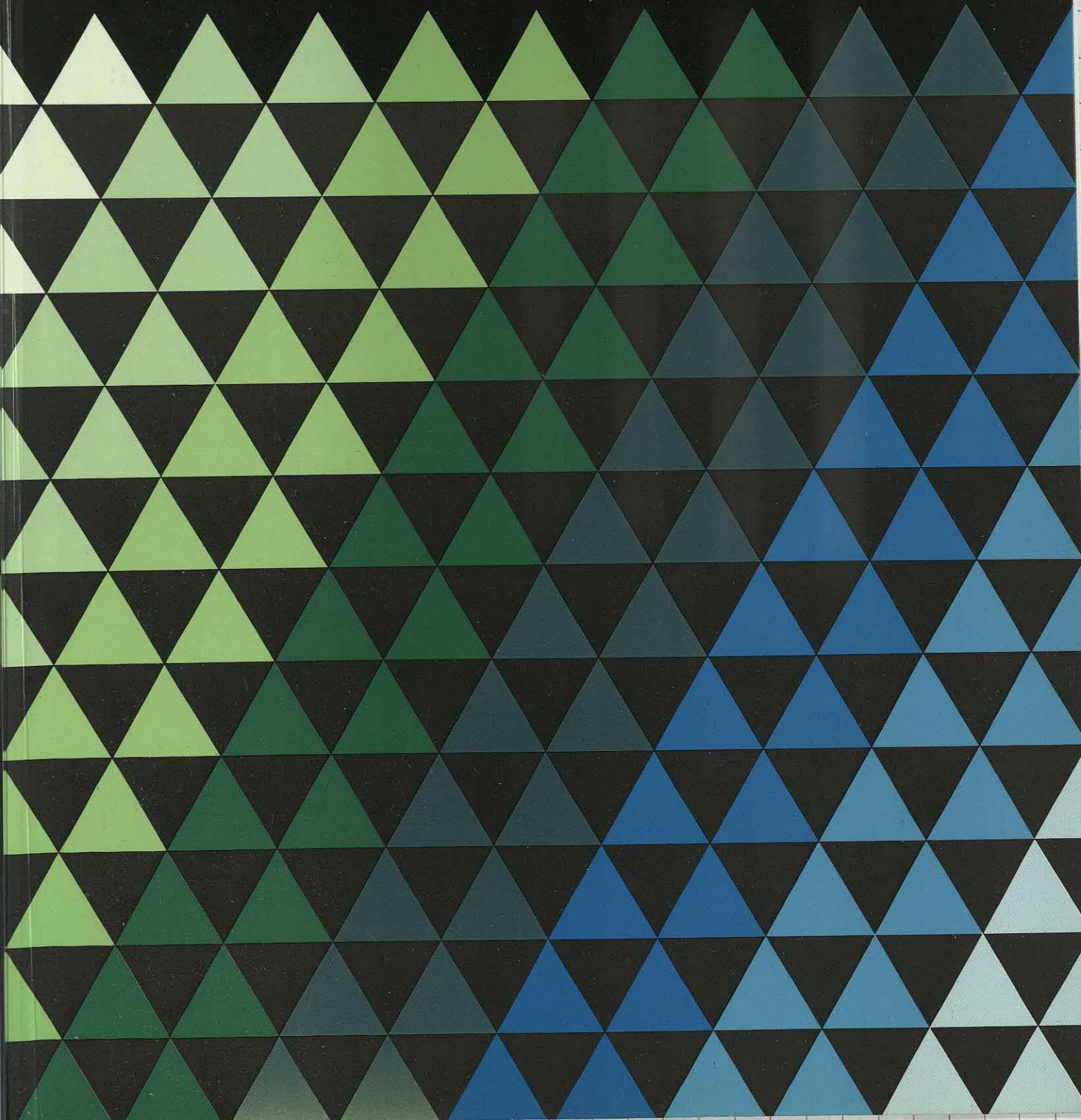
Mobile Communications

BUTLER COX FOUNDATION

Research Report 68, February 1989



BUTLER COX FOUNDATION

Mobile Communications

Research Report 68, February 1989

Butler Cox & Partners Limited

LONDON
AMSTERDAM MUNICH NEW YORK PARIS

Published by Butler Cox & Partners Limited
Butler Cox House
12 Bloomsbury Square
London WC1A 2LL
England

Availability of reports

Members of the Butler Cox Foundation receive three copies of each report upon publication; additional copies and copies of earlier reports may be purchased by members from Butler Cox.

