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COMPETITION OR COMPLEMENTARITY?

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MOBILE AND PSTN COMMUNICATION SERVICES: COMPETITION OR COMPLEMENTARITY?

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 1995

FOREWORD

These papers were prepared in the context of the work programme of the Committee for Information, Computer and Communications Policy. They were considered by the Working Party on Telecommunications and Information Services Policies in 1992 and recommended for derestriction by the Committee in 1993. Part A of the report was prepared by Dr. Tim Kelly of the Secretariat, and Part B was prepared by Messrs. Derek Laval and Kristen Hansen of the consultancy firm Schema (United Kingdom). The information contained in this paper is valid as of the end of 1992. However, significant changes have occurred in the mobile sector since then. Nevertheless, much of the discussion and arguments in the report remain valid and, for this reason, it has been viewed as useful to make the document available to the general public.

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MOBILE AND PSTN COMMUNICATION SERVICES: COMPETITION OR COMPLEMENTARITY?

I. SUMMARY

Mobile communication services, especially analogue cellular radio, have been one of the success stories of the last decade in the telecommunication industry. At the start of 1991, there were almost eleven million subscribers to cellular radio in the OECD area and a growing number of users of other technologies such as private mobile radio (PMR), telepoint, personal communication networks (PCN), radiopaging and mobile data communications. In the decade to come, the prospects are even more exciting as digital technologies are introduced, standards are harmonized and as equipment and usage prices fall. There is the very real possibility that mobile communication services will do for the telecommunication industry in the 1990s what the personal computer did for the computer industry in the 1980s; namely, to bring about a revolutionary change in the way products and services are sold and used.

The advent of mobile communication services as a mass market raises important questions about the economic effects of the extra competition it should bring to the telecommunication sector. The key question addressed in this report is as follows:

> *To what extent will mobile communication services eventually compete with, or substitute for, fixed link telecommunication services in terms of tariffs, traffic and subscribers? For how long will mobile communications continue to be regarded as a complementary service to traditional telephony?*

In other words, should mobile communications and the Public Switched Telephone Network (PSTN) be considered as competitive or complementary services in the foreseeable future? To put it more crudely, are mobile communication services a threat to, or an opportunity for, the revenue streams of conventional Public Telecommunication Operators (PTO)?

This question is important because it may determine how the industry is regulated. If mobile is to be regarded as a complementary service then it seems clear that existing operators of fixed link networks should be allowed to enter the market. On the other hand, if it is viewed as a competitive service, it may be necessary, as a minimum requirement, to control any cross-subsidy or abuse of dominant market position by the fixed link operator. The exact nature of the policy choice should hinge on an evaluation of the costs and benefits of each case.

In order to address this question, four main themes which form Sections II to V of this report are pursued. Section II presents a review of the *technical* options for providing mobile voice communications, including an analysis of different services (*e.g.* analogue or digital cellular radio, Telepoint, PCN). The future changeover from analogue to digital technology is a particular focus of this chapter.

Section III continues with a survey of market trends and forecasts for the development of mobile communication services. The experience of different OECD Member countries is examined and an assessment is made of the growth rates and likely ceilings for market development. It is clear while the introduction of analogue mobile communications has generally been successful, the experience of individual

countries varies widely. The factors for successful market development and the question of whether these can be replicated are also considered.

In Section IV the main theme of the report, *competition or complementarity?*, is examined in more detail. This section reports on the results of computer modelling carried out at the OECD to show the level of substitution between mobile and fixed link services in terms of subscribers growth, shown in the Nordic countries. The section goes on to look at issues of tariff structures and interconnection prices. The OECD's tariff comparison model is used in the analysis presented here. Part B of the report considers the specific topic of interconnection agreements between mobile and PSTN operators.

In Section V, the findings of the previous three chapters are summarised in the form of policy questions addressed to OECD Member countries. Even in a young industry such as cellular radio, there are already a range of different policy stances, each of which has different implications for the central question of whether or not mobile communication services will eventually compete with fixed link services. A number of questions to individual countries have been posed as the basis for discussion and for further development of the report. Written comments submitted by countries are summarised at the end of Section V.

The final section of Part A presents the conclusions of the report. It is argued that in the regions which have well-developed mobile communication services (such as Scandinavia) there is already a degree of competition and substitution between mobile and PSTN services, but for the most part cellular services are likely to continue to be complementary to fixed link services. As other national markets develop, it is likely that they too will soon shift from a situation in which mobile and PSTN operators complement each others' activities to one in which they compete for traffic; on price as well as on service availability. In particular, as technology develops from the current generation of analogue cellular radio systems towards digital systems and eventually towards "personal communications", and the market for these services grows, it is conceivable that falling prices and efficiency gains will enable mobile operators to take a growing share of a larger total communication market. Obviously cross-elasticities of demand and economies of scale and scope can play an important role in the development of the industry. But much of the required data are unavailable. These issues may need further reflection as the data become available.

If this argument is accepted, then policy-makers need to plan now how to ensure that there is a level playing ground for fair competition to develop. In order to promote discussion on this issue, the chapter presents a series of areas on which Member countries may wish to focus in developing their policies for future mobile communication systems. Specifically, a series of seven general principles that would promote competitive market entry are put forward for consideration (Figure 1.1). It is concluded that mobile communication services can be both competitive with, and complementary to, fixed link PSTN services and that policy-makers have much to gain from promoting competitive market entry by mobile operators on equitable terms.

Figure 1.1. **Principles for promoting competitive market entry in mobile communication services**

A.	Competition provides the best platform for market growth and development.
B.	Competition is the best market regulator.
C.	Mobile cellular radio and PSTN operations should be structurally and financially separated.
D.	The method for licensing operators should be open and transparent.
E.	The price of spectrum should reflect its true market value.
F.	Regulators should not attempt to impose particular technological choices upon the marketplace.
G.	Regulators should oversee licence conditions and the negotiation of interconnection agreements.

Note: For more details, please see the discussion in Section VI.

II. TECHNICAL REVIEW

1. A portfolio of services

As indicated above, emerging radio-based technologies have presented operators and users with a wide range of different technical options. The very fact that inter-personal communication services are dominantly carried by wire rather than over-the-air is more of an historical accident than a technological choice. In many ways it is inefficient to use a hard-wired service, with the associated infrastructure costs of cabling, transmission and switching, for telephony for which the average daily residential use is less than ten minutes per line. It might be more efficient to use the airwaves for personal communications and a cabled infrastructure for bandwidth-intensive entertainment services such as television. However, the fact is that the infrastructure exists and is already, to a large extent, depreciated in PTO investment schedules. For this reason, mobile solutions are unlikely to replace hard-wired networks even if they are cheaper to construct and operate. However in countries where the public switched telephone network (PSTN) is in a poor state of development or in rural areas with a low traffic volume, a radio-based solution may offer a viable alternative to fixed link infrastructures. This is true for many countries outside the OECD area, notably in Central and Eastern Europe and the less developed countries.

The basic principles behind wireless radio communications are well-established, and specific closed user groups -- such as emergency services, taxi services or the military -- have long been users of mobile radio. The provision of a public mobile telecommunication services was, however, delayed by a number of factors:

-- Sophisticated computer technology is necessary for switching between frequencies and/or between cells, and for squeezing as many channels as possible onto the limited frequencies. Such technology only became available in the 1970s.

-- Where switching is not available, privacy is a major problem because many users share each channel. Even where switching is carried out, privacy is only really possible in digital systems.

-- Frequency availability for mobile services was limited until the 1987 World Administrative Radio Conference (WARC) of the ITU proposed the allocation of a 25 MHz chunk of radio spectrum in the 900 MHz band (in addition to space in the 450 MHz band) to cellular radio in Europe.

-- Microchip and battery technology was, until recently, a limiting factor on the size, portability, safety and usage time between recharging of mobile phones.

During the 1980s these technical constraints on the development of radio-based services were progressively eroded. At the start of the 1990s therefore users are faced with a bewildering array of existing and imminent service options. The vast majority of voice mobile users in OECD countries

subscribe to cellular radio services. However, there are a significant number of users of older, non-cellular systems (such as citizens band, maritime radio, car telephones) as well as newer services, which are licensed in some OECD countries but not all, such as cordless public telephony systems (DECT/CT2) or micro-cellular systems (such as PCN). On the horizon are a number of proposals for spectrum allocation for which services do not yet exist. These proposals include:

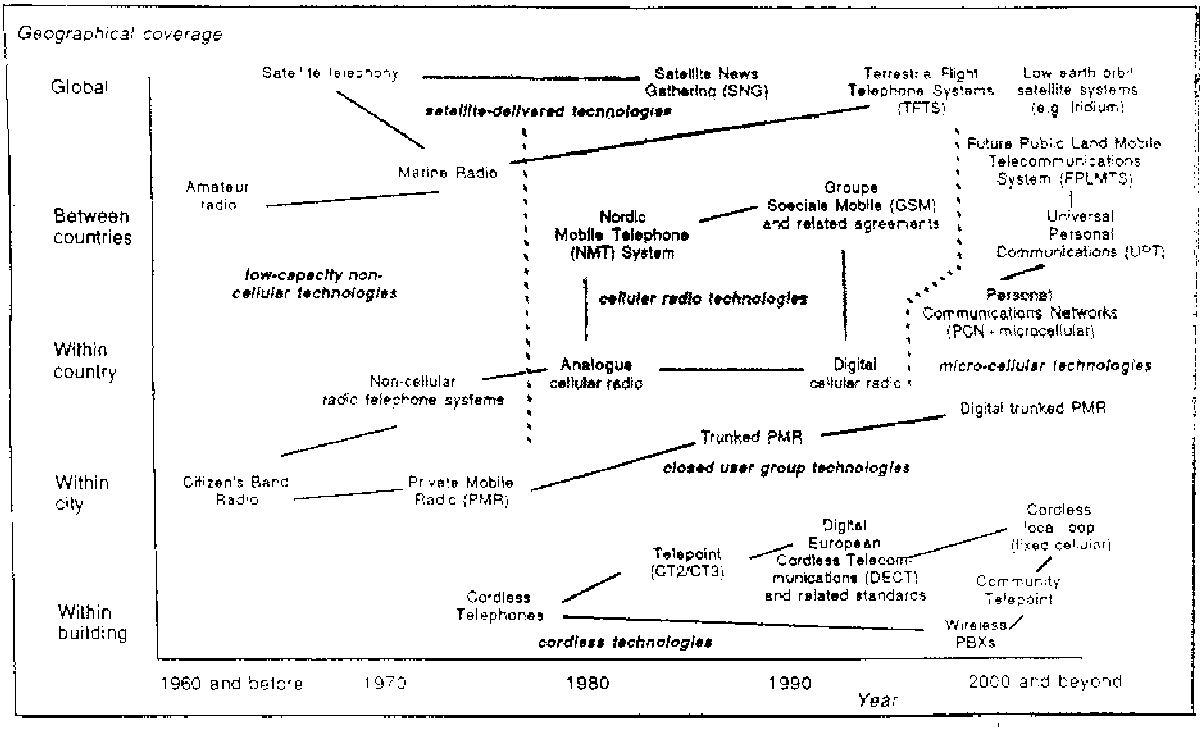
-- Universal Mobile Telecommunication System (UMTS);

-- Future Public Land Mobile Telecommunication Systems (FPLMTS);

-- satellite-delivered personal communication systems, such as Motorola's proposed IRIDIUM system;

-- other proposed systems to replace the local loop through radio access, such as community telepoint.

Figure 2.1. **Evolution of voice mobile communication systems, 1960-2000**



Note: The services represented in the diagram should be regarded as selective, not exhaustive; equally, dates are taken to be indicative, not exact.

Not all of these systems will be successful in gaining sufficient spectrum for an operational service. Furthermore, there is likely to be a high degree of overlap between services and consequently many will not survive. Figure 2.1 summarises the evolution of voice mobile communication systems over the period 1960-2000. At the start of the 1960s there were four basic technologies for radio-based voice delivery:

-- citizen's band over a local area;

-- microwave, for point-to-point delivery;

-- wide-area radio communication such as amateur radio or maritime radio services;

-- satellite-delivered services, starting in the early 1960s.

A fifth technology was developed commercially in the mid-1970s:

-- cordless telephones for use within a building or over a small area.

Each of these technologies has evolved, but the most dramatic leap forward in terms of market growth came with the development of public cellular radio systems in the early 1980s. Most of the discussion in the subsequent chapters of this report focuses on cellular radio, but it is important to consider to what extent cellular radio itself will be overtaken and substituted by newer technologies such as digital cellular radio cordless public access, micro-cellular systems, or satellite technology. The main contenders for voice mobile services are discussed below.

2. Analogue cellular radio

Cellular radio as a concept was developed in 1947, but at that time it would have been impossible to implement because of the need for rapid switching between cells and between frequencies which requires a high-performance computer. Experiments with cellular radio were conducted during the 1970s and a commercial analogue cellular radio service was introduced in Chicago in 1983. This technology was called the Advanced Mobile Phone Service (AMPS) and operated in the 800 MHz band. A close variant on this system, Total Access Communication Systems (TACS), was introduced shortly afterwards, and this is used in a number of European countries including the United Kingdom, Ireland and Italy in the 900 MHz band. AMPS is also used in Australia and New Zealand. In Japan, the first commercial analogue cellular radio service was introduced in Tokyo, in 1979, using the analogue system in the 900 MHz band which was originally developed in Japan.

In Scandinavia, the development of cellular radio has resulted in a unique co-operation between the PTOs of this region to develop the Nordic Mobile Telephone (NMT) system. This has been operating since the early 1980s at 450 MHz and since the mid-1980s at 900 MHz. Some of the highest densities of mobile telephones in the world are to be found in Scandinavia, which is a tribute to the success of this project as well as its early start relative to other countries. The major manufacturers of the region, such as Ericsson or Nokia (Mobira), have also benefited as the system has been exported to other neighbouring countries (*e.g.* BENELUX countries) and to other EFTA countries. More recently, NMT has scored new successes in Central and Eastern Europe, notably in Poland, Hungary, Latvia and St. Petersburg. One

specific advantage here is the fact that the 450 MHz band is more readily available and can be used with lower cost handsets, whereas the 800/900 MHz band is often occupied by military use and would, in any case, require more sophisticated handsets. The NMT system has also had some success as a "second generation" system in Austria (augmenting the older C450 system) and France (where SFR has adopted a variant of NMT 900 in competition to France Télécom's Radiocom 2000). On the other hand, an NMT 450 network has been superseded by a TACS 900 system in Spain.

While AMPS/TACS and NMT are the dominant systems worldwide, there are a small number of other systems introduced during the mid-1980s which still persist today. These include:

-- the Siemens-based C450 system which is used in Germany and has been exported to Portugal;

-- the Radiocom 2000 which is operated by France Télécom in the 200 MHz and 400 MHz ranges;

-- the RTMS system which operates in Italy in the 450 MHz range.

Significantly, in each of these countries the growth of the subscriber base of mobile telephone systems has been disappointing, at least until the introduction of more commonly-accepted standards (GSM in Germany; NMT 900 in France; TACS 900 in Italy). There are two main reasons for this disappointing performance: firstly these alternative technologies are generally not so efficient in their use of frequency which has compounded the existing problems of capacity constraints; the second problem relates to the fact that, without a mass market from export business, it is difficult to achieve the economies of scale sufficient to bring down prices for handsets and network infrastructure. For these countries, perhaps the best hope for future development of cellular radio services lies with digital systems.

3. Digital cellular radio

Despite their successful growth during the 1980s, it should nonetheless be remembered that most existing cellular radio systems in operation in OECD countries are still based on analogue technology. The next logical step is towards a digital system. This would have a number of advantages:

-- Digital switching and associated signal compression would permit a more efficient use of the available spectrum. It is estimated that initially around three times as many users could be accommodated within the same frequency allocation if a digital system is used and that further gains could be made as the technology, especially network access standards, matures. The quality of reception should also be much higher.

-- Digital encoding of messages should afford a much higher level of privacy for users. At present, personal calls can easily be intercepted by anyone equipped with a wide-band radio, which typically costs less than US$300.

-- Ultimately a digital system should enable cost reductions in both transmission and receiver equipment. These cost reductions may not be realised straightaway as economies of scale in manufacture need to be achieved first. Nevertheless, in the long term, digital handsets should be cheaper because they have a lower power consumption and their functional intelligence can

be squeezed onto fewer semiconductor chips. This should eventually be reflected also in lower usage costs.

Within Europe, it is hoped that the shift from an analogue to a digital technology can be achieved in the early 1990s with more agreement between countries than was achieved in the adoption of first generation analogue systems. In particular, it is hoped that, by adopting a common standard, it will be possible for users to "roam" between countries and to use the same basic handset wherever they travel. The principal contender in Europe is GSM: named originally after the *Groupe Spéciale Mobile* which was established to define it, but now commonly referred to as the "Global System of Mobile Communications".

The GSM was established in 1982 by the CEPT (European Conference of Postal and Telecommunication Administrations). In 1987 a Memorandum of Understanding (MoU) was signed by 17 countries (later increased to 18) to introduce an operational GSM service by 1 January 1991 (later postponed to 1 July 1991). However, at the time of writing there are relatively few operational GSM services in OECD countries despite many "official launches" and demonstration events. The countries which have made the most progress so far in GSM are:

-- Finland, where two companies have operational services -- Radiolinja and Finnish Telecom. Interestingly, Radiolinja's call charges are pitched at around 3-4 per cent lower than Finnish Telecoms NMT service.

-- In Sweden, three licensees have already been announced: Comvik/Tele2 (selected in November 1989), NordicTel (selected in December 1990) and the existing fixed link operator, Televerket.

-- Other Scandinavian countries which met the deadline to start the service but did not licence second operators in time to meet the terms of the MoU. In Denmark, the second operator (Dansk Mobil Telefon) was announced only in June 1991 and the start of services will be delayed until at least March 1992. In Norway, a second GSM licensee will be announced in the autumn of 1991.

-- In Germany, the second mobile operator (Mannesmann Mobilfunk: D2) was announced in December 1989 and succeeded in showing a demonstrator project on the official launch date but will not start an operational service until December 1992.

-- In France, following a decision taken on 26 March 1992, the two existing analogue cellular operators (France Télécom and SFR) were authorised to develop GSM networks. France Télécom's "ITINERIS" service opened on 1 July 1992 and SFR followed in mid-September 1992. At first, these networks will cover only Paris and Lyon, but they will be extended to all major cities and communication routes in 1993.

In most other European countries GSM services are planned but are not yet in operation. There is a clear need for systems that are capable of operation around and across borders without the penalty of multiple frequency allocations with their attendant management problems, whilst admitting multiple sourcing to encourage competition. The GSM standard provides users with significantly enhanced functionality over previous analogue systems and with some increase in spectrum efficiency. Taking into account the lack of cross-border problems and this improvement in functionality, the effective improvement

in spectral efficiency is enormous, as is the potential market for the systems -- a base now exists to support several manufacturers with half a million subscribers achieved in less than nine months.

Delays in announcing competitive operators for GSM services have slowed the development of the market, but the main problems are technical, in particular the lack of type-approved handsets. Those handsets which are available are generally bulky and quite expensive compared to existing analogue handsets. Some countries have adopted a "wait and see" approach preferring to let their neighbours prove the market potential of GSM before they commit major investments. In certain countries, notably Britain, there are spectrum constraints on GSM which will have to "compete" with other mobile communication technologies for allocations. There is a chicken and egg problem with all new radio-based services: what comes first, the service demand or the spectrum allocation?

The problems listed above would be damaging enough to the prospects of GSM, but the main obstacle to growth is the presence of a large existing user base of analogue cellular radio subscribers. Most of the potential pioneer users of a GSM service already subscribe to an analogue service and would be reluctant to swap their existing handsets for a new, unproven service. It is much harder to promote a replacement market than to create a new market, at least if there is not upwards compatibility in terminal equipment. The real challenge of GSM therefore will not be technical, but rather a marketing exercise. An analogy can be drawn with the fax market: Even though the Group 4 (G4) fax is a demonstrably superior, digital alternative to the older, analogue G3 fax and has been available in showrooms for more than five years, it has not yet succeeded in replacing the G3 market. The predominant market trend has been towards incremental improvement of G3 machines (plain paper faxes, memory functions, higher speed transmission) rather than a shift to G4. It is likely that GSM will be more successful in those countries where analogue cellular systems have not fulfilled their potential in terms of market demand (*e.g.* France, Spain) or where roaming is important (*e.g.* between eastern and western Germany).

Outside Europe, the selection of a standard for digital cellular radio may take longer. Some countries, including Australia, have indicated their intention to adopt the GSM standard. Hong Kong recently selected GSM. However, in the United States the problem is choosing among rival standards for network access technologies described generically as digital AMPS (DAMPS). These include:

-- Time Division Multiple Access (TDMA), approved by US industry as a preferred standard in January 1989, is currently used by McCaw Cellular and undergoing tests by Nynex and additional companies;

-- E-TDM, an enhanced form of TDMA, which is being promoted by Hughes Network Systems;

-- N-AMPS, an enhanced version of AMPS, promoted by Motorola, provides efficiency gains comparable to TDMA but without requiring a shift to a digital system;

-- Code Division Multiple Access (CDMA), which represents a fivefold efficiency increase over TDMA and is currently being tested by Nynex and other US companies;

Each of these systems is comparable or superior to GSM and all of them are currently being tried and tested by a number of American firms. At present, there exists no clear indication as to which one will be selected as the final standard for digital cellular radio in the United States.

In Japan, public cellular telecommunication services are now rapidly penetrating and there were approximately 1.6 million cellular subscribers at the end of 1992. In order to accommodate increasing demand, and to provide new services, research into digital cellular communication systems has been very active in Japan. Technical requirements for the digital cellular system were agreed to and published by the Telecommunication Technology Council of MPT in 1990. The detailed air-interface standard specifications for the digital cellular telecommunication system called PDC was established by RCR in 1991.

Since the frequency bands for the existing analogue cellular systems were already allocated, the digital systems were assigned new bands in the 800/900 MHz and in the 1.5 GHz band. The 800/900 MHz bands are shared by existing operators and the 1.5 GHz band was allocated to additional operators. Two new additional operators will utilise the 1.5 GHz band. Commercial service started in March 1993 in the Tokyo metropolitan area. The PDC can provide various high quality enhanced services with efficient spectrum utilisation by applying a newly developed full digital link control scheme and ISDN signalling systems. Compact base station equipment and portable phones are available.

4. Cordless public telephony

Cordless public telephone systems are based on the principle of using a cordless telephone in the home, in the office and in public places where a public base station has been installed. As cordless telephones have proved so popular in the home and are generally much cheaper to use than cellular telephones, it seems just a small step to extend their usage to public places and offices.

Three problems have prevented this simple idea from becoming a profitable market. The first is that cordless phones have a small range (typically less than 200 metres) and are susceptible to electromagnetic interference. Secondly, when used away from the home or a registered base station, there can be a problem in receiving calls and the handset can only be used effectively for sending calls. Thirdly, there are a number of rival standards available which will not interwork with each other. The two main standards are:

-- the CT2 (2nd generation Cordless Telephone standard) which is often known by its British trade name of Telepoint (Pointel in French). Even within this standard, there are a number of incompatible systems (*e.g.* CT1+/CT3), although a Common Air Interface (CAI) has been agreed between operators in the United Kingdom for CT2, and was approved as an Interim European Technical Standard (I-ETS) in September 1990.

-- The Digital European Cordless Telecommunication (DECT) standard currently being defined by the European Telecommunication Standards Institute (ETSI). DECT differs from CT2 in a number of technical characteristics, not least of which is that it operates in a higher portion of the frequency spectrum (at 1 880-1 990 MHz compared to 864-868 MHz for CT2 CAI).

-- The Personal Handy Phone (PHP) standard being defined by the RCR (Research and Development Centre for Radio Systems) in Japan is scheduled for completion in autumn 1993.

Public cordless telephone services are at an operational stage only in the United Kingdom and the experience there has been far from successful. Of the four consortia, which were chosen to offer services in the United Kingdom in January 1989, Mercury Callpoint has discontinued operations, Ferranti

Creditphone (now Liberal Telecom) and Phonepoint have suspended operations for the time being, and BYPS [now owned by Hutchison Telecommunications (UK) Ltd.] is yet to start operations, although a CT2 CAI service is planned for 1992. In all, there are less than 1 000 Telepoint subscribers in the United Kingdom, and no company is currently offering a service. Telecom commenced a Public Access Telecommunication Service (PACTS) (*i.e.* CT-2) in Brisbane in March 1993.

Elsewhere, CT2 operations have gone beyond the trial stage (some Asian countries and the Americas). DBP Telekom is conducting a trial of 2 800 users in Munich but has made no commitment to an operational service; France Télécom has been piloting a "Pointel" service in Strasburg since 1 December 1991 with the possibility of extending it to other towns if it is successful; and PTT Telecom Netherlands opened a CT2 service (Greenpoint) on 20 May 1992. There are also a number of small trials taking place in Canada, the United States, Hong Kong and elsewhere. The digitalisation and evolution of fixed network functions such as ISDN and Intelligent Network (IN) will contribute greatly to offer a variety of services using a cordless telephone system. The Personal Handy Phone system is a digital cordless telephone system which has been developed in Japan. Using the advanced network function such as location registration. PHP can offer both incoming and outgoing calls in homes, offices and outdoor enviroments with the same portable terminals. Standardisation activities concerning PHP CAI have already been completed in 1992 and those concerning network interface between cell stations and the fixed network will be completed in 1993.

Four technical developments offer brighter prospects for public cordless telephone systems. The first is the eventual maturity of the DECT standard which should bring a degree of harmony to the market. However, given that work on the GSM standard took nine years to reach completion, the completion of the DECT standard, which was initiated only in 1988, may take some time to become established. The second new development is the idea of combining CT2 terminals with pagers to provide some degree of interactivity. A third trend is the emergence on the market of cordless private branch exchanges (PBXs) which would be suitable for use in offices with a mobile workforce. This product may be regarded as a logical upgrade to in-house paging systems. Finally, the development of Community Telepoint is being touted as a way of by-passing the local loop. This solution seems particularly appropriate where telephone systems need to be established quickly (*e.g.* in the countries of Eastern and Central Europe) or where public utilities (*e.g.* electricity, water, gas, cable TV) are being encouraged to enter the telecommunication market in competition with a former monopoly operator.

