocation of frequencies. The existence of Comvik, and later Tele 2, the second mobile operator, shows it was possible, if difficult, to enter the market. Legislation has now been introduced, and a new regulatory body established, to address questions of interconnect and frequency allocation.

In the USA the Federal Communications Commission (FCC), an independent regulatory body which reports to Congress, oversees all telecommunications activity in both public and private sectors. In addition each State has its own regulatory bodies which control local telecommunications and cable TV operations, and the courts play a major role in regulation. As a result the US has a complex and legalistic regulatory structure. With the election of the Clinton administration three government departments have taken a major role in policy formulation as part of Vice President Gore's initiative on Information Superhighways , now known as the National Information Infrastructure (NII), and it is expected that one outcome will be the introduction of far greater competition between telecommunications and cable TV operators[4]. The departments are:

[4] In a speech in January 1994 VP Gore pointed to a lifting of present distinctions between long distance and local, and cable and telephony operators.

- *NTIA (National Telecommunications and Information Administration)* Responsible for government radio communications and the executive agency for development of telecommunications policy. (It gained this role as a result of the Watergate era to provide a deliberate distancing from executive.)

- *NEC (National Economic Council).* A new body created by the Clinton administration to oversee the economic viability of the nation. Telecommunications forms one part of this.

- *OSTP (Office of Science and Technology Policy)*

NTIA and OSTP have been given new life by Gore's interest in the subject. Together with the NEC, the three bodies now work as a team. The FCC has observer status. A full description of the NII initiative is given in the next section, National Initiatives.

The UK Government policy is to move to a fully open competitive market for all services. Regulation serves to provide protection in the short to medium term for new market entrants that would not otherwise be able to compete with a dominant operator. At present the remaining regulatory constraints on competition are in cable TV (on BT and Mercury), mobile radio (on BT), and international infrastructure.

2.2.1 Public Switched Telephone Network

France, Germany, and the Netherlands still maintain monopoly provision of switched voice services, and the national Telecommunications Operators remain effectively monopoly providers of the fixed network infrastructure. This position is already being relaxed in certain circumstances, and all three are committed to allow competition by 1998 under a European Commission directive. Competition in the fixed network exists in Japan, Sweden, the USA and the UK, although its extent varies. All four countries have competing operators for long distance traffic, and Japan, the US and the UK have licensed operators to provide local services to businesses in metropolitan areas. Only the UK has introduced effective competition for local residential services by licensing the cable TV operators to carry telephony. In addition the PCN[5] and fixed radio link operators are starting to provide additional competition in the residential market as their services become available. Mercury is also gaining a share of the residential trunk traffic.

Japan has licensed Type 1 carriers which offer services on long distance routes or in certain metropolitan areas. In the US competition exists for long distance traffic between the inter-exchange carriers AT&T, Sprint, MCI and others, and for local business traffic from the Competitive Access Providers.

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[5] Personal Communications Network

A summary of the competitive position in the fixed network is given in Figure 2.2.

	Local loop	Main Network	Future Plans
France	No	No	Possibly by 1998
Germany	No	No	Possibly by 1998
Japan	Very limited	Yes - Type I Carriers	
Netherlands	No	No	Possibly by 1998
Sweden	Permitted	Yes - Tele 2	
USA	Limited - CAP[6] s serve business only	Yes - IXE[7] s	Full local competition in local loop expected within 5 years
UK	Yes - cable TV operators, metropolitan nets and radio operators	Yes - multiple operators	

Figure 2.2 Competition in fixed network

2.2.2 Cable Television Networks

Provision of Cable Television (CATV) services has traditionally been treated separately from telecommunications and their provision is a monopoly, either locally or nationally, in most of the countries. Only Sweden allows open competition, and even here the costs of infrastructure provision mean that there remain *de facto* local monopolies. This separation of cable TV and telecommunications means that most countries do not allow cable TV operators to offer telephony services, and generally Telecommunications Operators may not offer cable TV services in their own right, although in some cases they may do so through subsidiaries (as in the Netherlands), or may apply for local licences. France Telecom offers cable TV services in some areas through its subsidiary France Telecom Cable, and in some cases also provides the infrastructure for other cable TV operators. In the UK BT is allowed to apply for local licences (and holds one in Westminster), but may not offer a national service at present. The same conditions apply to Mercury. Deutsche Telekom is the only operator to hold a national monopoly for cable TV infrastructure provision. Another consequence of the long standing separation is that many of the older purpose built cable TV networks have not been constructed to the level of quality that is expected for telecommunications networks.

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[6] Competitive Access Provider

[7] Interexchange Carriers

	Competition in CATV	CATV permitted to offer telephony	TO permitted to offer CATV	Future Plans
France	Local Monopoly	No Can carry data	Yes, on a local basis	Use of CATV networks for telepoint voice
Germany	National Monopoly	No	Yes	
Japan		In theory, but none do so[8]	No	
Netherlands	Local Monopoly	No Can carry data	Through subsidiary	
Sweden	Allowed but none exists	Yes	Yes	
USA	Local Monopoly	No Can provide leased circuits	No	Competition both ways within 5 years
UK	Local Monopoly	Yes	Yes, through local CATV licences	TO not permitted to offer CATV nationally until 1998 at the earliest

Figure 2.3 Competition in fixed network - CATV

In France provision of cable TV services is liberalised, but provision of the infrastructure is now delegated to France Telecom. The service operators focus on service provision and marketing. France Telecom provides cable TV services itself in some areas. In a recent development, cable TV infrastructure is to be used to carry voice traffic for a newly licensed telepoint operator. Deutsche Telekom holds the monopoly for provision of the national cable TV infrastructure, and it has been able to take advantage of this to install a combined telephony and cable TV infrastructure in the former East German states. Allocation of channels for service providers rests with the federal and national governments. PTT Telecom cannot offer cable TV services in its own right, but holds a majority shareholding in Casema, the country's largest cable TV operator.

[8] Changes announced early in 1994 indicate that it will be made easier for CATV operators to carry telephony

2.2.3. Mobile

Generally competition has been introduced in mobile services before its introduction in the fixed network. All seven countries except the Netherlands now have at least two competing operators offering cellular voice services, and open competition (ie three or more operators) will soon exist in most countries.

	Current Status	Future Plans
France	Duopoly	3rd licence to be issued in 1994
Germany	Competition	
Japan	Competition	More competition in PDC
Netherlands	Monopoly	2nd licence to be issued in 1994
Sweden	Competition	
USA	Local Duopoly	Multiple PCS licences to be issued in 1994.
UK	Competition	

Figure 2.4 Competition in cellular voice networks (includes PCN - DCS1800)

Most countries also allow some form of mobile personal communications service such as telepoint, although these have not always met with commercial success. These services usually have more limited functionality than cellular services.

	Current Status	Future Plans
France	Monopoly	2nd licence issued in 1993
Germany	No service (operator withdrawn)	
Japan	Monopoly (competition permitted)	Likely to licence PHS as operator
Netherlands	Monopoly (competition permitted - classed as VAS)	
Sweden	No service (competition permitted)	
USA	Trial services	Multiple PCS licences to be issued in 1994.
UK	Competition - no service (operators withdrawn)	

Figure 2.5 Competition in Personal Communications Services networks (telepoint and similar services)

In most of the countries competition also exists for the provision of paging and mobile data services.

	Current Status	Future Plans
France	Competition - both services	
Germany	Monopoly - both services	Licences to be issued
Japan	Competition - both services	
Netherlands	Paging Monopoly Mobile data classed as VAS, competition permitted	Competition planned for paging
Sweden	Monopoly (competition permitted)	
USA	Competition both services	
UK	Competition both services	

Figure 2.6 Competition in mobile data/paging networks

Competition for provision of trunked private mobile radio services is allowed in all countries.

2.2.4 Value Added Services

All countries permit open competition for Value Added Services offered over the fixed and mobile networks, although once again the nature of the services may be constrained by regulation, and simple resale is not yet permitted in all cases. A summary is given in figure 2.7.

	VAS	Resale
France	Not voice services*	No
Germany	Not voice services*	No
Japan	Yes	Yes - but restricted in practice for voice
Netherlands	Not voice services*	No
Sweden	Yes	Yes
USA	Yes	Yes
UK	Yes	Yes

* See Text

Figure 2.7 Competition in VAS

Restrictions apply only in France, Germany and the Netherlands and Japan. In France VAS offered solely over the PSTN, or to closed user groups, require no licence, nor need they be registered. There are some 17,000 Minitel services and a small number of audiotex services in this category. For services offered over leased lines, of which there are about 100, registration only is required. Services offering more than 5Mbit/s (until changes in 1992 this was 3.5Mbit/s) capacity require a class licence, which is virtually automatic. Until the changes in 1992 the value added element had to be 85% of the end user cost, which constrained development of the market, and focussed development into industry specific applications. VSAT networks are permitted, with interconnection to the PSTN for closed user groups only. However connections to third parties are permitted for EDI[9]. Cable TV networks are permitted to carry telecommunications traffic, but this is restricted to simple data transmission. Little interest has been shown as yet other than for internal use.

VAS are permitted in Germany, but must used leased circuits from Deutsche Telekom, and operators of services must register with the Ministry. Resale of capacity is allowed, but must not serve as a by-pass to the PSTN. Telekom is obliged to tariff services to competing operators at the same rates as it applies to its own subsidiaries/services.

Cable operators in the Netherlands are to be allowed to carry facsimile and data traffic, but not voice. A number of mobile services are classified as VAS, and therefore licences are not required for mobile data, telepoint, trunked mobile radio, and VSAT ground stations.

The VAS operators in Japan are licensed as Type II carriers. They are subject to relatively few restrictions, but are not allowed to interconnect to the PSTN for voice traffic. There are no restrictions on VAS operators in the UK or the USA.

2.2.5 Private networks

Prior to deregulation in France leased circuits were available, but a high level of tariffing, and the availability of inexpensive high quality packet switched services from Transpac, the France Telecom subsidiary, led to low take up of leased lines. As a result few private networks were established, chiefly for large corporations. Licences are available for companies to establish independent networks using their own infrastructure for private or shared use. These may interconnect with the PSTN provided the connections are not used for public traffic. Little interest has been expressed in these as yet. A licence was issued to SNCF, the French National Railway, for its existing network, but apart from this, most licences issued are for crossing the public highway within a factory complex.

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[9] Electronic Document Interchange

Traditionally, Germany was extremely restrictive on the provision of leased lines, which were only available for data at prohibitively high tariffs. As a result private networks were virtually nonexistent until recently. Companies are not allowed to establish their own transmission infrastructure, with the one exception of Mannesmann Mobilfunk, the second GSM operator. Under the latest changes to the national regulations two classes of licence are available for operators of voice corporate networks. A general licence is available for corporate voice networks serving businesses with common ownership. Individual licences are available for voice networks serving closed user groups. Interconnection to the PSTN is allowed, but this must not be used to carry 3rd party traffic. To facilitate communications into the former East German states two-way VSAT earth stations are permitted for both voice and data traffic.

Leased lines have always been available, and therefore there are a number of established private networks in the Netherlands. Higher tariff levels mean these have not become as widespread as in the UK and there are restrictions on use to prevent direct competition with PTT Telecom. Private network operators with their own infrastructure, such as the utilities, can sell capacity to closed user groups, but not to operators offering a public service, such as mobile operators. However users of networks composed of leased lines (ie leased from PTT Telecom) can resell capacity for use by public operators.

2.3 National Initiatives

Two of the seven countries, the USA and Japan, have a government inspired national plan or concept to upgrade their telecommunications infrastructure. Neither has turned out to be quite what was supposed in the early part of 1993. In addition, Germany has a number of programmes under way to provide a new infrastructure in the former East German states. Probably the best publicised national initiative is the vision of 'Information Super Highways' promoted by Vice President Al Gore of the USA. Despite the publicity surrounding their announcements the Japanese government's ideas are at the concept stage with no firm plans or budget commitment expected until the spring of 1994. However MPT, which is leading the discussion on this topic, does have budgetary approval for the Kansai project, which will act as a test bed for new broadband applications and infrastructure.

USA

Gore believed that the US Government needed to jump-start investment in a broadband national infrastructure. In 1991, before coming to power, he put a bill through Congress for a national computing network (NREN[10]) for universities and research establishments at a cost of $2.9 bn over the next 5 years. In September

[10] National Research and Engineering Network

1992 the Super Highway was introduced as an election idea for assisting the economic viability of the nation. Papers outlining Gore's ideas were issued in February 1993.

The industry reacted by stating that it was well able to provide the required infrastructure themselves, and that as the trunk networks were already almost entirely fibre, much of the broadband network infrastructure was already in place. It argued that the role of government should be to coordinate activities, but not to invest in the network itself, and that competition was the best tool to force investment. It also argued that the Government should act as leader and regulator, acting through tax incentives and support for applications. Early support could be shown by government by making its own data bases available in electronic form accessible over the Super Highway.

The US government has considerably modified its original thinking on the role it needs to play in the construction of an Information Superhighway, which has now been renamed the National Information Infrastructure (NII). It is now looking to industry to build the greater part of the network, and will restrict its activities to coordination, regulation, tax incentives and funding selected applications and demonstrations in the public sector. It will not build the NII, and will not commit the industry to using any particular technology, such as provision of fibre connections to individual homes.

Overall the government will spend perhaps $200m - $300m pa over five years, of which the Departments of Education, Health and Agriculture will contribute about $5-15m each per annum. There are now five programmes. Each will need several separate bills for funding to be provided (one for each government department taking part). They are:

1 **High Performance Computing and Communications Program**

The programme is designed to develop hardware and software to retain US pre-eminence in super computing as well as to allow communications between them - eg optical switching and repeaters. The only part that is currently funded is the NREN.

2 **Applications Program**

- to connect libraries
- to provide cooperative education
- to support remote magnetic imaging

3 **NTIA[11] Grants Program (Last Mile Connection)**

[11] National Telecommunications and Information Administration

Grants programme for state and local government, schools, hospitals, and libraries to plan and construct facilities to connect to the NII, using whatever technology is considered appropriate, including copper, coax, and radio. Funding will become available in fiscal year 1994, which is expected to be about $25m.

4. Government Data and Information Systems Program

To provide access to government data. The government believes that it holds large quantities of data which would be of great commercial value. At present there are fragmented activities only, with data on weather, and economic data, being made available

5. Regulatory Environment

The Information Industry task force has been formed, jointly from the NEC, OSTP, and NTIA. The task force is covering all the issues that have been around since divestiture including competition, universal service, and equal access.

The Information Industry task force has now issued a vision statement with the title 'The National Information Infrastructure - Agenda for Action'. This document sets out 9 principles for future development of the NII under an introduction which visualises ready access to work, education and health care regardless of location, via a 'network of networks'. The **nine principles** are listed below:

1. Promote private sector investment
2. Extend the "Universal Service" concept to ensure that information resources are available to all at affordable prices
3. Act as a catalyst to promote technological innovation and new applications
4. Promote seamless, interactive, user-driven operation of the NII
5. Ensure information security and network reliability
6. Improve management of the radio frequency spectrum
7. Protect intellectual property rights
8. Coordinate with other levels of government and with other Nations
9. Provide access to government information and improve government procurement.

The document specifically commits the US government to implement new legislation to increase competition, particularly in cable TV and local telephone networks, before the end of 1994. Government funding of universal service is a likely consequence. Industry has already reacted to these developments with a spate of mergers and alliances between Telecommunications Operators and cable TV operators, including Bell Atlantic and TCI, South Western Bell and Prime Cable, and US West and Time Warner.

Japan

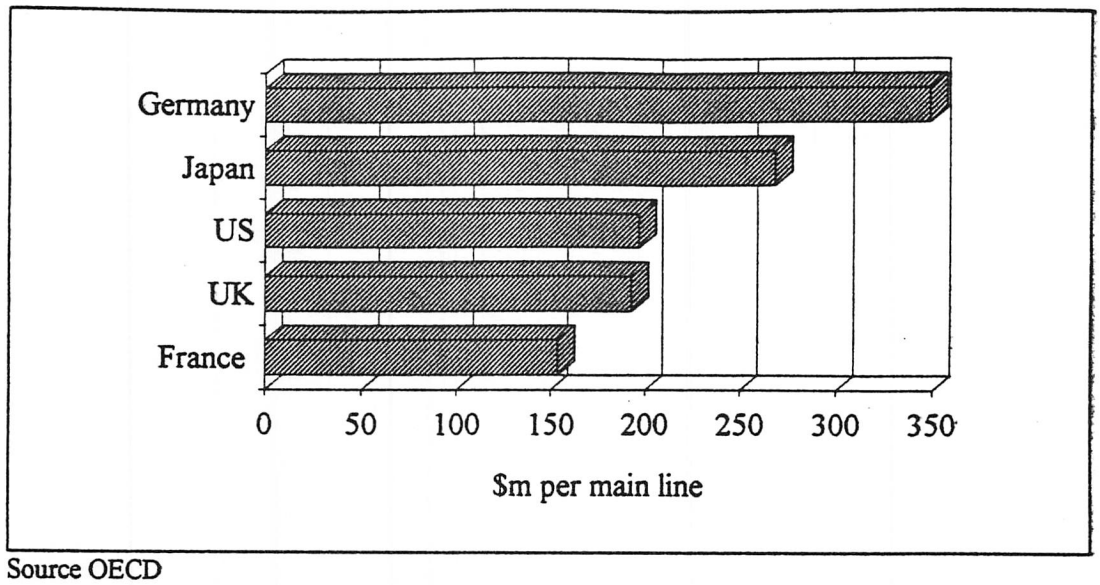
In Japan, MPT is closely involved in establishing a framework for introducing a new broadband infrastructure, which it believes would be to the benefit of the community at large, as well as to business users. It believes that both the private and public sector should be involved in its development. In support of this approach, the Law for the Enhancement of Telecommunications came into force in 1991, setting out the principle of government support for new infrastructure. Since then MPT has facilitated the establishment of two industry bodies, the Association for the Promotion of New Generation of Network Services - for the key telecommunications players, and the BBCC (The Association for Broadband Business Chance and Culture Creation) comprising 150 major Japanese corporations from all market sectors. About half are from the telecommunications industry. The Telecommunications Council is currently working on its proposals for funding a broadband infrastructure, which are expected in April 1994.

The Kansai region, centred on the Kansai science city, has been designated for broadband infrastructure and applications trials. The programme is being driven by the BBCC, and will include multipoint image transmission using high definition television (HDTV), high speed ATM - LAN[12] applications and remote multimedia applications. Its purpose is to support the government's long term aim of developing an advanced broadband infrastructure by demonstrating the usefulness of broadband applications to users. It is hoped to move from demonstrations to commercial deployment by the turn of the century.

2.4 Investment

The level of financial investment made by countries in their telecommunications infrastructure is often taken to provide a useful indication of the degree of modernisation being undertaken. Figure 2.8 shows a comparison of the 1990 investment figures for five of the seven countries.

[12] High speed data connections between local area networks using ATM (asynchronous transfer mode) technology



Source OECD

Figure 2.8 Investment in telecommunications equipment 1990

However, these figures should be regarded with considerable caution. Use of these figures as they stand takes no account of the different price levels that obtain for equipment and labour in different countries. In fact these can vary considerably, with switches (exchanges) costing up to four times the international price, depending on the country market. Figure 2.9 shows ratios of prices to international levels in five of the countries.

	Investment /main line $	Ratio switch price to internat. price	Ratio fibre price to internat. price	Average Divisor
France	154	3.05	3.14	2.05
UK	193	1.30	1.00	1.08
US	197	1.10	1.00	1.03
Japan	268	2.36	2.70	1.76
Germany	349	4.50	2.79	2.32

Source: Industry sources

Figure 2.9 National price levels versus international price levels

Adjusting the investment figures to reflect the differences in price of each item purchased by each Telecommunications Operator is a very complex task. However, as purchases of switching equipment and fibre optic cable represent a substantial proportion of any Telecommunications Operator's annual investment, and as price levels for all types of telecommunications equipment tend to maintain the same relationship to each other within any given market, it can be assumed as a first approximation that differences in prices for these commodities reflect the general price level for this class of equipment in each country market. The total

investment of a Telecommunications Operator will include other less specialised equipment and civil works where the price differential will be less significant. To allow for this investment it may be assumed that half of the total investment is for equipment and materials at prevailing international prices.

Figure 2.10 shows the effective investments made in the different countries after taking account of the differences in price levels. Although the result is only approximate, it can readily be seen that the apparently high levels spent in countries such as Germany and France provide a very poor indication of the actual amount of equipment purchased, owing to the higher prices paid. It should be noted, however, that Germany has increased its investment by up to half as much again in the past three years to fund the new infrastructure required for the former East Germany.

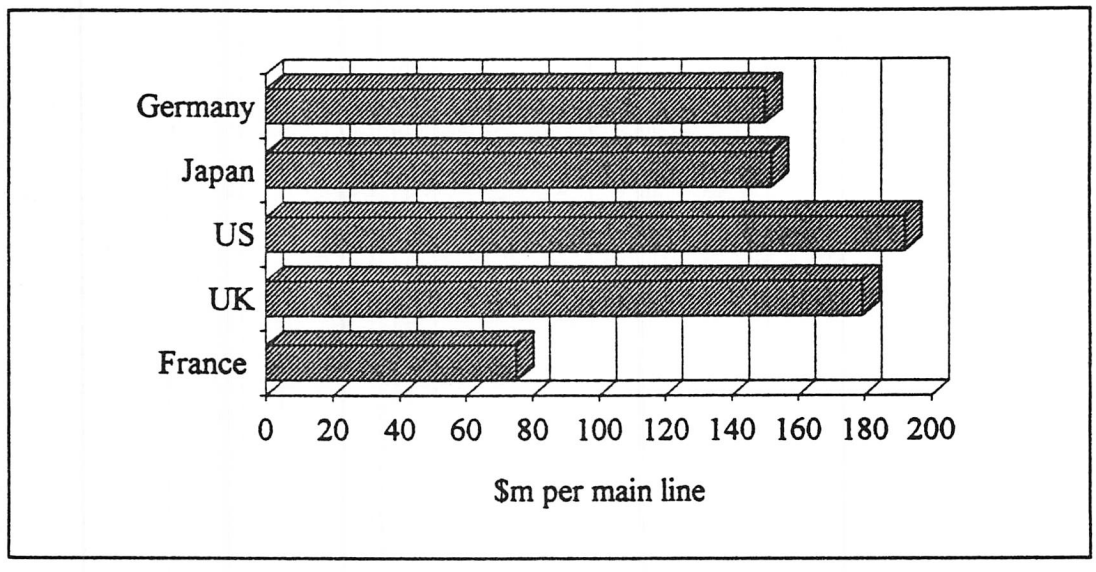


Figure 2.10 Indication of effective investment levels (Equivalent investment levels if actual purchases made at international prices)

2.5 Conclusions

Of the countries covered by the study, Japan, Sweden, the USA and the UK have generally open competitive regimes; the remaining three, France, Germany, and the Netherlands retain significant monopolies and restrictions on use of the networks. These markets will become more open to competition over the next five years. Although Sweden has fewer restrictions than the UK, the UK has achieved competition in more services. The UK is unusual in being the first country to establish effective competition for residential services, although at present this is of limited geographical extent.

Some countries, notably the USA and Japan, and to a lesser extent Germany, have established the perception that they have major long term plans in place to invest

substantial sums in their telecommunications infrastructure. Although these plans have less substance than is commonly believed, they give rise to the view that these countries are investing most in infrastructure, and in particular in broadband infrastructure. At first sight the sums being invested in Germany and Japan appear to bear out this view; however once account has been taken of the higher prices paid for equipment in these countries the net benefit of these higher sums is certainly no higher, and in all probability lower than in the UK. However, in addition, Germany is currently making substantial investments in the former East Germany, in order to bring the infrastructure up to modern standards, which will not need to be maintained in the longer term.

3. DIGITAL NETWORKS AND SERVICES

3.1 Introduction

This chapter reviews the current and likely future deployment of digital equipment in the countries covered by the study, together with the availability and penetration of services directly based on the provision of digital networks, namely ISDN[1] and digital leased lines.