Photoset and printed in Great Britain by Flexiprint Ltd., Lancing, Sussex.

BUTLER COX FOUNDATION

Mobile Communications

Research Report 68, February 1989

Contents

Management Summary

A Management Summary of this report has been published separately and distributed to all Foundation members. Additional copies of the Management Summary are available from Butler Cox

Chapter 1

A new management approach is needed

Until recently, mobile communications have been a somewhat neglected area of information technology, and their use has been limited and specialised. Organisations with an imperative business need to communicate with vehicles and staff on the move — for example, taxi companies and the emergency services — have operated their own private radio systems, but these usually require a substantial investment in specialist expertise and management time. Mobile telephony has been regarded, at one extreme, as a 'perk', and at the other, as a tool strictly for use by top management. The recent advent of cellular telephone services in many countries has done little to modify these views. Pagers have been widely adopted in some countries, but their use tends to be associated with very specific groups of users, like doctors and maintenance engineers. In few cases has the true business potential of mobile communications been realised, let alone exploited.

As a consequence, mobile communications services have received little management attention in most organisations. Responsibility has been devolved to the individual departments most directly concerned. Coordinated purchasing has been limited, and the use of mobile services has developed independently of the use of other information technology. When only paging, private mobile radio, and public mobile telephony were available, existing as separate services with no facility for interconnection, and when they fulfilled completely different requirements, this state of affairs may have been acceptable. It is no longer so.

NEW DEVELOPMENTS HAVE GREATLY INCREASED THE IMPORTANCE OF MOBILE COMMUNICATIONS

Over the past few years, a range of public mobile communications services, which offer an alternative to private systems in an increasing range of applications, has been made available in many countries: they open up new possibilities that it would be uneconomical or impracticable for most organisations to address with private systems. The most important of the new services are cellular telephony and display paging (where a telephone number or a short message can be displayed on the pager), both of which are now available in most developed countries. In addition, the technology to support data transmission to and from mobile units is now available in commercial form, and public mobile data communications and vehicle-location services have been launched.

Mobile services are now accessible to a much wider range of organisations than hitherto. Services that were previously available only on private systems are now offered as public services, with full back-up for customers without radio-transmission skills. New technologies have greatly increased the number of customers whom mobile services can support. Services are available in more countries and over a higher proportion of the land area (and, indeed, territorial waters) of those countries. Prices have fallen dramatically, and equipment and services are available in more universally usable forms — mobile terminals are much smaller than they used to be, and transmission quality has improved significantly.

As the new services appear, the boundaries between the different types of mobile communications are being eroded. The systems supporting mobile communications applications have become more sophisticated, and mobile services are being integrated with other systems and services as the technologies converge. In France, the Radiocom 2000 system provides both a cellular telephony service and a private mobile radio service, and messages for the Alphapage message-paging system can be input from terminals on the public videotex service. In the United Kingdom, it is possible to set up a direct link from a private network to a cellular telephony service provider's switch, so that mobile telephones can be treated as PABX extensions. Mobile data terminals can access company computer systems in the same way as conventional terminals.

These trends towards the availability of an increasing range of services, and the convergence of services, both with each other and with other systems technologies, will continue, and will make mobile services acceptable and accessible to a new

and growing range of customers. The market is growing at a remarkable rate and there is no sign that this rate is going to slacken. The European market for cellular telephones, for example, is expected to continue to grow at an annual rate of over 40 per cent for the next few years, to reach 3.4 million, or 1 per cent of the total population, by 1992. In the longer term, the industry expects that 5 per cent of the population will be using cellular telephones. The usage of other mobile communications services can be expected to grow at a similar rate. These growth rates represent a substantial increase in the importance of mobile communications in the telecommunications environment as a whole.

Some organisations have already recognised this and have taken steps to exploit the benefits that mobile services can bring. Clearly, some types of organisation are particularly dependent on mobile communications to conduct their business, but most can gain significant benefits from the introduction of selected applications. The introduction of mobile communications can produce quite diverse benefits: they enable organisations to be more responsive, both to their customers and to emergencies that arise within their own organisations; they cut fuel and manpower costs by facilitating more effective scheduling of vehicles and staff on the move; they can enable valuable staff to make productive use of travelling time. While it is not always easy to put a precise value on the advantages to be derived from mobile communications, actual cost savings can be demonstrated in many cases.