5. Personal communications

Despite much press coverage, "personal communications" remains more of a concept than a service. Indeed there is no general agreement as to what to call the service. A number of variations exist:

-- Personal Communication Networks (PCN) is the standard abbreviation used in the United Kingdom where three licensees were announced in December 1989.

-- Personal Communication Services (PCS) is the term used in the United States by the Federal Communications Commission (FCC) when it adopted Notices of Proposed Rulemaking, advocating frequency allocations and licensing rules for services from advanced paging to traditional voice offerings.

-- Digital Cellular System at 1800 MHz (DCS-1800) is the term used in the European standards-making environment where ETSI is engaged upon defining a standard.

-- Universal Mobile Telecommunication System (UMTS) is one of many terms used in the international standards-making environment, notably by the ETSI.

-- Future Public Land Mobile Telecommunication System (FPLMTS) is one of many terms used in the international standard-making environment, notably by the ITU.

-- Personal Handy Phone System (PHP) is the term named for the digital cordless telephone system which is developed in Japan and its CAI is standardised by the Research and Development Center for Radio systems.

Further uncertainty enters in trying to define how a new personal communication service would differ from existing services. Its characteristics might include:

-- it will be digital;

-- it will operate at higher frequencies -- in the United Kingdom, the frequency band between 1.7-1.9 GHz has been designated for PCN;

-- in consequence, cell sizes will be smaller; typically less than 500 metre radius (micro-cells);

-- handsets will be small; ideally pocket-sized;

-- personal communications will require personal numbering in the sense that each subscriber would be allocated a single transferable number which would refer to a person and not to a piece of equipment or a location.

It is clear even from these few distinguishing features that potential personal communication operators will need to cross a number of technical, standards-making and regulatory hurdles before they can begin offering a service. Also, because the cell-size is much smaller and the frequency band is high, the start-up costs for infrastructural investment will be much greater than for analogue cellular radio. Even in the United Kingdom, where three operators were licensed in 1989, it is not expected that any service will start before 1993.

Nevertheless, if these problems can be overcome, the long-term future for a personal communication service must be considered much brighter than for any of the services discussed above because it could represent a genuine mass-market, without the spectrum constraints of analogue cellular radio and with the possibility to compete directly with fixed-link services.

6. Satellite-delivered mobile communications

The possibility of satellite-delivered telecommunication services has existed since the mid-1960s, but until recently the potential was limited to fixed-link communications (*e.g.* to and from fixed satellite dishes) or for maritime tracking services. The development of mobile satellite phones has been pioneered by journalists, most dramatically in their coverage of the Gulf War. These satellite phones can be considered as "luggable", although not yet quite "portable". Their use is also still too expensive for normal

commercial users. New possibilities for satellite-delivered services are likely to open up with the next generation of high-power satellites and so-called Low Earth Orbit (LEO) satellites:

-- There are currently six applications before the US Federal Communication Commission (FCC) proposing satellite systems that offer a variety of voice and data mobile satellite services (MSS), including two-way messaging service with interconnection to the public switched network and paging services. Each will operate in the 1 610 to 1 626.5/2 483.5 to 2 500 MHz frequency bands allocated to the Radio Determination Satellite Service (RDSS). The six applicants and their proposed systems are: Motorola Satellite Communications (Iridium system); Ellipsat Corporation (Ellipso system); Constellation Communications (Aries system); Loral Cellular Systems (Globalstar system); TRW Inc. (Odyssey system); and American Mobile Satellite Corporation [proposes to modify its authorised geo-stationary orbit's (GSO) upper L-band MSS system to operate in the RDSS frequencies].

-- The International Maritime and Aeronautical Satellite services provider (INMARSAT), which already offers global voice, text, and data messaging via briefcase-sized terminals, is now considering its "Project 21" proposal to develop a global hand-held satellite-delivered personal communication system to begin service in 1998-2000.

-- The European satellite services supplier, EUTELSAT, is planning a similar service with a particular focus on the countries of Central and Eastern Europe.

-- In Japan, two geo-stationary satellites called N-STARs carrying S-band (2.6/2.5 GHz) transponders are to be placed in orbit in 1995. The satellites are planned to provide domestic land-mobile and maritime satellite services within Japan as well as its surrounding seas.

While these proposed new services will need to meet significant technical and regulatory challenges before they can be realised, the growing consumer demand for portable wireless communication services suggests that there is much promise for the future of satellite-delivered PCS. Because the quality and cost of these services is not likely to be competitive with most wireline services, the potential demand for such services will probably, at least initially, be in niche markets, such as communication services for international business, travellers in need of quality connections to, from, or within rural or developing areas, where no viable alternative exists. Optus has announced that it proposes to commence mobile satellite services in the last quarter of 1993. Anticipating the future demand for satellite-delivered mobile services, policy-makers at the WARC 92 meeting in Spain made some preliminary spectrum allocations intended for such services.

Certain other mobile satellite-delivered services are already in operation in a limited form including vehicle tracking services such as OMNITRACS in North America or EUTELTRACS in Europe; these services are, for the moment, data only and/or one way. However, the principal problem encountered by mobile satellite-delivered services at present is their high cost of usage, though this is likely to come down as high-power satellites allow the use of low-power receiving and ground transmitting equipment. The future development of satellite-delivered services will be considered in more detail in a parallel project entitled OECD (1995), "Satellite Communications: Structural Change and Competition".

This review of the technical options for voice mobile communications has shown a mix of success, failure and unproven potential. While many technical and regulatory challenges remain, the growing demand for portable wireless services should drive both markets and governments to overcome these challenges. The key technical factors for the successful development of the service include greater spectrum availability, continued miniaturisation and price cutting in terminal handsets, individually identified and

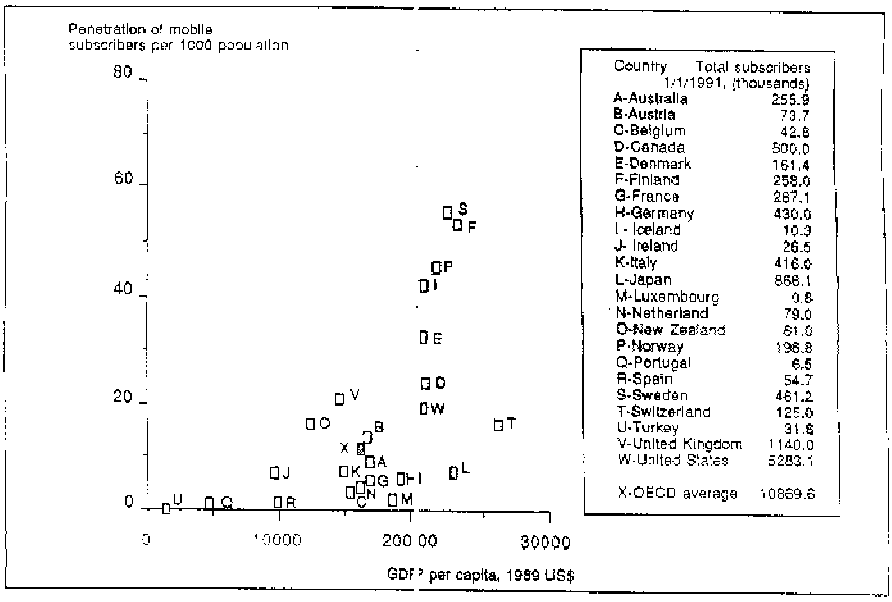
transferable subscriber numbers, longer life batteries and harmonisation of technical standards, particularly for digital and micro-cellular services.

III. MARKET TRENDS

1. Tortoises and hares

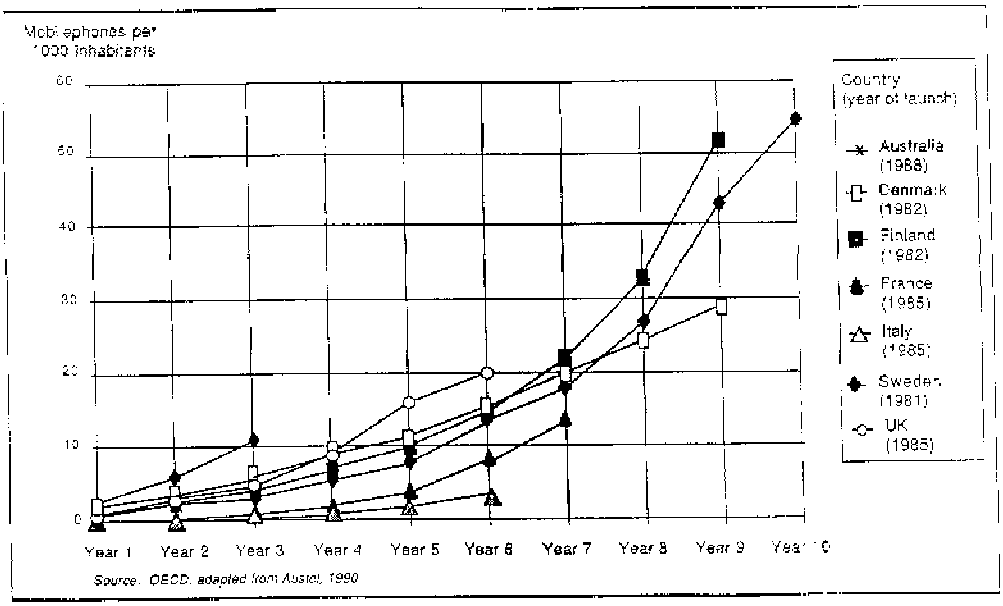
In broad terms it is true to say that the development of telecommunication infrastructure in a country corresponds to the general level of economic development of that country. There is, for instance, a close correlation between the density of main lines (or telephones) and Gross Domestic Product (GDP) per inhabitant. For the 24 OECD countries, the correlation coefficient (R-squared) from an ordinary least squares regression is 0.78 where 1.0 would indicate a perfect fit. For mobile communication services, it is not possible to draw such a straight-line relationship. The relationship between mobile subscribers per 1 000 population and GDP shows only a weak correlation (R-squared = 0.39) which suggests there are other factors at work that help to explain the level of variation in mobile phone development (Figure 3.1).

Figure 3.1. **Mobile communications and GDP per capita in OECD countries, 1991**



Figures 3.2 and 3.3 show the current status of development of mobile communications in OECD countries (the data shown are for 1991 and clearly since then there has been significant growth in the number of mobile subscribers in many Member countries). It is possible to identify several groups of countries:

Figure 3.2. **Mobile penetration rates since launch of service, selected OECD countries, 1981-91**



-- The five Nordic countries which have a penetration rate of between 30-60 mobile phones per 1 000 population. These countries all operate the Nordic Mobile Telephone System and have a service which has been in operation for around ten years.

-- Countries which have adopted TACS/AMPS based systems under competitive supply conditions (Canada, United Kingdom, United States) which now have a penetration rate of between 17-22 mobile phones per 1 000 population.

-- Countries which have adopted "standard" technologies and which have attractive tariffs (see Figure 4.4), including Australia (15.2), Austria (9.7), New Zealand (18.1) and Switzerland (18.2).

-- Other countries which have adopted "standard" technologies and which have achieved some measure of growth but which are generally below the OECD average. These include Ireland (7.5), Japan (7.1) and Italy (7.2) which joined this group after adopting TACS in 1990 since when it has enjoyed phenomenal growth.

-- Countries which have adopted non-standard systems or which have not yet reached the level of development which would have been expected from their level of wealth. These countries include Belgium (4.3), France (5.1), Germany (6.9), Luxembourg (2.0), Netherlands (5.3) and Spain (1.4).

Figure 3.3. **Analogue cellular radio networks: Size, penetration rate, and growth**

Country	Number of subscribers at 1 January 1991	Penetration rate (per 1 000 inhabitants)	3-year CADR [%]
Australia[1]	255 900	15.2	41.3
Austria	73 000	9.7	43.6
Belgium	42 000	4.3	38.1
Canada	600 000	21.0	57.9
Denmark	161 422	31.5	18.8
Finland	258 000	52.0	51.0
France	287 050	5.1	42.5
Germany	430 000	6.9	64.5
Greece	No service	0.0	n.a.
Iceland	10 259	40.5	40.4
Ireland	26 502	7.5	71.4
Italy	416 000	7.2	160.4
Japan	868 078	7.1	79.2
Luxembourg	758	2.0	50.8
Netherlands	79 000	5.3	50.7
New Zealand	61 000	18.1	136.4
Norway	196 828	46.6	22.6
Portugal	6 461	0.6	133.7
Spain	54 700	1.4	107.3
Sweden	461 200	54.3	42.3
Switzerland	125 047	18.6	63.9
Turkey	31 809	0.6	241.2
United Kingdom	1 140 000	19.9	72.1
United States	5 283 055	21.2	62.5
OECD	10 869 614	13.0	62.2[2]

1. In 1993 Australia had over 255 939 mobile subscribers. This acceleration occurred in many Member countries.
2. Weighted average (for 23 countries).
Source: OECD, adapted from ITU, Mobile Europe, Fintech and PTO Annual Reports.

-- Finally a number of OECD countries that are in the early stages of development of their networks such as Portugal (1.1), Turkey (0.1) and Greece which has not yet started offering a service.

From this analysis, it would seem that there are a number of factors which have affected growth to date:

-- the overall "wealth" of a country which partly determines the affordability of the service;

-- the choice of technological standard, where countries choosing NMT or AMPS/TACS have generally fared better than other countries;

-- the start-up date, in that countries with a longer history of service are better developed than those which have started recently;

-- the licensing of operators in countries which have national coverage provided by at least one operator has fared better than in those countries where franchises are limited to particular regions;

-- the degree of co-operation between countries, where the Nordic countries have clearly benefited from co-operative development of the market and the technology;

-- the level of competition within the country: although the evidence here is more ambiguous, it seems that (outside Scandinavia at least) countries which have attempted to grow their industries under conditions of competitive supply have generally done better than those which have relied upon the marketing efforts of a monopoly supplier;

-- finally, it is to be expected that those countries with a lower cost of service, especially a low connection and rental charge, will have a higher take-up of the service than countries with high tariffs. This issue is explored at greater length in Section IV.

It is worth drawing attention to the case of "the Italian mobile phone phenomenon" which seems to contradict many of these growth factors which have been observed in other markets. In particular, since 1989 the Italian market has grown faster than that of any other OECD country and has done so under monopoly conditions. This argument is used by some to sustain the idea that competition is unnecessary. However, a closer examination reveals that:

-- Mobile penetration rates in Italy are still well below the OECD average and a long way behind countries where competition is well established, such as North America, Sweden or the United Kingdom.

-- The recent high growth rates are part of a "catching up" process. The original Italian cellular system was a homegrown, incompatible system called RTMI. Handset prices were high and service roll-out was low until 1989 when, in a dramatic about-turn, SIP abandoned its own technology and adopted the TACS standard used in North America, the United Kingdom and elsewhere. At the same time, SIP introduced an ambitious service roll-out plan, cross-subsidised by its PSTN operations, to kick start the market.

-- Around the end of the 1980s, there also seemed to be a cultural change in Italian society towards greater acceptance by business users of mobile phones as a status symbol and fashion accessory, rather than just an ostentatious luxury. Coupled with growing problems of traffic congestion, these factors have apparently combined to create a short-term situation of high growth in Italy which is probably unique in the world.

2. Market potential

In order to estimate the market potential of mobile communications, it is useful to try to imagine what a hypothetical "ceiling" for market development may be. This is an inherently dangerous exercise because it ignores the constraints of spectrum or the progress that might be made through technical change. Nevertheless, it is a helpful exercise in setting limits on expectations. Figure 3.4 presents a series of three alternative assumptions. The first is that mobile phones may eventually equal a tenth of the level of penetration already achieved in the Public Switched Telephone Network (PSTN fixed-link network). This turns out to be a relatively modest assumption which would imply that the current installed base (10.9 million in OECD countries) would triple in size. A second way of forecasting growth would be to look at the country which currently has the highest degree of market penetration (Sweden) and assume that other countries will catch up. This would imply the market will increase five-fold. Finally, one could extrapolate the average growth rate that has been achieved over the last three years (62.2 per cent per year) over the next five years, which would give a market ceiling of 122 million subscribers worldwide. A

serious limitation on such growth projections based on extrapolation is that future technological developments may invalidate past growth experiences.

An alternative way of forecasting market growth is to look at how suppliers, operators, private consultancies or market research organisations have approached the matter. In Figure 3.5, a variety of estimates drawn from the trade press are assembled. When forecasters are challenged about why their market growth estimates differ, it is traditional for them to say that their definitions, coverage or methodology differ. Certainly the claims quoted in Figure 3.5 vary according to product coverage (GSM, cellular, PCN or all cordless) and geographical coverage, but even so this does not entirely explain the wide range of variations. BIS Strategic Decision is the most pessimistic, expecting less than 2 million GSM subscribers in Europe by 1995. On the other hand, ETCO expect more than 100 million cordless users in Europe by 2000. The significance of this projection is unclear and potentially misleading as it appears that most cordless telephones may be household extension telephones. In addition, many mobile subscribers may continue to be served by fixed-link telephones. In between are estimates for cellular phones only, where forecasts for 2000 range from 30 million (EMCI) to 80 million (Motorola) worldwide.

Finally, a third way of forecasting the market is to look at changes in the flow of traffic. Telecom Australia has published its own forecasts for traffic flow as part of the Australian regulatory body's (AUSTEL) inquiry into Public Mobile Telephone Services (AUSTEL, 1990 pp. 108-112). These figures are quoted in Figure 3.6. The key prediction here is that by the year 2000, almost 60 per cent of all calls will have some mobile component, despite the fact that mobile phones only account for 30 per cent of the installed base. Furthermore, Telecom Australia assumes that mobile phones will receive more calls than they send, especially PCN phones.

If these forecasts come true, they would imply that mobile communication systems will play a very significant role in the development of telecommunications over the next decade. In particular, because many subscribers (a projected 40 per cent) will have access to both mobile and fixed-link telephones, the choice of which to use for any particular call will depend, as much on the price and quality of service of the call, as its origin or destination. In other words, the degree of competition between mobile and fixed-link services will be determined both by regulatory choices (*e.g.* competitive market entry, interconnection prices) and technological factors. These issues are examined in the next section.

Figure 3.4. **Alternative assumptions for market saturation in mobile communications**

Assumption	Ceiling	New subscribers
Existing subscribers in OECD countries	10.9m at 1 January 1991	
Subscribers will grow to equal 10 per cent of PSTN installed base (338m)	33.8m	22.9m
Subscribers will grow to equal existing penetration rate of Sweden (66 per 1 000 inhabitants in mid-1991)	54.2m	43.3m
Subscribers growth will continue at current rate for next five years (62 per cent per year)	122.0m	111.1m

Figure 3.5. **Alternative forecasts of mobile market growth**

Organisation	Assumption	Base	Extended to OECD
BIS Strategic Decisions	1.9m in Europe by 1995	GSM only	5m by 1995
EMCI	11.5m in Europe by 2000	All cellular	30m by 2000
ETCO	16m in Europe by 2000	All cellular	41m by 2000
Economic Services	15 per cent per year growth	All cellular	45m by 2000
PA Consulting Group	20m in Europe by 2000	All cellular	50m by 2000
Motorola	100m in Europe by 2000	All cellular	80m by 2000
Hutchison Telecom	12m in UK by 2000	PCN	177m by 2000
Telecom Australia	4.7m in Australia by 2000	All cordless	235m by 2000
ETCO	100m in Europe by 2000	All cordless	255m by 2000

Source: Alternative market forecasts appearing in trade press, assembled by OECD.

Figure 3.6. **Traffic forecasts for telephony in Australia, 2000**

Source (calls from)	Installed base in 2000 (thousands)	Cellular [%]	Calls to PCN [%]	(in percentage) Other Cordless [%]	PSTN [%]	Total [%]
Cellular	2 000	2.2	2.5	0.2	7.5	12.4
PCN	1 500	1.6	1.9	0.2	5.6	9.3
Other Cordless	1 200	1.3	1.5	0.1	4.5	7.4
PSTN	11 423	12.4	14.3	1.3	42.9	70.8
Total	16 123	17.5	20.2	1.9	60.5	100.0

Source: Telecom Australia, adapted by AUSTEL and OECD

IV. COMPETITION OR COMPLEMENTARITY?

1. Subscriber growth

In the previous section, a number of alternative forecasts for the growth of the mobile communication market were produced. It is likely that by the year 2000 the number of mobile phone users will be at least three times and probably closer to seven times the current level. This may imply that some of the potential growth in the fixed-link network will be diverted to mobile phones. On the other hand, the growth of mobile phones may generate more traffic and therefore promote higher growth in the fixed-link network. Which of these assumptions is more realistic?

To begin to examine this question, it is useful to look at trends in the installed base and shipments of new telecommunication services up to the current date, especially in those countries where the mobile service is most mature (*i.e.* the five Nordic countries). Some of the available data is summarised in Figure 4.1 which gives estimates for mobile (cellular) and PSTN connections (installed base) and new lines installed (shipments) for 1980, 1987, 1989 and 1990. Perhaps the most significant statistic is that the growth rate of PSTN connections increased between 1987-90 for the OECD as a whole (from 3.2 to 3.5 per cent per year) but in the Nordic countries it actually decreased (from 3.3 to 2.2 per cent per year). In OECD countries, the increase in mainlines after 1987 can be attributed at least in part to the demand for fax machines and to a recovery from the trough of a business cycle. In the Nordic countries however there may have been a substitution or "displacement" effect of potential PSTN sales by mobile sales. It might be thought that the slowing down in Nordic mainline growth rates is because they have been approaching "saturation". However this hypothesis is contradicted by the fact that total telecommunication revenue growth in the Nordic countries (5.4 per cent per annum, 1985-90 in real terms) has been much faster than in the rest of the OECD (4.4 per cent per) even though tariffs are generally lower in Scandinavia than elsewhere in the OECD. Rather it would suggest that the competition that has taken place between mobile and PSTN services has produced a bigger total communication market. Far from being detrimental to PSTN operations, mobile services have actually promoted growth by stimulating overall traffic by generating calls which would not otherwise have been made.

While it is unlikely that any subscribers have given up their PSTN lines, there are a number of other possible reasons for this suppressed demand:

-- business users with multiple lines, or domestic users with one line, may choose a mobile phone connection in preference to an additional PSTN connection;

-- business users with a fixed budget for telecommunication services may be spending a higher proportion of it on mobile services.

The price for mobile services is generally below the OECD average in the Nordic countries (between 30 per cent and 64 per cent of the OECD mobile communication basket) but is still much higher than that of equivalent PSTN services. As this premium narrows over time, it is possible that mobile/PSTN traffic substitution may increase.

Figure 4.1. **Mobile and PSTN connections, OECD and Nordic countries, 1980-90**

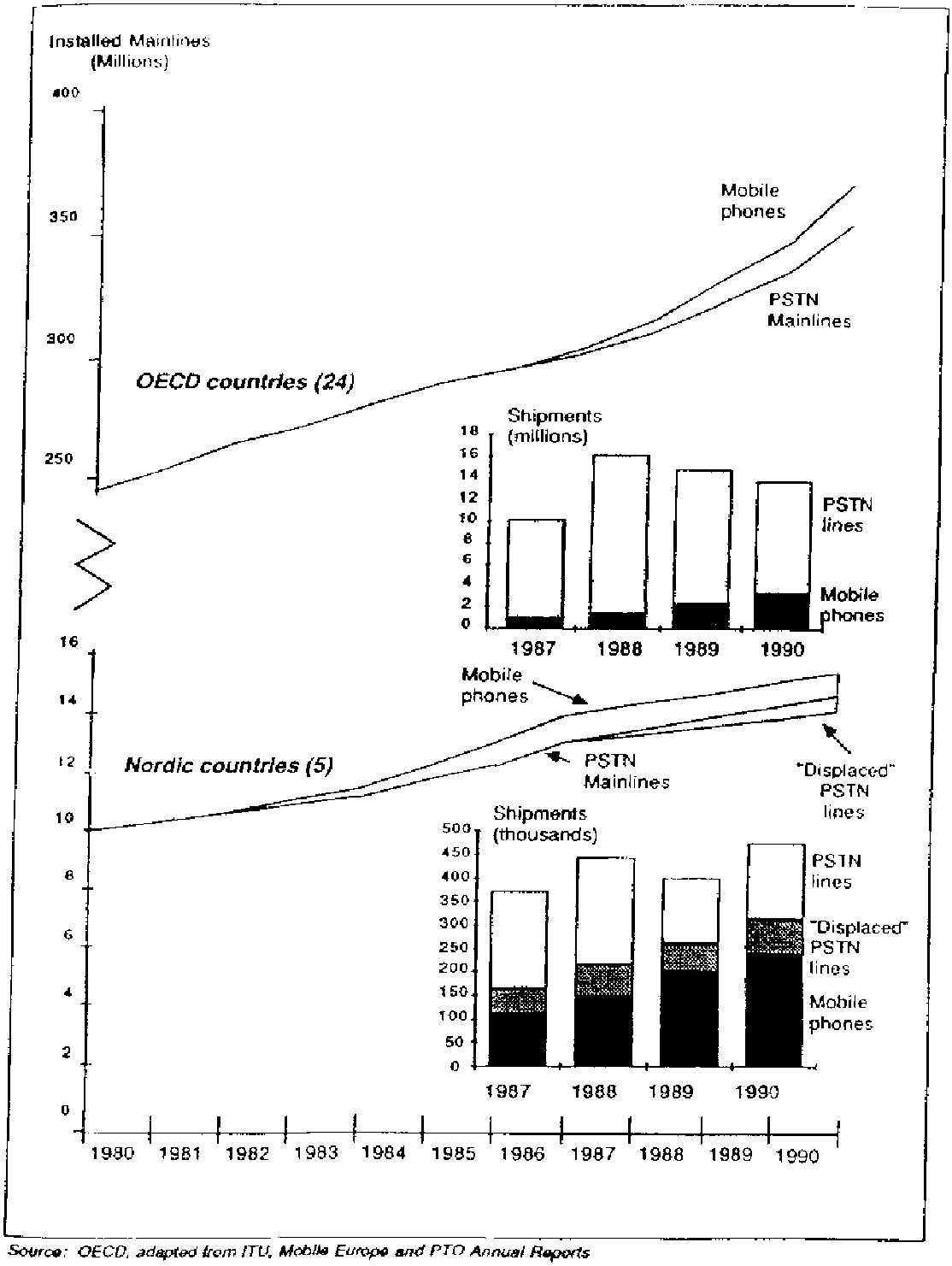
Category	1980	1987	1989	1990	CAGR 1980-87	CAGR 1987-90
Connections at end of year:						
PSTN (OECD)	245 825	307 280	338 552	352 590	3.24%	3.50%
Mobile (OECD	n.a.	3 499	7 358	10 792	n.a.	32.52%
PSTN (Nordic 5)	10 068	12 618	13 338	1 372	3.28%	2.16%
Mobile (Nordic 5)	n.a.	498	845	1 086	n.a.	21.50%
Shipments of new lines during year:						
PSTN (OECD)	12 316	10 379	14 917	404	-2.42%	7.84%
Mobile (OECD)	n.a.	1 023	2 344	240	n.a.	35.35%
PSTN (Nordic 5)	393	319	341	3.06%	2.97%	6.14%
Mobile (Nordic 5)	n.a.	111	199	7.90%	n.a.	21.26%
Mobile as a percentage of PSTN:						
Connections (OECD)	n.a.	1.14%	2.17%	3.06%	n.a.	n.a.
Connections (Nordic 5)		3.95%	6.34%	7.90%	n.a.	n.a.
Shipments (OECD)	n.a.	9.86%	15.71%	24.46%	n.a.	n.a.
Shipments (Nordic 5)		34.90%	58.33%	59.44%	n.a.	n.a.