Digital telecommunications equipment has a number of well established advantages over electromechanical and analogue equipment, as a result of its greater reliability and more consistent performance. For the telecommunications operators (TOs), these differences translate into reduced operating and maintenance costs, as well as offering improved and more consistent signal quality for the user. Primarily for financial reasons, the telecommunications operators have been steadily replacing electromechanical switching equipment and analogue transmission equipment with systems using digital technology since the 1970s. The cost of the equipment has rapidly fallen below that of analogue systems, making digital systems even more attractive.

Digital telecommunications systems for TOs were designed primarily for the transmission of traditional telephony traffic, and have therefore been based on a bit rate of 64kbit/s, originally chosen to allow satisfactory voice transmission over several digital links in tandem. The use of this rate has allowed operators to offer new services to users, including the transmission of data at higher bit rates, digital leased lines at multiples of 64kbit/s, and ISDN.

For users digital networks provide a high quality, high reliability switched network for voice and medium speed data communication. By using leased lines higher bandwidths are available.

3.2 Deployment of digital equipment

3.2.1 Current Status

The TOs in all countries covered by the study have deployed substantial quantities of digital equipment although the proportion of subscribers connected to digital exchanges still varies considerably from country to country. Figure 3.1 shows a graphical representation of the percentage of main lines attached to digital switches in each country.

[1] Integrated Services Digital Network

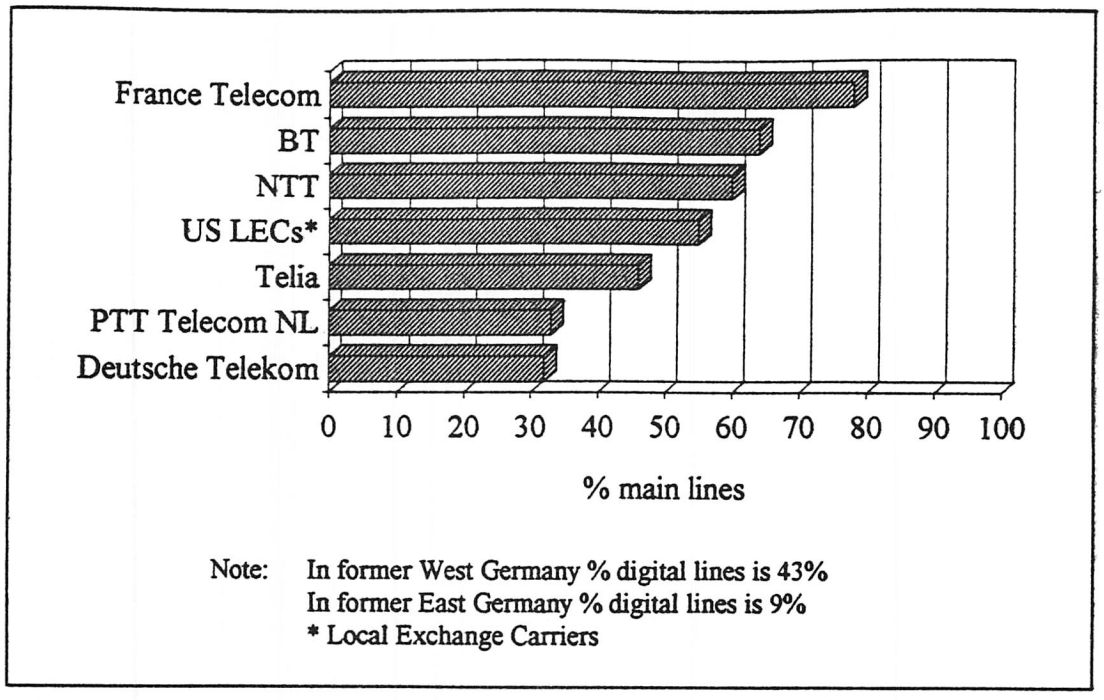


Figure 3.1 Percentage of Main Lines connected to Digital Exchanges

The current extent of deployment of digital exchanges is often dependent upon past investment policies. For example, in the 1970s both BT and France Telecom had networks with a high proportion of ageing equipment, but for different reasons. Both operators subsequently embarked on major programmes to install digital exchanges, and as a result have networks with the highest proportion of digital exchanges. Germany and the Netherlands, in contrast, had well developed networks and have not needed to replace their equipment so rapidly. The figure for US LEC[2]s hides considerable variations. GTE, for example has a higher proportion of main lines (nearly 80%) connected to digital exchanges than France Telecom; Southwestern Bell has under 40%. To reach its current level of 60% NTT has accelerated its programme to replace analogue exchanges several times, under pressure from the Ministry of Posts and Telecommunications (MPT).

New operators like Mercury (in the UK), Tele2 (in Sweden), and Japanese Type 1 carriers, as well as the US IXEs[3] and CAPs[4] have 100% digital networks. These operators do not have the enormous investment in local exchange equipment of the operators given in Figure 3.1, and their networks are not comparable.

3.2.2 Future Plans

All operators plan to replace all their remaining analogue exchanges with digital equipment over the next few years, most by the end of the century. However

[2] Local Exchange Carriers
[3] Inter-exchange Carriers
[4] Competitive Access Providers

operators with a high proportion of digital exchanges already in their networks have started to slow down deployment. This slow down has occurred because almost all electromechanical equipment has been replaced, leaving only SPC[5] analogue switches. These often have considerable life left in them, are reliable, provide low noise transmission of the signal, and, being computer controlled, can be readily upgraded to offer almost all the facilities offered by a digital switch (except of course, digital transmission). As this last capability is not at present important for the last connection to most residential, and indeed many business subscribers, many operators have decided to retain these switches until they have served their useful economic life. BT deferred the date for replacement of all analogue exchanges from 1995 to 2000, but will have replaced all non-SPC exchanges by 1995.

In addition, the more forward thinking operators are also bearing in mind the appearance of new, more flexible, switching technologies such as ATM[6] (see Chapter 4). The date by which the main operators in each country expect to convert all exchanges to digital technology is shown in the table in Figure 3.2.

Operator	90% digital	95% digital	100% digital
France Telecom	1995		-
Deutsche Telekom			2005
NTT, Japan			1997
PTT Telecom Netherlands			2000
Telia Sweden		1996	-
USA LECs			2005
BT, UK			2000

Figure 3.2 Plans for completion of digitalisation

3.3 Signalling System N°. 7 (CCSS7)

To provide many of the more advanced services now becoming available, it is necessary for the processors controlling exchange operation to communicate directly, without the establishment of a direct speech path. This capability is provided by the deployment of a separate packet switched network to carry signalling information. The international standard used is Common Channel Signalling System number 7 (CCSS7). Use of CCSS7 allows information about a call to be sent between exchanges before the call is established, whilst it is in progress, or after completion, and is used to support ISDN, Intelligent Network services such as call diversion, freefone, charge card and shared revenue services, and inter-operator billing. It can be extended to any SPC[5] exchange, whether

[5] Stored Programme Controlled

[6] Asynchronous Transfer Mode

analogue or digital. Operators have been deploying CCSS7 for a number of years, and many European operators have almost universal provision. Figure 3.3 shows the current level of deployment of CCSS7

CCSS7	Main lines with access to exchanges with CCSS7
France Telecom	100%
Deutsche Telekom	32%
NTT, Japan	n/a*
PTT Telecom Netherlands	n/a
Telia Sweden	100%
USA LECs	51%
BT, UK	64%

* Number of lines not known, but 57% exchanges are equipped for CCSS7

Figure 3.3 Proportion of main lines connected to exchanges with CCSS7

3.4 ISDN

3.4.1 Current Status

ISDN was originally conceived as a means of transmitting two 64kbit/s circuits over a single subscriber loop, thereby allowing TOs the opportunity to generate additional revenues from their existing substantial investment in copper in the local subscriber loops. The concept has developed since to provide a digital switched service at either 144kbit/s (basic rate)[7] or 2Mbit/s (primary rate, 1.5Mbit/s in the US and Japan)[8]. Many European operators, in particular Deutsche Telekom and France Telecom, have made a concerted effort to market and deploy ISDN, with strong support from the European Commission's TEN[9]-ISDN programme. This programme has not only promoted the deployment and use of ISDN, but is also promoting the implementation of a common standard for ISDN throughout Europe, known as Euro ISDN. US operators have generally been slower, reflecting a lack of interest from a market already well served by readily available and inexpensive leased digital circuits.

Figure 3.4 shows the proportions of main lines to which ISDN is claimed to be available. For comparison this is overlaid on the chart showing access to digital exchanges. It is notable that many European operators, including BT, and NTT will provide ISDN connections to subscribers who have no direct access to a digital exchange by patching circuits through to digital exchanges at other locations. BT and Deutsche Telekom claim near 100% availability of ISDN on this

[7] two 64kbit/s B channels, and one 16kbit/s D channel

[8] 30 B channels in Europe, 24 B channels in the US and Japan

[9] Trans European Network

basis, although users in Germany and the UK report that in some cases the operators have not been able to provide ISDN circuits. By contrast in many cases ISDN is not available to subscribers in the US directly connected to a digital switch. This apparent anomaly occurs because the operators have not yet equipped all their exchanges to handle the D[10] channel. Telia has not been aggressively deploying ISDN, and makes it clear that whilst it is very willing to provide ISDN where requested by customers, it does not wish to force a solution on its customers.

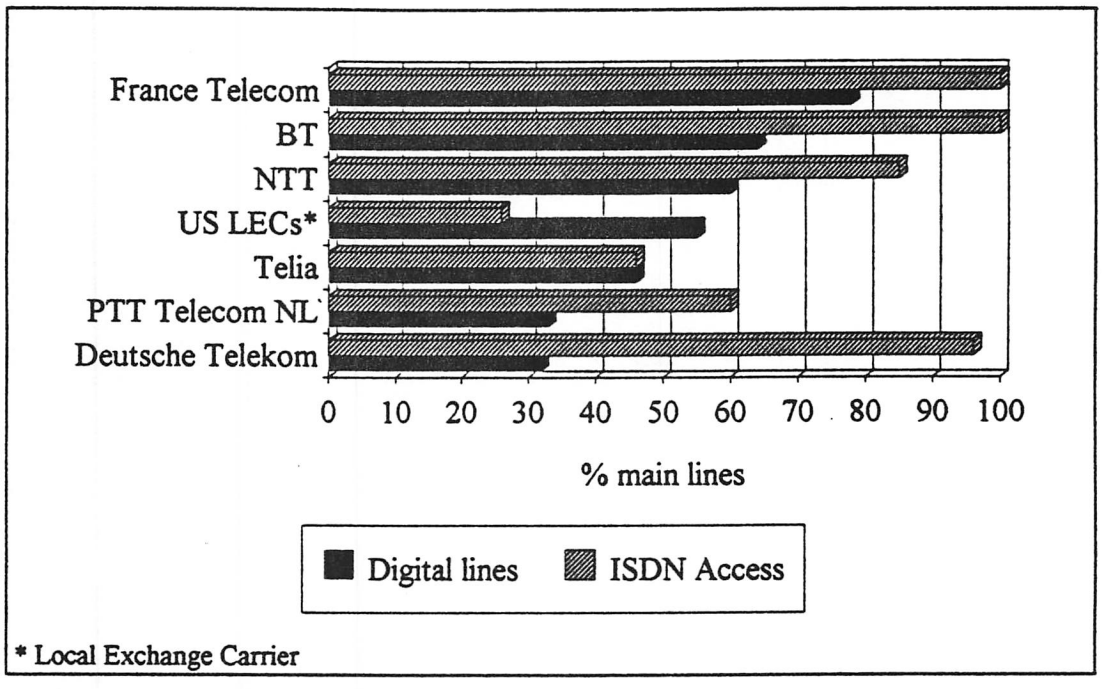


Figure 3.4 Main lines with access to ISDN

Until recently Mercury only offered ISDN at primary rate, and about 35% of its exchanges are equipped to offer it. 100% availability is planned by the end of 1994. Mercury announced a basic rate service in the fourth quarter of 1993, but access to it is largely determined by the availability of ISDN local loop connections provided by BT or other operators.

3.4.2 Penetration of ISDN

The introduction of ISDN has mainly been supplier, not market driven to date, and as a result demand for connections has been low. Few applications have been identified that are dependent on ISDN and suitable terminal equipment for the user has, in consequence, been slow to appear. This in turn has dampened demand further. In addition, the computer industry has tended to regard basic ISDN as being too slow for many applications, preferring to think in LAN[11] speeds of 10-

[10] 16kbit/s signalling channel

[11] Local Area Network

100Mbit/s. As a switched service ISDN is dependent upon the growth of communities of users with common equipment, and as a result market penetration can be expected to grow slowly initially, in the same manner as facsimile, until a critical mass is achieved.

Take up of ISDN by users has varied considerably from country to country, depending largely on the policies of the national operators. Deutsche Telekom, for example, has made a deliberate policy of promoting ISDN, has tariffed it at PSTN rates, and insisted that all PBX equipment is capable of handling ISDN. BT, by contrast, has tariffed basic rate ISDN at a premium, resulting in very low penetration. However primary rate is tariffed much more competitively, and has been widely used for PBX connections. Users in the UK have tended to opt for the cheaper kilostream leased line service where they have a requirement for basic rate ISDN speeds, whilst those in Germany and France, faced with the high cost of leased lines, have chosen the switched ISDN service instead. Whilst this difference is of little consequence at present, there is a risk that as applications that depend upon a switched basic rate ISDN service emerge, such as desk top video telephony, there may not be the critical mass of installed ISDN basic rate connections to support them, which may result in a slower take up in the UK than France or Germany.

The most common current applications for basic rate ISDN are for file transfer, telephony (including PBX connections), leased line back-up, and video conferencing/telephony. A number of user organisations contacted for the study mentioned plans to implement desk top video telephony in the next 2-4 years. As this technology requires digital transmission at 64 or 128kbit/s it seems likely that the demand for ISDN connections will rise to meet the need.

Penetration of ISDN is given in figure 3.5

Country	Basic rate	Primary rate
France	355,000 channels*	
Germany	138,831	11,304
Japan	170,000	30,000+
Netherlands	400	20
Sweden	800	30
US	not available	
UK (BT)	16,500	11,000

* split not available

Figure 3.5 Penetration of ISDN

3.4.3 Future developments

All operators are continuing to deploy ISDN. Figure 3.6 shows the dates by which ISDN and, where appropriate, Euro ISDN will be available to all subscribers.

	ISDN	Euro ISDN basic rate	Euro ISDN primary rate
France	now	1995	not stated
Germany	now for most	1995 (1993 new states)	1995
Japan	1995	n/a	n/a
Netherlands		1995	1995
Sweden	no firm commitment		
US	no firm commitment		
UK (BT)	now for most	1995	1994

Figure 3.6 Plans for availability of national coverage of ISDN

The EC also has plans for the introduction of broadband ISDN (B-ISDN). Plans for broadband ISDN are discussed in Chapter 5.

3.5 Leased Lines

3.5.1 Current Status

Leased lines are preferred by many businesses that wish to establish internal networks under their own control, and where for a number of technical reasons the switched networks cannot provide the performance they require. In many countries, particularly the US and the UK, leased lines have also proved economically very attractive for heavy users. The ready availability of leased lines in the US is held by many to be the major factor in stimulating the invention of many of the innovative data communications products that have originated in that country. Take up has in the past been low in Germany and France owing to the high tariffs, a competitive ISDN alternative and, in the case of France, the availability of an inexpensive high quality packet switched service, Transpac. Perhaps more importantly, their availability is a prerequisite for the establishment of many value added services, and to operators of mobile and other network services, particularly where regulations do not permit them to provide their own infrastructure.

All operators now offer leased lines for voice and data at a variety of different speeds. Digital leased lines, which may be used for voice or data (subject to local regulatory constraints on connection - see chapter 2) are provided at speeds that correspond to the two digital multiplexing hierarchies used in the world. The European hierarchy is based on a multiplexing unit of 2Mbit/s comprising thirty 64kbit/s channels. The US and Japan use a system developed from use of a twenty four 56kbit/s channel 1.5Mbit/s system.

Figure 3.7 shows the two hierarchies in use.

Europe		US and Japan		
Bit rate Mbit/s	**No 64k channels**	**Bit rate Mbit/s**	**Name**	**No 56/64k channels**
.064	1	.056		1
2	30	1.5	T1/DS1	24
8	120	6	DS2	96
34	480	45	DS3	672
140	1920			

Figure 3.7 Digital multiplex hierarchies

Although technically possible to provide leased lines at any of these speeds, in practice the higher rates are not made available by all operators. However, some offer lines at 155Mbit/s SDH/Sonet[12] rates, or dark fibre (see also Chapter 5). Fearful of loss of revenue from their switched networks, a number of European operators, in particular Deutsche Telekom, have until recently been very reluctant to provide leased circuits. Deutsche Telekom now offers private circuits at up to 140Mbit/s, albeit at very high tariffs.

In recognition of the needs of industry and in an effort to provide a uniform set of basic services throughout the community the European Commission issued a directive in 1992 requiring the national operators in all member states to offer a minimum of 5 types of leased lines. These consist of two types of voice circuit and digital circuits at 64kbit/s, and structured and unstructured 2Mbit/s. In some countries, notably France and Germany, network design has been based on the assumption that few leased lines at 2Mbit/s and above will be required, with the consequence that provision of full 2Mbit/s circuits including the signalling channel is technically very difficult. To cater for this the European Commission proposed two 2Mbit/s offerings, one at a full 2Mbit/s, and one formed from multiple 64kbit/s channels.

In practice many operators offer leased lines at additional speeds, and in general lines at up to 34/45Mbit/s are available from most TOs in the countries covered in the study. It is not clear however that lines at higher rates, such as 34, 45 or 140Mbit/s are available throughout the TOs' service area, particularly in those cases where the operator is reliant upon digital overlay networks for their provision, as for example is Deutsche Telekom. The range of data and digital circuits available in each country is given in figure 3.8.

[12] Synchronous Digital Hierarchy/Synchronous Optical NETwork

Country	Leased line speeds available							
	sub 64 kbit/s	64 kbit/s	nx64 kbit/s	2/1.5 Mbit/s	6/8 Mbit/s	34/45 Mbit/s	140 Mbit/s	155 Mbit/s
Deutsche Telekom	■	■	■	■		■	■	
France Telecom	■	■	■	■	on request			
Japan(NTT)	■	■	■	■				
PTT Telecom (NL)	■	■	■	■	not stated			
Telia (Sweden)	■	■	■	■	not stated			
UK (BT/MCL)	■	■	■	■	■	■		
USA (AT&T)	■	■	■	■	■	■		■

Key ■ Tariffed service

Notes

Bell Atlantic: 140 Mbit/s on request
Bell South: Sonet speeds OC1,OC3,OC12 available
South Western Bell: 140 Mbit/s on request
UK, BT & MCL: 140Mbit/s available on request
UK, Nynex: 140 Mbit/s on request
UK, Southwestern Bell: 34,140,155Mbit/s will be available in 1994
NTT: 140Mbit/s for selected clients in 2 yrs.
50 and 155Mbit/s on demand planned
PTT Telecom: Has offered dark fibre to satisfy demand
Deutsche Telekom: 2Mbit/s circuit operates at 1984kbit/s

Figure 3.8 Leased line availability

3.5.2 Future developments

Demand from service providers and network operators for leased lines to support their offerings will increase as liberalisation proceeds and competition increases in all countries covered by the study. In addition users will increasingly demand higher speed lines to support more advanced applications. Whilst the European Commission has no plans to extend its directive to higher speeds, it is expected to act should the TOs in the member states prove slow in providing them.

In response operators are starting to offer alternative services, including virtual private network services (VPNs)and high speed packet services such as frame relay and SMDS[13]. These are generally tariffed to address the needs of businesses that do not generate enough traffic to justify leased lines. In the US, many users are now using their leased lines for data only, having migrated their voice traffic to VPN and switched network services in response to recently introduced attractive

[13] Switched Multimegabit Data Service

tariff packages for bulk users. Nevertheless demand for leased lines can be expected to continue to grow.

In the future, the range of leased line speeds that can be offered will be increased by the deployment of SDH/Sonet multiplexed systems in the networks, which will also allow more rapid and flexible provisioning of leased lines at different speeds. SDH/Sonet transmission systems operate at the following speeds:

Rate (Mbit/s)	SDH (Europe)	Sonet (US)
51	n/a	OC1
155	STM-1	OC3
466	STM-3	OC9
622	STM-4	OC12
933	STM-6	OC18
1244	STM-8	OC24
2488	STM-16	OC48

Figure 3.9 SDH/Sonet hierarchies

These systems are able to carry payloads of bit streams at 1.5, 2, 3, 6, 8, 34, 45, and 140Mbit/s. In a future network employing SDH/Sonet transmission and ATM switching, leased lines could be provided either by using drop and insert techniques to provide by-pass to an ATM switch, or by providing protected logical circuits through the switch. In addition virtual circuits could be offered which provided guaranteed capacity only when traffic was present. As these technologies are introduced the differences between leased circuits and switched circuits are likely to become increasingly blurred, with the real distinctions being in terms of different guarantees of availability.

The deployment and capabilities of these broadband offerings are discussed in detail in Chapter 4.

3.6 Intelligent Network services

Intelligent networks (INs) make use of CCSS7 to transfer information about a call between computers associated with exchanges, independently of the call itself. According to the number dialled the network can initiate special routing or billing functions to provide a range of services. This does not however necessarily mean that IN services are not available to exchanges not equipped for CCSS7. The most common service, which is available in all countries, is Freefone, also known as 800 service, or Green Number service; others include Charge Card services, Single or Universal Number, Calling Name Delivery, Call Screening, Televoting, Premium Rate or Shared Revenue services, Virtual Private Networks (VPN), and Wide Area Centrex. Services were introduced initially in the USA in the mid 1980s, and are now in operation in all seven countries, although Deutsche Telekom is still operating trials. Most European operators installed systems in 1991/2, initially for

trial followed by commercial service. Operators in the USA are slowly upgrading their systems to AIN[14], which is closer to the European implementations.

There are efforts to establish a basic set of common services which are offered by all operators, but many operators, particularly those in the USA with more market experience, are discovering that they can maximise their competitive advantage and profitability by tailoring services to suit individual customers. In consequence operators do not necessarily offer equivalent services, and are frequently unwilling to discuss future plans. To confuse matters further, some services, including Green number, can be provided without IN capability, so that provision of a given service is not necessarily an indication that an operator uses IN for that service.

A summary of the main classes of IN service available in each country are given in Figure 3.10.

	Number Translation	Charge Card	Shared Revenue	VPN
France	YES	YES	YES	YES
Germany	YES	1995	YES	1994
Japan	YES	YES	YES	1995*
Netherlands	YES	YES	YES	YES
Sweden	YES	YES	YES	YES
USA	YES	YES	YES	YES
UK (BT, MCL)	YES	YES	YES	YES

* NTT is prohibited by MPT from offering VPN services until its competitors are able to do so.

Figure 3.10 Availability of IN services

In the UK some of the cable TV operators are also planning to offer IN services.

3.7 Conclusions

Deployment of digital systems in the UK compares well with other countries covered by the study. Plans for future deployment will not leave the UK behind others, and the availability of ISDN and digital leased lines ensures that the requirements of all users requiring digital connections can be accommodated. It is interesting to note that some of the UK cable TV operators as well as the newly licensed TOs such as Energis and COLT are offering leased lines at up to 140/155Mbit/s . Development of IN infrastructure and services in the UK compares well with other countries in Europe, but the range of services are not yet as well developed as by some US operators. The installed base of basic rate ISDN connections in France and Germany may create conditions in the future for the faster uptake of applications using basic rate ISDN than in the UK.

[14] Advanced Intelligent Network

In the longer term, ATM switches are expected to supersede conventional circuit switching digital exchanges, and it seems likely that the last analogue exchanges will be replaced directly by ATM switches. The widespread use of ATM and SDH/Sonet may well change the range and nature as well as the ease of provision of leased line offerings. The plans of the operators are not sufficiently far advanced to predict how the UK will compare when this stage of development is reached.