These, and the other benefits that organisations can potentially derive from the use of mobile communications, are discussed further in Chapter 2. The main types of mobile communications services (summarised in Figure 1.1), the products on which they are based, and the remarkable growth and development of the market are described in Chapter 3.

MOBILE COMMUNICATIONS NOW DESERVE TO BE TAKEN SERIOUSLY

The developments discussed above mean that, by 1993, mobile services will account for more than 10 per cent of spending on telecommunications in most companies. Foundation members can no longer afford, therefore, to treat mobile communications in an ad hoc manner. Mobile communications need to be planned for and managed in the same way as other areas of information technology (IT), and coordinated with them. Organisations therefore need to extend the scope of their IT strategy to include mobile communications. Where mobile communications are not actively managed, operations become inefficient, unnecessary costs are incurred, and opportunities to develop the business in the future are jeopardised. In such cases, organisations are failing to reap the commercial benefits that mobile communications could bring.

Figure 1.1 Mobile communications technologies make a wide range of services possible

Service	Nature of the service
Paging	An alerting service that activates a small, portable terminal (pager) either to emit a tone or to display a telephone number or a short message. Paging messages are transmitted on a single channel, one-way only, and each pager is identified by a code so that it responds only to the messages addressed to it.
Mobile radio	Used by organisations to support their own activities. Typically, users talk only to the operator, not to each other, only one party can transmit at any one time, and all users share the same channel. A more recent development, known as trunked mobile radio, allows users to share access to a number of channels, and they are allocated a free channel when they want to communicate. Both technologies may be privately operated or they may be used to provide a public service offering similar facilities.
Cellular telephony	A mobile telephone service using a number of low-power transmitters (base stations), each of which provides service within a small, well-defined area, or cell. Cellular systems can cater for more users than traditional mobile telephone systems because the same frequencies can be re-used in non-adjacent cells.
Wide-area cordless telephony	Public base units sited at locations such as railway stations and airports enable users to operate their own handsets, similar to those used with domestic cordless telephones, within 150 metres of one of these base units. Only outgoing calls are possible.
Mobile data communications	Mobile services that support data communications. In some cases, they transmit data only; in others, they support voice as well.
Vehicle location	A service that enables the user, at base, to pinpoint the location of a vehicle. In most cases, these services also provide limited data communication between the vehicle and base.
Satellite-based mobile services	Also known as land mobile satellite services (as opposed to satellite services for ships and aircraft). Planned services include paging, vehicle location, and messaging.
Air-to-ground telephony	An in-flight telephone service for airline passengers.
In-car information services	A service that provides traffic information, and in some cases, advice on routes, to drivers.

Because of the growing need to integrate mobile communications with fixed networks and existing systems, and because of the increasing share of the telecommunications budget that mobile communications will represent in most organisations in the next few years, we recommend that systems departments take responsibility for mobile communications. This will, of course, have wide-ranging implications for the systems department. Systems directors will have to ensure that the telecommunications managers, to whom they will logically delegate responsibility for mobile communications, are well informed about the new technologies so that they are in a position to provide support for users, and guidelines for the use of particular products and services. Systems departments will also have an important role to play in identifying requirements for specific applications, selecting appropriate types of mobile service to meet these needs, and choosing competent and reliable suppliers. These aspects of the systems department's role in planning for the introduction of mobile communications, and in managing their use, are discussed in Chapter 4.

SCOPE OF THE RESEARCH

In this report, we are concerned only with wide-area mobile communications — that is, communication with people or vehicles travelling away from the site at which they are based. On-site paging systems, short-range radio telephones ('walkie-talkies'), infra-red communication within rooms, and other aspects of the 'cable-less' office, were excluded from the scope of the research.