Notes: "Nordic 5" refers to Denmark, Finland, Iceland, Norway and Sweden.
"OECD" refers to the 24 OECD Member countries.
"Connections" refers to installed base of PSTN mainlines and subscribers to public cellular radio services.
"Shipments" refers to new PSTN mainlines or mobile subscribers connected during year.
Source: OECD, adapted from ITU Yearbook, Mobile Europe and PTO Annual Reports.

In order to test this "displacement" hypothesis, it is useful to look at shipments of new lines. In the Nordic countries during 1990 some 60 per cent of all new lines shipped were for the mobile service. This is much higher than in OECD countries as a whole (25 per cent). It appears that, with regard to shipments, most OECD countries are at the stage of market evolution reached by the Nordic countries in around 1985-86. This would be consistent with the the four/five-year head start the Nordic countries had over the rest of the world in starting a mobile service. Non-Nordic countries are also now increasing their mobile service at a much faster rate from a smaller base (mobile shipments increased by 35 per cent in the OECD as a whole, but only by 21 per cent in the Nordic countries between 1987-90).

When discussing time-series trends, it is easier to see their significance when drawn graphically. Figure 4.2 shows the growth of PSTN mainlines and mobile phone connections in the 24 countries of the OECD and the five Nordic countries. It also shows an estimate of the PSTN lines "displaced" by mobile phones. The assumption here is that PSTN lines in Nordic countries would have continued to grow at the same level as in OECD countries (3.5 per cent per year) if it were not for competition from mobile phones. "Displaced" PSTN lines are thus estimated to be around 60 000 new lines per year between 1987 and 1990. On the other hand, mobile PSTN competition can be shown to have produced extra revenues of around US$110 million per year (or US$8 per PSTN subscriber per year) which would have been lost if the Nordic countries had grown only at OECD rates (4.4 per cent per year). Such calculations do not take into account any cross-subsidisation that has occurred between mobile and PSTN services and the effects this may have had on demand.

Figure 4.2. **PSTN connections "displaced" by mobile phones in Nordic countries, 1987-90**



Source: OECD, adapted from ITU, Mobile Europe and PTO Annual Reports

In practice, because the main PSTN network supplier in the Nordic countries was also the main mobile supplier in these countries during the 1987-90 period, the extra revenue gained generally accrued to the same operator rather than being divided between different operators. However, in countries where competition between the operator of PSTN and mobile services is allowed, it is possible that PSTN lines displaced by the introduction of mobile services could represent a significant loss of revenue for the PSTN operator. In Sweden for instance, revenues from mobile communication services now provide around 12 per cent of Televerket's total revenue, even though mobile phones account for only 7.5 per cent of the installed base. Furthermore, mobile phone revenues are growing at a faster rate than Televerket's PSTN business. If Televerket is to "share" the mobile business with its two competitors (Tele2/Comvik and NordicTel) then some degree of revenue diversion may occur, if competition and lower prices do not stimulate demand sufficiently.

2. Tariff structures

One of the key reasons underlying the success of mobile communications in the Nordic countries has been the attractive pricing policy which has been followed. An example is provided by Denmark (Figure 4.3) where the start-up costs for a mobile phone user (connection and monthly rental) are actually cheaper than for a PSTN telephone. Admittedly, usage costs for national calls are set much higher for mobile phones (between 3.5 and 9 times higher) but the tariffs are structured in such a way as to encourage users who wish to make or receive calls from other Nordic countries to use a mobile phone.

Figure 4.3. **Mobile and PSTN charges in Denmark, January 1992**
(in Danish kroner including tax)

Charge	Mobile	PSTN
Connection charge	700.00	1 550.00
Monthly rental	80.00	99.67
Charge per minute:		
Local call	2.80	0.32
Suburban	2.80	0.375
Regional	2.80	0.47
Long distance	2.80	0.70
Off-peak discount	50%	50%
Call to Finland/Norway/Sweden to mobile	From mobile:	From PSTN:
to PSTN	2.80	2.80
	4.30	3.00

Note: Charges assume caller based in Copenhagen.
Source: Logica's TARIFICA tariff information service.

It is difficult to know whether or not this tariff structure is truly cost-based. On the one hand, it is logical for the start-up costs for a mobile service to be much lower than the PSTN as it is not necessary to lay or maintain any cables and therefore the operator's fixed charges are much lower. On the other hand, there is clearly some degree of distortion in the call charges, because Danish PSTN charges are distance dependent (with a large premium for international calls) while mobile phone call charges are not. Because any distortion of either PSTN or mobile call charges would consequently affect subscriber choices and calling patterns, the cost-price relationship and its possible effects requires further study for both services.

It will be interesting to see whether the low international call charges for the Nordic Mobile Telephone (NMT) system are extended to the countries of Poland and the Baltic States when they adopt their mobile communication systems. It will also be interesting to see what effect the introduction of competition (after March 1992) will have on TeleDanmark's tariff structure. Even though TeleDanmark currently has some of the cheapest mobile tariffs in the world (see Figure 4.4), it may nevertheless be forced to reduce its rates in line with those charged by its competitor, Dansk MobilTelefon which is a consortium owned by Great Nordic (36 per cent), Bell South (29 per cent), NordicTel (20 per cent) and Oeresund (15 per cent).

3. Tariff comparisons

One of the reasons advanced earlier for the disparities in the level of development of mobile communication services in OECD countries was the difference in tariff levels. It is to be expected that a cheaper service, especially for start-up costs, will grow faster than a more expensive service. The evidence on mobile prices gathered in Figure 4.4 appears to back this up. The countries with the cheapest service are dominantly those with the highest level of penetration, notably the five Nordic countries plus Switzerland. The correlation coefficient between a low tariffs environment and a high mobile penetration rate is reasonably high (R-squared = 0.32).

Figure 4.4. **OECD basket of mobile communication service charges, January 1992**
(Value express average annual spending by a business user,
in 1991 US$ PPPs, excluding tax)

	Fixed charge	Usage charge	Total	Ranking (lowest=1)
Australia (AOTC)	380.25	719.05	1 099.30	9
Austria	388.49	948.65	1 337.14	10
Belgium	484.69	885.04	1 369.74	12
Canada (Bell Canada)	374.92	634.16	1 009.09	7
Denmark (KTAS)	103.32	577.89	681.21	2
Finland (HTC)	120.35	778.18	898.53	4
France (Radiocom 2000)	929.56	1 168.35	2 097.91	21
Germany (DBP)	440.99	1 880.25	2 321.23	22
Greece	n.a.	n.a.	n.a.	
Iceland	87.96	364.40	452.36	1
Ireland	462.96	1 178.91	1 641.88	15
Italy	461.76	893.36	1 355.12	11
Japan (NTT)	821.33	1 065.19	1 886.52	18
Luxembourg	1 526.72	949.24	2 475.96	23
Netherlands	492.21	997.17	1 489.39	13
New Zealand (TCNZ)	511.54	984.60	1 496.14	14
Norway	159.14	755.60	914.74	5
Portugal	660.60	1 311.90	1 972.50	20
Spain	720.26	956.51	1 676.77	16
Sweden (Televerket)	93.37	846.36	939.73	6
Switzerland	377.98	381.74	759.72	3
Turkey	774.85	2 544.82	3 319.67	24
UK (Cellnet)	516.32	1 385.21	1 901.52	19
UK (Vodafone)	508.29	1 305.37	1 813.52	17
US (Nynex)	493.00	558.55	1 051.55	8
OECD[1]	494.89	989.79	1 484.68	

Note: This table shows charges for analogue cellular radio services in OECD countries. The basket is weighted so that fixed charges are one-third of total charges. The fixed charges include monthly rental plus one-third of initial connection charge. The usage charge includes a basket of 855 calls of different distance and duration made at different times of day or week. For full details of the methodology used, please see ICCP Series No. 22, *Performance Indicators for Public Telecommunication Operators*.
1. The average includes only Cellnet for the United Kingdom.
Source: OECD tarrif comparison model.

The data in Figure 4.4 represents an average annual subscriber bill for a cellular radio service and the basket has been calculated following the methodology established in the OECD's earlier work on performance indicators for PTOs (see ICCP Series No. 22). The methodology has been adapted slightly, (for instance, the user basket used for mobile services is equivalent to that used for national PSTN tariffs to facilitate comparisons) but is otherwise the same. The approach taken is to estimate a user's average annual bill on the basis of the installation charge (amortised over three years) the line rental, and a basket of calls (910) of different distance and duration, made at different times of day or week. The call distribution matrix is estimated from observed call patterns in a number of OECD countries.

The striking feature about mobile tariffs is the wide range of variation in OECD countries: between US$468.12 per year for Iceland (30 per cent of the OECD average) and US$3 429.72 for Turkey (223 per cent of the OECD average). This range of variation is also quite considerable in the PSTN business basket, shown in Figure 4.5 for which the cheapest country (Iceland again) is 24 per cent of the OECD average while the most expensive country (Turkey again) is 248 per cent of the OECD average. It is also instructive to compare the rankings of the different countries:

-- Austria, Australia, Ireland and Switzerland have relatively cheaper mobile services;

-- Belgium, France, Germany and the Netherlands have relatively cheaper PSTN services.

Figure 4.5. **OECD basket of business telephone charges, January 1992**
(Values express the average annual spending by a business user,
in 1991 US$ PPPs, excluding tax)

Country	Fixed charges	Usage charges	Total	Ranking (lowest=1)
Australia (AOTC)	253.75	936.97	1 190.72	16
Austria	155.40	1 205.38	1 360.78	20
Belgium	121.94	598.56	720.50	7
Canada (Bell Canada)	330.00	595.55	925.55	10
Denmark (KTAS)	125.71	278.60	404.31	2
Finland (HTC)	224.01	342.54	566.56	6
France	153.65	903.00	1 056.65	14
Germany	134.26	907.92	1 042.1	13
Greece	73.13	849.68	922.80	9
Iceland	92.33	152.05	244.39	1
Ireland	210.53	1 045.95	1 256.47	18
Italy	176.99	1 164.66	1 341.64	19
Japan (NTT)	165.60	825.38	990.98	12
Luxembourg	n.a.	n.a.	n.a.	
Netherlands	150.84	330.29	481.13	3
New Zealand (TCNZ)	471.82	592.20	1 064.02	15
Norway	148.96	401.60	550.56	5
Portugal	160.82	1 370.03	1 530.84	22
Spain	159.20	1 088.48	1 247.77	17
Sweden (Televerket)	199.17	296.09	495.25	4
Switzerland	146.43	724.61	871.04	8
Turkey	150.44	2 343.68	2 494.11	23
United Kingdom (BT)	241.08	695.98	927.05	11
United States (NY/AT&T)	570.67	817.96	1 388.63	21
OECD average	200.73	802.92	1 003.65	

Note: The basket is weighted so that fixed charges are one-fifth of total charges. The fixed charges include monthly rental plus one-fifth of the initial connection charge. The usage charge includes a basket of 2 783 calls of different distance and duration made at different times of day or week. For a full description of the tariff comparison methodology, please see ICCP No. 22, *Performance Indicators for Public Telecommunication Operators.*
Source: OECD tariff comparison model.

If the mobile user basket is used with the same weightings and number of calls (2 783) as the PSTN basket, it produces an average annual cost of US$3 710.28 which would imply a cost premium for mobile services of 3.7 times against PSTN services (Figure 4.6). Interestingly, in December 1989 when this analysis was last carried out, the cost premium was also four times. This suggests that mobile tariffs are still at a premium relative to PSTN tariffs, although the gap is narrowing. The table shows that in some countries, such as Germany or the Netherlands, the price differential between mobile and PSTN services is between six and eight times. Elsewhere, notably in Australia, Switzerland, Austria and Italy, the differential is three times or less. There is no obvious explanation for these differences in pricing policy between countries and they reinforce the suspicion that mobile tariffs are rarely cost-based, despite the introduction of competition in some countries.

Figure 4.6. **Comparison of mobile and PSTN charges, January 1992**

Country	Mobile tariff basket	PSTN business basket	Mobile as a percentage of PSTN basket
Australia	2 721.79	1 187.96	229.12
Austria	3 298.38	1 357.22	243.02
Belgium	3 366.78	718.74	468.43
Canada	2 440.04	923.79	264.13
Denmark	1 985.18	403.49	492.01
Finland	2 654.44	565.55	469.36
France	4 734.22	1 053.99	449.17
Germany	6 563.89	1 039.50	631.45
Greece	n.a.	920.30	n.a.
Iceland	1 274.61	298.35	427.22
Ireland	4 302.02	1 253.39	343.23
Italy	3 370.92	1 338.21	251.90
Japan	4 290.06	988.55	433.98
Luxembourg	4 617.85	n.a.	n.a.
Netherlands	3 739.45	480.16	778.79
New Zealand	3 717.82	1 062.27	349.99
Norway	2 619.71	549.37	476.85
Portugal	4 932.72	1 526.81	323.07
Spain	3 835.09	1 244.56	308.15
Sweden	2 849.50	494.38	576.38
Switzerland	1 621.10	868.90	186.57
Turkey	9 061.89	2 487.21	364.34
UK (Cellnet/BT)	5 027.15	935.00	537.66
United States	2 311.87	1 386.22	166.77
OECD	3 710.28	1 003.65	369.68

Note: This table shows the mobile tariff basket recalculated so that it has the same number of calls as the business PSTN basket (*i.e.* 2 783). In other words, it allows for a comparison of what the same user would pay for the same calls made from either a mobile phone or a fixed-link telephone. The final column shows the premium that the mobile phone user must pay.
Source: OECD tariff comparison model.

Competition in the telecommunication field can take many forms including competition between technologies (*e.g.* mobile versus PSTN; analogue versus digital; cellular versus micro-cellular) as well as between players. For this reason, it is the tariff structure of individual services relative to each other which is significant rather than the absolute level of prices. Furthermore, the trend in prices (downwards) and the perception of future price expectations in customer's minds is just as important as the current price structure. Mobile operators can already (in principle) offer calls to other mobiles in the same area (*i.e.* calls that stay on the same network) that are as cheap or cheaper than equivalent PSTN calls. However, at present, the majority of calls orginating on mobiles are routed to the fixed-link network thereby involving an interconnection charge. It is therefore appropriate to look at the relationships between the tariff structures of different services, in particular the interconnection prices between mobile and PSTN operators.

4. Interconnection prices

One of the major determinants of the degree to which mobile services are able to compete directly with PSTN services is the interconnection price. This may be defined as the payment made by the mobile operator to the PSTN operator for the termination of the call. The interconnection price will be a "cost" to the mobile operator but will be "revenue" to the PSTN operator. In the early years of development of a mobile service, the traffic flow between mobile and the PSTN will most likely be unbalanced in favour

of mobile as a sender of calls and PSTN operators terminating more calls. For this reason, the negotiation of interconnection agreements is critical to the economic viability of the mobile operator.

In countries where there is only a monopoly public provider of both mobile and PSTN services, the question of interconnection prices is largely academic. However it has become a major regulatory issue in those countries where competition has been allowed. A number of different approaches have been taken in OECD countries with different bases of calculation for the interconnection price. For instance it might be based on:

-- the full price of an equivalent PSTN call from the receiving exchange to the receiving party, including the local call component and a long distance component if necessary;

-- a proportion of the full price of an equivalent PSTN call;

-- the full price of the local call component only;

-- a proportion of the price of the local call component;

-- a fixed payment between operators which is independent of traffic volume.

As part of the on-going work on this project, Part B of this report provides a study of interconnection agreements which exist in OECD countries and the role they have played in promoting or retarding competition.

V. POLICY REVIEW

1. Policy issues

The discussion above has noted certain divergences in the policies adopted by OECD Member countries towards mobile communication services and the degree of competition which has been allowed. This chapter focuses on the main decisions which OECD policy-makers have had to make and poses specific questions to individual countries concerning those decisions. Responses from countries received by 1 May 1992 are summarised in Section 5.3.

The main decisions which policy-makers and regulators face may be summarised as follows:

-- Which technologies should be licensed (*e.g.* private mobile radio, analogue cellular radio, digital cellular radio, public cordless systems, micro-cellular systems) and what spectrum allocations should be assigned to each?

-- How many operators should be licensed in each service area and what degree of cross-sectoral service provision (*e.g.* provision of fixed-link as well as mobile services) should be permitted?

-- What criteria should be used for selecting operators?

-- What licensing conditions should be applied (*e.g.* geographical coverage, quality of service targets, price regulation) and what penalties should be imposed on operators that fail to meet licensing conditions?

-- What should be the role of the regulator in overseeing the establishment of interconnection prices between mobile operators, and between mobile operators and the PSTN service provider? Should the regulator specify conditions for transparent interconnection? If so, what conditions?

The role of the regulator is limited in that it cannot create markets or generate growth directly since, ultimately, markets are driven by demand. Nevertheless, the regulator can open or close market opportunities and has the responsibility for specifying an appropriate market structure, including the number of operators.

2. Market structure models

Within OECD countries, it is possible to identify a number of alternative models for market structures.

The Nordic model of *regional co-operation* has probably been the most successful in terms of market growth, technology development and attractive pricing of services. The Nordic Mobile Telephone (NMT) system has also been one of the most widely exported and copied systems internationally.

However, the Nordic model was originally developed in the context of a quasi-monopoly. Each of the operators in the original system:

-- TeleDanmark;
-- Telecom Finland;
-- Icelandic P&T;
-- Televerket (Sweden);
-- Norwegian Telcom;

also operates the fixed-link network. They were also free (initially) to cross-subsidise the development of mobile communications from their PSTN revenues, though latterly mobile services have proved highly profitable and have not required any ongoing subsidy. It is not clear to what extent this regional co-operation will survive the changeover to a digital, Europe-wide system (GSM) and the licensing of second operators (three operators in Sweden). Certainly it is to be hoped that Nordic users continue to benefit from wide-area roaming and low prices. However, mobile operators should not be subsidised by PSTN users and therefore it is necessary to create an equitable framework for functional separation between mobile and PSTN operations. The mobile operations of the PTOs of this region should pay interconnect prices which are equal to those offered to their competitors.

The second possible model in OECD countries is that of licensing two operators in each region (*regionalised duopoly*). This has been adopted as the interim policy in North America where the existing fixed link operators have been given a privileged position in gaining a local licence automatically, while a second operator has been selected either by comparative public hearings or by lottery. The US policy guarantees an existing wireline operator a cellular license in a particular market. However, in some instances, a market may contain more than one wireline operator, which will force a lottery if a partnership is not formed among the eligible wireline operators. In practice, a traded market has developed in cellular radio licences with license holders selling to the highest bidder. As cellular licences have grown in value there has been a degree of consolidation and license value rationalisation. Prices for traded licences tend to be based around a certain value per potential subscriber (or "price per pop"), typically around US$200-300 per head, in the franchise area. While the price paid for a licence in the secondary market covers the investment, if any, by the initial franchise owner, it also includes an element of windfall gain which approximates to the market value of spectrum in that area. While these licenses are currently being traded at prices that may seem dear, their market value is essentially a reflection of rising demands on spectrum and phenomenal growth in cellular services in the United States. It should be noted that the United States does not advocate a duopoly model as a long-term approach, and plans to ultimately move from its interim duopoly policy toward expanded competition. The spectrum constraints are viewed as requiring the present policy. However, it is not clear whether spectrum pricing would be applied retroactively to existing franchises or just to new market entrants.

A third model is the UK approach of licensing *competing technologies*. There are currently five main voice mobile technologies in competition with each other in the United Kingdom:

-- Analogue cellular radio (TACS 900), for which two operators (Vodafone Ltd. and Cellnet Ltd.) were licensed in 1985;

-- Digital cellular radio (GSM), for which the licensees are the same as for TACS 900. Vodafone is now offering a GSM service; Cellnet is not expected to begin service before 1994;

-- Private Mobile Radio (PMR), for which there is currently one company offering a nationwide service;

-- Telepoint (CT2/CAI), for which four licensees were announced in January 1989. Three licensees withdrew from service, but the fourth, Hutchinson Personal Communications is now offering a nationwide service under the name "Rabbit";

-- Personal Communication Network (PCN), for which three licensees were announced in December 1989. Two of the licensees merged, leaving Mercury Personal communications who will be launching their service this summer (1993) in the London area, and Hutchinson Microtel who will launch on a nationwide basis in the spring of 1994.

The great advantage of the UK approach has been that it has enabled market-makers rather than policy-makers to decide which technologies will thrive and which will flop. In this sense, the UK experience has been keenly observed by other countries as a seedbed of new technologies. However, it is generally acknowledged that the big disadvantage of the UK approach is that technologies have been pushed to market before they were sufficiently mature. In the case of Telepoint in particular, the choice to licence the service before a common standard had been agreed has had the effect of giving the technology a poor market reputation which is difficult to overcome at a later date. A parallel can be drawn here with the decision in the late 1970s to create an operational videotex service, based on the Prestel standard which was subsequently overtaken by alternative systems.

Figure 5.1. **Cellular radio networks: Operators, market status, technology and start-up dates**

Country	Operator	Status	Start-up date	Technology
Australia	Telecom Australia (Mobile Net)	AMPS[1] monopoly	1987	AMPS/TACS
	OPTUS communications	Digital	1992	GSM
	Vodafone	competition	1993	GSM
Austria	OPT	Monopoly	1984	C 450
			1990	NMT 900
Belgium	RTT	Monopoly	1987	NMT 450
Canada	Stentor (Cellnet Canada) Cantel Inc.	Regionalised duopoly with national coverage	1985	AMPS/TACS
Denmark	Telecom Denmark	Analogue monopoly	1981 1987	NMT 450 NMT 900
	Dansk MobilTelefon	GSM duopoly	1992	GSM
Finland	Telecom Finland	Analogue monopoly	1982 1987	NMT 450 NMT 900
	Radiolinja	GSM duopoly	1991	GSM
France	France Telecom (Radiocom 2000)	Analogue duopoly	1985	Radiocom 2000
	SFR		1990	NMT 900
		GSM duopoly	1992	GSM
Germany	DBP Telekom	Analogue monopoly	1986	C 450
	Mannesmann Mobilfunk	GSM duopoly	1991	GSM
Greece	Panafon Stet Hellas	GSM duopoly	1994	GSM
Iceland	P&T Administration	Monopoly	1986	NMT 450
Ireland	Telecom Eireann (Eircell)	Monopoly	1985	TACS 900
Italy	SIP	Analogue monopoly	1985 1990	RTMI TACS 900
	Planned 2nd operator	GSM duopoly		
Japan	NTT 12 other countries	Regionalised competition	1985	NAMTS - MCCSS - HCATS
Luxembourg	P&T Administration	Monopoly	1985	NMT 450
Netherlands	PTT Telecom Netherlands (ATF2, ATF3)	Analogue monopoly	1985 1989	NMT 450 NMT 900
	Planned 2nd operator	GSM duopoly		
New Zealand	Telecom New Zealand + 4 others	Open competition	1987	AMPS/TACS
Norway	Norwegian Telecom	Analogue monopoly	1981 1986	NMT 450 NMT 900
	Netcom GSM	GSM duopoly	1993	GSM

Figure 5.1. **Cellular radio networks: Operators, market status, technology and start-up dates** (cont'd)

Country	Operator	Status	Start-up date	Technology
Portugal	TP/TLP	Analogue monopoly	1989	C 450
		GSM duopoly	1992	GSM
Spain	Telefonica	Analogue monopoly	1986 1990	NMT 450 TACS 900
	2nd operator planned	GSM duopoly		
Sweden	Televerket	Open competition	1981 1986 1989 1991	NMT 450 NMT 900 NMT 900/GSM GSM
Switzerland	Swiss PTT (Natel C)	Monopoly	1987	NMT 900
Turkey	DG of PTT	Monopoly	1986	NMT 900
United Kingdom	Vodafone Cellnet	Duopoly until 1991	1985	TACS 900
			1992	GSM
United States	Seven RBOCs others	Regionalised duopoly (interim policy)	1983	AMPS

1. The three Australian mobile carriers are able to compete in the supply of analogue services using AOTC's network. AMPS can also be resold by non-carriers. Digital services will also be eligible for resale.