4. BROADBAND INFRASTRUCTURE AND SERVICES

4.1 Introduction

The creation of a broadband telecommunications infrastructure is widely regarded as being of significant economic importance. A broadband network serving both business and residential users offers the possibility of easy access to an enormous range of potential information and entertainment services under the direct control of the user. At present the number of applications requiring broadband networks is limited, but it is held by many in the industry that many more will appear as broadband networks become widely available.

Recent studies in both the USA[1] and Europe[2] have forecast significant increases in GDP over a prolonged period for those countries establishing broadband networks, with the potential for even more rapid growth of GDP if the deployment of broadband is accelerated. These forecasts are largely based on known productivity improvements achieved through the use of broadband communications networks operating at 1.5Mbit/s or 2Mbit/s to carry voice, data and image traffic, and do not take account of the appearance and spread of new applications requiring higher bandwidths, such as high quality desk top videoconferencing. As such these forecasts may be regarded as conservative.

This chapter describes the current state of development of broadband infrastructure and services in the countries covered by the study. It provides an overview of the many trials of broadband systems being carried out by operators and their plans for commercial deployment together with a view of likely future developments in the longer term.

4.1.1 Applications

Current applications requiring bandwidths in excess of the 64/128kbit/s circuits offered by narrowband ISDN[3] include CAD/CAM[4], LAN[5] interconnect, high quality videoconferencing, distance learning, medical imaging, and video entertainment services. As technological developments reduce the costs and increase the functionality of terminal equipment, these applications will become more widespread, and new applications can be expected to make their appearance. These developments will generate a demand for higher bandwidths both in the trunk (inter-exchange) networks, and the user access networks (local loop). Already the level of traffic in public networks is growing significantly faster than

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[1] The Impact of Broadband Communications on the US Economy and on Competitiveness: Robert Cohen, Economic Strategy Institute.

[2] Report by Technibank for DG XIII of the European Commission

[3] Integrated Services Digital Network

[4] Computer Aided Design/Computer Aided Manufacture

[5] Local Area Network

the growth in new connections. For example, Telia reports an annual growth in traffic of 15%.

Figure 4.1 shows current broadband applications with indications of the bandwidths required for their operation, and likely future trends in bandwidth required. With the notable exception of entertainment (CATV), most applications requiring bandwidths over 2Mbit/s are of a relatively specialist nature.

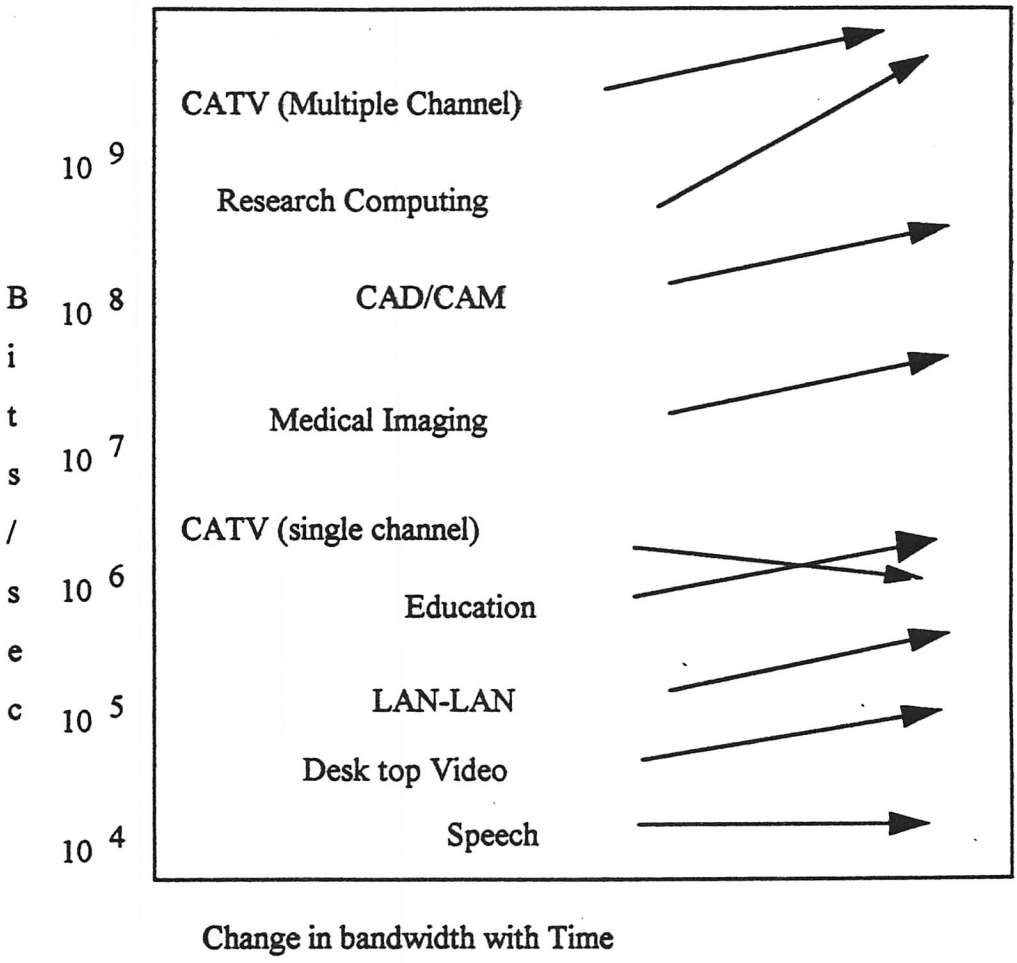

Figure 4.1 Development of Broadband Applications

4.1.2 Technologies

The provision of broadband capability in modern telecommunications networks centres around the deployment of optical fibre cable in the core network[6], and the use of appropriate technologies that can exploit the high bandwidth offered by the use of fibre. Optical fibre has a theoretical bandwidth of about 25 Terabit/s (25×10^{12}bit/s). This capability cannot however be fully exploited until suitable optical repeaters and switches have been developed. At present these technologies

[6] The interexchange network, and the primary part of the access network. Final distribution to the user may use other technologies dependent upon the economics of the application.

are the subject of advanced research programmes in several countries, including the UK. In the meantime new electronic multiplexing and switching techniques such as SDH (Synchronous Digital Hierarchy), Sonet (Synchronous Optical Network) and ATM (Asynchronous Transfer Mode) are being developed to make greater use of the available bandwidth, and new network services such as SMDS (Switched Multimegabit Data Service) are being introduced.

Although these new systems offer considerable potential benefits to both operators and users, their deployment is still determined largely by the financial considerations of the Telecommunications Operators (TOs), rather than the need to gain competitive advantage, although there are signs that this is changing in the USA and UK. The manner of their deployment depends upon the network architecture, and the application within the network. TOs have invested extensively in broadband equipment for their interexchange networks in order to achieve improvements in capacity and quality, and to reduce operating costs. The operational savings allow ready recovery of the capital investment. However the decision to invest in broadband infrastructure in the access network is heavily dependent on the forecast level of traffic generated by the users. As a consequence, the approaches being taken for heavy business users differ from those being taken for residential and small business users.

4.2 National and Regional Initiatives/Plans

In recognition of the potential economic benefits of broadband infrastructures, several of the countries covered by the report, together with the European Commission, have plans or proposals designed to promote their development. Both the USA and Japan have announced government inspired national initiatives to stimulate investment in broadband infrastructure. In addition many operators, including the monopoly operators in Germany and the Netherlands, have developed long term plans for the deployment of broadband infrastructure.

The US initiative, led by Vice President Gore, has been described in detail in Section 2, *Industry Structure and Regulation*. It is intended to encourage the development of a national broadband infrastructure (the National Information Infrastructure, or NII), together with a range of applications that will benefit the community at large. Since the announcement of the initiative several operators have announced investment plans for deployment of fibre in the residential access network; some are believed to be statements of plans which had already been developed. A number of announcements have been made in Japan concerning investment in broadband networks. In April 1993 NTT announced investment plans of $396bn over 22yrs to provide fibre to all subscribers by 2015. Despite these announcements there are at present no firm plans to develop a broadband network, merely a statement of intent and a commitment to an FTTK (Fibre to the kerb) trial. However the subject is under discussion at present and announcements of plans for the future are expected in the spring of 1994. Both initiatives include the creation of joint government-industry committees to help steer developments.

Deutsche Telekom has embarked on the most extensive deployment of wideband technology in Europe. This development is driven by the need to create a new infrastructure in the former East German states for both business and residential users, but also serves to provide a state-of-the-art overlay to the largely analogue West German infrastructure. The deployment is being carried out under the following programmes:

- OPAL - deployment of fibre in the access network to serve residential and small business users. FTTK systems are being used to carry telephony and CATV services
- VISYON - deployment of SDH fibre rings in major metropolitan areas for business users
- Netzknoten 2000 - installation of an overlay SDH fibre network for the country

PTT Telecom has developed a national scheme to deploy fibre in the access network for the transport of telephony and cable TV traffic to business and residential users and GSM[7] traffic to base stations. This plan envisages the deployment of optical fibre in the primary part of the access network (PAN) in ring and mesh configurations. The services will then be distributed from access points to end users or GSM base stations via separate infrastructures using fibre, copper pair or coax provided by the individual operators. Although the Dutch hold the view that duplicated infrastructures are a waste of resource, it is not clear whether competing operators will be obliged to use the PTT Telecom network.

BT is installing a national broadband network for academic research institutions, known as Super JANET. The initial phase will link Cambridge and Manchester Universities, Rutherford Appleton Laboratory, University College London, Imperial College London and Edinburgh University. It is planned to extend the network to 45 sites. Applications will include distance teaching, electronic publishing, library document distribution, high quality medical imaging, multimedia information services, distributed group communications and advanced data visualisation. Super JANET claims to be the world's biggest cohesive broadband network. France Telecom is installing a similar national research network called Renater.

The European Commission is actively promoting a broadband initiative under its TENs (Trans European Networks) programme which is primarily aimed at the development and trial of new applications. In advance of this many of the Western European TOs have signed a Memorandum of Understanding to establish a trial ATM[8] network between the participating countries.

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[7] Global System for Mobile Communications. The scheme will carry traffic to and from the fixed base stations.

[8] Asynchronous Transfer Mode, a broadband switching technology

4.3 Interexchange Fibre Deployment

Fibre has been deployed in the interexchange networks of all operators for a number of years, as it represents a more attractive investment than copper. Operators in Japan, Sweden, the USA, and the UK have all made extensive use of fibre in their networks, particularly for long haul trunk routes. France and Germany have by comparison installed relatively little, and in consequence both have programmes under way to provide fibre connections to all major centres.

Direct comparison of the total length of fibre installed in each country does not take account of the different populations or geographies of the countries. To make comparisons more meaningful the length of fibre installed per subscriber can be used for comparison. This is shown in figure 4.2.

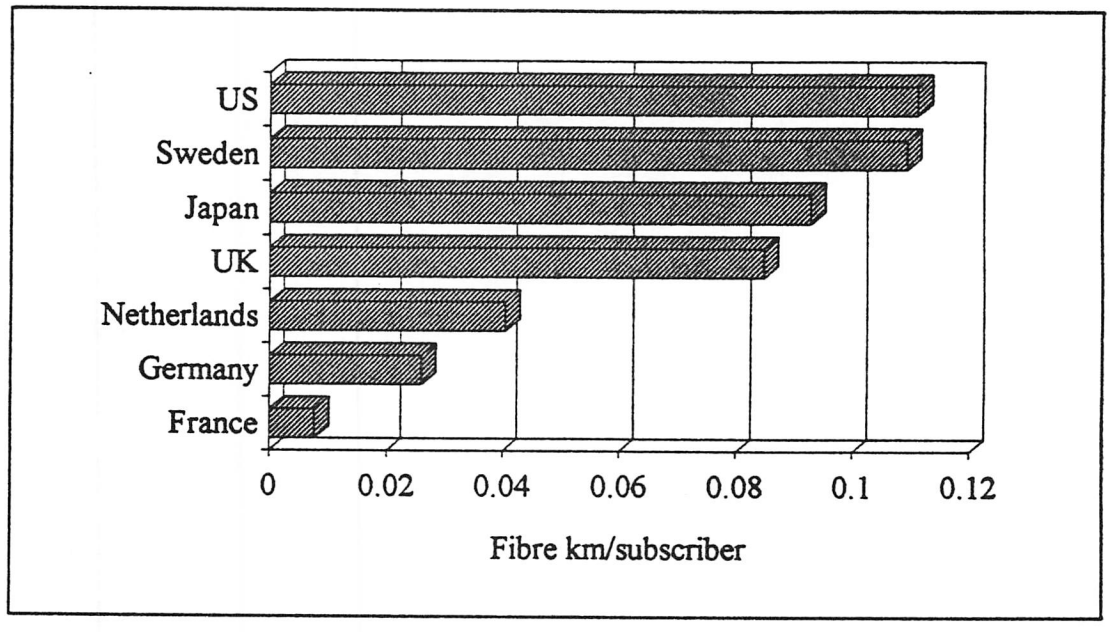

Figure 4.2 Installed fibre per subscriber in the interexchange network

The comparison shown in figure 4.2 does not take account of the relative sizes of the countries, and a more meaningful comparison might be expected if the length of fibre installed per subscriber were adjusted to take this into account. If this is done the relative position of the USA, and to a lesser extent those of Japan and Sweden, fall relative to the other countries, and the position of the Netherlands rises. The position of the UK rises to be one the countries with the highest deployment of fibre per subscriber in the interexchange network, together with the Netherlands and Sweden. However, variations in the distribution of population between the countries give anomalous results for some countries, particularly the USA, and the numerical results are not given here.

4.4 Business Subscriber Access

For business users with more than three or four lines, the cost of fibre for the entire link to the business premises can be readily cost justified. Fibre is widely used for this purpose in Japan, the US and the UK. In order to increase the resilience of the links, these fibres may be duplicated in separate cables, either following the same path or an alternate route. A development of this approach has been the deployment of fibre rings in the access network.

4.4.1 Fibre Rings

Many operators are now deploying or planning to deploy fibre ring structures in their access networks where there is heavy demand for capacity from business users. The earliest systems were installed in the US by the Competitive Access Providers (CAPs), and provided a fibre ring for each business. Most later systems use SDH technology in order to provide greater flexibility and make best use of the bandwidth available. Operators take different approaches over the physical deployment of the rings, and the connections between the rings and subscribers. Rings may be deployed in the primary part of the network only, with feeds to individual business subscribers via ADM[9] s and fibre tails. In some cases, where there are residential and small business subscribers in the same district, FTTK systems may also be fed from the rings. Other operators locate the SDH multiplex equipment on the subscriber's premises, and heavy users are often allocated their own dedicated ring.

In most cases the early systems will be upgraded to use SDH technology. Use of SDH provides the user with resilient broadband access that can be readily reconfigured to suit changing needs. Further resilience can be provided by providing a bypass to the local exchange with a digital cross-connect link to the trunk network, as shown in Figure 4.3.

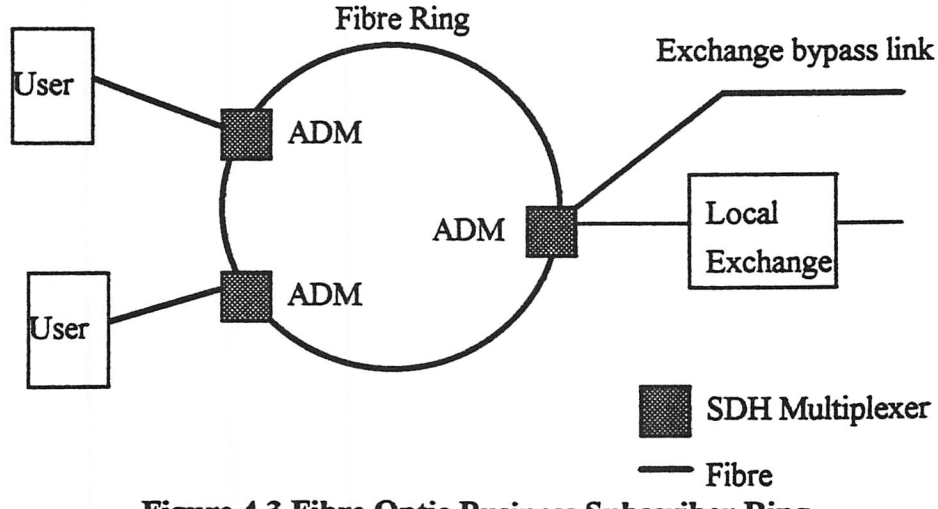

Figure 4.3 Fibre Optic Business Subscriber Ring

[9] Add-drop multiplexers

4.4.2 Current Activities and plans

Use of fibre rings, and of fibre for direct connection to business premises vary considerably between operators. France Telecom is at a relatively early stage in use of fibre in this manner, and has been conducting trials in Paris, offering PSTN, ISDN, PDN[10], and leased lines mainly for business users, since 1991. The systems use a mixture of ring and mesh structures and France Telecom plans to connect several hundred buildings over 4 years. NTT also commenced a fibre to the building pilot in 1991 in two business areas in Tokyo to which 100 buildings were connected. Current plans are for deployment of fibre to all business subscribers in Tokyo by 1995 and in other metropolitan areas by the year 2000.

PTT Telecom NL plans to implement fibre rings in the primary access network (PAN) to carry both telephony and CATV. Implementation will take place over the period 1993-1997, and will include fibre connections to business users (FTTO[11]). Telia declared a similar policy in 1990 to use fibre rings for the primary part of the local loop, connecting to remote concentrators (FTTK[12]), or business premises (FTTO). These will be installed primarily to serve business users on an 'as needed' basis.

Fibre rings are being installed for commercial use in Germany, the US and the UK. Of these the USA has by far the largest installed base. The first systems were installed by Competitive Access Providers (CAPs) seeking competitive advantage over the established Local Exchange Carriers (LECs) in provision of alternative access to Inter Exchange Carriers (IXEs). Urban Fibre systems had been installed by CAPs in 116 cities/60 major metropolitan areas by the end of 1992. In response, a number of LECs have also installed systems. Perhaps unsurprisingly, given the generally advanced state of its network, GTE has the most rings in commercial service, and plans to have over 50 by the end of 1993. Nynex, Bell Atlantic and US West all have firm plans for deployment. A number of operators in the US have also installed dedicated broadband links to academic institutions.

Deutsche Telekom is installing optical fibre rings in 4 cities for service in 1994 as part of its VISYON programme. They will provide transport at 2-155Mb/s for business users, and a further 52 rings in 34 cities are planned over the period up to 1997.

In the UK, BT and Mercury make extensive use of fibre for direct connection to business premises. BT has installed fibre to 8000 business premises. Where requested by the customer, a duplicate access link is provided to an alternative exchange. BT is now planning to deploy fibre rings on a large scale with the

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[10] Public Data Network

[11] Fibre to the Office

[12] Fibre to the Kerb

intention of connecting 95% of all business users to fibre rings within 5 years. Different arrangements will be used, depending on the level of traffic generated by the user. Major users will have a dedicated ring, with the multiplex equipment located on their own premises. Smaller users will share a ring, with ADMs used for individual access. Mercury also plans to start deploying SDH in ADM rings.

Also in the UK COLT is currently installing a network of fibre rings in central London. Users with several buildings in close proximity and generating high volumes of traffic will have a ring dedicated for their own use. Within 5 years COLT expects to have installed its network in most business areas within its licence area. The newest UK operator, MFS, is also installing metropolitan area fibre rings.

A comparison of the installations and plans in the different countries is given in Figure 4.4

	Fibre rings		
	Trial	Quantity	In service
France		<5	
Germany		4	1994
Japan	n/a	n/a	1995
Netherlands		<5	
Sweden		<5	
US		>150	
UK		<10	1994

Figure 4.4 Use of fibre rings in the access network

4.5 Residential and Small Business Subscriber Access

4.5.1 Costs/Technologies

The choice of technology to be used in the access network for residential and small business users depends heavily upon its cost. This part of the network represents a major part of the capital investment of a TO, and generates a relatively low level of traffic, and therefore revenue, per line. To meet their business objectives operators need a low cost, low maintenance network with a long working life. If the choice of access network permits the provision of any additional services that can increase the revenue stream, then the investment case for that technology can be improved.

Considerable research has gone into establishing the point at which fibre becomes more attractive than copper . At present the consensus amongst all operators covered by the study is that the cost of the terminal electronics makes fibre to the home (FTTH) uneconomic for both telephony and cable TV applications, whether supplied separately or in combination. The magnitude of the cost differential varies

according to the assumptions made, and whether the fibre is being considered for new or replacement installations, but on current costs it ranges between 3:1 to 18:1. FTTH is expected to become economic for new installations after 1995-7, and for replacement of existing copper early in the next century. However deployment of fibre to the kerb (FTTK), to multi-occupancy buildings (FTTB), or to businesses (offices) with several lines (FTTO) can usually be justified at today's costs for new installations. Most operators argue that the ability to carry both telephony and cable TV makes it easier to justify investment in fibre owing to the increased revenues returned by the investment, but in contrast PTT Telecom has published a chart showing an earlier cost cross-over point for telephony alone than for telephony and cable TV. This view is based on the high additional costs of the terminal equipment required to handle cable TV.

One US operator expressed the view during the study that, once installed, a fibre loop feeding residential subscribers from an ATM switch would prove the most cost effective solution, and would also allow costs to be matched to usage rather than the number of subscribers (see figure 4.5). This would have the added benefit of also addressing the cost issues of universal service, which is of particular relevance in the USA. However to justify the investment at current costs the network would need to carry cable TV traffic (on behalf of a cable company) *and* offer a minimal video on demand service in addition to telephony. As the majority of connections, and hence a substantial part of an operator's capital investment, are associated with residential customers, the operator sees these users as key to future business development. Its research shows that residential users are currently only prepared to pay for entertainment and household security/assurance (intrusion, health, heating etc). It plans commercial trials using this technology in the next two years or so.

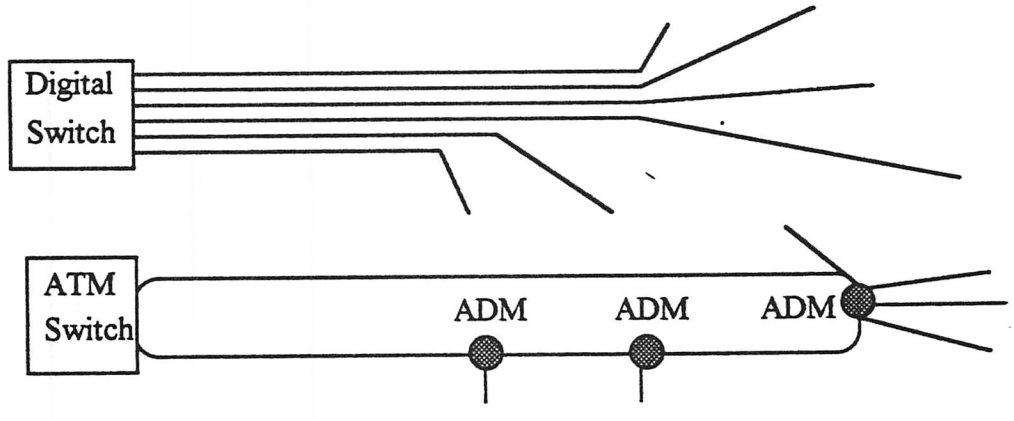

Figure 4.5 Possible ATM Fibre Optic Residential Subscriber Ring

Other technologies are emerging for increasing the bandwidth of copper circuits to 1.5 to 2Mbit/s (using HDSL/ADSL[13]) to provide more economic solutions, if only

[13] High Density bit rate Subscriber Loop/Asymmetric Digital Subscriber Loop

in the short term. Use of HDSL/ADSL is however limited to short loops of under 3km, and of reasonable quality.