Our recommendations are based on an extensive programme of research carried out during the spring, summer, and early autumn of 1988. The questionnaires sent out to Foundation members at the start of the research yielded 111 responses and much valuable information on the current levels of use and the applications of mobile communications, and on the barriers to more extensive use. We undertook a literature search to review mobile communications technologies and their current state of development, and to identify advanced applications. Over 50 users and suppliers of mobile communications products and services were interviewed in 12 countries on four continents. Mobile communications are, however, most highly developed and most widely used in the United Kingdom, Scandinavia, the United States, Australia, and Hong Kong. The examples described in this report, and the prices quoted, therefore apply particularly to these countries. We also sought the views of two leading mobile communications industry experts, John Carlton and Nigel Cawthorne. John Carlton is an independent consultant who recently retired from a senior position with Pye Telecommunications Ltd (now Philips Radio Communication Systems Ltd), where he was responsible for mobile radio developments. He has also served on many mobile communications industry committees and standards development groups. Nigel Cawthorne is the editor of *European Mobile Communications Report.*

The research was led by Karol Szlichcinski, a senior consultant with Butler Cox in London, who has extensive experience of studies of the business applications of telecommunications services. He was assisted by Cathal Conaty in the United Kingdom, and by Michel Lederman, Lothar Schmidt, and Onno Schroder from Butler Cox's offices in Paris, Munich, and Amsterdam respectively. Expert guidance was provided by Ray Northcott, a principal consultant with Butler Cox in London, and by Bill Sherratt, an associate of Butler Cox, both of whom have extensive experience in mobile communications.

Chapter 2

Mobile communications can bring substantial business benefits

Mobile communications services are only now beginning to be regarded as serious business tools. In their early days, mobile telephones acquired the reputation of being little more than executive toys, and pagers have been almost exclusively used in certain very specific applications. Existing paging, private mobile radio, and mobile telephone services can, however, bring substantial business benefits, in terms of more effective use of human and physical resources, which can result in competitive advantages or cost savings. Some of the greatest benefits are likely to arise from the use of mobile data communications that are still in their infancy. For some types of organisation (freight-haulage companies with fleets of trucks, for example), it is easy to see how mobile communications can provide benefits. Our research shows, however, that most organisations can obtain significant benefits from the introduction of selected mobile communications applications.

The main reason that the use of mobile communications is not more widespread is that many organisations believe the costs to be too high in relation to the benefits. We believe that, although the costs can be substantial, they can be justified, for specific applications, and in most types of organisation. Furthermore, the overall costs of mobile communications are likely to fall, making it easier to justify their use.

MOBILE COMMUNICATIONS CREATE COMPETITIVE ADVANTAGES AND REDUCE COSTS

Mobile communications enable more effective use to be made of people and physical resources, allowing the organisation and its staff to be more responsive to customer demands and to unexpected events. Sometimes, mobile services can be used as an alternative to conventional telecommunications, and they can also be used as part of an inclusive customer-service package. In many cases, they can result in a distinct competitive advantage for the organisation concerned, and can often reduce costs at the same time.

GREATER RESPONSIVENESS

The greatest benefit of mobile communications to most organisations is that staff can keep in touch while they are away from their offices, and hence, be more responsive. This responsiveness may be to customers with requests that can be reacted to immediately, or it may be to events, such as a change in share prices or a major delay at an airport or on the road. The quality of the response is improved as well as its timing because staff can contact their office (or other sources) for information. A fast response is essential for emergency services, and it is not surprising that they were the earliest civilian users of mobile communications services. Mobile communications play a vital role in directing police to where they are needed, alerting hospitals to the requirements of patients in ambulances, coordinating firemen at the site of a large fire, contacting the relevant authorities when the threat of pollution requires urgent attention, and notifying the relevant services about emergencies in the public utilities.

Other organisations and individuals in a wide range of business areas can also obtain benefits from the greater responsiveness possible with mobile communications. Using mobile communications, sales staff have been able to make contact with potential customers much more quickly, and to provide detailed information on the spot, thus putting them in a strong position to get a contract signed. Support engineers who are on the road can be notified of emergencies and can be directed to the customer's site. Road-haulage companies, knowing exactly where their trucks are at all times, can respond quickly to changed customer requirements, and can send help immediately in case of breakdowns. Financial dealers are alerted by their portable terminals or pagers when the prices of particular shares change by a given amount, and can act on that information immediately. Fishermen can inform their colleagues at sea of the location of shoals of fish; with cellular telephony, they can do this without being overheard by competitors.