A fourth model which has emerged is the *competitive market entry* approach adopted in Japan and New Zealand. In these countries multiple operators have been licensed with regional and/or national franchises. Significantly, both Japan and New Zealand are islands and therefore the choices which they make on frequency allocation are a great deal more free than would be the case for a land-locked country with close neighbours. In Japan there are currently eight operators offering cellular radio, three offering marine radio and one, Japan City Media Inc., offering digital mobile transmission in Tokyo. For analogue systems, a maximum of two operators are allowed in each region although multiple operators have been allowed digital systems. In March 1991, just over one-third of the 868 078 subscribers to cellular radio in Japan were with the new market entrants.

In New Zealand, four new licensees for cellular radio were opened to tender in 1990 by auction with franchises of 20 years on offer. The procedure adopted was "second price" auctions (so-called Vickrey auctions) in which the highest bidder wins but pays the price bid by the second highest. However, this procedure has been criticised because of the enormous disparities between the bids offered and also because no reserve price was set. Bell South, for example has paid NZ$ 25.2 million for a "management right" to a portion of the spectrum whereas Telecom Cellular paid only NZ$ 5 000 for an equivalent right.

3. Policy questions

The four models listed above:

-- regional co-operation;
-- duopoly;
-- competing technologies;
-- and competitive market entry;

show the diversity of policy responses in OECD countries. The current situation is summarised in Figure 5.2 which shows the market structure status in OECD countries.

Figure 5.2. **Summary table of market structures for mobile services**

Structure	Number	Countries
No competition (monopoly)	7	Austria, Belgium, Iceland, Ireland, Luxembourg, Switzerland, Turkey
No analogue service, GSM duopoly	1	Greece
Analogue monopoly, GSM duopoly promised but no 2nd licensee chosen	3	Italy, Netherlands, Spain
Analogue monopoly, GSM duopoly, 2nd licensee chosen	5	Denmark, Germany, Finland, Norway, Portugal
Analogue duopoly, GSM duopoly, 2nd license chosen	1	France
Interim duopoly	2	Canada, United States
Regional duopoly for analogue; open competition for digital	1	Japan
Three or more competitors	4	Australia, New Zealand, Sweden, United Kingdom

Note: For full description see Figure 5.1.
Source: OECD.

It can be seen from this summary table that there are various degrees of competition in a range which runs from no competition (monopoly) to open competition. A second feature is that many countries permit competition only in digital services. This can be justified in countries where spectrum is scarce but is difficult to explain elsewhere. Policy-makers have therefore been invited to respond to some specific questions and to provide additional information about their own choices.

Question to Austria, Belgium, Iceland, Ireland, Luxembourg, Switzerland and Turkey:

> Why has no competitor to the PTO been licensed? If the reason is the small size of the subscriber base; how big does the subscriber base have to be before a second operator is licensed?

Austria: (Response received from the Austrian Ministry for Public Economy and Transport)

About one-third of the total system cost of the Austrian "C" (450) and "D" (NMT 900) mobile services are related to infrastructure (*e.g.* mobile-services exchanges, radio stations), two-thirds to handset equipment. Taking that fact into account it has been possible to achieve a very favourable cost situation -- and attractive charges -- by liberalising the handset market (at the moment more than 110 different handset types from about 20 producers can be used).

Therefore it can not be expected that licensing competitors to the Austrian PTT would bring additional benefits for consumers.

In addition to that, due to its geographic situation, Austria has to pay attention to the resulting special problems of spectrum allocation.

The situation in the Austrian mobile services sector proves that monopoly structures do not necessarily lead to the use of inefficient technologies or to a slow service start-up and an inadequate investment.

Question to Finland, Germany and France:

> Why has only one additional GSM operator been selected?

Finland:

In Finland there are at present three GSM operators. The operators are Telecom Finland, Radiolinja Ltd. and Alands Mobiltelefon, Ltd. The latter is a regional operator and provides GSM service in the Province of Ahvenanmaa. At the moment there are some 5 000 GSM subscribers in Finland and the amount is quickly rising. The operators mentioned are so far the only ones that applied for a licence. The Finnish government has not in any way limited the amount of GSM licences nor has it rejected any GSM licence applications.

France: [Response received from General Directorate for Regulation (DRG) of the Ministry of Post and Telecommunications].

One additional GSM operator was selected for two reasons:

-- to achieve economies of scale, taking account of available frequency bands;
-- to stimulate the commercial development of the market by SFR, the private operator, and France Télécom, the public operator.

Germany: (Response received from German Ministry of Post and Telecommunications)

Two GSM networks are currently being established in Germany; DBP TELEKOM's D1 network and Mannesmann Mobilfunk's D2 network. Mannesmann Mobilfunk has been licensed for this. DBP TELEKOM, by virtue of its special position (a special asset of the federal government), does not require a licence. The licence provisions applicable to Mannesmann Mobilfunk's D2 network have been set out in administrative rules which also regulate DBP TELEKOM's D1 network. There are no plans for a third operator in the band 890-960 MHz set aside for GSM.

The BMPT has announced plans to tender a nationwide licence for pan-European digital cellular services in 1992. This licence will then entitle the holder to set up and operate a nationwide cellular network based on DCS 1800 in the 1.8 GHz band.

Question to Denmark, Norway and Portugal:

> Why has the choice of second GSM operator been delayed? Has this given a competition advantage to the PTO?

Norway: (Response received from Norwegian Ministry of Transport and Communications)

There are two main reasons why it took so long to licence a second GSM operator. Firstly, we had to go to the parliament with a paper suggesting that a second operator should be allowed, and get the parliament's approval. Then we had to implement a procedure of competition between two of these applicants and the process of picking the winner was very difficult.

This has of course led to a certain delay in the second operator's planning. The procedures and criteria for type-approval (internationally) have also been delayed and sale and marketing has not yet started. The activities of 1991 on GSM have been concentrated on testing systems and other pre-operational activities that all operators will benefit from. Taking this into consideration, we do not think that the delayed decision has given Norwegian Telecom a competitive advantage.

Question to Italy, Netherlands and Spain:

> When will a second mobile licence be awarded? Will this be for analogue as well as for GSM? Why has there been such a delay?

Italy: (Response received from STET)

The Concession from the Italian Government to the STET Group establishes a monopoly regime for the provision of all telecom services (including mobile communications), until the year 2004. The problem of a second licence should be, in any case, negotiated in order to reach a satisfactory solution for the licensee and the government.

Netherlands: (Response received from the Ministry of Transport and Public Works)

When will a second GSM-licence be awarded?

The process for amending the Telecommunications Act has started. The change will come into effect by the end of 1992 ("best estimate" depending on parliamentary priorities). The subsequent selection process will take approximately eight months. The GSM licences could then possibly be awarded by mid-1993.

Will this be for analogue as well as GSM?

The new regulatory system will initially only apply to GSM and ERMES. Later on, a decision will be taken on other digital public mobile systems, such as DCS 1800 or FPLMTS/UMTS. There will be an arrangement for the analogue system NMT-900 to be gradually phased out. The reason is that GSM (when introduced on a broad basis) and NMT-900 cannot co-exist because of the scarce availability of frequencies.

Why has there been such a delay?

The Telecommunications Act was thought to be very liberal when it entered into force on 1 January 1989. In drafting it in 1988, it was not anticipated that developments would be as fast as they have proved to be, especially in the area of mobile telecommunications. In the years 1989 and 1990, there was no political support for changing this Act so soon after it had entered into force.

Question to the United States and Canada:

What arrangements will be made for licensing digital services? How many operators will be permitted?

United States: (Response received from National Telecommunications and Information Administration)

Existing cellular services are beginning to shift from analogue to digital without changes in the current licensing scheme. The FCC is currently conducting a rule-making proceeding to determine the licensing arrangements for Personal Communication Services (PCS) which are anticipated to be digital. The FCC is addressing issues such as the geographic extent of the licences, the number of licencees in each area, and the spectrum included in each license.

Canada: (Response received from Department of Communications)

Cellular services are due to shift from analogue to digital starting in 1992 with no change in their current licensing regime. With respect to Personal Cordless Telephony, all proposed services will be digital in nature. The licensing regime and the number of licensees in each operating territory, or the country, has yet to be determined.

Question to Australia, New Zealand, Japan, Sweden and the United Kingdom:

> How many operators will be licensed to provide mobile services? How was this number chosen? What criteria have been chosen for the selection of operators?

Australia: (response received from the Department of Transport and Communications)

At present in Australia, each of the carriers -- AOTC (now known as TELSTRA) and Optus -- have been granted mobile licences. Arena GSM was licensed in 1993. The Government has also decided to issue no further mobile licenses until 1997. A third public mobile licence will be issued by December 1992, for commencement of services in July 1993. The issue of any additional mobile licences will be considered in 1995.

The issue of three licences was considered to be the most economically-feasible number for the Australian market as the first step to a fully competitive environment. Similar criteria to those used to select Australia's second telecommunication carrier are being used to select the third public mobile operator. These criteria include considerations of contribution to development of Australian industry, financial soundness and a "fair and reasonable price".

Under the Telecommunications Act 1991, mobile carriers are issued with mobile telecommunication licences as the primary suppliers of public mobile telecommunication services (PMTS) (in contrast to resellers). Mobile licences allow the carriers to provide PMTS in accordance with AUSTEL's standards but will restrict Optus and the third mobile licensee's use of analogue services to the sale of capacity acquired from AOTC. The licences stipulate the government's expectations regarding rights and privileges which carriers will extend to each other, to consumers and to other parties.

A service will only be a PMT service if it is offered to the public generally. By definition, PMT services are differentiated from other cordless services, such as CT2, by the existence of fixed-base stations and cell handover capabilities.

In relation to Public Access Cordless Telephone Systems (PACTS), the Australian market is open to any number of operators who meet the requirement of the class licence. It is only in relation to PMTS operators that a limitation on the number of operators is enforced through regulation.

General carriers (*i.e.* Telecom and Optus) have the right to be the primary suppliers of satellite services. Satellite services, including mobile satellite services, are eligible for resale by mobile carriers (Telecom, Optus and Vodafone) and service providers.

Public mobile services with restricted PSTN interconnection (*e.g.* private mobile radio, public access mobile radio) can be supplied under a class licence and selection criteria do not apply. There are no limits on the number of PMR or PAMR carriers.

New Zealand: (Response received from the Ministry of Commerce)

The assumption in this paper seems to be that "mobile services" are considered to be essentially "cellular" or PSTN-connected services. This is not the case in New Zealand and many other countries where a wide variety of mobile services, some with limited forms of PSTN connection, existed before cellular radio and continue today.

With regard to cellular services, New Zealand recognises that there are effectively two "standard frequency allocations":

-- 800 MHz used for AMPS (analogue) and shortly digital services;
-- 900 MHz used for TACS (analogue) and GSM (digital).

Accordingly, these bands, in the form of two sub-bands, give a total of four bands being made available. These represent all the spectrum which could be made readily available for cellular services, free of incumbent uses, in bands for which equipment is likely to be readily available internationally.

The actual spectrum holders may sub-divide, trade, or even use the bands for other services, but it is expected that four services will eventually result. However, if one operator purchases both bands, say both 800 MHz AMPS bands, there effectively will be only one operator in this area. The market effectively decides. However, the initial allocation, by a tender system, envisaged four operators.

United Kingdom: (response received from the Department of Trade and Industry)

The telecommunication market in the United Kingdom is open and deregulated. There is no set number of operators who will be licensed. In the case of mobile services, the availability of spectrum has limited the numbers of operators who have been licensed to provide particular services.

The United Kingdom has two operators of cellular mobile networks -- Cellnet (60 per cent owned by BT) and Vodafone. They currently operate analogue TACS networks, and will both also be implementing GSM in the United Kingdom.

In 1991, licences were also issued to provide services on Personal Communication Networks (PCN), which are based on the DCS-1800 standard, a variant of GSM. Three operators were originally licensed, in line with the availability of spectrum. Two merged in 1992, leaving two operators, Hutchison Microtel and Mercury Personal Communications.

In addition, the United Kingdom has six national paging networks, one national trunked public access mobile radio operator, over a dozen regional trunked public access mobile radio networks, and four operators licensed to provide mobile data services. A Telepoint operator, Hutchison Personal Communications, has been offering services since the spring of 1992 and continues to roll-out the network.

The criteria on which operators are selected have varied according to the type of sevices to be offered, but in general they have included the financial soundness of the business plan, the degree of commitment shown, the opportunities for promoting economic growth, the likelihood of early entry into service, technical expertise, and the managerial and operational competence of the applicant.

VI. CONCLUSIONS: PRINCIPLES FOR PROMOTING COMPETITIVE MARKET ENTRY

1. Mobile/PSTN competition

The research presented in this report has focused on issues of competition and complementarity between mobile communications and PSTN services. The main themes may be summarised as follows:

-- no real consensus in the choice of technologies, but rather a confusing array of competing and overtaking standards;

-- a wide degree of variation in the experience of market growth among OECD countries which shows little relationship to economic wealth, but rather is dependent upon regulatory and technical choices;

-- a range of market structures from monopoly to duopoly to almost unrestricted market entry;

-- large disparities between countries in the pricing structures for mobile services and a continuing premium price for cellular radio against PSTN services.

If this analysis is accepted, it would suggest that there is little agreement on policy directions for the development of mobile communications in OECD countries. The price for this lack of agreement is being paid, as ever, by users who find that their mobile phones are expensive to run, difficult to use in foreign countries and are rapidly being overtaken by newer, shinier technologies.

It is useful to return to the original question posed at the start of this report:

To what extent will mobile communication services eventually compete with, or substitute for, fixed-link telecommunication services in terms of tariffs, traffic and subscribers? For how long will mobile communications continue to be regarded as a complementary service to the traditional telephone?

The arguments developed in this report show that in some areas of the world, such as Scandinavia, mobile services may already compete for traffic and for potential new subscribers with PSTN services. Increasingly, too, this competition is being played out at the level of price comparisons as mobile operators introduce new pricing structures designed to encourage off-peak calling or to provide low cost service access (fixed charges) in return for higher call charges. Also, as the mobile user base grows, the proportion of calls which originate and terminate within the mobile network will also grow. Currently, these calls can be priced at a lower rate than calls which involve interconnection with the fixed link network. Several Scandinavian countries now have mobile tariffs aimed specifically at residential users and designated as "blue" or "red" tariffs. Similar schemes apply also in Canada, although there they are designated as "silver", "gold" or "platinum" pricing options.

In the United States, in its personal communication market trial, GTE has used an adaptive unit to replace the fixed-service loop with a wireless alternative. In this approach, all the in-place terminal equipment in the customers' premise continues to function as it did before, with the exception that the service is no longer carried to the central office over wires. Not only does the existing terminal equipment continue to function, but the customer does not have to change telephone numbers. As this technology is miniaturised and mass-marketed, it could lead to the replacement of today's wireline with wireless service.

The evidence from Scandinavia shows that while the rate of growth of new PSTN *mainlines* has slowed down under the influence of competition from mobile communications, the rate of growth in total telecommunication *revenue* has actually been much faster than in the rest of the OECD. Thus it can be seen that rather than being detrimental to the PSTN, competition from mobile has actually produced a bigger total market, in terms of traffic and revenues, in which both sectors have benefited, albeit with a declining share attributable to fixed link systems. In other words, competition has promoted complementarity.

A further example of competition promoting complementarity can be seen where mobile operators provide local network access for long-distance network operators as happens, for instance, in Japan. In this case, the two forms of New Common Carrier (mobile and long-distance) are exploiting different technologies (radio and fibre) in such a way as to provide effective competition against the primarily copper-based network of the incumbent. In the United States it is generally believed that, for the foreseeable future, cellular services will continue to be complementary. Cellular service is not currently viewed as an economic choice for business users when an acceptable wireline connection is available.

It is important to stress that the issue of competition versus complementarity is a short- to medium-term question and which ultimately will be only determined empirically. In the longer term, it is difficult to predict what technological mixture (*e.g.* radio-based or terrestrial-based) will be used in the basic infrastructure. It is likely that radio-based and terrestrial-based technologies will in the future become more mixed, changing the overall characteristics of the PSTN.

In terms of market maturity, Scandinavia is probably three to five years ahead of other OECD countries. It seems likely therefore that other countries too will begin to experience mobile/PSTN competition in the near future, and policy-making should seek to promote this competition actively. However, the arguments developed in this paper show that under current conditions, many of the factors that actually determine the level of competition are not decisions of the marketplace but rather they are regulatory and technical decisions, specifically:

-- the selection and licensing of mobile operators;
-- the choice of technology;
-- the allocation of spectrum to each technology and to each operator;
-- the degree of separation in financial accounting between PSTN and mobile operations;
-- the interconnection price agreements between mobile and PSTN operations.

Generally, market-based decisions with respect to the selection of technology and operators prove more durable than those imposed by regulators. So what basic principles should policy-makers follow with respect to the mobile communication market?

2. Principles for competitive market entry

The following seven guidelines are proposed in this study:

i) Competition provides the best platform for market growth and development

Of the 24 OECD Member countries covered in this report, 17 now allow some form of market competition in the provision of mobile communication services (Figure 5.2). Seven other OECD countries have retained monopolistic market structures in which the monopoly rights of the fixed-link operator are presumed to extend also to the provision of mobile services. For the most part, these countries have small market sizes which may not be sufficient to sustain a competitive operator (e.g. Iceland, Ireland, Luxembourg), or alternatively they are land-locked countries (*e.g.* Austria, Switzerland) which enjoy less freedom to allocate spectrum than free-standing countries. Four other countries (Italy, the Netherlands and Spain) have announced their intention to permit competition, at least for digital (GSM) cellular radio, but have not yet licensed operators (except Greece) because this was not foreseen in their respective telecommunication laws.

Although competition as a principle may now be regarded as the norm in mobile communications in the OECD area, the actual level of effective market competition is disappointing. Only in North America, France and the United Kingdom does the competitor to the incumbent PTO control more than a token share of the market for analogue services. In other countries, competitive operators either entered the market much later than the PTO (*e.g.* in Japan, France, Sweden, Australia, New Zealand) or are restricted to competing in the (as yet non-existent) market for digital services.

It would be nice to be able to measure the effect of competition on market growth and development. In practice, it is difficult to disentangle the effect of competition from other factors affecting market growth, such as geography, spectrum availability, choice of technology, wealth of the potential users or the level of tariffs. The mobile market has also been affected to a much greater extent than other communication markets by intangible social factors which have either promoted the use of cellular phones (*e.g.* as a symbol of social status) or retarded their acceptance within society (*e.g.* the nuisance value of mobile phones). Consequently, it is difficult to quantify the benefits of competition.

What has been the effect of competition on market growth? For every market which has developed rapidly under competitive conditions (*e.g.* the United Kingdom, North America), it is possible to draw parallels with markets that have also grown rapidly under monopoly conditions (*e.g.* Scandinavian markets in the early 1980s; Italy since 1990). However, it is possible to make the following observations which favour competition as a promoter of market growth and development:

- -- countries which have introduced competition have usually experienced an acceleration of market growth (*e.g.* France after 1990; Japan after 1988). Furthermore, there are no analogue cellular markets where competition has been introduced which have grown at slower rate than the OECD average;

- -- monopoly structures are often associated with the choice of proprietary, home-grown, non-standard technologies (*e.g.* France, Germany and Italy before 1990) whereas countries which began with competitive structures have usually adopted standard technologies even if "not-invented-here" (*e.g.* UK adoption of TACS);

-- monopoly structures are often associated with slow service start-up and an inadequate investment in national coverage and service roll-out (*e.g.* Spain, Greece, Belgium).

These observations are generalisations and exceptions can be found where, for example, monopoly structures did not lead to a slow start-up or to the use of inefficient technologies.

One way of measuring the impact of competition is to track the different experiences of market growth in analogue cellular radio in those countries which permitted more than one market entrant against those that preserved monopoly status. Figure 6.1 shows that, from a similar starting point in 1986, the six OECD countries that allowed competition had a much higher average growth rate (58.4 per cent per annum 1986-90) than the 18 other OECD countries (41.7 per cent). Thus by the start of 1991, the penetration rate in competitive markets was much higher (46.2 mobile phones per 1 000 mainlines) than for monopoly markets (30.5). While this comparison is admittedly crude, nevertheless it strongly suggests that competition promotes market growth.

ii) Competition is the best market regulator

Competition is the solution for market regulation favoured by most economists because it serves to promote innovation, reduce prices and raise quality. Certainly, the value of competition between suppliers is evident in the handset equipment market which has been characterised by rapid adoption of technical improvements in handset design and a swift reduction in prices as volume production has been achieved. The benefits of competition are harder to prove in the service market, as noted above, because genuine competition is still relatively rare and because there are so many other factors involved, including technical, geographic and socio-cultural factors. Nevertheless, it is possible to make the following observations:

-- *innovation* is more evident in those countries which have adopted competition whereas countries which have retained monopolies have tended to follow trends set in other countries rather than to be pioneers. In particular, countries with competitive market structures have been more willing to experiment with new technologies (*e.g.* CT2 and PCN in the United Kingdom), new ways of selling cellular radio services (*e.g.* selling connections *via* "airtime resellers" in North America and the United Kingdom), and flexible pricing options to attract residential customers (*e.g.* Sweden, Canada);

-- the most expensive *tariffs* for mobile services are found in those countries which have retained monopolistic service structures for analogue cellular radio (*e.g.* Turkey, Luxembourg, Portugal, Spain, Germany);

-- operators which have to compete in competitive markets are generally more open about revealing details of their service *quality* (*e.g.* Vodafone in the United Kingdom, SFR in France). It is difficult to prove whether this quality is any higher than operators in monopoly markets for the obvious reason that the latter rarely publish quality statistics;

-- when introducing competition into a market in which there is an established incumbent, regulation in the form of competitive safeguards (*e.g.* interconnection rights, charges, numbering) may be appropriate.

Figure 6.1. **Growth of mobile phone penetration rates under competitive and monopoly conditions, 1986-90**

	1986	1987	1988	1989	1990	1986-90 CAGR [1]
Competitive markets[2]						
Penetration rate[3]	7.34	12.14	18.86	30.46	46.18	
Growth rate		65.3%	55.4%	61.5%	51.6%	58.4%
Monopoly markets[4]						
Penetration rate[3]	7.57	11.44	15.99	22.57	30.47	
Growth rate		51.2%	39.7%	41.2%	35.0%	41.7%

1. Compound Annual Growth Rate.
2. Canada, France, Japan, Sweden, United Kingdom, United States.
3. Analogue cellular phones per 1 000 telephone mainlines.
4. 18 other OECD countries.

Source: OECD Communications Outlook database.

iii) Mobile cellular radio and PSTN operations should be structurally and financially separated

If the arguments presented above in favour of competition as the best promoter of market growth and regulator of market development are accepted, then it follows that certain regulatory choices need to be made to ensure that the actual form which competition takes is as open and fair as possible. One key issue to be addressed will be the overlap between mobile and PSTN operations. Almost all fixed-link PTOs in OECD countries also offer mobile services and most hold a dominant market position in both PSTN and mobile services. Furthermore, because more than 90 per cent of traffic which originates on mobile phones is routed *via* the public network to subscribers on fixed-link telephones, incumbent PTOs have a stranglehold over the future development of mobile services. However, it is also likely that PSTN operators will, in future, offer radio-based access to the PSTN infrastructure where the cost equation does not justify installing land lines, for instance in remote or dispersed rural areas.

At the same time, policy-makers should be cognisant of the existence of economies of scope. A November 1992 FCC Working Paper entitled "Putting It All Together: The Cost Structure of Personal Communications Services", determined that a significant level of such economies exists between personal communication services (PCS) and telephone, cable television and cellular services. It could be argued that, all other things being equal, firms should be permitted to offer PCS and other services concurrently.

However, some PTOs have substantial market power. In those cases where the same operator offers both PSTN (fixed-link or fixed-cellular) and mobile (cellular radio) services, the two operations should be structurally, or at least financially, separated to protect against cross-subsidisation, if true market competition is to be allowed to develop. In particular, separation should be aimed at:

-- striking a reasonable balance between permitting economies of scope to be realised and preventing operational cross-subsidy from one service to the other which might otherwise allow an incumbent to compete unfairly with a competitor which offers only one type of service;

-- setting fair interconnection prices between mobile and PSTN services so that the prices paid by the mobile services subsidiary of an incumbent PTO are the same as those paid by its independent competitor;

-- creating transparency in terms of network intelligence and directory information so that the mobile services subsidiary of an incumbent PTO does not receive preferential treatment compared with its independent competitor.

Some evidence for the proposition that the principle of separation actually promotes market growth is provided by Canada. In the Provinces where cellular operations have been separated from the start of service (Ontario, Quebec, British Columbia), market growth has generally been more rapid even though the incumbent telephone companies have not been allowed to cross-subsidise market development by revenues from monopoly areas.

iv) The method for licensing operators should be open and transparent

Perhaps the most important decision that policy-makers have to make is which operators should be licensed to compete in the market for mobile communication services. This decision really breaks down into four separate choices:

-- which technologies to license?
-- how many operators to license?
-- which operators to license?
-- what level of ongoing regulation is required and for how long?

Arguably, the first two choices depend on the decisions adopted concerning mechanisms for spectrum allocation (see discussion below). However, the regulator cannot avoid responsibility for the third choice.

OECD countries have used four main types of decision-making processes for licensing cellular radio operators:

-- statutory obligations which confer automatic rights to exploit communication market opportunities on state-owned PTOs;

-- random selection, for instance through a lottery;

-- a "beauty contest" based on a comparative public hearing of the arguments of a number of potential candidates;

-- an auction based on an invitation to tender for a particular licence.

Given the fact that cellular radio, once past its incipiency, has proved to be a high growth, high profit market wherever it has been introduced, there is no shortage of contenders for the licences which have been offered. The US Bell Operating Companies, in particular, have used invitations to tender for NMT licences in Eastern Europe and GSM licences in Western Europe as a way of gaining a foothold in Europe.