4.5.2 Current status and activities, and future plans

All operators in the seven countries that have universal service obligations have conducted trials using fibre in the local loop, with a view to reducing operating costs and opening the way to future service developments. Trials have included provision of telephony and entertainment services via both fibre to the kerb and fibre to the home systems.

France Telecom is again at an early stage of development in this field and is not at present conducting any trials specifically for residential users (see para 4.4 business access), but it is planning to launch three new trials in 1994, with a fourth starting in Corsica in 1996. The first trial will be near Annecy and will be for professional and small business users. The other three will each serve around 300 residential users. One trial, at Saint-Ouen l'Ouen, will also provide cable TV in addition to telephony. France Telecom also operates cable TV networks in 52 towns. All systems use FTTK except one in Montpellier (Paris) which employs FTTH. It is understood that France Telecom found this implementation too expensive, and has not used this approach since.

NTT and Telia are also at a relatively early stage in use of fibre for residential access. Although NTT conducted its first trial of fibre in the loop (FITL) in 1984, and there have been several announcements stating that fibre is to be provided to all homes by 2015[14], no firm plans have yet been established. In recognition of this a trial is to be held in Kansai Science Park in 1994, to help determine future policy (see also Chapter 2). However it should be noted that the concentrated nature of Japan's urban housing makes FTTB more attractive than in most countries. Telia is planning to launch a telephony over passive optical networks trial in Orebro in 1994 for residential users.

PTT Telecom commenced a FTTH field trial in 1991 in Sloten (Amsterdam). The trial used PON[15] technology to provide PSTN and cable TV services to 275 subscribers. Based on the results of the trial PTT Telecom has decided on a policy to provide one integrated infrastructure (PAN) for both cable TV and telephony which will be constructed over the period 1993-1997. Residential access, using FTTK, is not planned until 1997 when it will be introduced for new residential areas. From 2002 onwards, FTTH/FTTK will be installed for whole country.

Germany, the USA and the UK are all further advanced in the use of fibre for residential access. Deutsche Telekom has established the OPAL programme for deployment of fibre systems in the local loop in response to the requirement for new infrastructure in the former East Germany. OPAL uses FTTB for business

[14] Most recently 2010

[15] Passive Optical Network

users and FTTK for residential users. Under the OPAL programme 7 FITL pilots were established in 1991 for mixed broad and narrow band services for business and residential users. Users on some trials are provided with interactive services and cable TV. Under the programme 200,000 homes are to be connected by the end of 1993, and 1.2 million homes by the end of 1995.

In the USA all the major local exchange carriers (the RBOCs[16] and GTE) are running trials using fibre for telephony services, and in many cases they have stated that they are now starting to roll out FTTK systems for commercial service where it is economic to do so. Many, including Ameritech, Bell Atlantic, Bell South, GTE and US West are also trialling video services either in conjunction with a cable TV operator, or on their own under a regulatory waiver.

At present only one US operator is known to be testing ADSL equipment. Bell Atlantic is testing AT&T ADSL equipment in Virginia, to put 1.5Mbit/s (T1) over twisted pair subscriber loops. This system is being used to trial residential video on demand services.

Several US TOs have announced major plans to roll out FTTK systems over the next few years. In February 1993 US West announced a major programme to build a fibre network to its 14.2 million customers which is expected to cost US$14.2bn spread over a period of 26 years. Other operators have similar plans for large scale deployment of FTTK systems. Bell South is already using fibre to replace copper wherever it is economic to do so, and plans to start large scale deployment of FTTK in 1994. It expects penetration of the local loop to reach 35% by 2004, and that all subscribers should be on FTTK systems by 2014-2017. GTE has deployed fibre to 11 FTTK systems and plans to extend FTTK to 4,000,000 customers over the next 10 years. It may ultimately use wireless rather than fibre for some rural locations. A summary of forecasts made by telecommunications operators is given in Figure 4.6.

	1993	1994	1995	1996
Deutsche Telekom	200,000		1,200,000	
Bell Atlantic		nx100,000		
Bell South				450,000
GTE			500,000	
Nynex		10,000	360,000	875,000
US West	100,000		500,000	1,100,000

Figure 4.6 Operator's forecasts of number of subscribers to be served by FTTK systems

[16] Regional Bell Operating Company

The two major cable TV operators in the US, TCI (Tele-Communications Inc) and Time Warner have announced major plans for deployment of fibre in their networks. In January 1993 Time Warner announced plans to connect 4000 homes in Orlando with fibre for telephony, video and information services. This project is planned to be the first of a series, but regulatory dispensation will be required. TCI announced plans to spend $2bn over 4 years in 300 cities upgrading its cable network to fibre, including $753m due to have been spent by the end of 1993 on its networks in 100 cities. This will enable to provision of up to 500 channels of video programming. By 1996 TCI plans to serve 90% of its 10.2 million customers over fibre networks.

BT conducted an initial trial in Milton Keynes in 1983, connecting 25 subscribers to cable TV, interactive voice, data and video services, and in 1985 BT established the Westminster cable TV network using FTTK . A further trial was established in Bishops Stortford using TPON[17] (in both FTTK and FTTH configurations) and ran from 1990-93. On the basis of the results of these trials commercial pilots are planned to start in 1994 in Bristol and Harlow for a few hundred users. These will run for around 1 year, and be followed by roll-out if successful. Deployment will be FTTO for small businesses (5-10 lines) and FTTK where viable for residences (eg where the local exchange is congested, or on a green field site). BT has stated that further deployment depends upon the regulatory position. In addition BT plans to start technical trials of a video on demand service to 2,500 homes in the Colchester area during 1994. This will be followed by a more extensive commercial trial of up to 250,000 homes. These will operate over new infrastructure using fibre, coax and ADSL, and will be separate from the deployment of fibre described above. BT's plans put it well ahead of the TOs in France, Japan, the Netherlands and Sweden.

In addition, the cable TV operators in the UK are making extensive use of fibre in installing their networks. None are deploying fibre direct to the home (FTTH), but most are using fibre to street cabinets, for final distribution by copper. Many now offer telephony as well as video. As a result an increasing number of telephone subscribers in the UK are being served by fibre in the access network. By the year 2000 the cable operators expect to have passed nearly two thirds of homes, mainly with fibre in the loop systems.

The plans outlined by the operators enable a number of comparisons to be made. Firstly, a forecast can be prepared showing the number of telephone subscribers in each country that will be served by access networks using fibre over the next two to three years. Comparison of the number of subscribers to telephony services connected by FITL networks is shown in figure 4.7 The figures include all TOs in each country, including cable TV operators licensed to offer telephony services, but do not include other cable TV networks.

[17] Telephony over Passive Optical Network

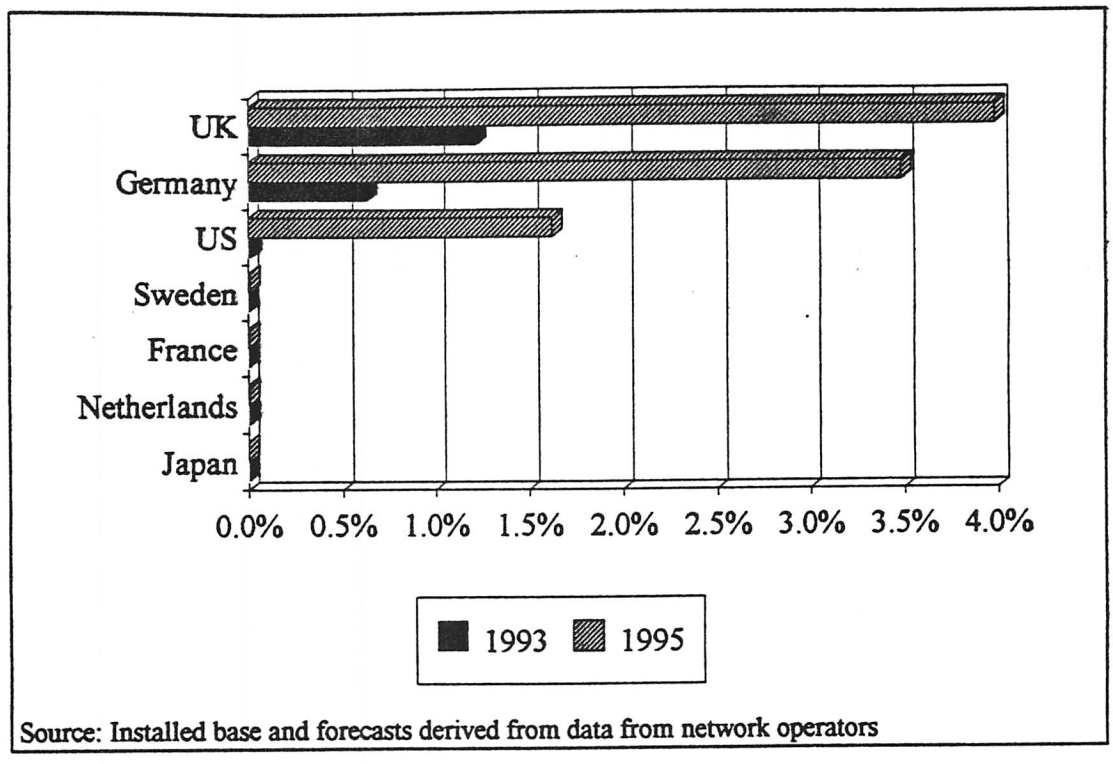

Figure 4.7. Percntage of telephone subscribers served by fibre in the loop networks

This comparison does not necessarily provide a clear indication of either the amount of fibre being installed in the access network per subscriber in each country or the number of subscribers that potentially have access to it. Cable TV operators are also installing fibre for users not taking a telephony service, and indeed for those not yet taking their service at all. To that extent the comparison serves as an understatement of deployment in the UK and USA. Figure 4.8 shows the number of telephone subscribers in the Uk served by fibre in the loop systems, compared to the number of homes passed by such systems.

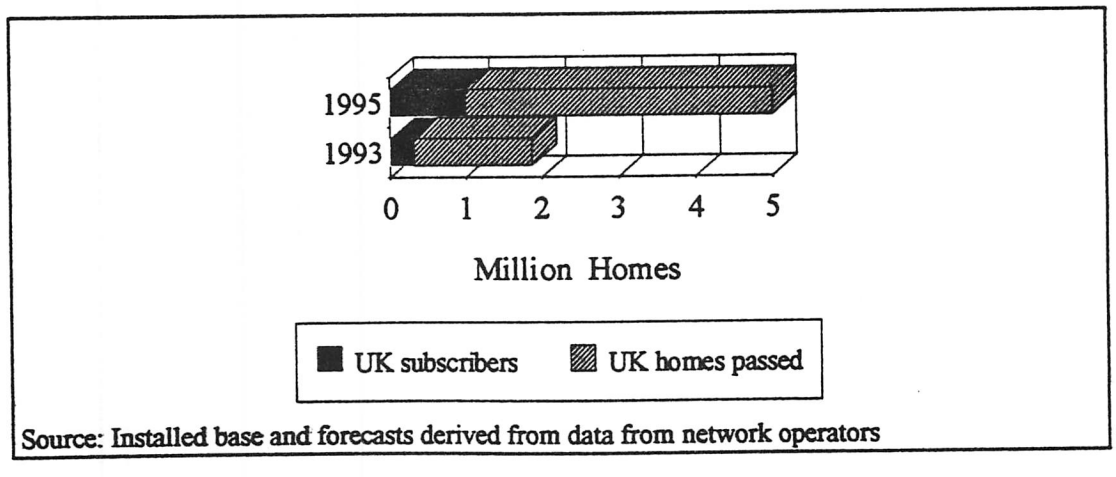

Figure 4.8 Fibre in the loop:
Number of telephone subscribers served vs number of UK homes passed

On the other hand, cable TV operators do not always extend fibre as close to the user as a TO. At present the more advanced cable operators in the UK typically take fibre to within 3-400m of the subscriber. Within the next two years this distance is expected to fall to under 100m for new installations, a distance comparable to that used by TOs. Inclusion of fibre installed by cable TV operators in other countries that are not permitted to offer telephony services, on the basis that it could form the basis of an interactive broadband network would also affect the comparison. However it should be borne in mind that most of the existing networks use tree and branch coax systems which are quite unsuitable for interactive networks. France has made extensive use of fibre for cable TV, which would improve its overall position. Table 4.9 shows the current penetration of all cable TV services.

	Homes Passed (000)	Penetration	% with CATV
France	5,081(23.5%)	16.4%	3.9%
Germany	20,671 (62%)	63.5%	39%
Japan	n/a	n/a	21%
Netherlands	5500 (90%)	85%	77%
Sweden	1900 (50%)	90%	45%
USA	90000 (95%)	60%	34%
UK	2,554[18] (12%)	20.4%	2.4%

Figure 4.9 Penetration of CATV (all types of system)

4.6 SDH/Sonet deployment and plans

Transmission and multiplexing systems for use on fibre have been developed that work at up to 2.5Gbit/s, and development is currently under way at up to 10Gbit/s. Two sets of standards have been established for this technology, Sonet (Synchronous Optical Network) in the USA, and SDH (Synchronous Digital Hierarchy) in Europe. At present final standards for SDH only exist at 155Mbit/s, but several suppliers are delivering equipment that operates at up to 2.5Gbit/s. The two standards are largely compatible.

SDH/Sonet is now regarded by many operators as an 'off the shelf' product, and is being installed for commercial service in several countries. All newly licensed operators are constructing SDH/Sonet networks, and many of the US operators and some European TOs are actively deploying equipment. Some European TOs are still conducting trials.

Many of the US operators are actively deploying Sonet equipment in their trunk and access networks. At present most of the equipment being installed is to cater for new growth, but over the next 10 years much of the installed PDH[19] equipment

[18] Data as at September 1993; by the end of the year this had risen to 3.1 million.

[19] Plesiochronous Digital Hierarchy

will reach the end of its economic life and will be replaced by Sonet equipment. Some operators, like Bell South, which started volume deployment in 1992, are also starting to install some additional equipment to position itself for future market demand for broadband services. Over the next two to three years it plans to provide about 10% of newly installed capacity for this purpose. GTE already has many links in service, and other operators including AT&T, Bell Atlantic, Nynex, and Southwestern Bell, were introducing Sonet for commercial service in 1993. Bell South, GTE and Nynex stated that they expect to replace all PDH equipment over a ten year period.

Deutsche Telekom has also introduced SDH equipment to its network as part of its programme to provide a broadband overlay network. Equipment has been in service for point to point connections in the trunk network since 1992 and from 1994, SDH cross-connects will also be installed to switch single channels as part of the Netzknoten U 2000 programme (see para 4.2). SDH will also be deployed in VISYON ring structures in the access network from 1994 (see section 4.5). Over the next 10 years Telekom also expects procurement of PDH equipment will cease.

NTT has been deploying Sonet equipment in its trunk network, and the first equipment has now entered commercial service. Telia AB established an SDH test in 1992, and planned to have introduced it into the network for commercial service at 2.5Gbit/s by the end of 1993.

BT has installed SDH equipment for trials and commercial service for a business network in Northern Ireland. It had planned to conduct further trials in mainland Britain in 1994 followed by installation of a full overlay network over the next 2-3 years. As a result of pressure from newly licensed operators BT has brought forward its programme to provide interconnect to these operators using SDH bit rates. SDH will be also used for the Super JANET network (see para 4.2). BT plans that SDH will be used for all growth by the end of a 10 year period. Mercury already has 2.5Gbit/s SDH systems in commercial service and plans to deploy SDH cross-connects as required.

The newly licensed operators in the UK and in Sweden are making exclusive use of SDH equipment in their fibre networks. Energis is constructing a network throughout England and Wales by wrapping fibre around the earth wire on high tension overhead lines, and COLT is using SDH in its network in London. Tele 2, the second operator in Sweden makes use of an SDH fibre network installed by the state railway company, Bahnwerket.

4.7 ATM

Development of new switching systems using ATM (Asynchronous Transfer Mode) is at an advanced stage. These systems provide flexible switching for voice, data and image at different speeds, making the provision of separate circuit and packet switched networks unnecessary. Equipment is currently undergoing

commercial trials, and the first fully operational services will be introduced in early 1994 in the USA. Trials of ATM switches are being carried out by Deutsche Telekom and several operators in the USA.

Figure 4.10 provides a summary of ATM trials, showing comparison with deployment of SDH and fibre rings.

	Fibre Rings		SDH Access n/w		SDH Trunk n/w		ATM	
	Trial	Service	Trial	Service	Trial	Service	Trial	Service
France								
Germany		1994		1994		1994		
Japan	?	1995	?	1995?				1995
Netherlands						1996	1994	
Sweden				1994		1994		
US								1994
UK		1994		1993			1994	

Figure 4.10 ATM and SDH Trials

Some doubts about ATM exist amongst operators in Europe, particularly in respect of tariffing, and its ability to handle broadband real time traffic such as video at the same time as high volumes of data. Nevertheless most European operators have signed a Memorandum of Understanding (MoU) for the trialling of ATM equipment, and are setting up an international network operating at 34Mbit/s. The original MoU was signed by BT, Deutsche Telekom, France Telecom, STET (Italy), and Telefonica (Spain). Operators now include Norwegian Telecom, PTT Telecom, Belgacom, PTT Switzerland, TLP (Portugal), and Telia. The network will run until mid 1994, and the speed may be increased to 155Mbit/s. After that, application based pilot tests will be run.

In addition Deutsche Telekom has established a pilot project linking Hamburg, Berlin, Bonn, and Cologne, which is being used to test high speed applications for voice, data, video and high definition TV (HDTV).

Several US operators including AT&T, Bell South, GTE, and Southwestern Bell are currently running trials of ATM switches, with the first system from GTE due to enter commercial service early in 1994. ATM services will initially be made available in metropolitan areas.

Bell South and Southwestern Bell both plan ATM service to be available in their major metropolitan LATAs[20] in two to three years, and AT&T expects to deploy ATM widely. Bell South and GTE plan to interconnect their networks as part of their trials, and state that they will offer ATM throughout their networks within 10 years. Nynex installed ATM in 1993 to link Cornell and Syracuse Universities.

[20] Local Access and Transport Area.

Later the network will be extended to Columbia and Brooklyn Polytechnic Universities in New York City and Nynex Science and Technology Center in White Plains. It will operate at 55Mb/s initially, and be increased to 622Mb/s by the end of 1994. Later the rate may be increased again to 1.2Gb/s.

BT is planning a two node internal ATM trial in 1994, and is also a participant in the pan-European MoU. BT expects to migrate its switched broadband and data services to ATM when it is cost effective to do so, and the technology is proven and available. The Super JANET network will use ATM for switching. Mercury plans ATM field trials over the next 2-3 years.

4.8 Broadband Services

MANs (Metropolitan Area Networks) using the DQDB[21] protocol have been deployed by some operators as a means of providing broadband communications over a city wide area. However these are beginning to drop out of favour in preference to ATM which is widely expected to supersede them. SMDS (Switched Multi-megabit Data Service) is increasingly being offered in many broadband environments to provide a high speed connectionless link between LANs. This too may be supplanted in time by provision of native ATM (ie basic ATM transport, rather than SMDS offered over ATM). Operators that have been slow to introduce these services expect to move straight to ATM.

In Europe, France Telecom has no plans to introduce MANs to its network, as it believes they are unsuitable for the network topology. It plans to move straight to ATM. Deutsche Telekom has installed two MANs, which are in commercial service. It plans to deploy MANs in a further 10 locations, but in the longer term to migrate to ATM.

MANs and SMDS are available from several operators in the US in a small number of locations. Bell South has SMDS in commercial service in four metropolitan areas. SMDS is to be deployed in all major LATAs over the next 2-3 years, using ATM platforms and in the long term native ATM may supplant SMDS. GTE has seven SMDS switches in service, but it expects to migrate SMDS to ATM platforms in the future. Nynex will be conducting FDDI[22] MAN trials in New York City in late 1993 or early 1994, and over the following 2-3 years it plans to deploy them in 2-4 cities as an interim for ATM. South Western Bell has MANs under consideration and is also evaluating SMDS; deployment will be by business case.

BT has installed one trial MAN with University College London and Bloomsbury Computing Centre. A further 5 are being installed as part of Super JANET. SMDS will be used on the Super JANET network for speeds up to 34Mbits, running on DQDB and ATM switches. Special protocols will be used for higher

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[21] Distributed Queue Dual Bus

[22] Fibre Distributed Data Interchange

rates when required for particular projects. Cable TV companies are also participating in the provision of infrastructure for Super JANET. Videotron has provided MAN connections for Imperial College, and Queen Charlotte and Hammersmith hospitals, and the link between ULCC and Super JANET has been provided by Cable London.

BT plans to launch SMDS nationally in 1993/4. The pilot service will operate at up to 10Mbit/s, the full service will operate in the range 1.4Mbit/s-25Mbit/s. Mercury does not plan to deploy any MANs, but expects to leap-frog straight to ATM, and also plans to offer SMDS. COLT and Energis will also go straight to ATM. COLT will be offering 10Mbit/s Ethernet and 100Mbit/s FDDI.

4.9 Conclusions

Applications requiring broadband capacity are generally at an early stage of development. They fall into two groups. Very high bandwidths are needed for some specialised research, medical and design applications, but the number of users is fairly small. Broadband capability is required for residential entertainment services, although the actual requirements depend on whether the service is broadcast or provided on demand to the individual user.

The position of the UK compared with other countries varies from topic to topic. Deployment of fibre in the inter-exchange network is extensive, and amongst the most extensive in relation to the number of subscribers and geography. As significant further installation of fibre in the trunk network in the UK is not required, the less well equipped countries can be expected to catch up over the next 5 years or so. Use of SDH/Sonet by BT is less advanced than in Germany or the US, but the smaller operators are making extensive use of the technology, with the result that installation in the UK again compares well. The operators' plans for future deployment indicate that the UK will maintain its position.

Fibre is widely used in the UK for connection of business subscribers, although the use of SDH rings lags a little behind the USA. Germany is again well advanced. Use of fibre for residential access is more widespread than all countries except the US and Germany. Although this owes much to the cable TV operators, BT is ahead of many countries in its own right. Broadband service provision, such as SMDS and ATM is again a little behind the US and Germany, but overall compares well. Again plans of operators indicate that the UK will maintain its position.

Altogether the UK compares well with the best in the installation of broadband networks, helped by the opportunity given to new operators to install up to date networks. In general the USA and Germany are also well advanced, with the other countries lagging behind. The USA has particularly extensive deployment of fibre rings for business access. It is interesting to note how the need to update the networks in the eastern states of Germany has affected that country's deployment of broadband systems. Future developments seem likely to ensure that the UK will continue to have a broadband infrastructure that compares well with that in the US and Germany. Japan, France and the Netherlands will take several years to catch up.

5. MOBILE NETWORKS AND SERVICES

5.1 Introduction

Public mobile telephone services have only become widely available in the past 10 years since the introduction of cellular technology, but have rapidly become an essential part of business life. The high costs of ownership have meant that cellular radio has been too expensive for the non-business market until recently. All countries in the study have established cellular analogue networks providing widespread coverage in the country, and all are now in the process of introducing digital services. Digital radio provides a cleaner signal, without the problems of fading and interference experienced with analogue networks, and permits more channels to be provided in a given spectrum. However, whereas an analogue signal degrades at the edge of its service area giving the user some warning of an imminent cut-off, digital signals can cut off abruptly, and therefore require more careful system planning. Digital radio also offers the possibility of carrying data transmission of superior quality and at higher rates than is possible over analogue voice networks.

With the development of digital technologies for mobile has come the concept of personal communications systems (PCS). These take a variety of forms ranging from simple one-way telepoint to the UK PCN[1] systems. The basic concept behind all is a more individual and often more localised service than that offered by traditional cellular systems. In practice the different implementations provide a continuum from telepoint to full cellular systems. The UK PCN concept, embodied in the DCS1800[2] standard, has become in effect a full cellular system, and in the following analysis it is considered alongside digital cellular systems such as GSM[3] from which it is derived. Its specification is however built around the use of lower power hand portables, and the use of microcells. Initially such systems were far more expensive to install than GSM, but recent improvements in technology, which permit the use of larger cells, have substantially reduced the costs, although coverage may not be as comprehensive.