The case histories in Figures 2.1 and 2.2 describe the advantages that two organisations have gained

from the greater responsiveness provided by mobile communications. It is not always easy to place a value on greater responsiveness, however, because the benefits arise largely from the ability to react to irregular and unpredictable events. Measuring the reduction in the average time taken to respond to a query, or the increase in the number of face-to-face sales contacts, gives some indication of the benefits. Sometimes, managers can quote the value of specific deals that have been closed because of the availability of mobile communications. An alternative approach is to look at the performance of the organisation as a whole, before and after the introduction of mobile communications — for example, measures of system resilience where systems staff have been provided with mobile communications, or increased turnover when a road transport company has introduced mobile communications.

MORE PRODUCTIVE USE OF RESOURCES

Using mobile communications, managers and other highly paid staff can make productive use

Figure 2.1 Greater responsiveness has significantly improved the service offered by a supplier of computer systems

Hewlett-Packard Ltd

Hewlett-Packard Ltd is one of the largest suppliers of computer systems in the United Kingdom, with a turnover of £428 million ($770 million) in 1987. It has over 600 staff with cellular telephones, most of them sales account managers and customer support engineers.

Account managers responsible for sales of commercial systems have portable cellular telephones so that they can be contacted at any time by customers. Commercial systems are usually large configurations, and timing is critical in sales of this kind. Sales staff claim that they have won some contracts because they were able to contact potential customers, or be contacted, at critical times in a deal. On occasions, sales staff also use the facility of diverting their calls to a voice-messaging system.

Customer support engineers are provided with a Hewlett-Packard HP110 portable personal computer, and their cars are equipped with a cellular telephone and a Racal-Vodata modem that uses the cellular data link control (CDLC) protocol. The support engineers run the Advancelink communications package on their portable computers to exchange data over the Vodafone network both with a scheduling system that downloads information about calls to be made, and with the company's electronic mail system. Communication is asynchronous, at 1200 bit/s, via an RS232 interface between the personal computer and the modem. The cost is about £1,700 ($3,060) per installation, which includes the cellular telephone and the modem. The personal computer (with 1 megabyte of memory) and the software are Hewlett-Packard's own, but would cost about £3,000 ($5,400) in the marketplace.

The benefit to Hewlett-Packard is improved productivity; engineers can make more calls per day and can be provided with more information about each call. Information on the availability of parts, or technical back-up, is provided via electronic mail. Information can be transmitted while engineers are on the move, and stored in the personal computer for access when required.

Hewlett-Packard has also installed a 2M bit/s Megastream private circuit link from its corporate telecommunications network to the Vodafone switch. Compared with access over the public telephone network, the private circuit gives quicker call set-up time, better quality, direct-to-desk dialling and, above all, cost savings: call charges are typically reduced from about 35p (63c)/minute to about 20p (36c)/minute. The one-off costs were between £10,000 ($18,000) and £20,000 ($36,000) for multiplexors, PABX cards, and Megastream installation. The Megastream rental is about £11,000 ($19,800) a year.

Figure 2.2 Greater responsiveness has dramatically improved a building society's service to potential house buyers

Cheltenham and Gloucester Building Society

The Cheltenham and Gloucester Building Society is one of the top 10 building societies in the United Kingdom. (Building societies are UK financial institutions providing savings accounts, mortgages — that is, loans for house purchase — and other financial services.) Competition in the market for providing mortgages is acute; the Cheltenham and Gloucester reviewed the service it was providing and set itself the objective of reducing the time it took to make a mortgage offer.

As part of the preparation of a mortgage offer, a valuer visits the house for which the mortgage is being requested and assesses its physical condition and likely market value. The valuation process, with the building society instructing the valuer, and the valuer making an appointment with the current occupants of the house, viewing the house, and writing and submitting a report, could take several days and caused the longest delay in the process of making a mortgage offer.

The Cheltenham and Gloucester has used mobile communications to reduce this delay radically. About 20 valuers now have cars equipped with a Motorola car telephone and a Sharp 200 facsimile machine set up to transmit over the cellular telephone network. The installation was developed in conjunction with Astec, an air-time and equipment retailer. When a customer requests a mortgage, the mortgage proposal, with details of the property on which the mortgage is required, is faxed to the valuer in his car. The valuer uses the car telephone to make an appointment to view the house, the same day if possible. When he conducts the survey, he fills out a special form, designed to be quick to complete, and faxes it back to the manager of the building society branch handling the mortgage application.