There has been a frenetic pace of activity in forming and re-forming consortia to bid for the licences on offer. Yet the complaint heard most frequently is that the approval procedure does not produce a fair contest. Candidates for licences (usually those that are unsuccessful) complain that the criteria for approval are never stated clearly or that the conditions that the licencees must fulfil are defined in terms which are too vague to allow the candidate to put together a viable business plan. Each of the approval procedures suggested in the paragraph above are "legitimate", but the latter two (a beauty contest or an auction) are to be preferred. Most national approval procedures combine an element of each. An auction

tends to provide more transparency. Certainly, it is important to discourage speculators from participating in the process. This is discussed in more detail below.

v) The price of spectrum should reflect its true market value

Two of the most important choices that have determined the development of mobile communication service markets -- the number of operators and the choice of technologies to be licensed -- have tended to be made by regulatory bodies rather than by the market. This type of continued intervention may actually hinder market development by placing artificial constraints on competition and innovation. In taking responsibility for this decision away from the marketplace, regulators have hidden behind the supposed shortage of spectrum, arguing that this justifies their decision to impose artificial limits on the number of licencees and to impose technological choices.

Parallel work by the TISP Working Party on the economics of frequency allocation [see for instance OECD (1993), *The Economics of Radio Frequency*, ICCP Series No. 33, Paris] suggests that there is no real shortage of spectrum, just an inefficient system of allocation. With a few exceptions, notably New Zealand, most countries have retained a "first come, first served" method of allocation which means that latecomer technologies, of which mobile communications is a prime example, have had to fill whatever gaps remain in the least attractive portions of the spectrum. Most users pay only a fraction of the true market rent for the spectrum they control, and therefore have little incentive to become more efficient or to transfer unused portions of their spectrum allocation to other uses.

Countries are approaching the problem of spectrum reform armed with two main policies: spectrum pricing and spectrum auctions. Of these two alternatives, spectrum pricing fulfils some of the objectives of reform, for instance by placing an incentive on users to economise their use of spectrum, but it does little to alter the basic allocatory mechanism. Spectrum auctions for cellular radio represent a more radical alternative which has been employed successfully in New Zealand and Greece, and is now being considered in the United States, the United Kingdom and elsewhere. The underlying idea is to create a market in spectrum by defining tradeable property rights. Auctions also bring additional benefits such as maximising spectrum licence revenue, reducing the regulatory workload, potentially increasing the efficiency of spectrum usage and reducing delays in the selection and licensing of operators. If such a market-based mechanism were adopted, the problem of selecting a certain number of operators would largely solve itself. Potential operators could bid for as much or as little spectrum as they need to start a service. If they trade successfully, the value of their assets (*i.e.* their existing spectrum) will rise and they can bid for more spectrum. If they do not trade successfully, they can sell the spectrum they do not need to other bidders. Obviously, there would still be a need for some regulatory safeguards to protect against the misuse or abuse of spectrum, and to follow general ITU/CCIR guidelines on frequency planning, but at least the normal market processes of entrepreneurship, innovation and rationalisation would be able to operate freely. A market-based allocatory system should also resolve some of the regulator's problems about choosing between competing technologies. However, further analysis is needed with regard to how frequency auctions impact on competition, on the efficient use of frequencies, as well as the impact of frequency auctions on the standardisation of technology.

vi) Regulators should not attempt to impose particular technological choices on the marketplace

The supposed shortage of spectrum has also been used by regulators as a reason for preferring certain technologies over others. Unfortunately, regulators often make poor technical choices. An example of this is the way regulators in Europe have tried to "manage" the changeover from analogue to digital

cellular radio. Whereas, the introduction of analogue cellular radio in the early 1980s in North America (the Motorola-designed AMPS/TACS system) and Scandinavia (the Ericsson-designed NMT system) was achieved swiftly, the GSM standard has been "under discussion" now for over a decade and, even a year after its official "launch", there are still barely a handful of operational schemes. The GSM standard has proved to be so complex that it is beyond the capabilities of most type approval test houses. Furthermore, compared to other digital alternatives such as CDMA, GSM does not even represent a significant improvement in spectrum efficiency over conventional analogue alternatives. GSM will be squeezed between the continuing growth of analogue cellular system on the one hand and emergent technologies (such as PCN) on the other hand.

If a market-based mechanism for allocating spectrum is adopted, it should not be necessary for regulators to choose between competing technologies. Rather, businessmen with innovative new services to offer can express their faith in the commercial potential of the new service by bidding for spectrum. If required, some portions of the spectrum can be set aside for experimental services, but there must be an understanding that services which become commercially operational must move to other wavebands.

vii) Regulators should oversee licence conditions and the negotiation of interconnection agreements

The discussion above suggests relieving regulators of their responsibility for choosing which operators should be licensed for spectrum use and what technologies they should adopt. It might be inferred from this that the regulator will soon be unemployed. Nothing could be further from the truth. However, it is likely that the role of the regulator will change now that the mobile market is maturing and shifting towards a competitive basis.

Until the ideal of perfect competition can be achieved, the regulatory body will need to assume responsibility for two main tasks. Firstly, to set licence conditions that operators must fulfil according to a certain timetable; secondly, to oversee the negotiation of interconnection agreements both between mobile operators and PSTN operators and between competitive mobile operators.

If mobile licences are to be allocated by an open tender, then it is perfectly legitimate for the regulator to specify what conditions must be fulfilled. These might include, for instance:

-- a set time period during which the licence is valid and before it is reviewed or opened to a fresh invitation to tender. This period should be long enough to encourage investment, but short enough to allow flexibility and to encourage entrepreneurship. A period of 20 years, with a mid-term review after ten years, seems reasonable;

-- a commitment to international standards and to interworking with existing operators;

-- a timetable for the roll-out of a service with specific target dates for geographical coverage;

-- a forecast of minimum and likely levels of investment and a business plan showing the expected development of the service and the evolution of spectrum requirements over time;

-- an assessment of the tariff level that would be charged for the service and an agreement to reduce tariffs as the service matures;

-- setting targets for minimum quality of service and a commitment to publish quality measures on a regular basis.

Once a licence has been awarded, the regulator should continue to monitor whether or not these targets are achieved and, if necessary, should be prepared to impose fines or to review the conditions of the licence.

The regulator may also need to review interconnection agreements which are negotiated between mobile and PSTN operators. Because the PSTN operator is usually much stronger financially than a mobile competitor, it may impose interconnection prices which are too high or which favour the PSTN operators' own mobile subsidiary. While interconnection agreements should ideally be negotiated on a bilateral, commercial basis, the regulator may need to intervene to ensure fair-play. In particular, the interconnection tariffs offered should be based on a realistic assessment of the incremental costs of providing an interconnection service and should not be merely a profits tax on a smaller or weaker competitor. If necessary, the regulator should be prepared to define a formula that could be used for setting interconnection prices and a framework for periodic reviews. Regulators should also encourage the publication of interconnection agreements to promote transparency.

* * * * * * *

These guiding principles outlined above will not be sufficient in themselves to create a competitive market for the development of mobile services. That will require entrepreneurship, innovation, investment and marketing which no regulator can undertake because it is the responsibility of the market. The expansion of the mobile market will also require a much larger allocation of spectrum than is available at present in most OECD countries. Furthermore, none of the OECD countries really has the chance to "start from scratch", and all are faced with the problem of a powerful incumbent PSTN operator that can largely dictate the terms of operation to smaller mobile services competitors. In the short term, regulators may need to discriminate positively in favour of new market entrants in order to ensure that they have a fair chance of becoming established but, in the longer term, new market entrants must be able to prove their commercial viability. The goal should be to support market competition, not to sustain individual competitors.

One conclusion which does arise strongly out of the discussion above is the need for regulators initially to tackle a number of different areas of reform in tandem: frequency allocation, licensing conditions, interconnection agreements and the selection of operators being the most urgent. Nevertheless, if the principles suggested above are adopted, this should eventually lead to a market environment in which the regulator can afford to play a background role to the operation of normal market forces.

The analysis presented above has shown that mobile services can be both competitive with, and complementary to existing PSTN services. Indeed, the full benefits of competition will only be realised if mobile services are allowed to interconnect with fixed-link services on an equal access basis. The relationship is a symbiotic one in which mobile operators cannot exist without access to the fixed-link infrastructure and contribute more traffic (and therefore revenues) to the PSTN than they divert. The conclusion should therefore be that competition promotes complementarity, while complementarity aids competition.

Part B

REVIEW OF MOBILE/PSTN INTERCONNECT TARIFF POLICY IN OECD MEMBER COUNTRIES

I. SUMMARY

1. Introduction

The aim of this part of the report is to determine the tariff principles for interconnection between mobile communication networks and fixed-link networks. This paper presents a survey of interconnection policies in five OECD Member countries (Australia, Germany, Sweden, the United Kingdom and the New York region of the United States) and its findings are summarised below. As part of this study, a model has been developed that determines the likely effect of interconnect tariffing on the revenues expected by a mobile communication network operator.

2. Interconnection policy in OECD Member countries

The OECD Member countries covered in this study have generally tried to define cost-based tariffing principles for interconnect. The costs are defined as those costs that are directly attributable to the provision of interconnect together with other costs that reasonably vary according to the volume of interconnect traffic traversing the fixed-link network.

Although each country has adopted a different tariff schedule for interconnect, there is much in common between the basic structures. The key building blocks of an interconnect tariff are:

-- charges for the provision and operation of the point of interconnection;

-- charges for the use of the fixed-link network for transmission, switching and delivery of the call;

-- charges for supplementary services provided by fixed-link network operators that complement the network but are not directly related to the operation of that network for the carriage of traffic. An example is directory enquiries.

3. Inconsistencies in interconnect policy

The interconnection policies followed by the authorities in the OECD Member countries surveyed appears to be effective. Otherwise, mobile services would never have been able to develop as successfully as they undoubtedly have. The key to the success of current interconnect policy is that:

-- it relates to existing tariffing schemes and is therefore relatively familiar;

-- it provides encouragement and protection to new service operators against an incumbent service provider.

However, cost-based tariffs are very difficult to calculate and in most cases, the interconnect agreements in the OECD Member countries have used simplified tariffs. Before the actual level of tariffs can even be discussed, the operators involved must agree on:

-- mutually-acceptable tariffing practices;

-- the definition of attributable costs;

-- how to calculate these costs from different accounting bases.

In a competitive market this process can take a very long time and the delay can adversely affect the viability of the new operator. Future technical advances will probably require significant modification of existing interconnect policies in order for the full benefits of competition to be realised.

As mobile, and indeed fixed-link, services evolve, current interconnect policies will need to be reviewed to remove the nurturing protection that the new services have enjoyed. In the future, tariffing of interconnect should move away from traditional patterns of charging based on duration of use towards a regime based on the cost of supply of required network capacity. Although appropriate in an immature market dominated by one operator, the use of cost-based tariffs may also need to be reviewed as it restricts the owner of an asset to exploit that asset's revenue earning potential. Instead, interconnect should be controlled by the rules that affect other commercial transactions. The policies followed in the United Kingdom and in West Germany which encourage agreement by private commercial discussion will be important to efficient interconnect in an environment where the incumbent fixed-link network operator is no longer in a dominant position.

4. Recommendations

Following this study of the interconnect agreements in selected OECD Member countries, the following recommendations are offered:

-- The mobile and land-line operations of incumbent fixed-link operators should be structurally and/or financially separated and should be offered interconnect terms on an equal and equivalent basis to competing mobile operators.

-- In the short to medium term, interconnect agreements should be based on directly attributable costs with a reasonable rate of return on attributable assets.

-- In the longer term, flat-rate interconnect charges that relate to the level of fixed-link network capacity demanded might be considered rather than simple volume usage charges.

-- Private commercial negotiation of interconnect agreements between the operators concerned should be considered.

-- Regulators should give clear indications of the methodology that should be adopted for the negotiation of interconnect agreements. Formal mechanisms should be used if necessary to avoid lengthy discussion or delays.

-- Policy-makers should encourage the gradual shift towards market forces to determine interconnect charges, and therefore end-user prices, as the number and significance of market players grows.

-- The terms for interconnection should be cost-oriented, non-discriminatory and transparent.

II. INTRODUCTION

1. Background

One of the key issues identified in Part A of this report is the need to focus on the tariff principles of interconnection between mobile communication networks and fixed-link networks.

In particular, it is stated in Part A that the traffic flow between the mobile communication network and the public switched telephone network (PSTN) is likely to be unbalanced in favour of the mobile user as a sender of calls and the PSTN providing the call termination. As a result the format of the interconnect agreement will be critical to the economic viability of the mobile communication network operator.

2. Study scope and objectives

The aim of the study is to determine the impact of different interconnect tariffing policies on the viability of a mobile communication network operator. To achieve this end, Part B presents:

-- a review of the existing interconnect agreements used by the operators of fixed-link PSTN and mobile services in Australia, Germany, Sweden, the United Kingdom and the United States;

-- an analysis of the impact of different interconnect policies on the revenue that would be generated by a mobile communication network operator;

-- recommendations on the best practice policies for interconnect agreements.

3. Structure

Part B of this report is made up of seven sections. Section I provides a summary of the main findings and recommendations of the study. The other sections are as follows:

-- Section II describes the context of the report, the field of study and the objectives.

-- Section III reviews the status of mobile communications in the OECD Member countries and places them in the context of changes in the wider communication market.

-- Sections IV and V present the key issues in interconnection tariffing and review the current interconnection agreements in Australia, Germany, Sweden, the United Kingdom and the United States.

-- Section V explains the assumptions and the methodology used in developing an interconnection tariff model.

-- Conclusions and recommendations on best practice interconnection tariffing policy are presented in the final section, Section VII.

This part of the report is supported by appendices containing a copy of both the model and the algorithms used in preparing the interconnection tariff model.

III. BROADER ISSUES IN MOBILE COMMUNICATIONS

Mobile communications have been available for many years although it is only since the development of cellular telephony that it has been possible for a large number of people to have access to the service. It is the success of cellular telephony that has made mobile communications a critical issue for the future economic performance of the OECD Member countries.

The success of mobile communications has co-incided with fundamental changes in communication legislation. The transition towards an environment driven by market forces began in the early 1980s and is still progressing towards its conclusion. This section reviews the current status of mobile communications in OECD Member countries and addresses the implications of this transition on the developing industry.

1. Market overview

Mobile communications based on cellular and private mobile radio technology is available in all OECD Member countries with the exception of Greece, where the decision has been taken to circumvent the introduction of analogue cellular and to progress directly to a digital service based on GSM.

In the countries covered in this survey, it has been government policy to set up two or more mobile telephony providers so as to encourage competition between providers. In each case (except for Greece), the incumbent fixed-link network operator is involved in the mobile market either directly through a wholly-owned and operated subsidiary, or *via* an independent company affiliated with the fixed-link network operator through equity ownership. Figure 3.1 shows the providers in each of the countries and summarises the link between fixed-link and mobile operators.

2. The transition from monopoly to competition

The move from national monopoly to a competitive environment requires careful adjustment if disruption to key services is to be avoided. During the initial years of this transition, the market will be dominated by the organisation that was originally responsible for providing the monopoly service. The incumbent operator will not only dominate the market in terms of the number of subscribers connected, but also the volume of traffic that it handles. For example, Telecom Australia, the monopoly national operator at the time, served almost 9.5 million local exchange lines compared to 363 000 mobile connections. It also delivered a total of 9.9 billion calls during 1989, of which only 0.75 per cent were delivered to the mobile communication network. Traffic between subscribers to the mobile service was almost negligible and traffic from the mobile to the fixed-link networks is believed to amount to only 3.5 per cent of all calls during that year (see Figure 3.2). Given that the fixed-link network operator's capital costs have already been written off, the new operators in such a market are at a distinct disadvantage.

Figure 3.1. **Mobile operator status in selected OECD Member countries**

Country (operator)	Technology	Subscribers (market share)	Operator status
Australia			
MobileNet	AMPS	170 000 (100%)	Operated by fixed-link operator
Optus Communications	--	0 (0%)	Independent
Germany			
DBP Telekom	C-450 & GSM	340 000 (100%)	Operated by fixed-link operator
Mannesmann Mobilfunk	GSM	0 (0%)	Independent
Sweden			
STR	NMT-450/900 NMT-450	574 000 (96%)	Operated by fixed-link operator
Comvik	GSM	21 000 (4%)	Independent
Nordic Telecom		0 (0%)	Independent
United Kingdom			
Cellnet	TACS-900	541 000 (44%)	Equity ownership
Vodafone	TACS-900	695 000 (56%)	Independent
United States (New York region)			
NYNEX (Mobile Communications Company)	D-AMPS	300 000 plus (55%)	Affiliated to fixed operator
Cellular One	D-AMPS	250 000 (45%)	Independent

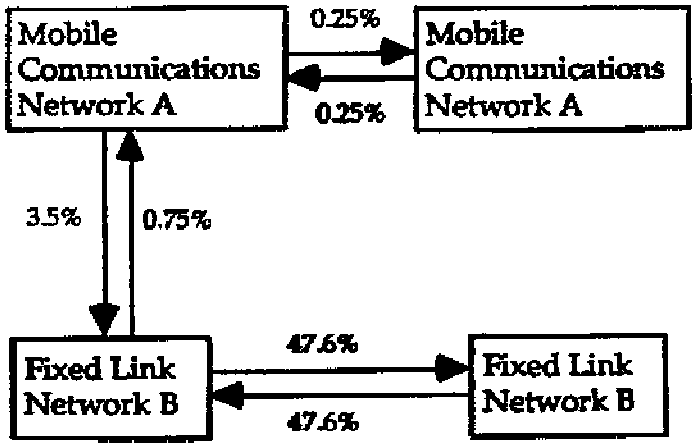
In addition, the incumbent operator is invariably involved in the mobile market, either as an active participant in one of the mobile operators or as the principal access to users of the fixed-link network. Frequently the fixed-link network operator was the first operator of a mobile communication network thereby gaining the double advantage of its fixed-link infrastructure and the early market opportunities. To permit the fixed-link network operator to provide mobile services without some curbs on its activities would stifle competition and obviate the main aims of introducing competition to the market. To enable competition in these unfavourable conditions, governments have chosen to impose limits on competition which facilitate both the independent mobile communication network operators and those affiliated to the fixed-link network operator to operate on equitable terms.

These limits take different forms in each country:

-- In the United Kingdom, the incumbent operator is forbidden from competing directly in the mobile market except through investment in a totally independent company.

-- In Germany and Sweden, the fixed-link network operator may operate a mobile communication network but its activities are subject to regulatory oversight.

Figure 3.2 **Traffic flows between fixed-link and mobile communication networks Australia -- Percentage of calls**



-- In the United States, a fixed-link network operator may operate a mobile communication network through a separate subsidiary. However, the fixed-link network operator must satisfy publicly-available regulatory conditions that will artificially ensure equal terms for both mobile communication network operators.

-- In Japan, NTT has been encouraged to divide its mobile subsidiary into regional units which have an arms-length relationship with the PSTN operations and are closer in scale to the size of NTT's regional mobile competitors.

The question of ownership of mobile network operators is important since ownership can influence market development and can have competitive implications. However, many Member countries have put in place safeguards to ensure that mobile operators owned by fixed link service providers do not have an unfair advantage. Since this study is aimed essentially at determining appropriate tariff principles for interconnection it is assumed that appropriate safeguards have been put into place to create a level playing field between competing operators. In addition to control of the fixed-link network operators' activities in the mobile communication field, interconnection between the fixed-link and the mobile communication networks is essential to the success of mobile communication networks. It is estimated that intra-network traffic on mobile communication networks accounts for less than 5 per cent of all traffic that originates from a mobile terminal. On average, 90 per cent of traffic that originates on mobile communication networks is for off-network destinations. Without the capacity to terminate calls on the fixed-link network, mobile operators would be unable to attract all but a tiny proportion of subscribers. It is essential therefore that mobile communication networks can connect to fixed-link networks and that this connection is:

-- agreed and instituted quickly; and
-- achieved at a reasonable cost to the mobile communication network operator.

Delay in agreeing and instituting interconnection between fixed-link and mobile operators can have a devastating effect on the viability of the latter organisation. Mannesmann Mobilfunk has calculated that delay in the provision of a full service costs DM 1 million (US$600 000) per day in wages and overheads to a mobile operator of a similar size. This figure does not include the lost opportunity that occurs in situations where a competing mobile operator might reach an interconnect agreement more rapidly because of commercial ties with the incumbent operator. In the case of Mannesmann Mobilfunk, agreement over interconnect charges has already taken over two years despite government intervention. This could have represented a considerable cost had it not coincided with a delay in terminal equipment approval which threatens to pose a greater threat to the new service.

The cost of interconnection is critical to the success of mobile operators. It is clear from the preceding discussion that access to the fixed network is essential for the bulk of mobile traffic and consequently to the levels of subscription to the service. Taking the example of Mannesmann Mobilfunk further, charges for interconnection can vary enormously depending upon the stance taken by each operator. The fixed-link network operator, DBP Telekom, proposed that Mannesmann should be charged the commercial rate for traffic and physical interconnect to its PSTN because Mannesmann was an end-user, albeit a high volume user. Mannesmann disputed the charges and the government has been forced to intervene. In 1992 it eventually imposed a tariff on DBP Telekom of 54 per cent and 79 per cent of the commercial tariff for leased lines and the PSTN respectively.

The remaining sections of this part of the report address the key tariff issues concerned with interconnect.

IV. INTERCONNECT TARIFF ARRANGEMENTS

1. Tariff policy

i) Principal premise

In the countries covered by this study, the principal aim of government is to encourage competition in the belief that this will ensure optimal economic efficiency. Allowing competition at the level of network infrastructure as well as service provision is not seen merely as a duplication of investment. Rather it is the hope that this will result in a better choice of services for the end-user at a reasonable price, while ensuring that the organisations involved are capable of competing on an equal basis, nationally and with foreign companies. A key premise is that tariffs should reflect the true cost of service provision thereby creating an equitable basis for competition.

Each of the national interconnect agreements covered in this report have either attempted to determine the cost of interconnection or have made a statement indicating that this is the ultimate target of national tariff policy. In Australia, Germany, the United Kingdom and the United States considerable effort has been expended to determine what items contribute to the cost of service provision. In Sweden the cost of service provision has been approximated.

Cost-based tariffing has proved a very complex matter, affected not only by the vested interests of the service providers but also by traditional telecommunication tariff structures and the rapid development of the technology itself. In most cases national regulatory bodies have had to make assumptions to simplify the calculation of cost of provision. In Sweden, the original intention to calculate the cost of service provision was replaced by a fixed-charge equivalent to the local extension call duration charge levied on calls between Nordic countries. It was decided that the charging regime for the fixed-link network reflected less the real cost than the social cost of provision. This made it difficult to calculate a tariff structure that would truly reflect the costs of interconnection.

The intention of the OECD Member country governments in choosing to promote cost-based tariffing is to encourage competition and thus allow market forces to control the evolution of the national economy. However, for market forces to work successfully, there must be sufficient information in the market on which companies can base their commercial positioning. The current trend in the United Kingdom and Germany is to encourage private commercial agreements on interconnect between fixed-link and mobile communication network operators. This practice may be open to abuse through the creation of an unofficial cartel between operators or by the misuse of commercial power by the incumbent operator. In the United States all interconnect tariff agreements are filed with the FCC, and made available for public inspection, to ensure that the mobile communication network operators were able to compete on equal terms. This requirement was included in the legislation to avoid undue favour being paid to one mobile communication network operator by the fixed-link network operator. This could have occurred because one of the mobile communication network operators in each region is affiliated to the fixed-link network operator of that region.

ii) Defining interconnect costs

The Australian and UK authorities have progressed the furthest towards defining a stable basis for interconnect costs. The key to their tariff policy is the concept of directly attributable/allocated costs. The simplest components are those costs incurred by a network operator directly as a result of providing network capacity to handle the calls that are exchanged with another operator. This would include the discrete costs of creating the point of interconnection plus the marginal costs of switching and transmission that arise from the additional capacity. In addition both the Australian and UK authorities include costs that may not be directly attributable to the provision and support of interconnect. The Australian authority, Austel, defines these additional costs as those that:

> *have a direct traceable cause and effect relationship between activity and output* (p. 38, Ref. 3);

or that may

> *not have a directly traceable cause and effect relationship to a single level of activity, but does vary with incremental output of the network* (p. 38, Ref. 3).

In the United Kingdom, similar arrangements apply although they are termed differently. The UK national telecommunication authority, Oftel, recommends that the costs are assessed in terms of the fully allocated costs of establishing the interconnection. In addition the mobile communication network operator should be charged:

> *a reasonable contribution to* (the fixed-link network operator's) *overheads* (p. 3ff, Ref. 8);

and should be allowed:

> *a reasonable rate of return on* (the fixed-link network operator's) *attributable assets* (p. 3ff, Ref. 8).

iii) Interconnect charging structure

The common basis for interconnect charging in those OECD Member countries covered by this report is the cost of interconnect provision. Although each country practices different interconnect charging structures, interconnect charges can be broken down into a series of generic classes into which most national interconnection regimes fall. These classes are:

- -- interconnection costs;
- -- traffic related costs;
- -- costs of supplementary network services.

In Australia these cost classes are all expressed separately and in some detail. At the other extreme, in Sweden, interconnection costs and traffic-related costs are amalgamated into a single per-minute charge, while charges for supplementary network services are separate. Despite these differences in charging structure, the underlying basis remains the same in each of the countries albeit at different levels of complexity. It is therefore important to examine the details of these charging components to evaluate the effect of interconnect tariffs on mobile communication network operators' revenue.

a) Interconnection costs

Interconnection costs are the simplest costs to identify. They only relate to the exchange of calls between the mobile and fixed-link networks at the point of interconnection. These costs will have several sub-components, including:

-- fixed charges; for supply, installation and engineering of the physical connection, leased lines and interfaces;

-- recurring charges; for leasing the interconnection infrastructure and for its operation and maintenance.