Other PCS implementations and concepts including the Japanese Personal Handy Phone system and the recent US PCS announcements are discussed separately under the heading Personal Communications Systems.

Mobile data services are provided in two basic forms. The most common is paging, a one way service which may include messaging, and which is well established in all countries. However new services continue to be introduced. True mobile data for communication with or between computers is less well developed and has at present limited market appeal, usually linked to specific applications.

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[1] Personal Communications Network

[2] Digital Communication System 1800. ETSI specification for a cellular radio network operating at 1800MHz for use as a personal communications system

[3] Global System for Mobile communications. ETSI specification for a cellular radio network operating at 900MHz

However in recent months laptop computer products and personal digital assistants (PDAs) such as Apple's Powerbook and Newton products have started to appear with radio interfaces. It seems likely that in time a radio interface for these and similar products will become commonplace, creating a sizable market for mobile data connections. Whether these will be achieved through use of dedicated mobile data networks, or by using the data capability of digital voice networks like GSM, remains to be seen and will depend on factors such as the availability and cost of the services.

5.2 Analogue Cellular Networks

The analogue systems in service use a variety of standards, and almost every country in the study uses systems to a different standard. Of the seven countries only Sweden and the Netherlands use the same standards, NMT[4] 450/900. Competition was introduced in Sweden, the UK and the US from the start. France introduced a second operator in 1988, as did Japan. Germany and the Netherlands retain monopoly provision of analogue services. Figure 5.1 shows the analogue systems in use in each country, together with the operators providing service..

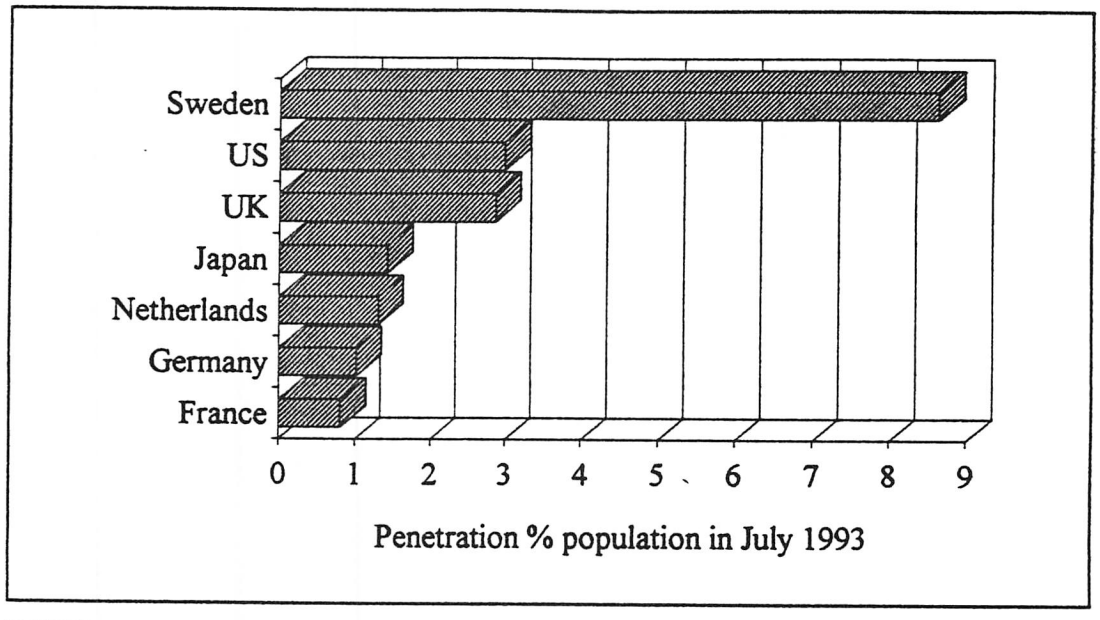
Country	Service	Service start date	Operator
France	R2000	1985	France Telecom
	NMT 450*	1989	SFR
Germany	C-450 (CNetz)	1985	Deutsche Telekom
Japan	J(HC)S	1979	NTT
	J(HC)S, N-TACS	1988	IDO - Tokyo, Nagoya
	J-TACS, N-TACS	1989	DDI (8 local networks)
Netherlands	NMT 450	1985	PTT Telecom
	NMT 900		PTT Telecom
Sweden	Comvik	1981	Comvik
	NMT 450	1981	Telia
	NMT900	1986	Telia
US	AMPs	1983	Local wireline carrier and one competitor in each LATA
UK	TACS 900	1985	Cellnet Vodafone

* not compatible with systems in the Netherlands or Sweden

Figure 5.1 Analogue Mobile Radio Services

[4] Nordic Mobile Telephone. Cellular system developed by the four Nordic countries.

The operators of these services have met with varying degrees of success. The system used by France Telecom, Radiocom 2000, has a number of technical limitations. These, together with high costs of use, have kept down the number of users. The NMT 450 system used by SFR, the second French Operator, has limited capacity, so it has also been unable to provide service for a large number of users. The German CNetz service was expensive, and of limited capacity, so it too has been unable to support large numbers of users. As a result these countries have the lowest penetrations of analogue cellular radio in the seven countries covered by the study. Of the seven, Sweden has the highest penetration, partly due to the early start of the service, and partly to the low level of the tariffs and effective marketing. Figure 5.2 shows the penetration of analogue services.



Source Fintech

Figure 5.2 Penetration of Analogue Mobile Services

5.3 Digital Cellular Networks

All the countries are in the process of introducing digital services. With the introduction of digital technology an effort has been made to reduce the number of standards in use. All European countries, and many elsewhere in the world, use the GSM standard which operates at 900MHz, and in some cases also use DCS1800, a variation of GSM for use at 1800MHz. GSM was specifically developed, with the encouragement of the European Commission, to provide the countries of Europe with a mobile radio system to a single standard which would allow users to roam freely from country to country without interruption of the service. There are now 39 countries which are signatories to the GSM Memorandum of Understanding (MoU), and 19 applicants. The US and Japan use different standards. With the introduction of digital services, all countries have introduced competition. Figure 5.3 shows the services in operation and planned for each country, and the operators.

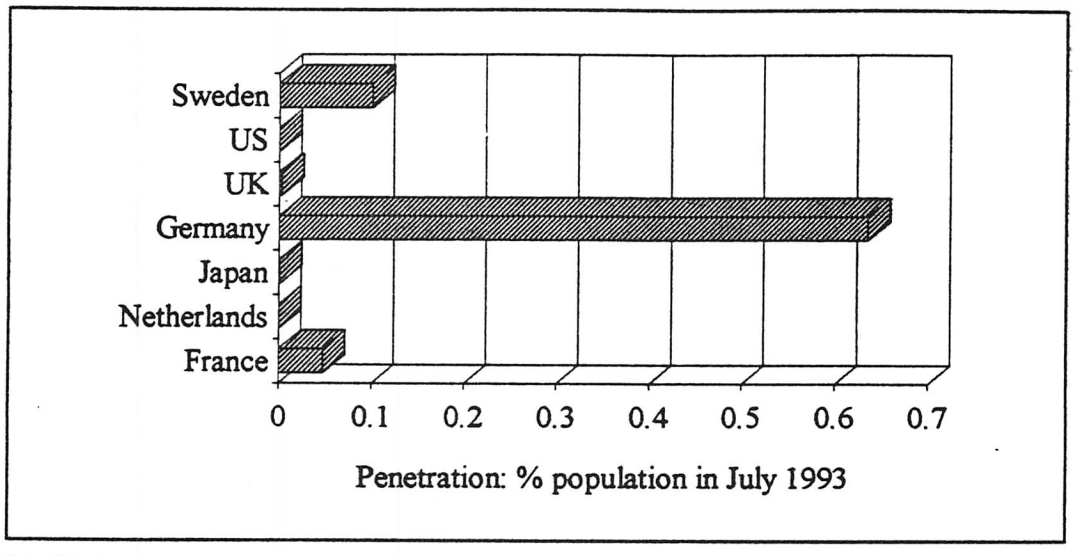
Country	Service	Service start date	Operator
France	GSM	1992 1993	France Telecom SFR
	DCS1800	TBA	France Telecom SFR TBA
Germany	GSM	1992 1992	Deutsche Telekom Mannesmann Mobilfunk
	DCS1800	1994	E-Plus
Japan	PDC 800	1993	NTT
Netherlands	GSM	1994	PTT Telecom 2nd operator licence procedure TBA end 93
Sweden	GSM	1992 1992 1992	Comvik Telia Nordictel
	DCS1800	TBA	app'n by Telia
US	DAMPS (TDMA or CDMA)	1993	Local wireline carrier and competitor
UK	GSM	1994 1992	Cellnet Vodafone
	DSC1800	1993 1994	Mercury One-2-One Hutchison

Figure 5.3 Digital Mobile Radio Services

Take up of the digital services already in operation has been highly dependent on the quality of the analogue service previously available, and the extent of roll-out provided by the digital operator. Because of the poor take up of analogue services in France and Germany penetration of GSM was expected to be high in both countries. Take up in France has been disappointing. This may in part be due to the late start by SFR which did not open for full service until April 1993, but is probably also related to high tariffs and under-investment in coverage and marketing. Both France Telecom and SFR have recently cut charges to boost the market. Under the terms of the operators' licences, GSM has to cover 70% of the French population by 1995. As can be seen from the map in Figure 5.4 coverage in France is still fairly limited, although it does cover the main centres of population.

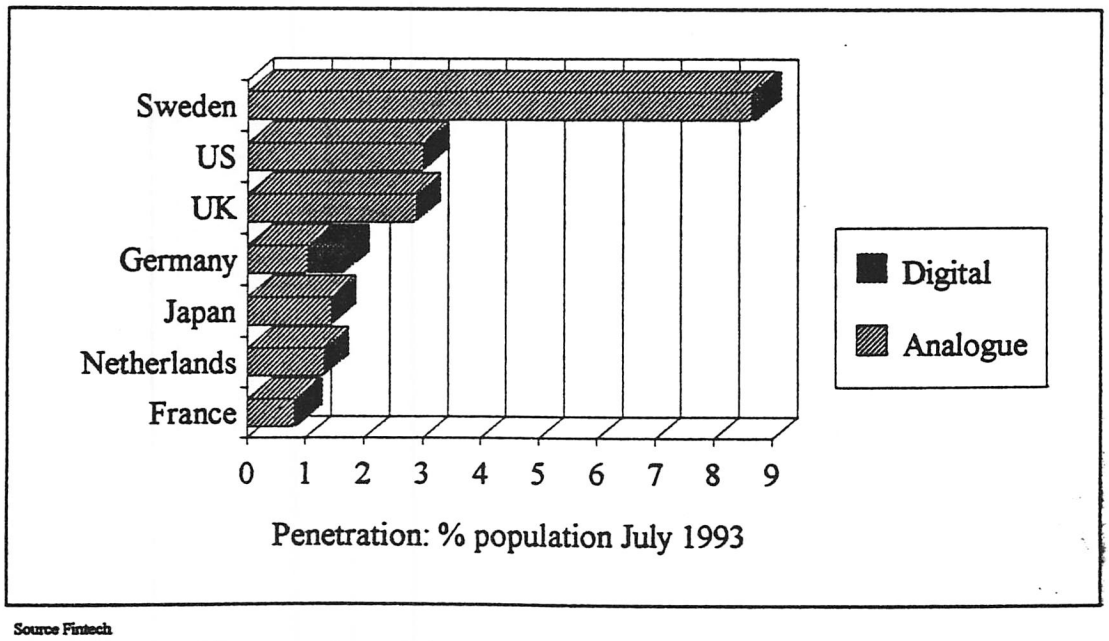
Figure 5.4 Coverage of GSM Services in Europe

By contrast in Germany the rapid provision of widespread coverage by Mannesmann Mobilfunk, followed very closely by Deutsche Telekom, coupled with successful marketing has unleashed considerable pent-up demand for cellular radio. The coverage provided is shown in Figure 5.4 The difference in penetration of the digital services is shown clearly in Figure 5.5; nearly 40% of Germany's subscribers[5] are users of the digital services. The rapid penetration of GSM has been assisted by the early availability of mobile terminals at lower costs than CNetz mobiles. In turn the high demand for GSM in Germany will have the added benefit of bringing down terminal costs making service more attractive in other countries. Figure 5.6 shows this penetration overlaid on that for analogue.



Source Fintech

Figure 5.5 Penetration of Digital Mobile Services



Source Fintech

Figure 5.6 Penetration of Analogue and Digital Mobile Services

[5] This had risen to more than half by the end of 1993

Take up of digital services is low in the UK. This can be attributed to the fact that until September 1993 only one operator, Vodafone, was offering a digital service, and that the UK was already well served by two analogue networks. Following the launch of the Mercury One-2-One service take up has increased, and by the first of October the number of subscribers to digital services had risen from 1,750 at the end of July to over 13,000[6]. Vodafone plans to cover 97% of the population by March 1994, corresponding to 80% of the country. The early introduction of PCN services in the UK has led both GSM operators to engineer their networks to offer microcellular service comparable to that offered by a PCN network. Vodafone markets this service as Metrodigital to distinguish it from its national GSM service, Eurodigital, and has had to install additional base stations to ensure adequate quality. Cellnet is reported to be planning a similar approach when it launches in 1994. Mercury One-2-One plans to reach 65% of the population by 1995. Hutchison Microtel will also launch a PCN service in 1994.

By contrast take up of digital services is significant in Sweden, although analogue coverage is good, and penetration of cellular radio is already very high. This may be attributed to the existence of three competing services since 1992 as well as the traditionally high penetration of mobile services in Sweden.

NTT launched a digital service in Tokyo in March 1993, Osaka and Nagoya will follow in 1994. The service will be national in 1995. Current take up is in the hundreds.

No standard is being enforced for digital cellular in the US, where systems using both TDMA[7] and CDMA[8] technologies are being developed. Neither offers the Intelligent Network capabilities of GSM[9], and the TDMA system, known as DAMPS[10], is designed as a 'plug in' replacement for analogue AMPs. Handsets will be compatible with AMPS to ensure continuity of service. Some operators are using N-AMPS[11] or microcellular technology to increase capacity. Several operators have introduced digital services, including Southwestern Bell and McCaw. These operators use TDMA, similar to the technology used in GSM, but take up so far has been small. Other operators have announced plans to introduce services using CDMA. These include US West (launch 1994) and Bell South (launch 1995). Nynex and Pactel are testing CDMA. Other future services are discussed in the following section on PCS.

Also in the US, Nextel started service in Los Angeles in August 1993. It offers cellular-type voice services along with mobile data and paging services over its

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6 Estimated at over 30,000 by the year end
7 Time Division Multiple Access
8 Code Division Multiple Access
9 GSM and DCS1800 use TDMA
10 Digital AMPS
11 Narrow band AMPS

upgraded PAMR[12] network. Service will be rolled out in 1994/5 to San Francisco, New York, Chicago, Dallas and Houston.

Countries are continuing to issue licences for additional mobile services, although according to a KPMG report for the European Commission, second operators often face more difficult conditions as they frequently have to lease lines owned by their competitor, and have limited terms for their licence. Of the seven countries only the Netherlands now insists that mobile operators use leased lines from PTT Telecom. France is reported to have recently decided to allow mobile operators to provide their own infrastructure, and the German Ministry of Posts and Telecommunications (BMPT) had to give specific permission to Mannesmann to use its own microwave links in order to avoid the use of expensive leased lines from Deutsche Telekom. In the UK Mercury One-2-One uses 38GHz millimetric radio links to connect base stations. Vodafone has been using similar links, but to avoid regulatory constraints these have been provided by an independent company, Microcell Links.

BMPT has issued a licence to E-Plus for a DCS1800 network, which is placing priority on the former East German states. E-Plus aims to launch in early 1994 in Berlin and Leipzig, most of Eastern Germany by the end of 1995, and 98% of the entire country by the end of 1997. E-Plus is a consortium in which Bell South and Vodafone are members.

The DRG[13] in France has announced that it will issue three PCN (DCS1800) licences. One will go to each of France Telecom and SFR. The third will be advertised soon and will carry more favourable conditions to help counteract the advantage held by the established operators. All three are expected to be able to provide their own infrastructure, on which they will be able to lease spare capacity. At present SFR has to lease lines from France Telecom, and it has complained to the DRG about the high costs of leased lines and the costs of carriage traffic over the switched network.

The Netherlands plans to issue a second GSM licence by mid 1994, coinciding with the launch of PTT Telecom's GSM service. In Sweden, Telia has applied for frequencies to operate a DCS1800 service.

5.4 Personal Communications Services

The only other PCS services in operation in Europe, apart from the PCN networks described in the preceding paragraphs, are based on the telepoint concept, using CT2 cordless technology. Although this approach has shown that it can be highly successful in a dense urban environment such as Hong Kong where full coverage is easy to provide, it has met with very mixed success in Europe. All four of the operators licensed to provide service in the UK have now abandoned their services.

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[12] Public Access Mobile Radio
[13] The French Regulatory body

The Deutsche Bundespost also abandoned the service after trials. Telia has no intention of starting a service, which it considers inappropriate for Sweden's geography. Telepoint services are available in France and the Netherlands.

France Telecom conducted trials of its service, called Bi-Bop, in Strasbourg, and on the basis of these results it has opened service in Paris. By the end of September it had 23,000 subscribers, compared with the 7,000 achieved by Hutchison's national Rabbit service in the UK before it closed in the autumn of 1993. Recognising that one of the draw-backs of basic telepoint is the inability to receive calls France Telecom launched Bi-Bop Response in November 1993. This service makes use of intelligence in the network to allow users to receive incoming calls by logging on to a local base station. This facility was not available to UK telepoint operators who had no control over the PSTN for regulatory reasons, although Rabbit planned to use paging to alert users to incoming calls. Other versions of the service are Bi-Bop Avenue (one way telepoint) and Bi-Bop Residence (residential use). An interesting development has been the introduction in conjunction with Apple of Power-Bop, an Apple Powerbook with built in telepoint transceiver. This provides access to all Minitel services and is understood to have been well received. France Telecom will make a decision on further extension of Bi-Bop next year. It seems likely that France Telecom has achieved greater success with telepoint than UK operators because the poor performance and high cost - especially in Paris - of cellular radio in France has left a market window for a cheap telepoint service which does not exist in the UK where the costs of the cellular services are lower.

At the end of September the DRG announced a Telepoint licence for CGE (which owns 40% of Cofira, the holding company for SFR) using DECT[14] technology, which has the advantage of automatically logging users on. CGE will conduct a trial at the end of this year in La Defense in Paris, extending to a residential suburb in 1994. An interesting development is that CGE will make use of cable TV infrastructure to carry the voice traffic to the base stations. With the launch of GSM services in France the success of this service seems less assured. PTT Telecom in the Netherlands has also launched a telepoint service called Greenpoint.

Most major mobile operators in the US, including Southwestern Bell, GTE, US West, and Bell Atlantic have been trialling various forms of PCS for several years. Some of these, like Bell Atlantic, track users on the fixed network as well as on mobiles. In September the FCC announced the terms under which it would issue licences for PCS services at around 2GHz. The FCC has divided the USA into 51 "Major Trading Areas" (MTAs) each of which is divided into "Basic Trading Areas" (BTAs). There are 492 BTAs. 120 MHz will be made available at auction to MTAs and BTAs in 1994. The frequencies are in blocks of 5-15MHz in the 1.85-2.2GHz band.

[14] Digital European Cordless Telecommunications. ETSI specified cordless system.

In each MTA the FCC will offer 30MHz to each of two PCS operators for service throughout the area. There will be a further 5 operators in each BTA. One will receive 20MHz, the rest 10MHz each. Altogether there will be 1460 BTA licences and 102 MTA licences, although there will be no constraint on operators acquiring licences for adjacent areas in order to build up a regional or national network. Interest is being shown by all the current major operators, including the RBOCs, GTE, AT&T McCaw and the MCI consortium. Southwestern Bell plans to offer PCS under the new licence scheme early in 1996.

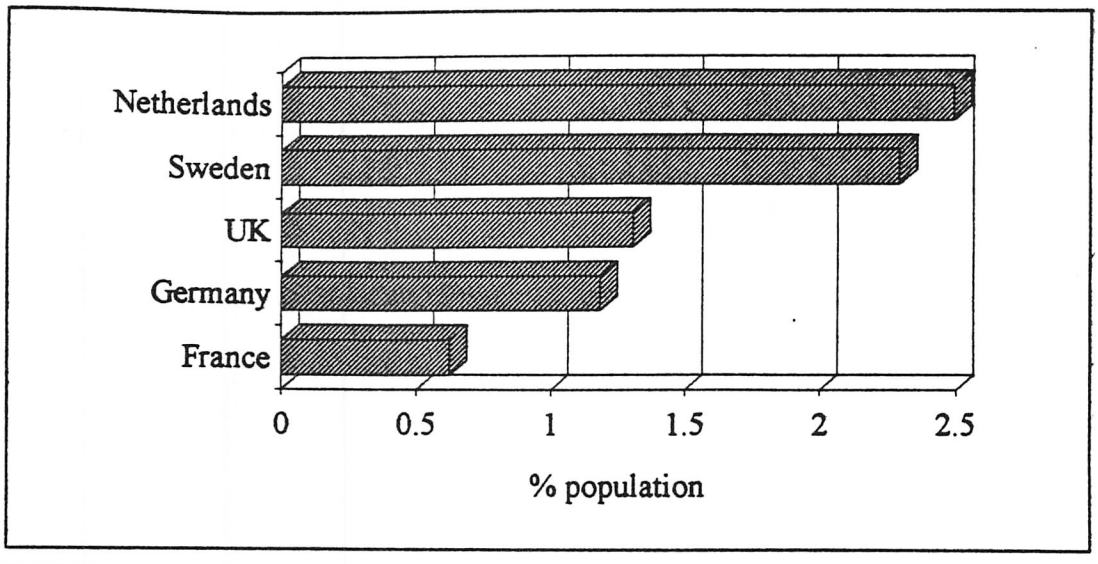
Again, as with other digital mobile services in the USA, no technologies are being specified, but it seems increasingly likely that established European standards like DCS1800 will be employed by some operators.

In Japan, NTT has been pursuing the Personal Handy Phone (PHP) concept which works like a two-way telepoint system. It is under trial in Okaido. NTT plans to replace the installed base of 5 million CT2-like cordless phones with PHP.

5.5 Paging

Paging services are well established and widespread throughout the seven countries. In Europe the European Commission has promoted a pan-European standard called ERMES, although there is already a *de facto* pan-European standard known as POCSAG.

Plans to introduce ERMES are moving ahead in most European countries. In France the DRG announced three ERMES licences at the end of September to go to France Telecom, Cofira (parent of SFR) and a consortium called Omnicom. They will compete with the 3 existing services. Alphapage and Eurosignal from France Telecom, and Operator from Telefusion de France, which is owned by France Telecom. Sweden has two systems, and is planning to introduce ERMES in addition. In Germany plans to introduce ERMES have been deferred because of technical problems, and instead a UHF POCSAG service will be introduced in 1994.
The penetration of paging is given in Figure 5.7.



Source Fintech

Figure 5.7 Penetration of Paging

5.6 Mobile Data

Mobile data services have been in operation since the mid 1980s and are in operation in Europe, USA and Japan. All seven countries covered by the study have or plan to have mobile data services. They provide a cost effective alternative to data over cellular radio for heavy data users. However altogether there is little activity in the market, and few services are in operation. Market take up has been very slow, and the world-wide total number of mobiles is estimated at little more than 50,000. There are two major standards in the world; Mobitex, an open standard developed by Ericsson, and the Motorola system. ETSI is working on a European standard as part of TETRA a proposed European standard for a digital trunked radio system.