The issue remains as to which of the two operators is responsible for paying for the interconnect. In the United Kingdom the consequential incremental costs arising from interconnection are shared equally between the two operators because the interconnect can be used by both parties. In Australia, interconnection is assumed to provide no immediate benefit to the incumbent operator. All costs of interconnect are directly attributable to the interconnection and therefore the mobile communication network operator must pay 100 per cent of them.

b) Traffic-related costs

Traffic-related charges include fees for the use of the fixed-link network operator's network capacity. This includes switching, transmission and the final distribution of each call. Currently the policy in the OECD Member countries covered by this report is that the traffic-related costs should be charged by:

-- *Duration*: based on billing units used during a successful call. These can vary according to the distance traversed by the call and the time of day or week when the call was made;

-- *Call attempts*: both successful and unsuccessful calls made by mobile communication network operators utilise the capacity of the fixed-link network. In the United Kingdom and Australia interconnect policy allows for a fixed charge to be levied on each call. A fixed charge, rather than a variable charge, is used even though a call attempt will use as much network capacity as a successful call of the same duration. The preference for a fixed charge is due to the limitations of most billing systems which are designed to monitor units used during successful calls.

c) Costs of supplementary network services

Operators of both mobile and fixed-link networks in the OECD Member countries covered in this report agree that supplementary network services should be tariffed separately from interconnect and traffic charges. However, there is less agreement as to which services are:

-- an intrinsic part of the fixed-link network offering and should therefore be included in the interconnection and traffic charges described above;

-- an essential requirement for full interconnection but which can be charged separately;

-- a non-essential requirement for interconnection but which may be provided by the fixed-link network operator if it wishes.

In Australia, supplementary services are defined as:

functions which are not primarily concerned with the transference or carriage of a telephone call across a network, but are concerned with monitoring, recording and reporting functions (p. 24, Ref. 3).

Essential interconnect functions include directory assistance, customer and network fault analysis and handling, billing, etc. By comparison, non-essential interconnect functions include support of customer enquiries, fault handling on networks owned by other organisations, and access to other networks operated by the incumbent operator.

2. Inconsistencies in interconnect tariff policy

This review of interconnect tariff policy demonstrates measures of agreement among the telecommunication regulatory policies in the OECD Member countries surveyed. Each country covered in this study espouses cost based tariffs as the foundation of interconnect charging. Without exception, these interconnect tariffs are a combination of fixed and recurring charges, and usage dependent charges. In addition to the huge complexity involved in identifying those costs that can be attributed to interconnect, this charging regime has two principal flaws. These flaws can be overlooked now while the mobile and fixed-link networks remain like David and Goliath but, when the mobile communication network operators begin to compete seriously with the incumbent fixed-link network operator, the current cost-based tariffing schemes may collapse. This state of affairs is not as far distant as many believe; in Eastern Europe, the parlous state of the fixed-link network and the speed at which mobile communication networks can be constructed will combine to create a situation where radio-based communication networks may compete directly with the fixed-link network.

This study of interconnect arrangements has identified two key inconsistencies in the tariffing of interconnect:

-- tariff regimes that are still strongly influenced by traditional public switched network tariffing and therefore reflect many of the inconsistencies of social value based tariffing;

-- interconnect policy that is firmly linked to the concept of cost-based tariffing and could pose problems in an environment where competition is strong.

i) Traditional tariff schemes

Mobile communication network operators are generally charged a fixed and recurring interconnection fee plus a charge on the duration of each call, just as the end-user has traditionally paid for connection, rental and traffic.

It can be argued that the interconnecting operator requires a guarantee of capacity over the fixed-link network operator's network. It could be argued that on mature networks, such as those operated by the incumbent provider, the cost of providing capacity is not sensitive to traffic volume, time of day, or even distance traversed. Indeed the cost of interconnection should consist of:

-- fixed one-off charges for physical interconnection to the fixed-link network;

-- fixed one-off charges to purchase sufficient capacity to match the mobile communication network operator's estimated demand;

-- a recurring charge for the operation and maintenance of the interconnection and the capacity.

The mobile communication network operator would then be free to adopt any time of day or distance orientated charges that would reduce demand at peak times and enable the mobile communication network operator to use less of the fixed-link network capacity than would otherwise be the case. A fixed and recurring non-traffic based charging system would also circumvent customer resistance to call attempt charges when the call is not successful.

The use of a tariff that consists entirely of fixed and recurring charges for interconnect does, however, place greater strain on the resources of a new mobile communication network operator. On mobile communication networks, revenues are earned mainly from call traffic and, in the early period after launch, these revenues are small. As subscriptions rise, so too will traffic and revenues. However, throughout the period the fixed and recurring charges levied will remain static, which will make their contribution to costs proportionally higher in the early years.

ii) Cost-based tariffing

This survey has shown that cost-based tariffing is a popular and effective method of charging for interconnect. It is appropriate during the early stages of market development where direct competition between mobile communication network operators and fixed-link network operators is limited. Rather, the new mobile operator is a customer of the PSTN operator, albeit a very significant one. The mobile operator must have access to existing communication users for the service to be viable. A new network operator cannot provide connection to existing users without both unreasonable expense and unnecessary duplication of existing communication network facilities. The only logical conclusion is that the new operator must be offered interconnect to the established fixed-link network at the level that it would cost it to provide the service itself if the telecommunication infrastructure was infinitely divisible. This remains the case until such time as the mobile communication network operator has sufficient network infrastructure and subscribers to no longer justify the protective tariff.

At this time, the tariff policy should be reviewed to enable full competition between the mobile and fixed-link communication networks.

However, cost-based tariffing is a complex method to determine interconnect costs. Competing operators must first agree on a single tariff practice and on what constitutes attributable costs. Furthermore, different operators use different accounting practices, which makes determining mutually acceptable attributable cost components almost impossible without the intervention of the independent national telecommunication authority. Finally, privately negotiated agreements are preferable, but in some cases regulatory intervention may be required to achieve a fair result.

As has begun to occur in the mature Nordic markets and is likely to occur in Eastern Europe, mobile communication network operators will eventually satisfy the purely mobile telecommunication market. This will occur first with traffic. As call charges fall, users will make increasing use of the mobile networks for calls. The majority of this traffic could have been carried end-to-end by the fixed-link network and represents revenue lost by the incumbent operator. The extent to which this occurs will

depend on the operators' tariff policy. Already, calls from Denmark to other Scandinavian countries are cheaper on the mobile than on the fixed-link network because the former does not use distance-dependent tariffs. In several of the other Nordic countries, international calls made from the mobile network are less expensive than from the fixed-link network. Inevitably this will lead to competition for traffic based on tariffs and other convenience factors.

Eventually the mobile communication network operators will turn their attention to subscribers that would normally use a fixed-link network connection and begin to compete for subscribers. The extent to which this will occur will be limited by:

-- the cost of mobile communication services. Where there is an existing fixed-link network of adequate quality, mobile services are unlikely to be able to compete on the basis of cost. The majority of existing fixed-link network end-users will remain connected to the fixed-link network;

-- in most of the OECD Member countries the proportion of the population that is not connected to the fixed-link network comes from the lower social classes. It is unlikely that these new subscribers will take mobile services unless the cost of installation and rental is competitive with fixed-link networks.

As competition between mobile and fixed-link networks starts to occur, cost-based tariffing schemes may conspire against even-handed competition and the encouragement of mobile communication network operators to continue to develop their own infrastructure.

Some telecommunication authorities, notably Oftel in the United Kingdom, have suggested phasing in access deficit charges (ADCs) to compensate the incumbent operator for the use of its network. The premise behind ADCs is that as a new operator begins to compete with the dominant operator, it should be charged for the use of the incumbent operator's assets when it crosses a particular revenue size threshold, thereby encouraging it to develop its own exchange network. In the United Kingdom, Oftel has recommended that current operators should be progressively exposed to ADCs as the size of their network or the volume of traffic handled increases so as to achieve finally a uniformly competitive market. The ADC payments would therefore become a recognition of the past investment and universal service obligations of the fixed-link operator.

In a competitive market, the use of cost-based tariffing may be flawed. Rather, it might be replaced by a system that is similar to those used in other areas of commerce. The mobile communication network operator, and indeed new fixed-link network operators, are interested in interconnect as a method of accessing other users (for inbound traffic) and ensuring that their subscribers are not isolated. The incumbent fixed-link network operator is providing interconnect to the capacity of its network. It would appear logical that the fixed-link network operator is selling a service to the mobile communication network operator for which a price should be agreed in discussion between the two operators. How the fixed-link network operator decides on its price will depend upon its analysis of how much it costs for it to provide the capacity to the mobile communication network operator plus a reasonable rate of return that it wishes to make to offset the effects of competition. As a result, interconnect need not be based on the cost of provision but rather on the mobile communication network operator's willingness to pay. This may involve a shift towards flat-rate charges, similar to leased-line tariff practices, rather than simple volume-based charges.

V. NATIONAL INTERCONNECT TARIFF POLICY

The interconnect tariffing policies in each of the countries covered by this report are in theory based on the same prime objective, namely cost-based pricing. In an attempt to identify the components of cost-based pricing, interconnect tariffs have been unbundled into interconnect, traffic and supplementary service usage charges albeit to differing levels of detail in each country. This section describes the interconnect tariff policy in Australia, Germany, Sweden, the United Kingdom and the Nynex region of the United States.

1. Australia

Following the Australian Government's decision to implement extensive telecommunication policy reform in November 1990, it commissioned the telecommunication authority, Austel, to investigate the issues of interconnection and equal access. The key elements of the policy review were:

-- the formation of a duopoly in fixed-link telecommunications with a private sector operator in competition with the incumbent operator Telecom/OTC. The duopoly would be opened to competition from the end of June 1997;

-- the issue of three licences for public mobile telecommunication services with the opportunity for further licences in 1995.

Austel's investigation produced a detailed analysis of the economics of interconnection which is applicable to both mobile-to-fixed-link and fixed-to-fixed-link interconnection.

As with the other OECD Member countries covered in this report, the Australian interconnection policy aims to establish cost-based tariffs for interconnection. The principal measure behind cost-based tariffs is the concept of directly attributable incremental costs. The key to interpreting the concept is that of causality; a cost is attributable if a change can be shown to have taken place caused by the act of interconnection. Austel identified two tests to show causality:

-- *costs are attributable if they are incurred specifically for the provision of the network, for example, switching, transmission, or ...have a direct traceable cause and effect relationship between activity and output* (p. 38, Ref. 3);

-- *if a cost does not have a directly traceable cause and effect relationship to a single level of activity, but does vary with incremental output of the network, then it may warrant inclusion* (in the attributable costs) (p. 38, Ref 3).

To determine further the costs of interconnect, Austel unbundled charges into interconnection costs, traffic costs and charges for supplementary services.

i) Interconnection costs

Within the category of interconnection costs, Austel includes:

-- the fixed capital costs and the related actions associated with providing the physical interconnection;

-- the variable costs associated with the use of the interconnection facilities.

The size of these interconnection costs would depend upon the mobile communication network operator's roll-out plans, preferred network architecture and customer access methods etc.

ii) Traffic costs

Traffic costs apply only to public switched telephony traffic; other communication services are deemed to be supplementary services.

As with the interconnect charge, there are fixed, recurring and variable charges for traffic handling. Three factors contribute towards the final traffic charge suggested by Austel:

-- fixed capital cost of relevant assets;
-- directly attributable incremental recurring non-capital costs such as operating costs and maintenance;
-- the variable usage charge for traffic handling.

The final format of the usage charge defined by Austel includes a fixed charge per call, whether the call is successful or not, plus a duration charge that varies according to the distance covered and the time of day or week.

iii) Supplementary services

Austel recognises that a telecommunication network is more than its switching and transmission components. In addition a range of services and information sources are essential to its smooth running. Any new network operator, whether mobile or fixed-link, will require access to some of those facilities to offer a viable service. However other facilities represent a competitive advantage to the operator which it should retain. As a result, Austel has segregated network services into:

-- mandatory functions, which must be provided to the interconnecting network operator by virtue of ownership of the incumbent network;

-- discretionary functions, which need not necessarily be provided to the interconnecting network operator but that the new operator may choose to provide itself or by sub-contracting the provision to the incumbent operator or a third party.

Figure 5.1 describes the breakdown between mandatory and discretionary functions in the Australian market.

Figure 5.1. **Division of supplementary services into essential and non-essential services in Australia**

Essential services	Non-essential services
Customer operations and operator-assisted services	
Directory enquiries Customer contact staff training Customer fault analysis	Customer education General customer enquiries Customer fault report handling Manual assistance
Charging and billing	
Charging	Billing Carrier to carrier reconciliation
Network maintenance and service quality management	
Service quality management (inter-gateway segments) Network complaints processing Traffic management and service restoration (inter-gateway segments) Network congestion management (inter-gateway segments) Tariff management Infrastructure sharing Directory provision	Service quality management (on fixed-link network segments) Maintenance and fault handling Traffic management & service restoration (on fixed-link network segments) Network congestion management (on fixed-link network segments) Management of document interchange

Source: Australia (1991, Part 1).

2. Germany

In February 1993 the Federal Minister of Posts and Telecommunications issued a license for a third digital mobile communication network. Thus the two present operators of digital mobile communication networks, Deutsche Bundespost TELEKOM and Mannesmann Mobilfunk GmbH, which have been providing their services since mid-1992, now have a strong competitor. The third digital mobile communication network will be set up and operated by the E-PLUS consortium, a group led by the companies Thyssen and VEBA. Like the D1 and D2 networks, E1 is also based on GSM technology. The E1 network provider will develop a nearly nation-wide telecommunication infrastructure in Germany by the end of 1997. The telecommunication infrastructure in the new federal states is planned to have been completed to a large extent by 1995.

It is the German Government's policy that interconnect costs should reflect the cost of service provision. As in the United Kingdom, it is also the government's aim to encourage the mobile and fixed-link service operators to arrive at interconnection agreements through private discussion. Any decision remains a commercial secret between the two partners unless that decision has an effect on the tariffs for either service. In this case, the agreement is subject to approval by the Government. If the mobile communication network operator and DBP Telekom can not agree on the interconnect charges, the license terms allow DBP Telekom to fix them arbitrarily. This type of agreement is subject to approval by the

government under the terms of the Deutsche Bundespost Constitution Act within eight months of the imposed agreement.

In common with the other OECD Member countries covered in this report, the German Government has identified two components that are liable to interconnection charges:

-- Interconnection charges; one-off and recurring tariffs related to the physical link between the networks at the point of interconnection. These tariffs may be any combination of lump sum or duration-related charges.

-- Traffic charges; one-off and recurring tariffs related to the volume of calls carried by the destination network.

In both cases the rates for interconnection will be determined by private operators agreement between the two operators. Tariffs for the carriage of traffic should reflect the savings to the fixed-link network operator (DBP Telekom) of connection at a higher level in the switching hierarchy.

3. Sweden

The Swedish mobile telecommunication services were amongst the very first to be set up. Initially the issue of interconnect was less important than in other countries because the main mobile service operator was also the incumbent telecommunication operator. However, with the additional presence of Comvik in the analogue cellular market and of both Comvik and NordicTel in the GSM cellular market, interconnect has become of critical importance.

Discussions about interconnect between Televerket and Comvik were long and finally unsuccessful. In January 1991 the government intervened and imposed a settlement on both parties. The settlement included both technical and economic terms.

Early in its review of interconnect tariffing, the government planned that the charging structure should reflect the directly attributable cost of provision of the interconnect service. Determining what should be included in directly attributable cost was very complex, and eventually the Swedish Government rejected it as being a non-viable option.

Instead of directly attributable costs, the Swedish Government considered two other alternative charging options based on existing telecommunication tariffs. The two options considered were:

-- Interconnection (in both directions) between mobile and fixed-link network operators should be charged as if the call originated on the destination network rather than the origin network. The operator of the call origin network would pay the destination network operator the full commercial cost of delivering the call as if the origin network was a customer connected to the destination network. These charges would vary according to the distance covered by the call and the time of day when it was placed.

-- Interconnection (in both directions) between mobile and fixed-link network operators should be charged at the cost of the national extension for international calls between Nordic countries. This is currently SKr 0.65 per minute (US$0.12) irrespective of distance or time of day and is less than the national extension charge for international calls from non-Nordic countries.

The government finally chose the latter of the two alternatives. It was decided that payment of the full commercial charge for the delivery of a call over the fixed-link network was not appropriate because:

-- The call would only traverse one local exchange line compared to an end-to-end call over the fixed-link network.

-- Calls from the fixed-link network to the mobile communication network are outnumbered by calls in the opposite direction and this would place undue strain on the mobile communication network operator's viability.

-- The distance-based tariffs used on the fixed-link network do not represent the actual cost of call delivery. For social reasons, the cost of local calls has been kept artificially low while long-distance tariffs have been raised to cross-subsidise the service.

On first impression, the Swedish interconnect solution appears to contradict the norm of using cost-based tariffs unbundled into interconnection costs, traffic charges and charges for supplementary services. However, the Swedish Government considers that the use of the national extension charge reflects the cost as closely as is possible without complex and disputable formulae. The national extension charge includes a proportion of costs for the use of the national fixed-link network, for interconnection and for the handling of traffic. In effect, the interconnection cost and traffic charges have been amalgamated and charged on a per-minute basis. Supplementary services such as network services, connection to other networks or provision of leased lines are charged separately and at commercial rates.

The Swedish Government sees the current national extension solution as an interim solution to interconnection charges. It continues to encourage the fixed-link network operators to move towards cost-based tariffing for its services which will enable accurate cost-based interconnect charges to be determined. In the meantime, it has also requested that Televerket works to reduce the national extension charge which would benefit both international and mobile users.

4. United Kingdom

In the United Kingdom, interconnect agreements are reached by private discussion between the parties involved. If the parties are unable to reach an agreement, the case can be referred to the Office of Telecommunications, Oftel, for a determination. The interconnect arrangements made between the dominant fixed-link network operator, BT, and the mobile communication network operators were arrived at by private discussion and are commercial secrets. However the agreements between the competing fixed-link network operators, and between the mobile communication network operators and Mercury Communications have been determined by Oftel. These agreements show how Oftel would expect interconnect agreements to be set up but may or may not mirror the agreements reached between BT and Vodafone or Cellnet.

Oftel recommends that interconnect tariffs between mobile and fixed-link network operators should be based on the cost of service provision and, as far as possible, to be applicable to interconnection between mobile and fixed-link networks and between fixed and fixed-link networks. In calculating the cost of interconnect, Oftel recommends that the costs are assessed in terms of:

-- *fully allocated costs of establishing the interconnection;*
-- *a reasonable contribution to overheads;*

-- *a reasonable rate of return on attributable assets* (p. 3ff, Ref. 8).

The interconnect tariff structure recommended by Oftel varies between each determination but is based on a simplified version of the Australian structure. It is made up of interconnection and traffic costs.

i) Interconnection costs

Interconnection costs include:

-- the direct cost of materials, equipment and appliances used to provide the interconnection plus the cost of labour at usual rates;

-- the consequential incremental costs of providing the interconnection. These are the costs that have increased as a direct result of the provision of the point of interconnection;

-- the cost of exchange lines at the prevalent commercial rate.

The share of the interconnection costs paid by the two operators varies between determinations. Materials and labour costs, and the cost of exchange lines, are charged in full to the operator requesting interconnect. The share of the consequential incremental costs is based on the number of customers each operator will provide or on an arbitrary figure such as 50 per cent for each operator.

ii) Traffic costs

Oftel recommends that charges for the use of the fixed-link network are levied on the duration of successful calls. The charges are dependent upon the network segment traversed by the call and the time of day at which the call was made. Although Oftel recognises the case for a call attempt charge, it does not support the current practice of charging an amount identical to a unit of a successful call. BT argues that the high call attempt charge allows for lower call charges for all interconnect traffic.

In addition to conventional traffic costs, Oftel has considered access deficit charges (ADC) for interconnection. ADCs may be required to compensate the incumbent fixed-link network operator for the use of its local exchange lines. Each call that is sourced or delivered by the operator would be charged a fee per local exchange line used. Hence a call to, or from, a mobile user which uses the fixed-link network for one end of the call would realise one ADC. The use of ADCs would ensure that:

-- BT would receive compensation for the use of its assets by the other network operators.

-- Competitive network operators are not unfairly favoured when they start to compete directly with the incumbent operator for local exchange lines.

-- The competitive network operator would be encouraged to find the most economical method of delivering and receiving calls from fixed-link network users. This could include radio-based local loops, agreements with other carriers etc.

Oftel argues that new service operators, which do not compete directly with incumbent network, should not be charged ADCs. The traffic generated by the new operator supplements that generated by the incumbent operator and the latter benefits from the additional revenue. At the same time the absence of

ADCs protects the new service from undue competition from the dominant player in the market. As the new service grows, it captures an increasing proportion of the incumbent operator's traffic. In this situation, the new operator's use of the incumbent's local distribution network constitutes the exploitation of the latter's assets and less of an augmentation of its traffic volume. As a result, a charge for the use of that asset should be made. Currently in the United Kingdom and in the majority of the mobile communication networks outside of the Nordic countries, the mobile service providers are complementary to the fixed-link operator and hence ADCs should not be necessary. As these services begin to compete, as they do in the Nordic region, and as the market share of the rival operators grows to a significant size, Oftel argues that ADCs should be gradually introduced.

5. United States (New York region)

The interconnect tariffing policy of the United States in the New York region attempts to identify the actual costs of provision. In common with the countries reviewed above, the tariffing policy separates interconnect into costs related to the link, usage-related tariffs and charges for supplementary service. However, the US experience differs from the European model in three key aspects:

-- In the United States, the compensation payments among cellular operators and local telephone companies are largely a matter of state rather than federal concern.

-- There are three operators involved in interconnect discussions, the mobile communication network operator, the regional fixed-link network operator and the long-istance carrier. The mobile communication network operator is responsible for reaching interconnection agreements with both fixed-link network operators.

-- In each region there are two mobile communication network operators of which one may be directly affiliated to the regional fixed-link network operator and the other is independent.

These two points have led to a different approach to reaching interconnect agreements without largely changing the format of the final tariff. In a market with a mobile communication network operator affiliated to the fixed-link network operator, and a government encouraging competition, it is essential that information is made available to all the parties involved. In the United States, interconnect agreements must be made available in the public domain. The fixed-link network operator is legally required to provide as favourable terms for interconnect to a competitive mobile communication network operator as to its related mobile communication network operator. The publication of interconnect agreements in the United States has not inhibited the progress of competition but has enhanced it. The end-user has the choice of operator on the basis of service offering and cost savings. These savings are generated by the efficient running of the service rather than the arbitrary fortune of a successful interconnect negotiation. As a result the two principal aims of market-led government policy are achieved; the improvement of efficiency and of choice.

The interconnect tariff structure depends upon the type of interconnection required by the mobile communication network operator. Nynex offer two types of interconnect:

-- Type I interconnect where the point of interconnect is between the mobile telephone switching exchange and the fixed-link network operator's central office which gives access to other exchanges operated by that regional fixed-link network operator and to the common carriers that are licensed to carry traffic between regional operators.

-- Type II interconnect. Type II interconnect is separated into two forms which are usually used in conjunction with each other known as Type IIA and B. In the case of a Type IIA interconnect, the point of interconnect is between the mobile telephone switching exchange and the fixed-link network operator's tandem exchange which gives access to other exchanges operated by that regional fixed-link network operator and to the common carriers. In Type IIB interconnection, the interface is again at the fixed-link network operator's central office but only gives access to local numbers served by that exchange. Typically, Type II interconnect is used to provide alternate routing between the mobile switching exchange and the regional fixed-link network operator's network.

i) Interconnection costs

In the Nynex region, mobile communication network operators are charged a fixed interconnection cost, which includes:

> *the non-recoverable cost of equipment and material ordered, plus the non-recoverable cost of installation and removal including the costs of engineering, labour, supervision, transportation, rights-of-way and other associated costs* (Section 4, C2, p. 8, Ref. 12).

NYNEX states that in the markets in which it provides cellular service, charges are structured as follows: when obtaining cellular service, a one-time charge for installation of the cellular phone and activation of a cellular number is applied. In addition, a monthly access charge is applied to the subscriber in order to use the cellular system. The monthly access charge can vary in price, depending on what pricing plan the subscriber chooses. Generally, a subscriber who uses the system frequently by making numerous calls would choose a plan that has a lower per-inute charge with a higher monthly access charge. A subscriber who uses the system infrequently would choose a plan that has a higher per-minute charge, but a lower monthly access charge.

ii) Traffic costs

Traffic costs are charged according to duration of use of the fixed-link network. Although these costs, vary there is a minimum charge per trunk circuit connected to the mobile communication network operator to protect the fixed-link network operator against under-utilisation. The minimum charge is calculated from:

-- the minimum acceptable monthly minutes of use per trunk line;
-- the weighted average of the interstate transport rate for calls delivered between states.

Both these charges are published. The call-related tariff is made up of charges for use of:

-- line termination;
-- local call transport;
-- local switching;
-- trunk transmission and switching;
-- call intercept.

How these charges are applied depends upon the route taken by the call, as summarised in Figure 5.2.

Figure 5.2. **Charges for Type I interconnection in the New York region**

Type I Interconnect (Mobile communication network to fixed-link network only)		
Call destination	Charges levied against mobile communication network operator	Refunds to mobile communication network operator
In the same exchange area as point of interconnection	Local call charge only	None
In a different exchange area as point of interconnection, but still within fixed-link network operator's region	Line termination Local transmission Local switching Trunk transmission and switching Call intercept	None
On another mobile communication network within the fixed-link network operator's region	Line termination Local transmission Local switching Trunk transmission and switching Call intercept	Local call refund[1]
Call requires interstate common carrier for delivery to final destination	None[2]	None

1. The volume of local call refunds to the mobile communication network operator that are permitted must not exceed the fixed-link network operator's applicable access elements.
2. The mobile communication network operator is not charged directly by the regional fixed-link network operator. The latter charges the common carrier for the transfer of call between the mobile/fixed point of interconnection and the fixed-link/common carrier interface.

Type II interconnect differs from Type I because of the different location of the interconnection interface in the fixed-link network operator's network hierarchy. Charges for Type II interconnect are summarised in Figure 5.3.

iii) Supplementary services

Supplementary services that are provided by the fixed-link network operator and are not directly related to the provision of interconnection services are charged separately. These services include the emergency service, operator services and IDDD.

Figure 5.3. **Charges for Type II interconnection in the New York region**

Type II Interconnect (Mobile communication network to fixed-link network only)		
Call destination	Charges levied against mobile communication network operator	Refunds to mobile communication network operator
In the same exchange area as point of interconnection to tandem exchange	Line termination Local transmission Local switching Trunk transmission and switching Call intercept	None
In a different exchange area as point of interconnection, but still within fixed-link network operator's region	Line termination Local transmission Local switching Trunk transmission and switching Call intercept	None
On another mobile communication network within the fixed-link network operator's region	Line termination Local transmission Local switching Trunk transmission and switching Call intercept	Local call refund[1]
Call requires interstate common carrier for delivery to final destination	None[2]	None

1. As for Type I interconnect.
2. As for Type I interconnect.

VI. INTERCONNECT TARIFF MODEL

The interconnect tariff model presented here is based on the method of charging for interconnection that is most widely used in the OECD Member countries. As a result it has interconnection and usage components.

1. Modelling assumptions

The model forecasts the expected revenue for a typical mobile communication network operator. It shows the impact of interconnection charges on a mobile communication network operator in an imaginary country. It does not attempt to assess the viability of that mobile communication network operator because of the huge variation between the set-up and operating costs in each country. However, it would not be difficult to conduct a country-by-country analysis of viability using the revenue projections that this model produces and country-specific data for set-up and operation costs.

In line with the assertion that the traffic flow between the mobile communication network and the PSTN will most likely be unbalanced initially in favour of the mobile communication network as the sender of calls, the model concentrates on the impact of outbound calls on the revenue expected by a mobile service operator. Inbound traffic from the fixed-link network can be calculated using the same algorithms used in the outbound model although a new set of assumptions will be required and the relationship between tariffs will have to be rebalanced to reflect the cost of operating a mobile communication network.

While preparing the model, we have taken great care to ensure that the model is applicable to the majority of the OECD-type countries. In doing so, we have made assumptions on:

-- the mobile communication network operator's revenues;
-- the average mobile telephone user's basket of calls;
-- the interconnection charges levied;
-- the expected network growth.

i) Mobile communication network operator revenue assumptions

In the interconnect tariff model, it is assumed that the mobile communication network operator's gross revenues comprise the following items:

-- a one-off installation/subscription charge;
-- a recurring rental (charged at least annually);
-- duration of usage charges (charged per decimal minute) that vary by the time of day at which the call was placed and the distance covered by the call;
-- no fixed call charge raised on each call attempt.

The charges are defined in arbitrary units which are in proportion to the typical price of mobile phone use in an average OECD Member country using data derived from the OECD tariff comparison methodology (for more information, see OECD (1990), *Performance Indicators for Public Telecommunication Operators*, ICCP Series No. 22, Paris). By substituting the actual tariffs in a particular country, the model will generate data in the national currency. The tariffs used are described in Figure 6.1.

Figure 6.1. **Mobile communication network operator's gross revenue assumptions**

Revenue sources	**Value (units)**	
Installation/subscription charge	340.00	
Recurring rental fee (annual)	1 650.00	
Duration charges (per minute)	**Peak**	**Off-peak**
Local	1.30	0.78
Intermediate/regional	1.70	1.00
Long distance	2.00	1.20
International (neighbouring country)	6.00	4.00
Call attempt charge	0.00	0.00

ii) Mobile call traffic basket

Based on 1988 statistics regarding the experience of new mobile network operators in the United Kingdom, it is assumed that the average mobile telephone user makes a basket of calls which is assembled from:

-- the average number of calls per subscriber per annum. In the model, a figure of 906 calls per year is used as this is consistent with the tariff comparison models used by OECD;

-- average duration of calls from mobile terminals (2.5 minutes);

-- at present only 5 per cent of calls originating on a mobile communication network have a destination on the same mobile communication network. The model assumes that this is a negligible proportion of calls;

-- the assumption that a negligible proportion of mobile users make international calls. This assumption depends upon the relative difference between international call charges on the fixed-link and the mobile communication networks. In some Nordic countries international calls are less expensive for calls originating on the mobile communication network than on the fixed-link network. However, even in these situations, international calls generally form less than 2 per cent of all calls;

-- the assumption that 40 per cent of calls to the fixed-link network are to destinations within local areas, a further 40 per cent are intermediate-distance calls or to regional areas, and the remaining 20 per cent are long-distance. Similarly calls on the mobile communication network are split into three distance-based charge bands;

-- the assumption that 80 per cent of calls made on the mobile network are made at peak times and 20 per cent at off-peak times (only two time-dependent tariffs are used in the model).

Each of these assumptions can be varied to test the sensitivity of the model or to adapt it for use in a particular country.

These estimates are based on data obtained from the following sources of data regarding existing cellular mobile service providers in several OECD Member countries:

-- OECD statistics (calls/subscriber/year);
-- United Kingdom, Sweden and France (average call duration);
-- United Kingdom and Australia (call destinations); and
-- United Kingdom (time of day).

In the model, it is assumed that there are two competing operators and that the networks use one of the major technologies. No differentiation has been made based on the ownership of mobile network operators because of the assumption that market development is more affected by the level of competition or the choice of technology adopted than by the ownership of the operator. (This does not imply in general that ownership is not important. On the contrary without regulatory safeguards ownership can significantly influence market development.) This, in turn, is premised on the notion that public policy-makers have been able to create an arena where no competitor enjoys an unfair advantage -- "a level playing field" -- for new and PSTN-owned mobile service providers. The data derived from the sources cited above is summarised in Figure 6.2.

Figure 6.2. **End-user call basket**

End-user call basket	
Calls/subscriber/year	906
Average duration/call (mins.)	2.5
Call destinations	**% of calls**
Mobile communication network	0
International	0
National (local)	40
National (intermediate/regional)	40
National (long distance)	20
Time of day	**% of calls**
Peak	80
Off-peak	20

iii) Interconnection charges

Interconnect charges are assumed to include the following components:

-- a one-off interconnection charge. It is assumed that this charge is amortised over a seven-year period. It is based on a mobile service serving five major population centres from launch and capable of delivering calls over the entire fixed-link network. Typical charges for other networks are given in Figure 6.3;

-- a recurring charge for operation and maintenance of the interconnection which is charged at least annually. This cost has been derived from the one-off interconnection cost using a typical ratio between installation and rental charges for other telecommunication infrastructure;

-- duration of usage charges (charged per decimal minute) that vary by the time of day at which the call was placed and distance covered by the call;

-- a fixed call charge raised on each call attempt.

Details of the fixed and variable usage charges for interconnection are given in Figure 6.4.

Figure 6.3. **Interconnect charge scenarios**

Interconnect scenarios	Units
2 population centres at launch. Fixed-link network delivery over whole network	8 000 000
5 population centres at launch. Fixed-link network delivery over whole network	12 500 000
10 population centres at launch. Fixed-link network delivery over whole network	16 000 000
15 population centres at launch. Fixed-link network delivery over whole network	19 000 000

Figure 6.4. **Fixed and variable usage charges for interconnection between mobile and fixed-link communication networks**

Call Destination	Peak		Off-peak	
Units	**/Call attempt**	**/Minute**	**/Call attempt**	**/Minute**
Local	0.040	0.100	0.010	0.030
Intermediate/region	0.040	0.120	0.010	0.045
Long distance	0.040	0.140	0.010	0.060

iv) Expected network growth

The critical time for a new mobile communication network operator is the first seven years of operation when capital costs are highest, network subscriptions are low and traffic levels are less developed. As a result the model is based on the typical growth expected for a new network during its first seven years of operation. It is also assumed that:

-- 100 000 subscribers are signed up by the end of the seventh year. We have chosen this number of subscribers after an analysis of the actual subscriber levels attained in the seventh year of operation of cellular services in the United Kingdom, France, Germany, Italy, the Netherlands, Switzerland and the Nordic countries. Obviously the number of subscribers actually attained depends on the regulatory environment in each country, the technology used and factors such as population distribution, development of fixed link infrastrucutre, etc.

-- Churn in the subscriber base is negligible. The rate of churn will depend considerably on a variety of factors. New networks are less susceptible to churn than established ones. Conversely networks that encourage connection through heavily discounted end-user terminals like those in the United Kingdom are more likely to have churn rates as high as 15 per cent.

-- It is assumed that the mobile network is structurally and financially separated from an incumbent fixed-link PTO and that any links which do exist do not materially affect the growth of the mobile operator.

Again, these assumptions can be varied to test the sensitivity of the model or adapt it to a particular national market.

These assumptions are clearly marked in the model and can be changed to produce a series of curves that demonstrate the impact on the mobile communication network operator's revenue.

Appendix A gives a full listing of the algorithm assumptions that have been made in the model.

2. Model evaluation

Two measures generated by the model are critical to evaluating the effect of different interconnect tariff strategies:

-- *Actual revenue after deductions for interconnect (AR).* This figure is in national currency units and is calculated from the gross revenue earned by the mobile communication network operator from subscriptions, rentals and traffic, less the charges for interconnection (including call attempt charges, fixed and recurring costs of interconnection, and usage charges).

-- *Percentage gross revenue achieved (%GR).* This figure is a measure of the actual revenue after deductions for interconnect (AR) expressed as a proportion of the original gross revenue. As percentage gross revenue achieved is not expressed in national currency units, it can be compared between countries.

By varying the contribution of individual components of the model to the interconnect charge, the effect of different interconnect tariff structures can be compared against the balanced picture originally presented in the model. The cost of interconnect is usually levied through one or more of the following types of charges:

-- call attempt charges;
-- usage charges (as is the case in Sweden);
-- fixed and recurring charges.

i) Interconnect call attempt charges

The model was adjusted to measure the AR and %GR in situations where the interconnect call attempt charge varied between zero and five times the level used in the original model. The effect of different interconnect call attempt charges on the AR and %GR is shown in Figure 6.5. It shows that varying the size of the call attempt charge has little effect on either revenue measure. As call numbers are directly in proportion to subscribers, it would be expected that the call attempt charges would rise at the same rate as the subscription rate.

ii) Interconnect usage charges

The model was adjusted to measure the AR and %GR in situations where the interconnect call usage charge varied between half and five times the level used in the original model. The effect of different interconnect call attempt charges on the AR and %GR is shown in Figure 6.6.

Figure 6.5. **Effect of Variable Call Attempt Charges on AR & %GR**

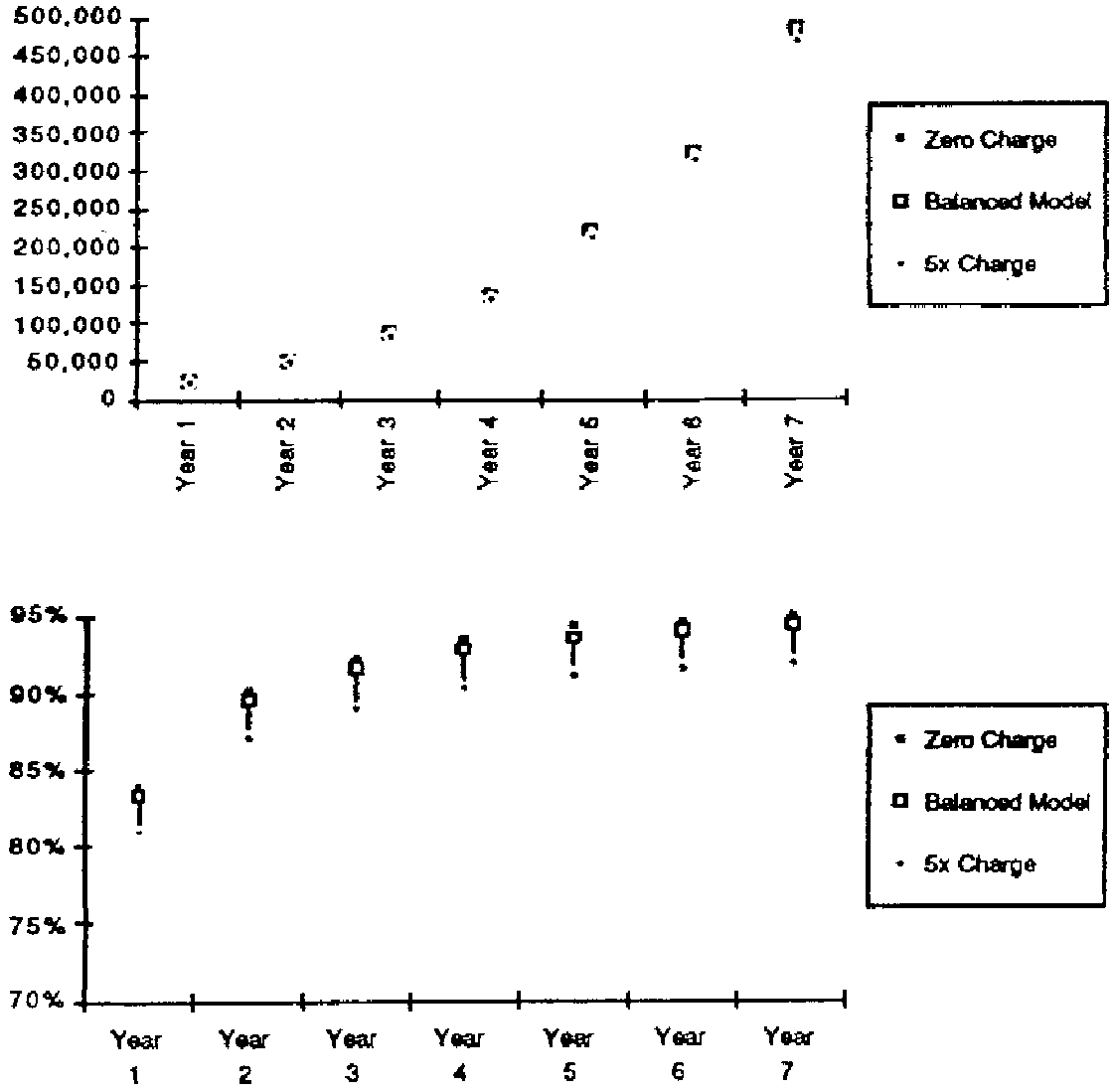
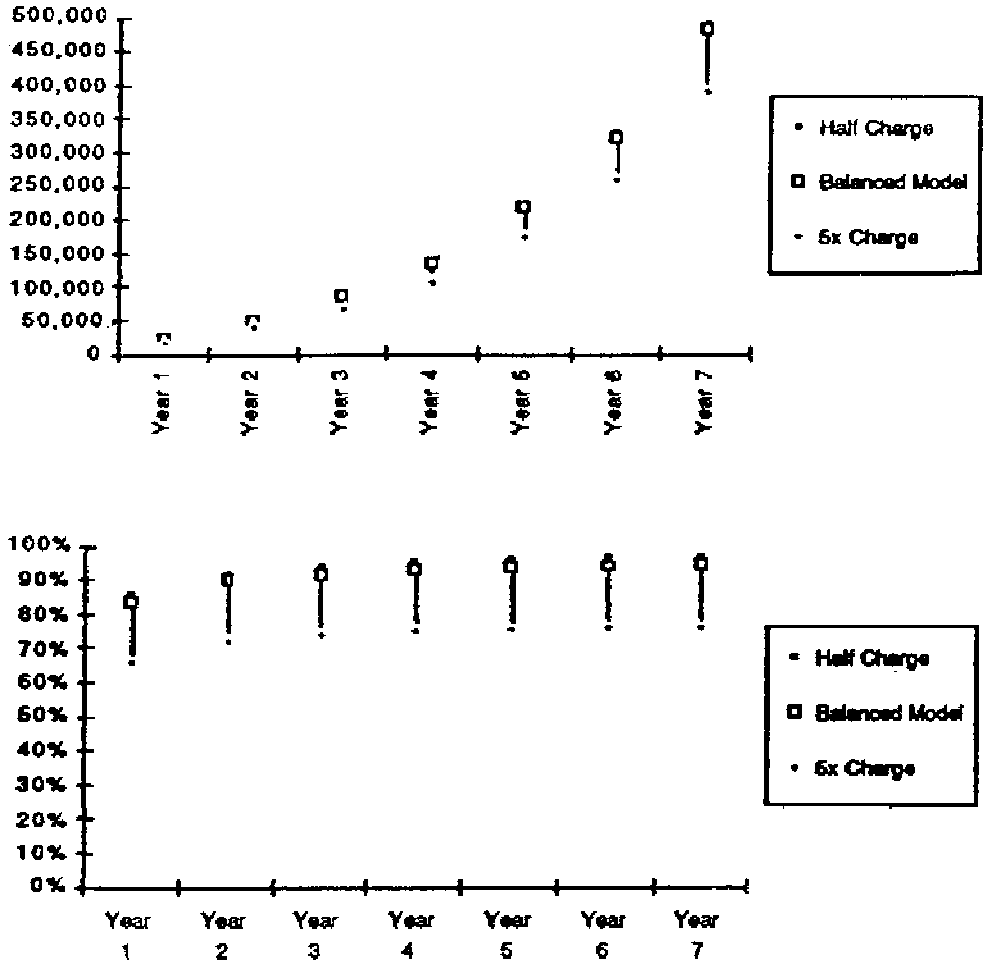


Figure 6.6: **Effect of Variable Usage Charges on AR & %GR**

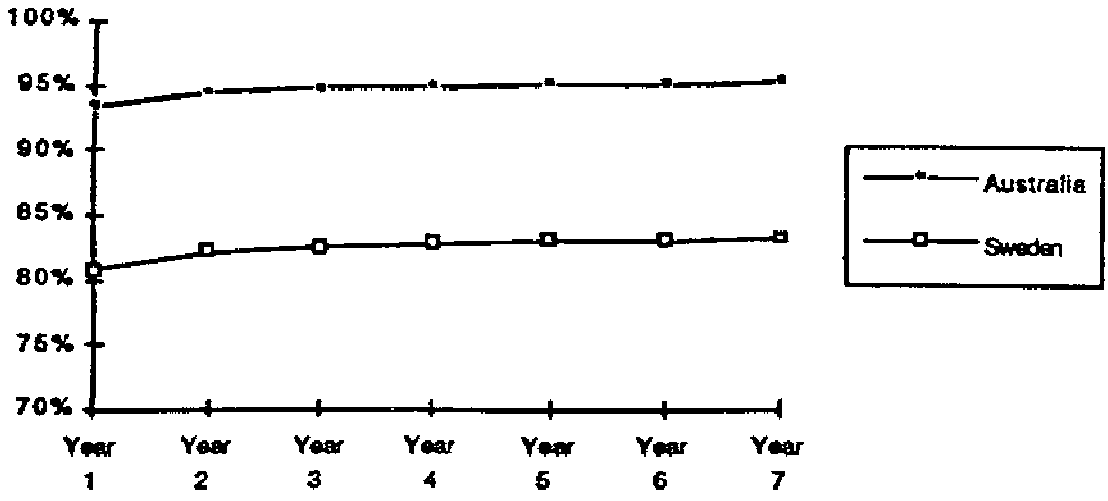


The figure shows that the AR expected by the mobile communication network operator is considerably reduced over the forecast period if interconnect usage charges are high. The greater the weighting of interconnect charges towards usage, the more slowly the AR increases because the volume of calls increases at the same time as the network matures. Over the same period, the %GR levels out. In the first few years the volume of interconnect traffic is small and consequently the interconnect usage charge is also low. However, the fixed and recurring costs associated with interconnection form a large contribution to interconnect costs and will depress the revenue expectations. This accounts for the low %GR in the early years.

The model was run using actual tariff and interconnect data for Australia and Sweden. The Swedish tariff regime allocates all interconnect costs to a per minute usage rate whereas the proposed Australian interconnect tariff approximates to the balanced model. For comparison, the growth in the numbers of subscribers was adjusted to match the historical figures for growth over the first seven years of operation in Sweden (1981 to 1988) and first six years in Australia (1986 to 1992). Details of the data used in these runs is included in Appendix B.

As would be expected from the discussion above, an analysis of the %GR generated by the model for the two countries shows that the Swedish mobile operator achieves a lower percentage of its gross revenue after deductions for interconnect have been made compared to an Australian operator (see Figure 6.7). The effect also persists throughout the seven years of operation covered by the model.

Figure 6.7: **Comparison of %GR in Australia & Sweden**



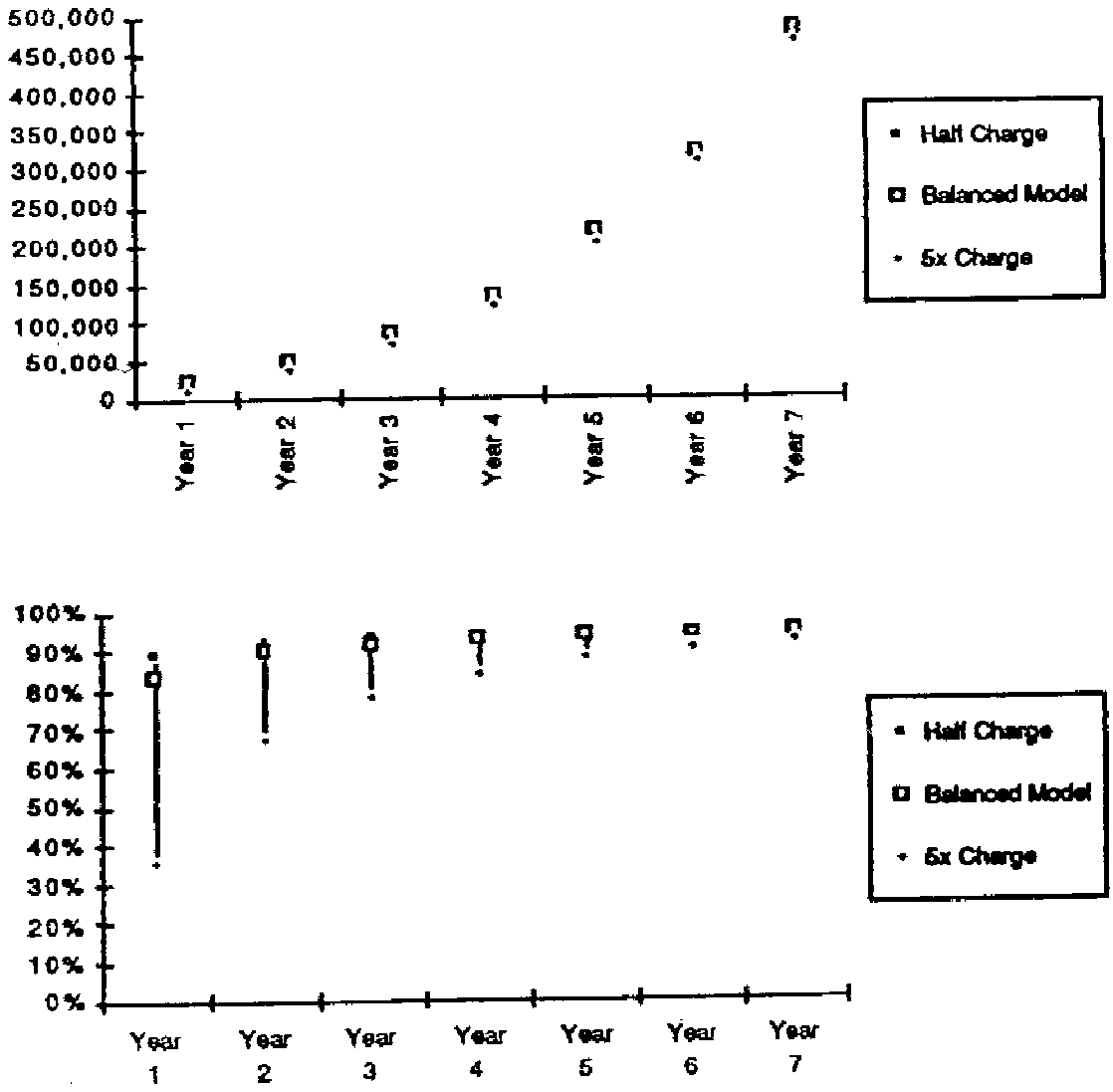
iii) Interconnect fixed & recurring charges

The model was adjusted to measure the AR and %GR in situations where the interconnect fixed and recurring charges varied between half and five times the level used in the original model. The effect of different interconnect fixed and recurring charges on the AR and %GR is shown in Figure 6.8.

Variations in the weighting of interconnect charges towards fixed and recurring fees has a limited effect on the AR expected from the network over the first seven years. However the impact on the %GR during the early years is significant. In the first years of service provision, the numbers of subscribers are small and the mobile communication network operator's revenue levels are low. However, by its nature, the fixed and recurring costs are the same irrespective of the numbers of subscribers. Hence their contribution to the reduction in %GR is considerable.

The sensitivity of interconnect fees to the fixed and recurring costs during the early years of service availability has contributed to the delay in launching the competitive cellular service in Germany. Mannesmann Mobilfunk has argued that even the current reduction of 46 per cent on the cost of leased lines makes interconnect more expensive than in other European countries where the full commercial rate for leased lines can be six to seven times lower than the equivalent commercial rate in Germany.

Figure 6.8. **Effect of Variable Fixed & Recurring Charges on AR & %GR**



iv) Conclusions

From the above analysis, it is clear that a tariff based around the balanced approach presented in the model is the fairest approach to charging for interconnect. Variations in the size of the call attempt charge can be tolerated but significant rebalancing of the cost of interconnect towards either fixed and recurring fees or usage charges can seriously affect the mobile communication network operator's ability to compete. In particular, the fixed and recurring charges place considerable strain on the mobile communication network operator's viability during the early years of service operation.

VII. RECOMMENDATIONS FOR INTERCONNECT TARIFF POLICY

From the above study of the OECD Member countries, a series of recommendations can be proposed that are applicable in both the short and the long term. The latter would require further study to determine the impact on mobile and fixed-link network operators.

1. Immediate recommendations for interconnect tariffs

Most mobile communication markets are in their infancy and direct competition between the mobile and fixed-link networks is negligible. Under these conditions, competition needs to be fostered by a favourable regulatory regime where an independent authority proposes or determines the structure of interconnect charging. Despite the limitations of current fixed-link network tariffing, it provides the only basis for estimating the cost of sharing networks for delivery purposes. For this reason we recommend that the OECD Member countries promote the use of a tariff method based on:

-- directly attributable costs using the definition proposed by Austel, and including;
-- a reasonable rate of return on those assets that are related to the provision of interconnect.