The first service was launched by Telia (then Swedish Televerket) in 1987 using the Mobitex system. Take up was initially very slow, but the service now has well over 9000 subscribers (mobiles) and covers 88.5% country, or 99.1% pop Telia is now building a 400MHz network in Stockholm, Gothenburg and Malmo for launch in mid 1994 which will run at 8kbit/s

2 operators offer nationwide service in the US, covering the major conurbations: These are ARDIS, using the Motorola system which runs at 4800 bps, and supports some 30,000 mobiles, many of them IBM users. Originally this was a private network built for IBM field service teams. The other service is RAM Mobile Data, which uses the Mobitex system at 8000bps.

France issued two licences early in 1993 to France Telecom and Cofira. Mobipac, offered by France Telecom, came into service during the summer, and France Telecom plans to cover all towns with a population over 100,000 by the end of 1994. Cofira also uses the mobitex system and planned to start trials in November

1993 It expects to launch the service in March 1994, and to reach 60% of the population by 1996/7.

Deutsche Telekom has been offering a service since 1992. Germany plans to advertise a competing licence before the end of 1993.

A service in the Netherlands, Ram Mobile data, was launched 1993 by a consortium in which Bell South and France Telecom are major shareholders. National coverage is planned for 1994.

No mobile data service is provided by NTT.

The UK licensed 4 operators. Of these three entered service in 1991, Ram, Hutchison and Cognito, and subsequently the licence of a fifth, Paknet, which had specialised in fixed radio services, was modified to cover mobile services. The fourth licensee did not build a network. The operators rolled out their networks to cover the major population areas and highways in 1992, but have met with mixed success with purely mobile services.

	In service	Planned
France	1	1
Germany	1	1
Japan	1	
Netherlands	1	
Sweden	1	
USA	2	
UK	3	

Figure 5.8 Mobile data services

The current market is for end-to-end solutions, rather than basic data transport and is heavily dependent on the identification of suitable applications, and subsequent development of suitable software. There is as yet little off-the-shelf software, although this is growing. In the longer term the spread of personal digital assistants (PDAs) and laptops with radio access may open up the market. At present the main applications are messaging, dispatch services for taxis, haulage operators, emergency services and field service operations, telemetry/telecontrol for utilities, and data base access.

5.7 Conclusions

The UK is well served by mobile radio networks for analogue cellular radio, paging, and mobile data. Digital cellular networks are being rolled out rapidly, and as can be seen from the map in figure 5.4, coverage compares well with other countries in Europe. Only Germany has more complete coverage at present. Although take up of digital mobile telephony has been slow, this is primarily a

reflection of the success of the analogue networks, and the capacity remaining in them, and of the fact that significant marketing of digital services has only recently begun.

In the medium term, as the analogue networks in the UK become saturated, and as competition between operators of digital services increases with the opening of the third and fourth networks, take up of digital can be expected to increase rapidly. By this time, in 2-3 years, the four UK services will all provide near national coverage, with widespread use of microcells in urban areas. These can be expected to provide high quality coverage able to support light and inexpensive handsets, thereby also addressing the market targeted for telepoint services.

In the longer term CDMA may become the preferred solution for digital cellular communications, but this application of the technology is still too immature for its commercial viability to be judged. Although behind France, Germany, Sweden and the UK on implementation of TDMA networks, some US operators have chosen to adopt CDMA.

Should the use of mobile data networks become the preferred option for portable data devices such as PDAs and lap top computers, the UK is well served with suitable networks.

6. COSTS AND QUALITY OF SERVICES

6.1 Introduction

However up-to-date the telecommunications infrastructure may be, or how wide the range of services, the value to the user depends upon the affordability of the services offered. A high tariff for a service may impose additional costs on a business, with a consequent effect on competitiveness and profitability, or deter users altogether. Conversely a low tariff will encourage use of that service, and may encourage the development of new applications by the user. Not only do the tariffs charged vary considerably from operator to operator, but the ratio of costs between different services can vary considerably. This causes users to use different services in different countries according to the suitability for the application and the relative costs of the services. A user may use a leased line in one country and the PSTN or PSDN[1] in another. As a result direct comparisons of the tariffs for individual services are not always meaningful. In recognition of this, the study attempted to identify the actual effects on business of different tariff schemes rather than looking in detail at the comparative costs of different services.

6.2 Tariff Comparisons

Comparison of tariffs is a complex subject. Simple comparisons of charges for calls over a particular distance or time of day do not take account of differences in the tariff structures used by the network operators, and therefore cannot accurately reflect the variations in actual costs incurred. To address this shortcoming, a number of organisations have attempted to assess the impact of different tariff schemes on users by constructing baskets of a typical selection of calls made by different types of user. The OECD, Tariffica and Oftel have all constructed baskets for business users of the PSTN. Tariffica have considered three types of business user, and the OECD and Oftel have also constructed baskets for the residential user. Inevitably these can only provide an indication of the differences in costs actually incurred which depends upon the assumptions made. A detailed analysis of costs of this nature is beyond the scope of this study, but for completeness comparisons of costs for the use of the PSTN, cellular radio services and leased lines are given in Appendix B. These comparisons are based on work by the OECD, Tariffica, Oftel, and a survey of costs carried out by the user group Intug[2].

6.3 Impact of costs on users

6.3.1 Overall telecommunications costs

In order to assess the actual impact on business users of different tariff structures, a number of multinational businesses were asked for data on their

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[1] Public Switched Data Network

[2] International Telecommunications User Group

telecommunications expenditure in different countries where there existed some equivalence of business activity, for example factories producing similar quantities of the same product. In these cases costs of usage were compared. An example is given in the following paragraphs.

A financial services organisation provided actual data on its business operations which enabled a comparison to be made of the costs to the business in four different countries for the use of four different services, PSTN, National Leased Lines, International Leased Lines, and telex. Because of the nature of the company's business, which relies heavily on the use of telecommunications the costs form a much higher proportion of the total operating costs than would usually be the case. The following three charts illustrate the variations in cost experienced by the company in the different countries.

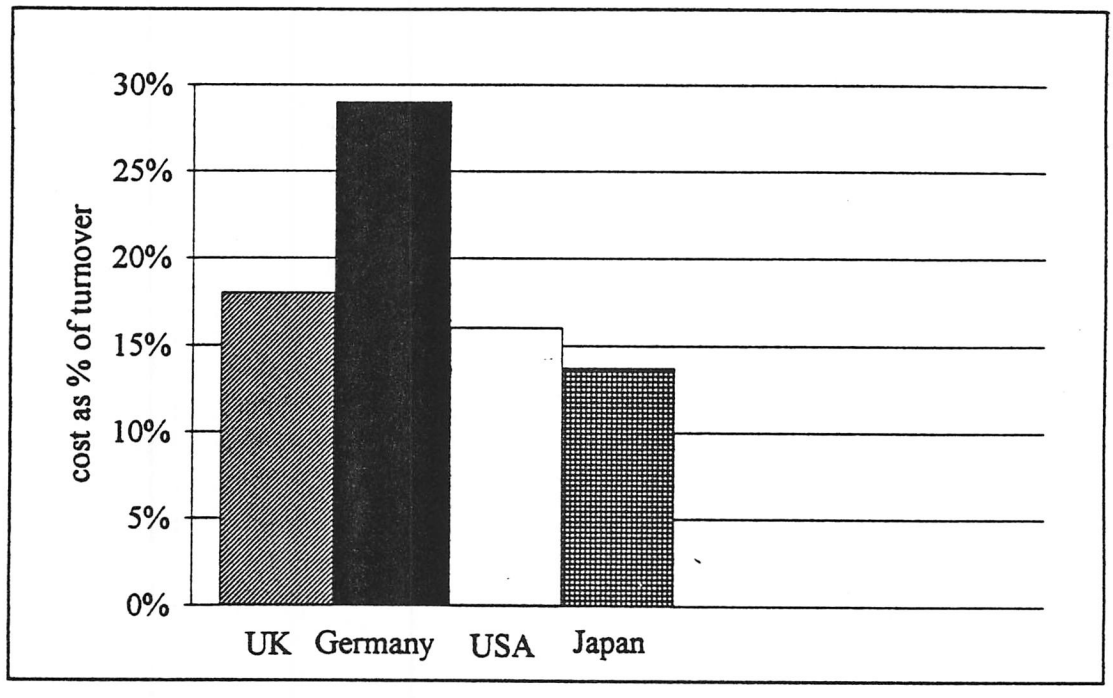

Figure 6.1 Telecommunications costs/turnover for the business in each country

Figure 6.1 shows the overall costs of telecommunications in each country as a percentage of the business turnover of the company in that country. It can be seen that Germany is the most expensive, with nearly 30% of the business costs attributable to telecommunications. Costs in the other countries are all between 14 and 18%.

Figure 6.2 shows how the costs of use of each of the four services varies from country to country. Figure 6.3 presents the same information by country, showing how the share of the business costs in each country is attributable to each service. It can be seen that the costs of international leased lines are highest in Germany. However the most interesting point is that Germany has the lowest cost for

national leased lines - not because the lines are inexpensive, but because they are so expensive that the company decided it was not viable to offer many of its services.

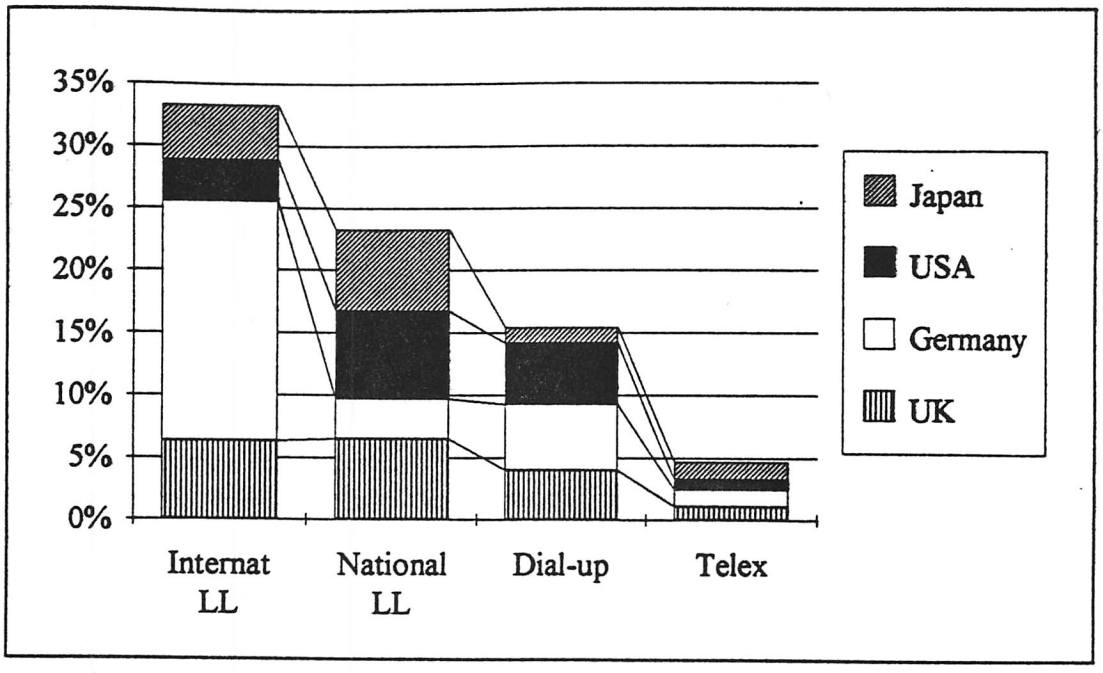

Figure 6.2 Costs of each service used by the business broken down by country

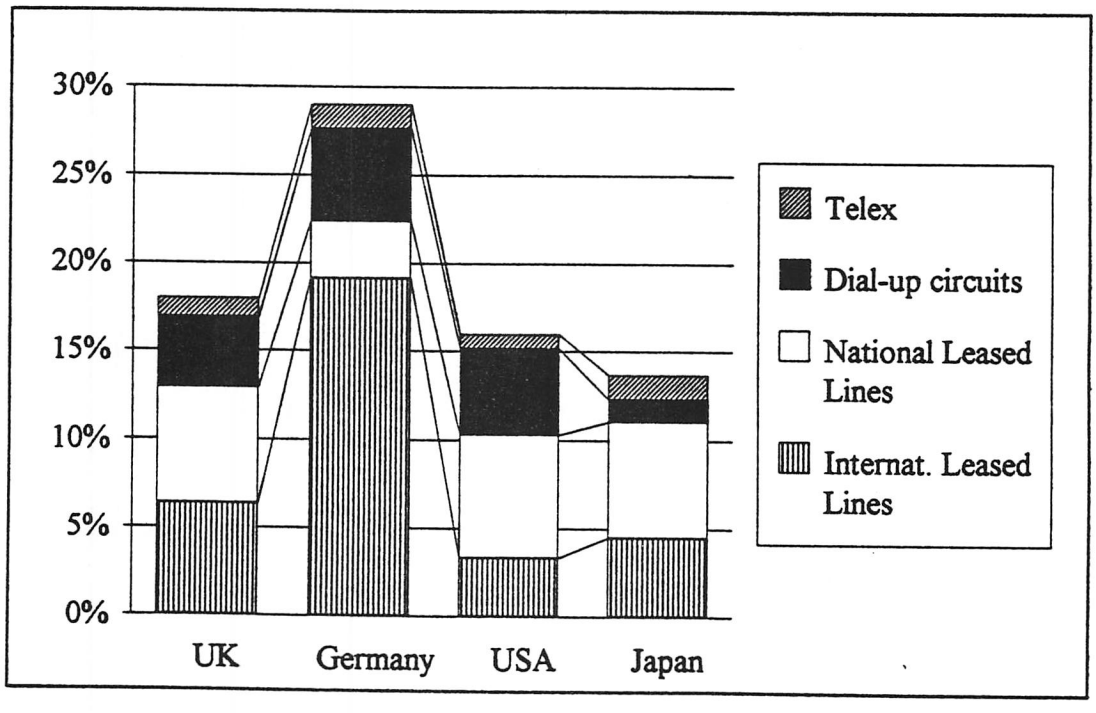

Figure 6.3 Telecommunications costs to the business in each country broken down by service

6.3.2 Costs of Leased Lines

Organisations establish networks of leased lines primarily to reduce costs. The ability of users to do this varies considerably from country to country. This has had a direct effect on the number of private networks established in each country. For example, at the end of 1990, the UK had over 5000 private networks, compared to about 2,500 in France and round 2000 in Germany. Nor were these networks comparable in composition, as the UK makes far more use of 2Mbit/s circuits owing to their low cost. The French have tended to use packet switched circuits, and more recently ISDN, in preference to leased lines, owing to their ready availability at low cost.

However businesses have other reasons for establishing networks of leased lines, including security, quality of service, and the ability to overlay software defined network functions. Leased lines are particularly important for providers of network services that require a permanent infrastructure in order to offer their service, for whom the costs can have a major impact. The high costs of leased lines in Germany and France have been a major factor forcing the regulators to allow competing cellular radio operators to build their own network infrastructure.

Another factor influencing the use of broadband circuits is the high cost of international leased lines in Europe. Figure 6.4 shows the costs of leased lines between the major economies in Europe compared with 200km circuits within the same countries and 200km and 1000km circuits in the US. It is clear that businesses operating in the US benefit from far lower costs when operating across the region than businesses operating in Europe.

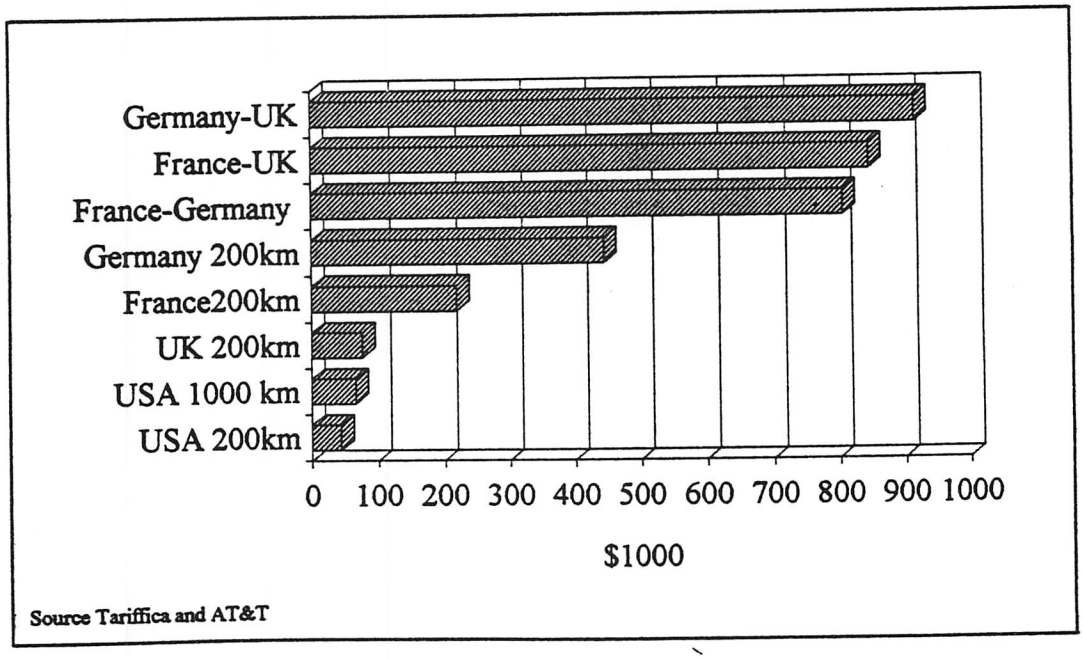

Figure 6.4 Comparison of Leased Line Costs: National vs International in Europe
(fixed and variable charges at Jan 1993 per year over 2 years)

The effect of the costs of leased lines to a business can be substantial. Reuters, which has the largest private network in the world pays around 10% of its cost base for telecommunications services. It has prepared a comparison of the costs it pays in Europe for leased lines with the costs it would pay if its entire network were in the USA. This comparison is reproduced below.

Route	Capacity Mbit/s	Distance Miles	Cost £/month	Equivalent US cost, £/month
Brussels/Paris	2	170	27.87	2.06
Brussels/Amsterdam	1	98	17.74	1.54
Brussels/Luxembourg	1	117	17.70	1.58
Brussels/London	2	211	31.53	2.12
London/Amsterdam	2	230	32.12	2.17
London/Frankfurt	2	400	42.64	2.56
London/Geneva	2	457	43.69	2.69
London/Paris	4	209	80.83	4.24
London/Stockholm	4	908	73.44	7.45
Paris/Luxembourg	1.5	180	21.8	1.96
Paris/Geneva	2	250	29.2	2.21
Paris/Madrid	1	649	29.35	2.59
Frankfurt/Amsterdam	2	228	31.88	2.16
Frankfurt/Geneva	2	287	34.29	2.30
Frankfurt/Luxembourg	1.5	110	28.03	1.80
Amsterdam/Luxemb'g	1	196	17.51	1.73
Geneva/Barcelona	1	395	34.56	2.36
Geneva/Milan	2	147	40.16	1.98
Local loop				16.87
Totals			**634.14**	**62.37**

Source: Reuters

Notes:

1. Exchange rates as at Jan 1 1993
2. European costs are actuals
3. USA costs are calculated from rate book without discounts
4. USA includes an estimate of local loop charges

Figure 6.5 Intra-European digital circuits/network costs compared to equivalent circuit/s network costs in domestic USA

6.3.3 Differential cost of bandwidth

Another factor which influences the use of leased lines is the ratio of costs for lines of different speeds. Figure 6.7 shows the ratio between 1.5/2Mbit/s and 56/64kbit/s for the different countries.

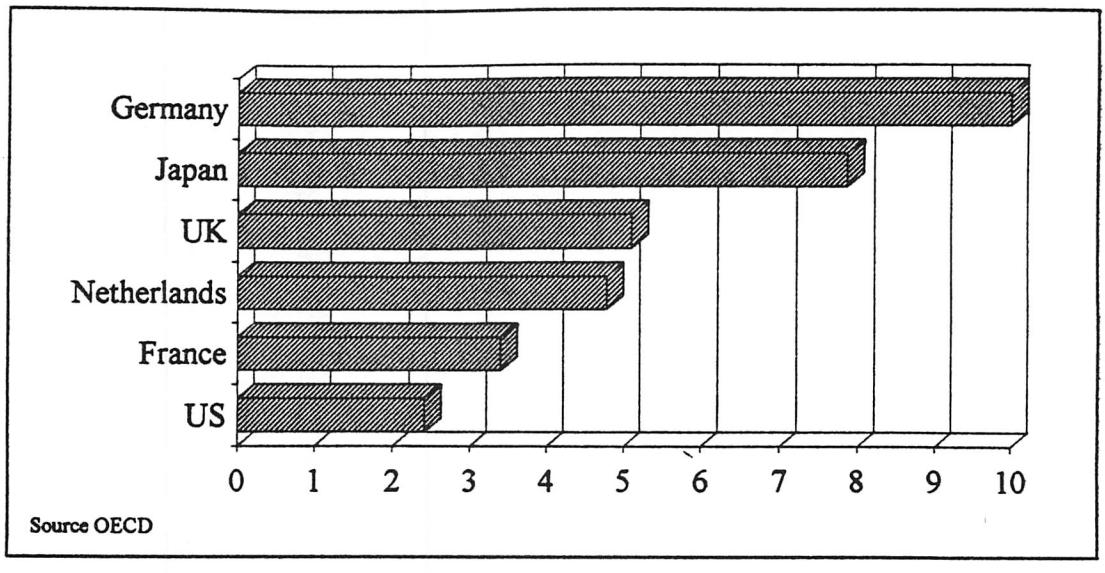

Figure 6.6 Comparison of costs of leased lines of different speeds: Ratio of costs of baskets of 1.5/2Mbit/s to 56/64kbit/s leased lines
(fixed and variable charges at Jan 1992)

It is notable that the lowest ratio is in the US, which also has the lowest tariffs for 1.5Mbit/s leased lines. The proportionally low increase in cost for the higher speed circuits makes it very attractive for US businesses to use them in preference to lower speed lines. The same pattern can be seen for 34/45Mbit/s circuits, where UK costs over a 50km link are more than 2.6 times those in the US. This difference in tariffing policy between the US and other countries means that users in the US tend to regard bandwidth as a commodity, and face a far lower cost penalty in experimenting with broadband applications. If maintained such tariffing policies will act as a brake on the development and use of broadband applications in Europe when compared with the US.

6.3.4 Impact on business activity

In discussion with users it became clear that in some cases the costs of certain services were so high that businesses were discouraged from carrying out some business activities at all. Three examples will serve to illustrate the point.

The financial services business whose costs are illustrated above operates in Germany, Japan, the USA and the UK. It offers a range of services to other businesses which are highly time critical. Guaranteed delivery of the information in the required time window necessitates the use of leased lines. In Germany, the cost of the lines are such as to make the bulk of the services offered elsewhere

uneconomic, with the result that, whilst in most countries it offers between 25 and 40 different services, in Germany this is reduced to four. Thus, not only is the scope of activity of the service supplier reduced, but so is the range of services made available to businesses in Germany.

A major value added network operator planned to established an enhanced LAN-LAN service in the US. It considered establishing a similar service in Europe, but found that the costs of the leased lines required for the service, and in particular the costs of the international leased lines within Europe, made the proposed service uneconomic. The VAN operator decided not to pursue its plans in Europe.

A major manufacturer has design offices in Germany, the US and the UK. It uses a supercomputer in the US for computer aided design, and links its design offices in the US via high speed (100Mbit/s) links to achieve the desired response time. It would like to provide access to such a facility to their design engineers in Europe. Access to the one in the US is impractical on the grounds of cost and response times, so a new one in Europe is being considered. However the costs of circuits within Europe are too high for access from each country to a single computer to be economic. The alternative of a supercomputer in both Germany and the UK cannot be cost justified.

6.4 Quality of service

Although many operators publish quality of service statistics, the figures cannot often be directly compared. All operators were asked for quality of service indicators during the course of the study, but the fragmented nature of the data provided did not permit any useful comparison to be made. In addition, most of the statistics relate to failure rates and repair times, and do not give a useful indication of the perceived quality of service received by users, who take into account a wider range of factors.

To try to obtain a broader view of the perceived quality of service offered by the major operators in each country, the users consulted during the study were asked to compare the overall quality of service provided by each operator with which they were familiar. They were asked to mark each operator with a score in the range one (unacceptable) to five (excellent), against four major parameters: Sales and Delivery of Service, Technical Quality, Service Support, and Billing. Most received scores of 3, 4 or 5. None were awarded a 1. Although most of the users responded, the number of responses received for each operator proved too small to provide conclusive results.

None of the operators was considered to give a totally unsatisfactory service. Equally, comments accompanying some highish scores implied that they were more a measure of the rate of improvement in quality than an absolute measure. In this respect Deutsche Telekom is seen to have made significant progress. Other comments suggested that users felt that most operators were trying harder to provide good quality service, but the more conservative regimes still had some way

to go in providing the flexibility that users would wish to see. One user took the view that the US had seen too much price competition amongst the inter-exchange carriers, with the result that quality of service had deteriorated. BT was generally well regarded, and was perceived to have improved enormously over the past 10 years. A theme that was taken up by several users was the reluctance on the part of many operators to be as flexible in the packaging of service options as the users would wish. In the case of BT this was attributed to regulatory constraint, with comparison being drawn with AT&T's Tariff 12.

The sample was too small to make detailed comparisons, and the general conclusion must be that while none of the operators in the study provide a completely unsatisfactory service, there was generally room for improvement from the continental European operators. Operators from the USA, Sweden and the UK were regarded best.

6.5 Conclusions

Germany stands out as the most expensive country covered by the study for leased lines. Reference to Appendix B shows that Germany is the most expensive country for most services. The country with consistently low tariffs is Sweden, despite its difficult terrain. The UK compares relatively well, and has amongst the lowest costs for PSTN business use, mobile and leased lines. Residential costs in the UK are slightly higher than in Germany and France.

The relative costs of different speed leased lines will be important in encouraging business to develop and use broadband applications. A lower differential between low and high speed circuits, as in the US, will be needed to encourage use of broadband circuits, even though users of lower speed services may well feel that they are paying a disproportionately high cost. There is a risk that reluctance to use broadband circuits will delay the development and exploitation of broadband applications, and consequent revenue generation opportunities.

All the multinational companies consulted during the course of the study think in terms of economic regions as well as individual countries. For many purposes Europe is considered as a whole, and as a result the range and costs of services in one country will influence the choice in another. In many cases this may mean only using a service that is available and affordable in all countries. In other cases, as illustrated above, businesses may curb their activities in the face of unacceptable costs. The net result can be that one country with high costs can inhibit activities in all others, to the detriment of the whole European economy. In this respect although costs in the UK are generally reasonably low in comparison to the other countries, it will tend to suffer as a European country as a result of the high costs elsewhere in the region.

Quality of service was generally regarded as acceptable from all operators. The small sample questioned regarded the US and UK most favourably.

7. CONCLUSIONS

7.1 Introduction

The report has covered a wide range of topics concerning the telecommunications infrastructure, the services offered and their cost and quality. At the end of each chapter the findings have been drawn together as conclusions on each main subject. A summary of the main findings from the preceding chapters is given below. From these findings overall conclusions have been drawn, which are set out at the end of this chapter.

7.2 Main Findings

Chapter 2 - Industry Structure and Regulation

- Only Sweden is in theory more liberalised than the UK, but the UK is developing competition over a wider range of activities than is the case in Sweden. The only remaining monopoly in the UK is that enjoyed by the cable TV operators in relation to cable TV services, although they do face competition from the combination of terrestrial and satellite broadcasters for alternative delivery of off-air services.

- Although the well publicised initiatives in the USA and Japan are neither as ambitious or advanced as is commonly portrayed, they do serve a valuable purpose as a focus for national debate and a vehicle for seed corn investment and regulatory reform.

- UK investment levels per subscriber are similar to the USA, and lower than Germany and Japan in absolute value, but after account is taken of the differences in the costs of equipment between the countries, the UK obtains more from its investment than either Germany or Japan.

- Digitalisation of the UK main network is one of the most advanced, being second only to France. In the longer term ATM[1] switching can be expected to supersede conventional digital exchanges.

Chapter 3 - Digital Networks and Services

- The availability of ISDN[2] in the UK is amongst the highest together with France and Germany, but basic rate ISDN is expensive compared to other countries, and consequently penetration has been much lower. The low penetration does not materially affect users at present, as they are able to use alternative services, such as digital leased lines, for current applications. However there is a risk that take up of future multimedia applications that are

[1] Asynchronous Transfer Mode
[2] Integrated Services Digital Network

dependent on ISDN, such as desk top video telephony, will be slower in the UK.

- The availability of leased lines at higher bit rates is increasing. Digital leased lines up to 34Mbit/s are now tariffed by BT and other operators in the UK. Rates above 34Mbit/s can be obtained, but are not universally available. Higher speeds are tariffed by some operators in the USA, and by Deutsche Telekom. There is a steady move towards SDH/Sonet[3] speeds of 155Mbit/s or more. This trend ensures the availability of high speed lines for broadband applications.

- Development of intelligent network infrastructure and services in the UK compares well with other European countries and Japan, although some USA operators offer a wider range of services.

Chapter 4 - Broadband Infrastructure and Services

- Broadband and multimedia applications are at an early stage of development, and as a result provision of broadband infrastructure and services is not yet a major issue for most users. In the longer term, as new multimedia applications become established, the broadband capacity of the networks may need to be increased more rapidly.

- Fibre is already extensively deployed in the UK's trunk networks, and little further investment is required to cope with current traffic demands.

- SDH is already being used in the UK for commercial traffic, and is being installed by BT, Mercury, and new operators. Plans for deployment in the core network will keep the UK amongst the leaders, which include the USA and Germany.

- Fibre is used extensively in the UK for connections to business subscribers. Use of fibre rings lags behind the widespread use in the USA, and is slightly behind Germany, but there are aggressive programmes for deployment.

- The UK is one of the three countries making extensive use of fibre in the access network for residential users. The others are the USA and Germany which has the need to rebuild the infrastructure of the former East Germany. Most of the fibre in the UK residential access network is being installed by the cable TV operators, but BT's own plans for deployment are in advance of France, Japan, the Netherlands and Sweden. On the basis of current plans the UK will maintain its position as one of the three leading countries over the medium term.

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[3] Synchronous Digital Hierarchy/Synchronous Optical Network

- The UK is about a year later than the operators in most countries in starting trials of ATM switches, but plans by BT for Super JANET[4] and for commercial SMDS[5] services in 1994, position the UK amongst the leaders for MANs[6] and SMDS. Current plans suggest the UK will maintain its position in the medium term.

Chapter 5 - Mobile Networks and Services

- The UK has one of the most competitive markets for cellular radio networks, and will shortly have four national digital networks, more than any other country. Analogue networks already cover 98% of the population, and the digital networks are being rolled out rapidly. Only Germany provides more complete coverage with its digital services, although all the European countries are well advanced compared to the USA and Japan, and benefit from their collective adoption of GSM[7] which is rapidly becoming a global standard. Uptake of GSM has so far been much higher in Germany and Sweden than other countries in Europe.

- In the longer term CDMA[8] may become the preferred solution for digital cellular communications, although this application of the technology is still too immature for judgement to be made on its commercial success. Although behind the other countries on implementation of digital networks, including TDMA[9], some USA operators have chosen to adopt CDMA. In the meantime the more proven DCS1800 (the standard for UK PCN[10] used by Mercury One-2-One) may well be adopted in the USA for PCS[11] networks.

- The UK also has more mobile data networks than other countries, although the market is not yet well developed. It is well placed for future development of markets for portable data devices such as PDAs[12] and lap top computers with radio access.

Chapter 6 - Costs and Quality of Services

- Overall, Germany stands out as the most expensive country covered by the study, particularly in its leased line charges, although Deutsche Telekom has stated its intention to reduce these. The country with consistently low tariffs is Sweden. The UK has low costs for mobile services, leased lines and business

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[4] Joint Academic Network
[5] Switched Multimegabit Data Services
[6] Metropolitan Area Networks
[7] Global System for Mobile Communications
[8] Code Division Multiple Access
[9] Time Division Multiple Access
[10] Personal Communications Network
[11] Personal Communications Systems
[12] Personal Digital Assistant

use of the PSTN[13]. Costs are high for basic rate ISDN and for residential PSTN use. The actions of new competitors are starting to cause some price reductions.

- The differential cost of broadband leased lines is higher in the UK than in the USA, and higher still in some other countries. The low differential in the USA coupled with the low level of tariffs for leased lines encourages the use of broadband circuits, making it inexpensive to experiment with and adopt innovative broadband multimedia applications. The differentials in some European countries are too high to encourage ready experimentation with broadband multimedia applications.

- Business users often think in European terms. Although the relatively low costs in the UK help to make it attractive as a business location within Europe, the high costs and other constraints elsewhere in the region, particularly in respect of leased lines, mean that the overall variety of business applications and level of business activities are reduced, to the detriment of the UK. GSM stands out as an example of the benefits that can come from a coordinated European approach.

- Overall, users perceive quality of service as reasonable to good in all countries, and that operators are trying harder. The UK and USA operators were generally well regarded.

- Users generally want greater flexibility from operators. A particular point was made in relation to packaging of service offerings by BT, where there is a perception that BT is constrained in this respect by regulatory actions.

7.3 Overview and Summary

The UK has competition in the supply of almost all telecommunications services, and as additional operators enter the business, pressures are growing for operators to seek competitive advantage by introducing innovative services, more flexibly packaged service offerings, and new tariffs targetted at specific market sectors. Only the cable TV operators do not face direct competition in relation to cable TV services, but they do already compete with alternative means of receiving the off-air combination of terrestrial and satellite broadcasts. BT's planned video-on-demand service, if commercially deployed, can be expected to encourage innovation in interactive services.

Altogether the state of development of the UK telecommunications infrastructure and the range of services available to users compares well with the the other countries covered by the study. Although the UK's position is helped by the number of new operators which are taking the opportunity to install up-to-date

[13] Public Switched Telephone Network

networks, and the competitive pressure this has introduced, it would be misleading to imply that BT, as the major operator, is lagging in any significant respect. In fact BT's network is amongst the most modern in the world. Although never the most advanced in any one area, the UK is consistently a good second and does not lag significantly in any major respect, with no one country being a consistent first. In general the US is also well advanced. Germany is putting particular emphasis on updating its infrastructure with broadband and digital cellular radio networks, but demands high prices for its services. Its rates for leased lines are particularly high, although Deutsche Telekom has indicated that it plans to reduce these over time. In contrast UK price levels are, by comparison with the other countries, generally reasonable for business. Competitive pressures are exerting downward pressure on prices.

In the medium term the plans of the operators suggest that UK infrastructure will continue to develop at a rate to keep it abreast of its competitors. In the longer term much will depend upon the rate of development and adoption of new broadband multimedia applications, and the ability of the operators to continue to keep abreast of developments and provide the infrastructure and services required to support the applications and encourage their ongoing development. There is a view held by some in the industry that a clearer shared vision of the future would help ensure that the industry was able to to so.

This generally encouraging picture is not always reflected in the perceptions held by the community at large, particularly in respect of broadband infrastructure. This must be a point of concern. It would be desirable if such perceptions could be altered to reflect more accurately the more positive position in fact currently held by the UK, and thus form a basis for informed discussion on the requirements for the future.

7.4 Trends to monitor

As the networks in the UK and the other countries continue to develop, a number of trends can be expected to emerge or continue. It will be worthwhile to monitor these as indicators of continuing positive developments in the UK telecommunications environment. They may be summarised as:

- Development of innovative tariff and service packages as a result of increased competition in both fixed and mobile networks.

- Development and uptake of business and residential broadband applications, including multimedia, in the UK, with resulting user demands for increasing bandwidth. Developments in the USA and elsewhere will serve as useful reference points.

- Increased availability of low cost high bandwidth services and supporting infrastructure in UK *and* Europe to meet those needs.

- Ongoing development of the American and Japanese initiatives, with a particular regard to any significant changes in the rate of development that may result.

GLOSSARY

GLOSSARY

ADM	Add-Drop Multiplexer. Allows removal and/or insertion of a stream of data from a multiplexed stream
ADSL	Asymmetric Digital Subscriber Loop. Digital transmission system which carries data over subscriber twisted pair copper cable at speeds of up to about 2Mbit/s, in conjunction with a lower speed return path of at least 64kbps. Currently speeds of up to 10Mbit/s are being tested.
AIN	Advanced Intelligent Network. Intelligent Networking standard developed in the USA by Bellcore.
AMPS	Advanced Mobile Phone System. Analogue cellular radio standard used in the USA and elsewhere.
ARDIS	Name of a mobile data service in the US originally built for IBM by Motorola.
ATM	Asynchronous Transfer Mode. The name given to a technique for handling and switching voice, video or data traffic as packets of data of different sizes.
BTA	Basic Trading Area as defined by Rand McNally. Used to define service areas for PCS licences in the USA.
CAD/CAM	Computer Aided Design/Computer Aided Manufacture
CAP	Competive Access Provider. Term used for telecommunications operator in the US that provides direct access for the user to an interexchange carrier (IXE), bypassing the local operator or local exchange carrier (LEC). See also IXE and LEC
CATV	Cable TV
CCSS7	Common Channel Signalling System No 7. CCITT recommendation for interexchange signalling systems. Required for operation of an intelligent network.
CDMA	Code Division Multiple Access. A method of encoding signals digitally used for mobile radio applications.
CT2	Cordless Telephony system 2. UK standard for digital cordless telephony used for telepoint services, and cordless PBX applications. Adopted as an interim standard by ETSI, and by most telepoint operators in the world.
DAMPS	Digital AMPS (see AMPs)
DCS1800	Digital Communication System 1800. Standard defined to meet UK requirements for PCN service at 1800MHz. Based substantially on GSM

GLOSSARY

DECT	Digital European Cordless Telecommunications. ETSI standard for digital cordless telephony used for cordless PBX applications and by some telepoint operators.
DQDB	Distributed Queue Dual Bus. A distributed protocol adopted for Metropolitan Area Networks, standardised by the IEEE
DRG	Direction Generale Reglementation. French government body that regulates the telecommunications industry.
EDI	Electronic Document Interchange.
ERMES	ETSI standard for paging systems.
ETSI	European Telecommunications Standards Institute.
FCC	US Federal Communications Commission
FDDI	Fibre Distributed Data Interchange. A standard for high speed local areas networks (LANs)
FITL	Fibre In The local Loop. General term describing the use of optical fibre in the subscriber loop.
FTTB	Fibre To The Building. Term describing the use of optical fibre for direct connection to a building containing one or more subscribers.
FTTC	Fibre To The Curb (or Kerb). General term describing the use of optical fibre for direct connection to a street cabinet, for onward connection to the subscriber by copper cables.
FTTH	Fibre To The Home. Term describing the use of optical fibre for direct connection to a subscriber's home.
FTTK	Fibre To The Kerb (or Curb). Term describing the use of optical fibre for direct connection to a street cabinet, for onward connection to the subscriber by copper cables.
FTTO	Fibre To The Office. Term describing the use of optical fibre for direct connection to a subscriber's office.
GSM	Global System for Mobile communications. ETSI standard for digital cellular radio networks, which encompasses both the radio link and the supporting intelligent network. (formerly Groupe Speciale Mobile, a CEPT working party)
HDSL	High bit-rate Digital Subscriber Loop. Digital transmission system which carries data in both directions over subscriber twisted pair copper cable at speeds of up to about 2Mbit/s.
HDTV	High Definition TV
IN	Intelligent Network. A concept which allows creation and provision of new telecommunications services through the provision of distributed computers across a network.

GLOSSARY

ISDN	Integrated Services Digital Network.
IXE	Inter Exchange Carrier. Term used in the US for a telecommunications operator licensed to provide long distance (inter LATA) telecommuications services
LAN	Local Area Network. Network within an office used to connect computer equipment
LATA	Local Access and Transport Area. Term used in the US to describe the area within which the local exchange carrier (LEC) can provide end-to-end connection, without the need to use an inter-exchange carrier (IXE).
LEC	Local Exchange Carrier. Term used in the US to describe the local operator, including the RBOCs and GTE, which can handle traffic within a LATA.
MAN	Metropolitan Area Network. Concept of a broadband city wide network for voice data and image, using DQDB protocol.
Multiplexing	A technique used to carry several messages, generally from different sources, on a single transmission channel.
MPT	Ministry of Posts and Telecommunications in Japan
MTA	Major Trading Area as defined by Rand McNally. Used to define service areas for PCS licences in the USA.
N-AMPS	Narrow band AMPS (see AMPS)
NII	National Information Infrastructure. Term used in the USA to describe Vice President Gore's vision of an Information Superhighway.
NMT	Nordic Mobile Telephone. Analogue cellular radio system developed for use in the Nordic countries and widely used elsewhere.
NREN	National Research and Education Network. US broadband network for research establishments and universities.
NTIA	National Telecommunications and Information Administration. US government body.
OECD	Organisation for Economic Cooperation and Development
Packet	A variable length stream of data generally assembled with routing information for transmission purposes
PAMR	Public Access Mobile Radio. Used for provision of multiple private networks.
PBX	Private Branch Exchange

GLOSSARY

PCN	Personal Communications Network. Has come to mean the mobile networks first established in the UK using the DCS1800 standard
PCS	Personal Communications Service. Term used largely in the US for a network, usually for mobiles, directed towards service for the individual.
PDA	Personal Digital Assistant. Hand held computer which accepts handwritten input such as Apple's Newton.
PDH	Plesiochronous Digital Hierarchy. Digital multiplexing system.
PDN	Public Data Network
PHP	Personal Handy Phone. Japanese concept for personal mobile telephony.
POCSAG	A standard for radio paging established throughout the world.
PSTN	Public Switched Telephone Network
RBOC	Regional Bell Operating Company. Regional telecommunications operating company in the USA formed after divestiture from AT&T.
SDH	Synchronous Digital Hierarchy. Digital multiplexing system offering more flexibility and higher speeds than PDH (see above).
SMDS	Switched Multi-megabit Data Service. A high speed connectionless data service which extends LAN characteristics over a wide area.
Sonet	Synchronous Optical Network, the US ANSI standard version of SDH, used in the USA and Japan.
SPC	Stored Program Contolled, used to describe exchanges that are controlled by an inbuilt computer.
TACS	Total Access Communications System. Cellular radio standard used in the UK and elsewhere
Telepoint	Mobile telephone system which does not automatically track the mobile unit to allow automatic transfer from one base station to the next over a wide area, and usually does not provide contiguous coverage. Calls may be made within a limited range of the base station, and provision is sometimes made for the user to log-on in order to be able to receive calls.
TDMA	Time Division Multiple Access. A method of encoding signals digitally used for mobile radio applications.
TEN	Trans European Network. A concept used by the European Commission.

GLOSSARY

TETRA	Standard being developed by ETSI for digital private mobile radio systems for voice or data.
TO	Telecommunications Operator
TPON	Telephony on Passive Optical Network
UHF	Ultra High Frequency
VAS	Value Added Service
VPN	Virtual Private Network. A concept for forming logical private networks within the public switched network.
VSAT	Very Small Aperture Terminal. Term used to describe a technique for communications via satellite, usually used for private point to point or point to multipoint links.

APPENDIX A

TERMS OF REFERENCE

APPENDIX A

TERMS OF REFERENCE

Objective of Study

To examine the UK's infrastructure and that of our major international competitors and assess the balance of advantage in terms of national competitiveness for industry and commerce. The study will focus on the infrastructure as an enabling tool for the development of new services and products that will enhance the competitiveness of both industry in general, and the telecommunications industry in particular. In order to address the latter it will look at infrastructure developments for both residential and commercial use.

It is intended that the study be repeated at regular intervals, probably every two or three years, so that developments can be monitored, and the view of likely future developments adjusted accordingly.

Countries to be included in the comparison

To strike a balance between including a large enough number of countries to make comparisons meaningful and to contain the size of the task, it is proposed to cover seven countries including the UK. These have been chosen on the basis of their economic importance together with the state of development of their telecommunications infrastructure and regulatory environment:

USA
Japan
France
Germany
Netherlands
Sweden
UK

Inclusion of the first four are key to the study. Inclusion of the Netherlands and Sweden will add breadth to the study from two other developed and liberalised markets.

Scope of Study

Fixed and mobile public telecommunications networks, including:

- switched two way networks
- leased two way networks
- cable TV networks
- mobile radio networks

The study will cover the current situation and trends, and likely developments over the next 2-3 years, and in the longer term.

Parameters to be compared

1. Services

There are three main groups of users of products and services that make use of the telecommunications infrastructure. These are:

a) business users
b) residential users
c) telecommunications service providers.

It is proposed to cover **network** services used by each group, including the availability of:

ISDN (basic rate and primary rate)
Range of Intelligent Network and similar services, eg
- Virtual Private Networks
- Freefone
- Shared revenue services
- Call-rerouting

Bandwidth (fixed rates including circuits above 2Mbit/s)
Bandwidth on demand
Managed Network Services
Mobile services (voice and data)
Cable services (TV and telephony)

2. Network Modernisation

The study will cover the following areas that will enable provision and development of current and future services:

a) the deployment of broadband capability including:
- penetration of fibre in the network (local and trunk)
- SDH (allows more flexible and efficient use of wideband circuits)
- ATM (allows more flexible and efficient use of wideband circuits)
- MANs (Metroploitan Area Networks)
- wideband circuits to end users including cable TV

b) the deployment of management and control systems including
- SS7 (allows introduction and operation of IN services)
- IN (SCPs etc) (permits rapid new service provision)
- TMN (permits control of entire network increasing efficiency and flexibility of use, and potentially provides direct user access to service provision and billing)
- Interactive TV (will relate to creation of new (eg multimedia) services)

c) the deployment of public mobile systems including
- digital cellular radio
- Personal Communications System services
- Mobile data

d) extent of digitalisation of the network

e) provision for both access to and control of the above by others than the network owner (eg service providers).

Details of investment plans will be sought to help predict future developments. Softer data, such as statements of intent, will be used to assess likely future developments in the light of other factors including availability of finance.

3. Degree of Liberalisation

The development of future services will be directly affected by the extent to which potential users and service providers are or will be allowed use of and access to the telecommunications network(s), service creation features, and service management facilities.

Comparison of the current status and developments in this area will be required to help develop forecasts of likely future service development and deployment, and will be included in the study.

4. Affordable price

Comparison of the true costs of telecommunications in different countries is notoriously difficult to achieve, as different pricing policies can cause users to opt for different services or usage patterns. The fairest comparison would be to compare the actual costs incurred by similar business operations in different countries.

It is proposed to attempt to gather data on this basis, comparing data from a number of multinational companies each of which operates similar sites in different countries, including if possible an international Value Added Service (VAS) operator. It is recognised that it may not prove possible to identify directly comparable sites. If this approach proves not to be feasible an alternative would be to compare a small number of specific business applications.

Given the importance to service providers, whether VAS or mobile operators, of the cost of leased lines, specific data on the comparative costs of leased circuits will be included.

5. Service Quality

Where comparable data can be obtained:

Installation wait time
Availability of circuits (ie % time free of faults)
Dropped call rate on cellular radio
Congestion on cellular radio
Failure rate/availability for 2Mbps leased lines.

Data will also be gathered from users on actual experienced fault rates, using the same sources as for pricing.

APPENDIX B

TARIFFS

APPENDIX B

Comparison of tariffs

Comparative analysis of call charges has been made by a number of organisations. Charts showing a selection of these are given below: Where zero values are shown, information was not available. Although the analyses differ, most show a similar pattern for the same service. However it will be seen that figures supplied by the OECD tend to show higher charges for the USA, and lower charges for Japan, than those from other sources. OECD comparisons use PPP (purchasing power parity) to take acccount of variations in the average costs of goods and services between countries, and it is possible that this may contribute to the differences from the other comparisons.