To ensure that market forces are allowed to operate without obstruction, we recommend that interconnect tariff data is published in the public domain. Without the availability of this information, interconnect agreements will not reflect the cost of service provision but the power of the incumbent operator.

The final tariff for interconnect might therefore be structured as proposed by the Austel study:

-- interconnection charges;
-- traffic charges;
-- charges for supplementary services.

It is important to stress that the calculation of these costs is very complex and the participation of an independent telecommunication authority in determining the definition of attributable cost may be essential in avoiding crippling delay to interconnection.

i) Interconnection set-up and rental charges

Both fixed and recurring interconnection charges which include the capital cost of interconnection and the running costs associated with provision at the point of interconnection should be levied. Fixed costs should be amortized over an appropriate accounting period.

ii) Interconnection usage charges

Both successful and unsuccessful calls should be charged on a duration basis with allowances made for the time of day or week when the call is placed and the distance covered by the call. Identical charges for both successful and unsuccessful calls would reflect the cost of provision but may be politically unacceptable, in which case a lower duration-based tariff for call attempts would be acceptable. Duration-based call attempt charges may not be feasible with existing billing systems, so a fixed call attempt charge could be used as a substitute.

Distance should be measured in network segments rather than geographical distance. Hence the mobile communication network operator would be charged per trunk and local segment used. This would allow the mobile communication network operator the maximum flexibility in choosing the delivery route. It could also be used to avoid the introduction of ADCs as a separate charge.

iii) Interconnection charges for supplementary services

Charging for any other services is essential. We believe that the availability of all services, beyond those required to run the fixed-link network and the points of interconnection, should be decided by the fixed-link network operator. These services are value added services without which the network will still provide the essential call carriage and delivery. With sole access to these services, the fixed-link operator should provide a competitive offering based on service level or sell access to the services to the mobile communication network operator. The charges for these services should be determined by agreement between the mobile and fixed-link network operator.

2. Recommendations for future interconnect tariffs

This study has identified flaws in the current tariff regime that will become more serious as the mobile services develop and begin to compete directly with the incumbent fixed-link network. Given these problems we strongly recommend that OECD Member countries apply the following observations:

-- The mobile and land-line operations of incumbent fixed-link operators should be financially separated and should be offered interconnect terms on an equal and equivalent basis to competing mobile operators.

-- In the short to medium term, interconnect agreements should be based on directly attributable costs with a reasonable rate of return on attributable assets.

-- In the longer term, flat-rate interconnect charges that relate to the level of fixed-link network capacity demanded might be considered rather than simple volume usage charges.

-- Private commercial negotiation of interconnect agreements between the operators concerned should be considered.

-- Regulators should give clear indications of the methodology that should be adopted for the negotiation of interconnect agreements. Formal mechanisms should be used if necessary to avoid lengthy discussion or delays.

-- Policy-makers should encourage the gradual shift towards market forces to determine interconnect charges, and therefore end-user prices, as the number and significance of market players grows.

-- The terms for interconnection should be cost-oriented, non-discriminatory and transparent.

Appendix A

INTERCONNECTION TARIFF MODEL

Proportion of traffic by time of day and distance traversed by call (%)

	Peak	Off-peak	Total
Local	32	8	40
Intermediate/regional	32	8	40
Long-distance	16	4	20
International	0	0	0
Total	80	20	100

Call charges for mobile service end-user by time of day and distance

	Peak	Off-peak	
Local	1.30	0.78	
Intermediate/regional	1.70	1.00	1.00
Long-distance	2.00	1.20	
International	6.00	4.00	

Average call charge per call for mobile service end-user

	Peak	Off-peak	Total
Local	0.42	0.06	0.48
Intermediate/regional	0.54	0.08	0.62
Long-distance	0.32	0.05	0.37
International	0.00	0.00	0.00
Total	1.28	0.19	1.47

Fixed and recurring interconnect charges for calls originating on mobile service by time of day and distance

		Peak	Off-peak	
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	0.04	0.10	0.01	0.03
Intermediate/regional	0.04	0.12	0.01	0.05
Long-distance	0.04	0.14	0.01	0.06
International	0.35	0.46	0.09	2.00
Fixed IC charge (’000 units)	12.500	Utilisation		1.00
		Call attempt		1.00
Recurring IC charge (’000 units)	1.375	Fixed IC		1.00

Average interconnect charge per call for mobile service end-user

		Peak	Off-peak	
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	0.0128	0.0320	0.0008	0.0024
Intermediate/regional	0.0128	0.0384	0.0008	0.0036
Long-distance	0.0064	0.0224	0.0004	0.0024
International	0.0000	0.0000	0.0000	0.0000
Total	0.0320	0.0928	0.0020	0.0084

Mobile operator revenue assumptions

No. of calls per subcriber per year	906.00	1.00
Average minutes per call	2.50	1.00
Minutes per subscriber per year	2 265.00	
Usage revenue per subscriber per year	3 330.46	
Installation per subscriber	340.00	1.00
Rental per subscriber per year	1 650.00	1.00

Network growth (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
New subscribers per year	5 000	6 000	7 000	10 000	17 000	22 000	33 000
Total subscribers (year end)	5 000	11 000	18 000	28 000	45 000	67 000	100 000
Subscriber churn rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Network revenue, ’000 units (Year 1 to Year 7)

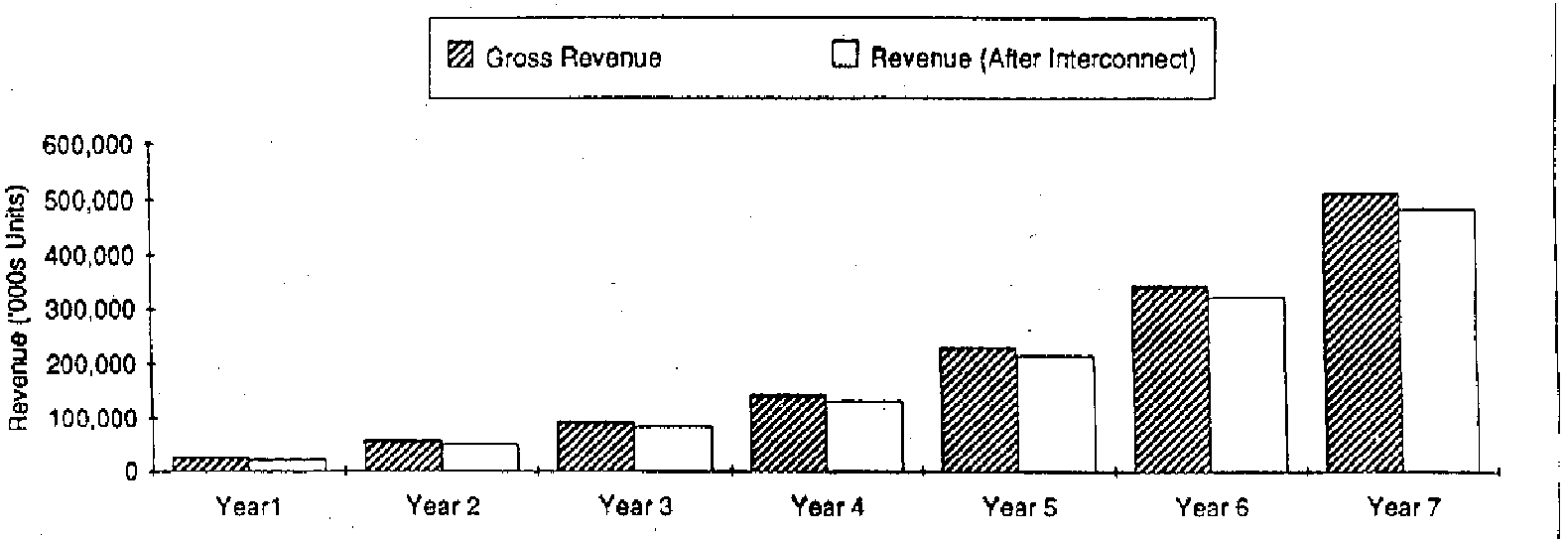
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Installation	1 700	2 040	2 380	3 400	5 780	7 480	11 220
Annual rental	8 250	18 150	29 700	46 200	74 250	110 550	165 000
Call revenue	16 652	36 635	59 948	93 253	149 871	223 141	333 046
Gross revenue	26 602	56 825	92 028	142 853	229 901	341 171	509 266

Interconnect costs, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Fixed capital costs	1 786	1 786	1 786	1 786	1 786	1 786	1 786
Recurring costs	1 375	1 375	1 375	1 375	1 375	1 375	1 375
Call attempt contribution	154	339	554	863	1 386	2 064	3 080
Usage contribution	1 146	2 521	4 128	6 418	10 315	15 358	22 922
Total interconnect charge	4 461	6 021	7 841	10 441	14 862	20 582	29 163

Revenue comparison, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Gross revenue	26 602	56 865	92 028	142 853	229 901	341 171	509 266
Revenue (after interconnect)	22 141	50 804	84 187	132 411	215 039	320 588	480 103
Revenue (as percentage of gross revenue)	83	89	91	93	94	94	94


Gross Revenue
Revenue (After Interconnect)
Revenue ('000s Units)
600,000
500,000
400,000
300,000
200,000
100,000
0
Year1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7

Proportion of traffic by time of day and distance traversed by call

	Peak	Off-peak	Total
Local	0.32	0.08	=SUM(B5:C5)
Intermediate/regional	0.32	0.08	=SUM(B6:C6)
Long-distance	0.16	0.04	=SUM(B7:C7)
International	0	0	=SUM(B8:C8)
Total	=SUM(B5:B8)	=SUM(C5:C8)	=SUM(D5:D8)

Call charges for mobile service end-user by time of day and distance

	Peak	Off-peak
Local	=1.3"E$14	=0.78"E$14
Intermediate/regional	=1.7"E$14	=1"E$14
Long-distance	=2"E$14	=1.2"E$14
International	8	4

Average call charge per call for mobile service end-user

	Peak	Off-peak	Total
Local	=B5"B14	=C5"C14	=SUM(B22:C22)
Intermediate/regional	=B6"B15	=C8"C15	=SUM(B23:C23)
Long-distance	=B7"B16	=C7"C16	=SUM(B24:C24)
International	=B8"B17	=C8"C17	=SUM(B25:C25)
Total	=SUM(B22:B25)	=SUM(C22:C25)	=SUM(D22:D25)

Fixed and recurring interconnect charges for calls originating on mobile service by time of day and distance

	Peak		Off-peak	
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	=0.04"E$38	=0.1"E$37	=0.01"E$38	=0.03"E$37
Intermediate/regional	=0.04"E$38	=0.12"E$37	=0.01"E$38	=0.045"E$37
Long-distance	=0.04"E$38	=0.14"E$37	=0.01"E$38	=0.06"E$37
International	0.35	0.46	0.09	2
Fixed IC charge (’000 units)	=12500000"E39		Usage	1
			Call attempt	1
Recurring IC charge (’000 units)	=0.11"B37		Fixed IC	1

Average interconnect charge per call for mobile service end-user

	Peak		Off-peak	
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	=$B5"B32	=$B5"C32	=$C5"D32	=$C5"E32
Intermediate/regional	=$B6"B33	=$B6"C33	=$C6"D33	=$C6"E33
Long-distance	=$B7"B34	=$B7"C34	=$C7"D34	=$C7"E34
International	=$B8"B35	=$B8"C35	=$C8"D35	=$C8"E35
Total	=SUM(B45:B48)	=SUM(C45:C48)	=SUM(D45:D48)	=SUM(E45:E48)

Appendix B

EXAMPLES OF MODEL OUTPUT FOR AUSTRALIA AND SWEDEN

Mobile operator revenue assumptions

Number of call/subscriber/year	=906"D54	1
Average minutes per call	=2.5"D55	1
Minutes per subscriber per year	=B54"B55	
Usage revenue/subscriber/year	=B56"D26	
Installation/subscriber	=340"D58	1
Rental/subscriber/year	=1 650"D59	1

Network growth (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
New subscribers per year	=B65	=C65-B65+(B65"C66)	=E65-D65+(D65"E66)	=F65-E65+(E65"F66)	=G65-F65+(F65"G66)	=H65-G65+(G65"H66)	=C65-B85+(B85"C66)
Total subscribers (year end)	=H65"0.05	=H65"0.11	=H65"0.18	=H65"0.28	=H65"0.45	=H65"0.67	100 000
Subscriber churn rate	0	0	0	0	0	0	0

Network revenue, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Installation	=B64"$B58	=C64"$B58	=D64"$B58	=E64"$B58	=F64"$B58	=G64"$B58	=H64"$B58
Annual rental	=B65"$B59	=C65"$B59	=D65"$B59	=E65"$B59	=F65"$B59	=G65"$B59	=H65"$B59
Call revenue	=B65"$B57	=C65"$B57	=D65"$B57	=E65"$B57	=F65"$B57	=G65"$B57	=H65"$B57
Gross revenue	=SUM(B71:B73)	=SUM(C71:C73)	=SUM(D71:D73)	=SUM(E71:E73)	=SUM(E71:E73)	=SUM(G71:G73)	=SUM(H71:H73)

Interconnect costs, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Fixed capital costs	=$B37/7	=$B37/7	=$B37/7	=$B37/7	=$B37/7	=$B37/7	=$B37/7
Recurring costs	=$B39	=$B39	=$B39	=$B39	=$B39	=$B39	=$B39
Call attempt contribution	=$B54"($B49+$D49)"B65	=$B54"($B49+$D49)"C65	=$B54"($B49+$D49)"D65	=$B54"($B49+$D49)"E65	=$B54"($B49+$D49)"F65	=$B54"($B49+$D49)"G65	=$B54"($B49+$D49)"H65
Usage contribution	=$B56"($C49+$E49)"B65	=$B56"($C49+$E49)"C65	=$B56"($C49+$E49)"D65	=$B56"($C49+$E49)"E65	=$B56"($C49+$E49)"F65	=$B56"($C49+$E49)"G65	=$B56"($C49+$E49)"H65
Total interconnect charge	=SUM(B79:B82)	=SUM(C79:C82)	=SUM(D79:D82)	=SUM(E79:E82)	=SUM(F79:F82)	=SUM(G79:G82)	=SUM(H79:H82)

Revenue comparison, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Gross revenue	=B74	=C74	=D74	=E74	=F74	=G74	=H74
Revenue (after interconnect)	=B74-B83	=C74-C83	=D74-D83	=E74-E83	=F74-F83	=G74-G83	=H74-H83
Revenue (as % of gross revenue)	=B89/B88	=C89/C88	=D89/D88	=E89/E88	=F89/F88	=G89/G88	=H89/H88

Sweden

Proportion of traffic by time or day and distance traversed by call (percentage)

	Peak	Off-peak	Total
Local	32	8	40
Intermediate/regional	32	8	40
Long-distance	16	4	20
Total	80	20	100

Call charges for mobile service end-users by time of day and distance

	Peak	Off-peak
Local	3.45	2.30
Intermediate/regional	3.45	2.30
Long-distance	3.45	2.30

Average call charge per call for mobile service end-user

	Peak	Off-peak	Total
Local	1.10	0.18	1.29
Intermediate/regional	1.10	0.18	1.29
Long-distance	0.55	0.09	0.64
Total	2.76	0.46	3.22

Fixed and recurring interconnect charges for calls originating on mobile service by time of day and distance

		Peak		Off-peak
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	0.00	0.65	0.00	0.65
Intermediate/regional	0.00	0.65	0.00	0.65
Long-distance	0.00	0.65	0.00	0.65
Fixed IC charge (’000 SKr)	11 000			
Recurring IC charge (’000 SKr)	1 210			

Average interconnect charge per call for mobile service end-user

		Peak		Off-peak
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	0.00	0.2080	0.00	0.052
Intermediate/regional	0.00	0.2080	0.00	0.052
Long-distance	0.00	0.1040	0.00	0.026
Total	0.00	0.5200	0.00	0.130

Mobile operator revenue assumptions

No. of calls/subscriber/year	906.00
Average minutes/call	2.50
Minutes/subscriber/year	2 265.00
Usage revenue/subscriber/year	7 293.30
Installation/subscriber	300.00
Rental/subscriber/year	1 400.00

Network growth (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
New subscribers/year	10 400	12 480	14 560	20 800	35 360	45 760	68 640
Total subscribers (year end)	10 400	22 880	37 440	58 240	93 600	139 360	208 000
Subscriber churn rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Network revenue, ’000 units (Year 1 to Year 7)

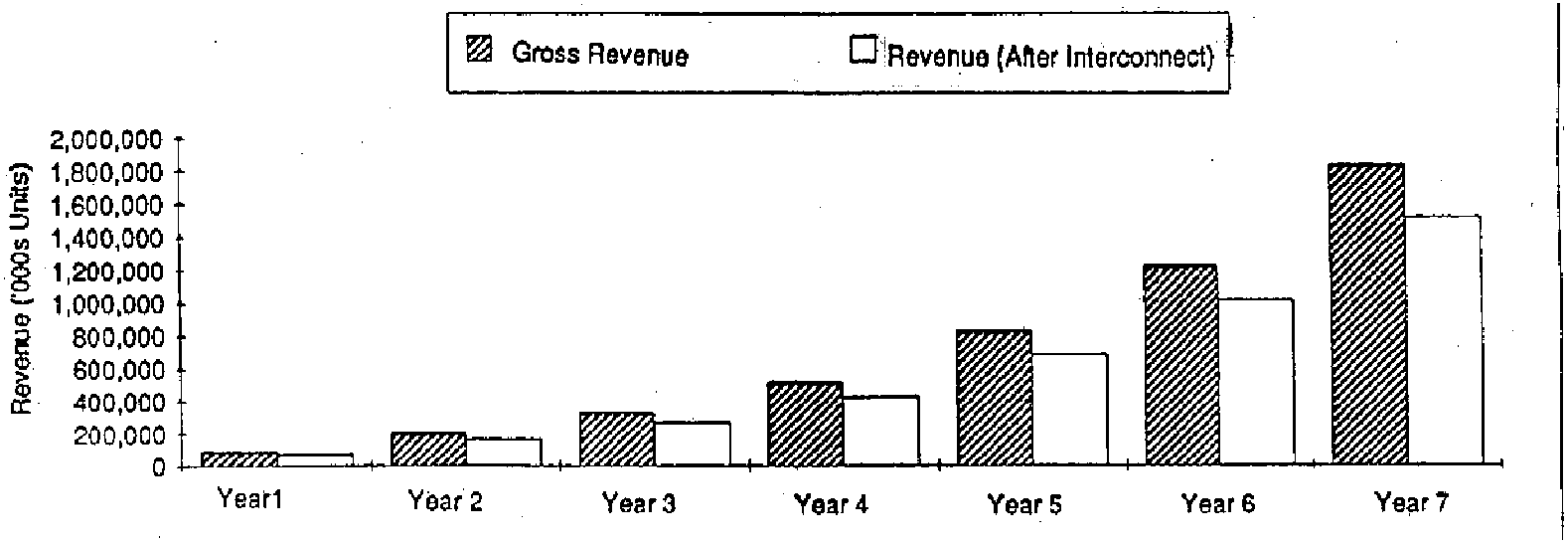
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Installation	3 120	3 744	4 368	6 240	10 608	13 728	20 592
Annual rental	14 560	32 032	52 416	81 536	131 040	195 104	291 200
Call revenue	75 850	166 871	273 061	424 762	682 653	1 016 394	1 517 006
Gross revenue	93 530	202 647	329 845	512 538	824 301	1 225 226	1 828 798

Interconnect costs, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Fixed capital costs	1 571	1 571	1 571	1 571	1 571	1 571	1 571
Recurring costs	1 210	1 210	1 210	1 210	1 210	1 210	1 210
Call attempt contribution	0	0	0	0	0	0	0
Usage contribution	15 311	33 685	55 121	85 744	137 803	205 173	306 228
Total interconnect charge	18 093	36 467	57 902	88 525	140 584	207 954	309 009

Revenue comparison, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Gross revenue	93 530	202 647	329 845	512 538	824 301	1 225 226	1 828 798
Revenue (after interconnect)	75 437	166 180	271 943	424 013	683 717	1 017 272	1 519 789
Revenue (as % of gross revenue)	0.81	0.82	0.82	0.83	0.83	0.83	0.83


Gross Revenue
Revenue (After Interconnect)
Revenue ('000s Units)
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Year1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7

Australia

Proportion of traffic by time of day and distance traversed by call

	Peak	Off-peak	Total
Local	32	8	40
Intermediate/regional	32	8	40
Long-distance	16	4	20
Total	80	20	100

Call charges for mobile service end-user by time of day and distance

	Peak	Off-peak
Local	0.38	0.19
Intermediate/regional	0.38	0.19
Long-distance	0.60	0.30

Average call charge per call for mobile service end-user

	Peak	Off-peak	Total
Local	0.12	0.02	0.14
Intermediate/regional	0.12	0.02	0.14
Long-distance	0.10	0.01	0.11
Total	0.34	0.04	0.38

Fixed and recurring interconnect charges for calls originating on mobile service by time of day and distance

	Peak		Off-peak	
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	0.0114	0.0272	0.0029	0.0081
Intermediate/regional	0.0096	0.0248	0.0029	0.0096
Long-distance	0.0114	0.0363	0.0029	0.0170
Fixed IC charge (’000 units)	3 519			
Recurring IC charge (’000 units)	387			

Average interconnect charge per call for mobile service end-user

	Peak		Off-peak	
	(Call attempt)	(Usage/min)	(Call attempt)	(Usage/min)
Local	0.0036	0.0087	0.0002	0.0006
Intermediate/regional	0.0031	0.0079	0.0002	0.0008
Long-distance	0.0018	0.0058	0.0001	0.0007
Total	0.0085	0.0224	0.0006	0.0021

Mobile operator revenue assumptions

No. of calls per subscriber per year	906.00
Average minutes per call	2.50
Minutes per subscriber per year	2 265.00
Usage revenue per subscriber per year	864.32
Installation per subscriber	100.00
Rental per subscriber per year	480.00

Network growth (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
New subscribers per year	27 090	32 507	37 925	54 179	92 104	119 194	178 791
Total subscribers (year end)	27 090	59 597	97 522	151 701	243 808	363 000	541 791
Subscriber churn rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Network revenue, ’000 units (Year 1 to Year 7)

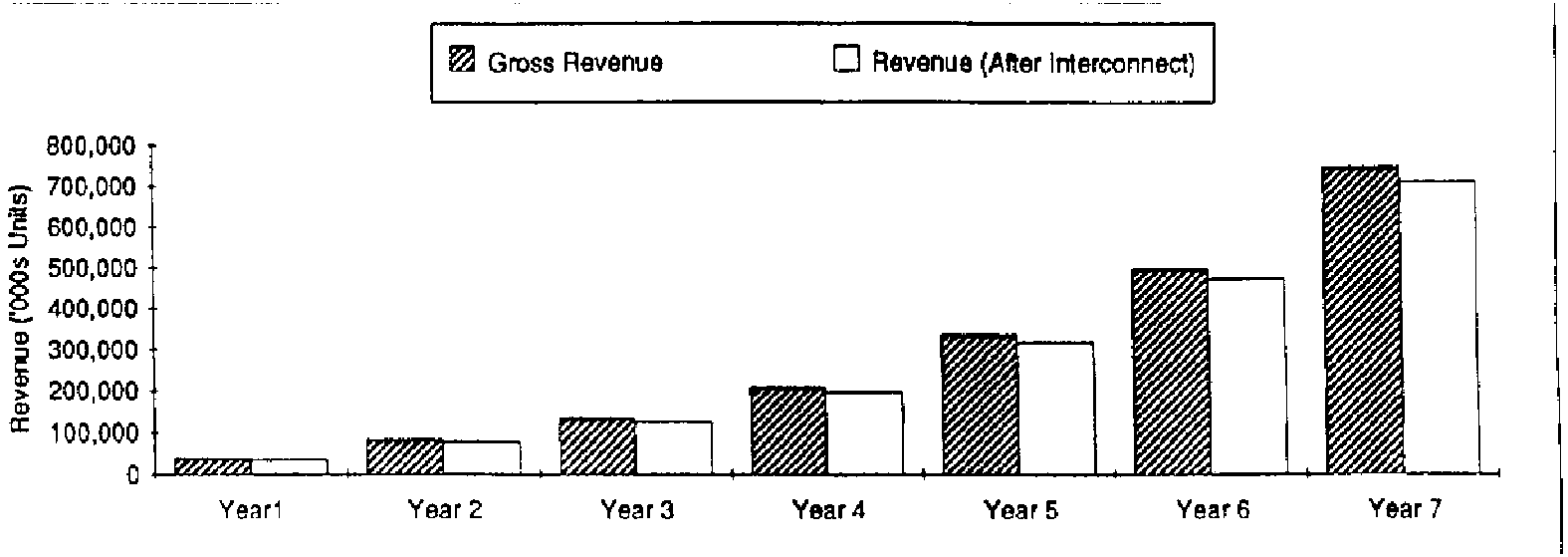
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Installation	2 709	3 251	3 793	5 418	9 210	11 919	17 879
Annual rental	13 003	29 607	46 811	72 817	117 027	174 240	260 060
Call revenue	23 414	51 511	84 291	131 119	210 727	313 750	468 283
Gross revenue	39 126	83 368	134 894	209 354	336 965	499 909	746 222

Interconnect costs, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Fixed capital costs	503	503	503	503	503	503	503
Recurring costs	387	387	387	387	387	387	387
Call attempt contribution	224	493	806	1 254	2 015	3 001	4 479
Usage contribution	1 506	3 313	5 421	8 433	13 554	20 180	30 119
Total interconnect charge	2 620	4 696	7 117	10 577	16 459	24 070	35 488

Revenue comparison, ’000 units (Year 1 to Year 7)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Gross revenue	39 126	83 368	134 894	209 354	336 965	499 909	746 222
Revenue (after interconnect)	36 506	78 673	127 777	198 777	320 506	475 839	710 734
Revenue (as % of gross revenue)	0.93	0.94	0.95	0.95	0.95	0.95	0.95


Gross Revenue
Revenue (After Interconnect)
Revenue ('000s Units)
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Year1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7

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