Costs for business users of the PSTN in the UK are generally higher than in the Netherlands or Sweden, but cheaper than Germany. Despite the high figure quoted by OECD, the USA is generally considered by users to be a low tariff country.

Costs of business calls over the PSTN

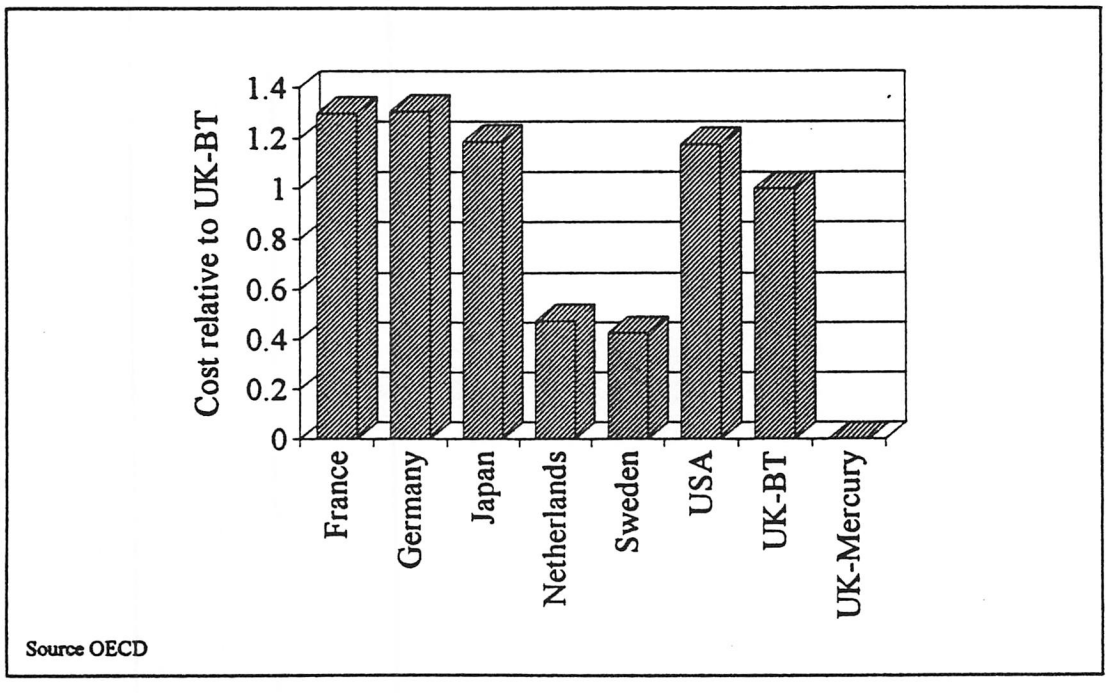

Figure B1: Comparison of PSTN costs - Business basket, OECD
(fixed and variable charges at Jan 1992)

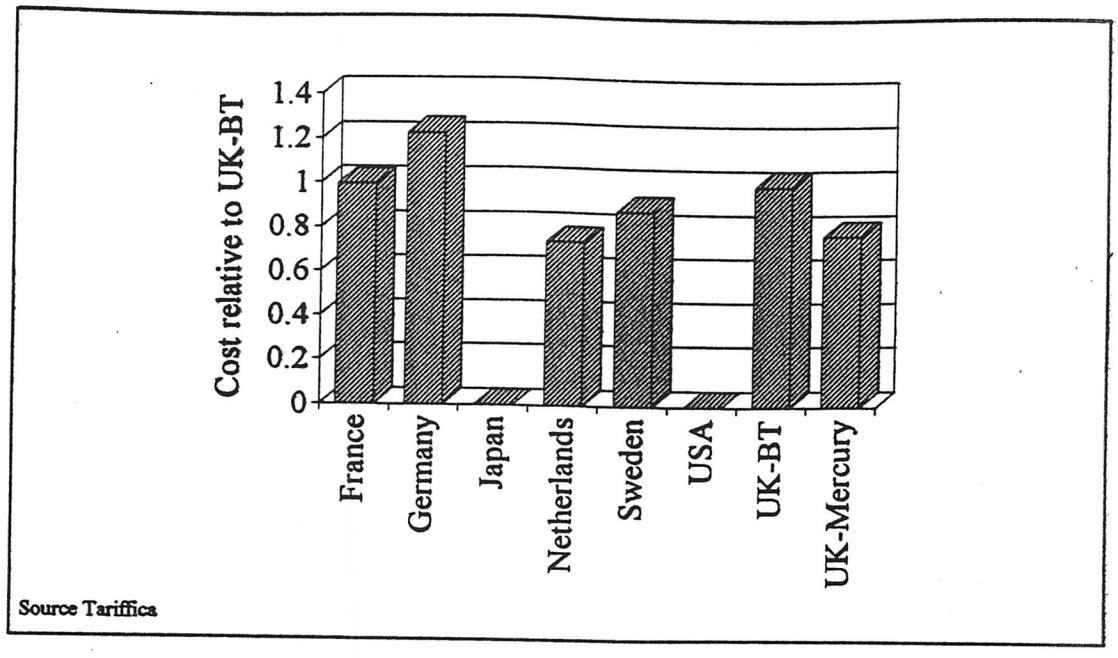

Figure B2: Comparison of PSTN costs - Business basket, Tariffica index
(fixed and variable charges at July 1993)

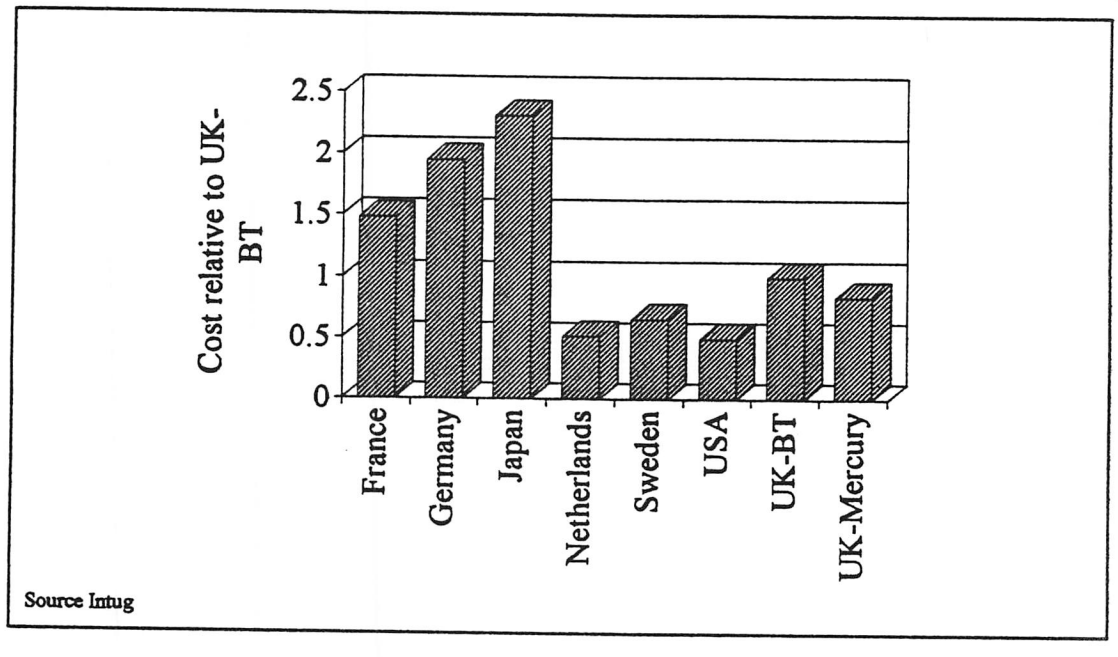

Figure B3: Comparison of PSTN call charges
Average of local, 10km and 300km calls - Intug survey
(variable charges at September 1993)

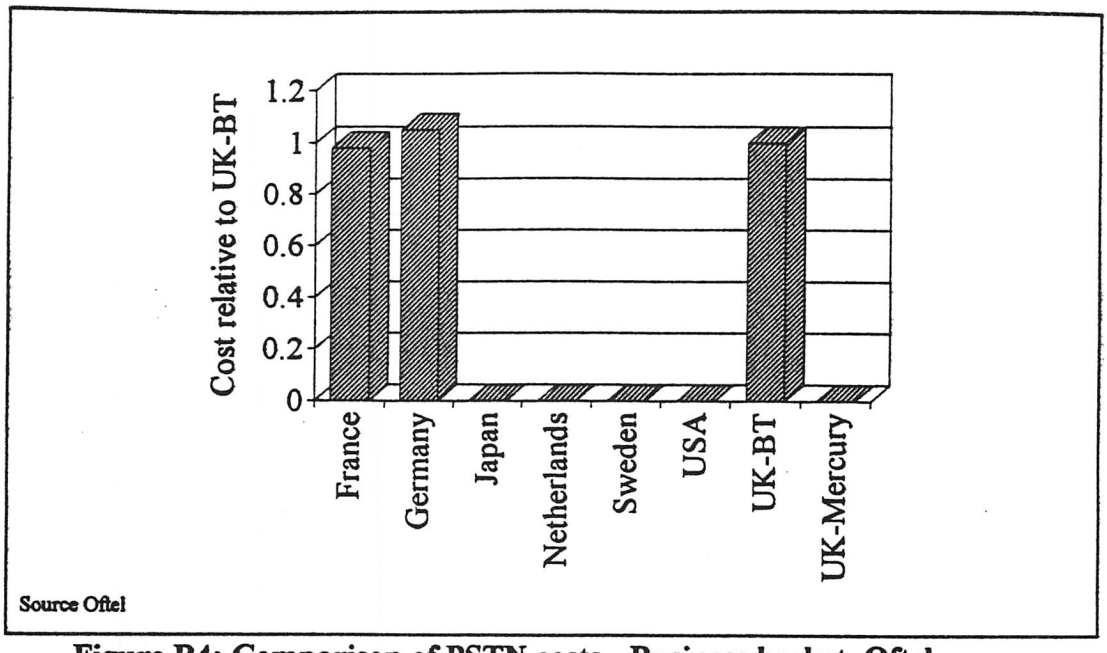

Figure B4: Comparison of PSTN costs - Business basket, Oftel
(fixed and variable charges at Jan 1993)

Costs of leased lines

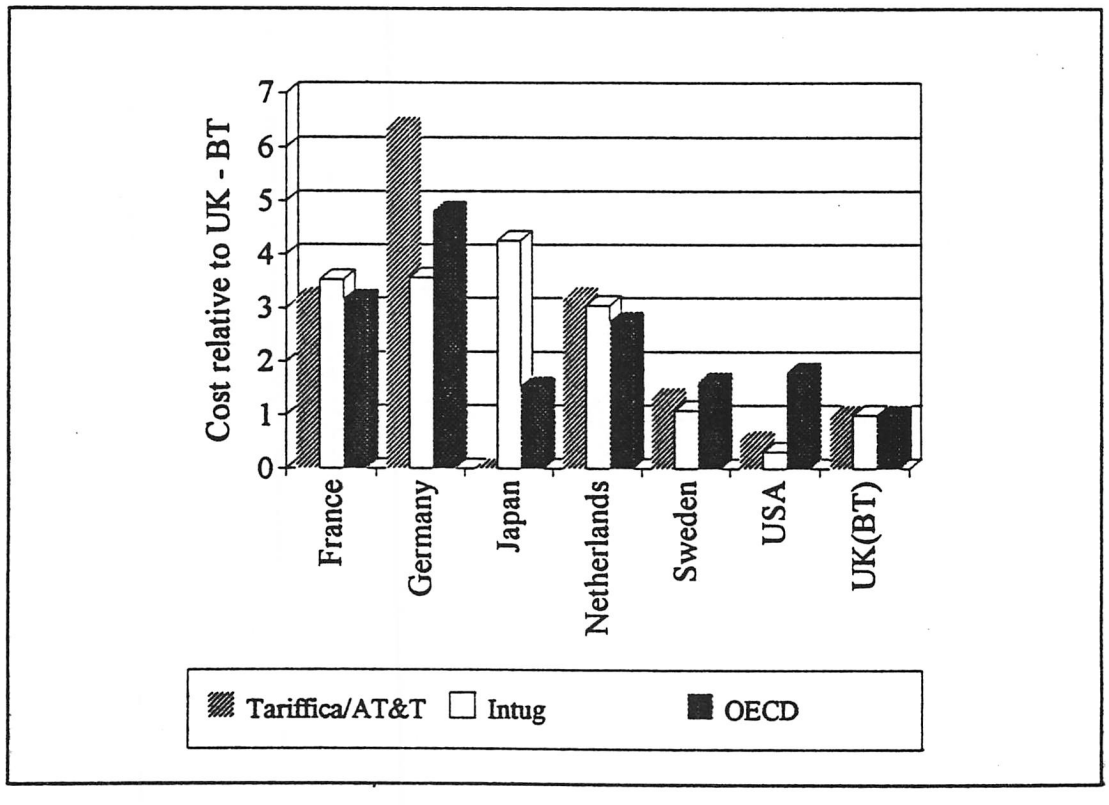

Figure B5: Comparison of relative costs of rental of 64kbps circuit over 100km vs OECD basket
(OECD - fixed and variable charges at Jan 1992
Tariffica/AT&T - fixed and variable charges at July 1993
Intug - variable charges at Setember 1993)

Costs of residential calls over the PSTN

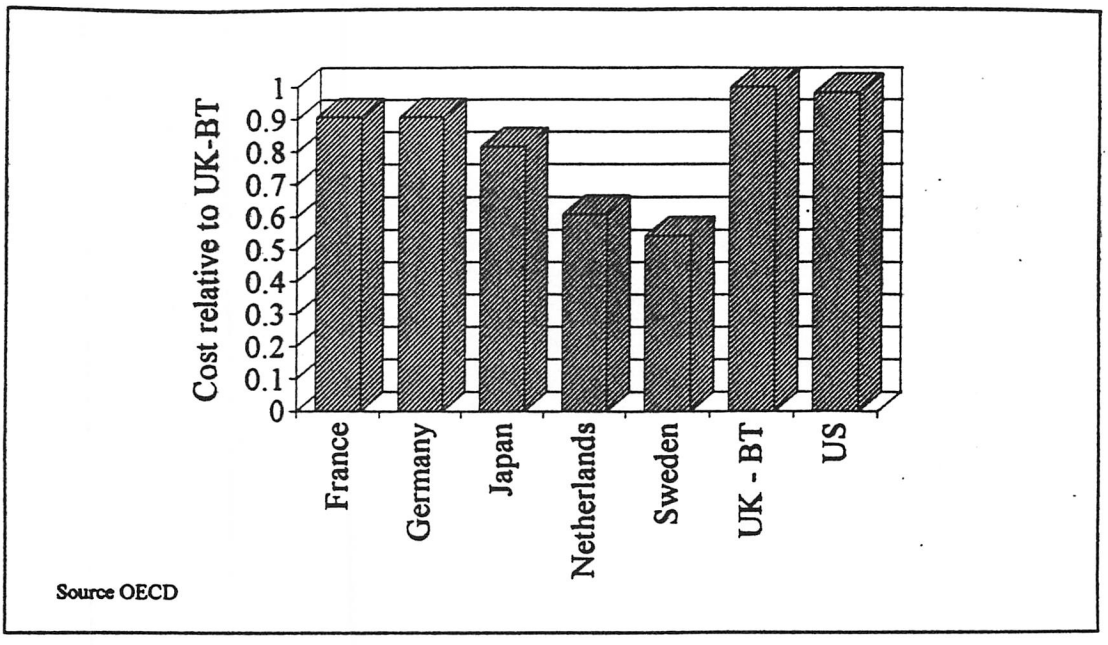

Figure B6: Comparison of PSTN costs - Residential basket, OECD
(fixed and variable charges at Jan 1992)

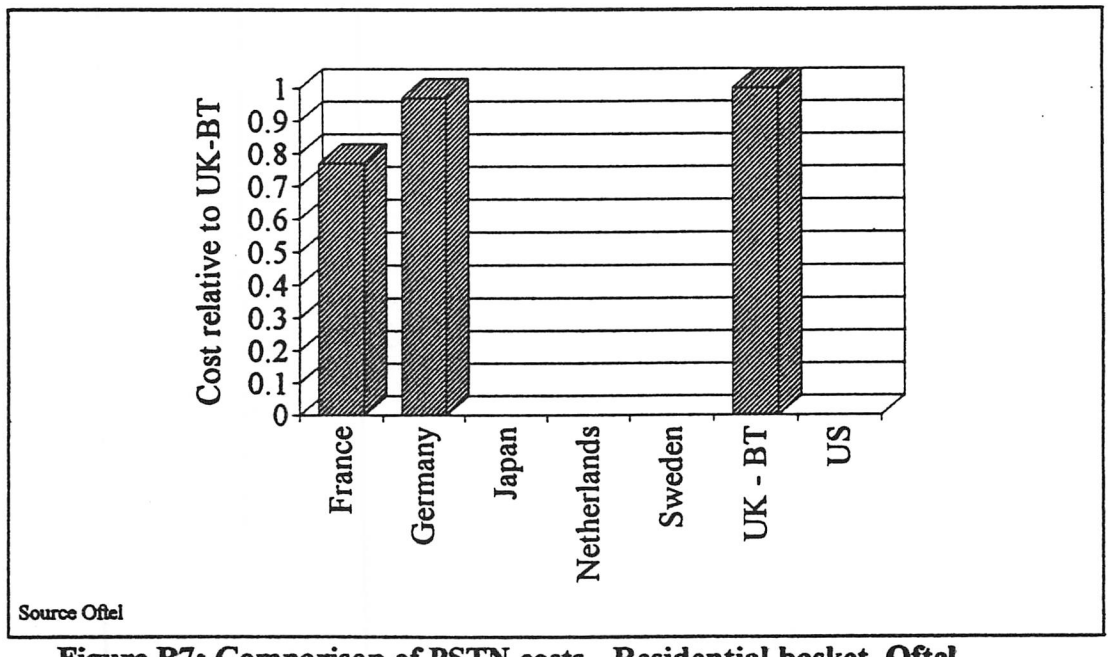

Figure B7: Comparison of PSTN costs - Residential basket, Oftel
(fixed and variable charges at Jan 1993)

Costs of business calls over cellular radio

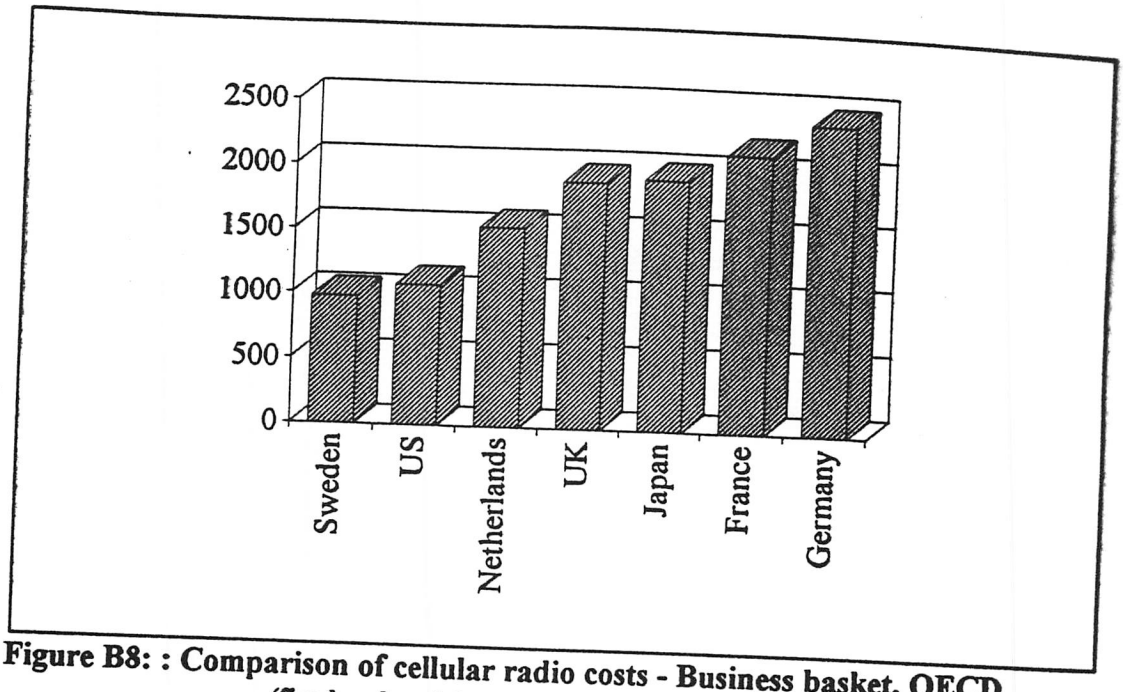

Figure B8: : Comparison of cellular radio costs - Business basket, OECD
(fixed and variable charges at Jan 1992)

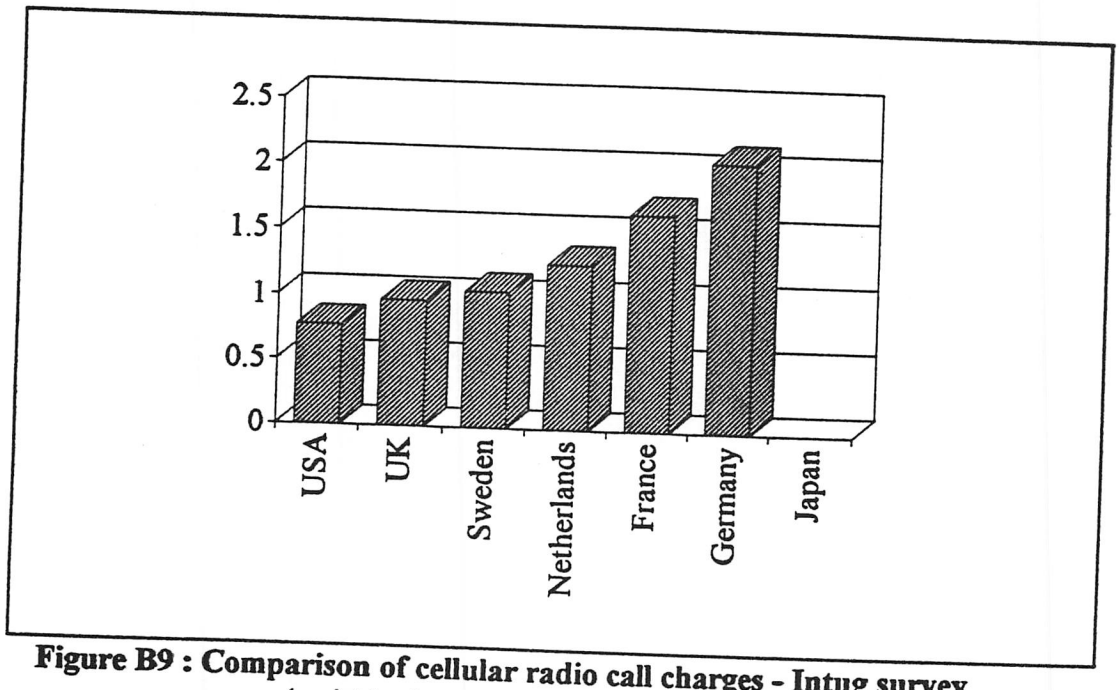

Figure B9 : Comparison of cellular radio call charges - Intug survey
(variable charges at September 1993)

APPENDIX C

CONTRIBUTORS

APPENDIX C

CONTRIBUTORS

The assistance of the following organisations and their staff in providing information is gratefully acknowledged:

American Express
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BICC
BT
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Federal Communications Commission
Ford
France Telecom
Galileo
GPT
GTE
ICI
INTUG
(inc Industry members of INTUG)
Japanese Embassy
John Deere
Martin Bierbaum
MCI
Mercury
Mitsubishi
Northern Telecom
NTT
Nynex
Oftel
Pacific Telesis
PTT Telecom
Reuters
Southwestern Bell
Telewest
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TMA (inc industry members of TMA)
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Unilever
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US Sprint
US West
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