The target time for converting proposals into offers of a mortgage is 36 hours: sometimes, it takes less time, occasionally more. During the pilot study, one delighted customer received an offer just two hours after handing in his proposal — but that was exceptional.

All internal procedures have been streamlined to ensure that the customer receives the best and quickest possible service: the investment in technology, coupled with simple procedures, helps to achieve this.

of their time when they are travelling. Many of the managers we interviewed said that they used train and car journeys to catch up on routine telephone calls or to review activities with their staff. Figure 2.3 shows how, in the United Kingdom, the increase in productive time of a manager who makes 40 calls a week while travelling more than compensates for the cost of a mobile telephone and the increased call costs. (We hope that it is not necessary to remind Foundation members that it is not safe to use a 'hands-on' mobile communications terminal while driving a car.)

Mobile services permit more effective scheduling and allocation of vehicles and staff on the move. In many jobs, where staff are on the road most of the time, it is highly desirable to be able to adjust their calling schedule during the day, either to take account of jobs that have taken more or less time than expected, or to respond to cancellations and new calls. Mobile communications make this possible. The scale of the benefits will depend on the precise nature of the organisation's operations. As an indication of the potential, however, organisations employing teams of service engineers have found that the use of mobile communications (sometimes in conjunction with computer-assisted dispatching) has enabled them to increase the average number of calls per day made by their engineers by between 20 and 66 per cent.

Figure 2.3 Use of mobile telephones by managers can produce a net benefit to their organisations

Take a UK manager on a salary of £30,000 a year.	
Total cost of his employment to the company: say £60,000 a year.	
Assume he makes 40 calls a week from his car, of average duration 2.5 minutes. (This is the average usage rate reported in a 1987 survey in the United Kingdom.)	
Total calling time: 100 minutes a week, or 20 minutes a day.	
If he works a ten-hour day, this represents an annual increase of 1/30th in his productive time, equivalent to	£2,000
Against this must be set the cost of the mobile telephone, and the additional costs of mobile calls compared with fixed-link ones.	
Annual cost of mobile calls at 25p/minute	£1,150
Cost of equivalent fixed-link calls, assuming 80 per cent local calls, 20 per cent long-distance calls, all made at peak rates	£322
Additional annual cost of mobile calls	£828
Equipment cost £600 over three years, or, annually	£200
Total cost of mobile service	£1,028
Net benefit	**£972**

More effective scheduling through mobile communications also permits more effective use of vehicles for any organisation operating fleets of vehicles — for example, road-haulage, bus and taxi companies, courier and parcel-delivery firms, and operators of specialist vehicles such as recovery vehicles. Figure 2.4 describes the experience of a large freight-transport company whose use of mobile communications has enabled it to schedule its vehicles so successfully that it has won a number of major contracts from competitors and, at the same time, achieved significant cost savings. In 1982, a wide-ranging study of the UK transport industry predicted that the use of mobile communications could, on average, reduce the running time of each vehicle by two hours a week, equivalent to £1,900 ($3,400) per vehicle per year, and cut fuel costs by 10 per cent (£600 ($1,000) per vehicle per year) if the same level of business was maintained. The transport businesses that can benefit most from mobile communications are those that need to do multiple pick-ups and deliveries during a single trip.

Savings are, indeed, achieved in practice. The transport company quoted in Figure 2.4 found that its vehicle-location system enabled it to reduce the empty mileage covered by its trucks. Southern Counties Garages, a vehicle-recovery operation based in the south of England, noted a marked improvement in its operations when it installed equipment in its recovery vehicles to access Band Three Radio, a private trunked mobile radio system. Prior to the installation of the Band Three Radio system, each vehicle-recovery operation typically required 11 calls, with drivers using pagers, public telephones, and their home telephones to contact the garage. Savings in communications costs, with four mobile units, amounted to £570 ($1,025) per quarter. In addition, Southern Counties Garages was able to increase productivity by 35 per cent, with the same fleet and the same number of drivers, and to reduce vehicle running costs by eliminating unnecessary mileage. As a result, the business has been expanded; the recovery fleet has been increased from six to nine vehicles in the year since the system was installed.

A major factor contributing to the more effective use of staff and vehicles is the elimination of repeat visits to their home base for information about the next call. Perhaps the clearest example we found was of a utility company, San Diego Gas and Electric, that has installed cellular facsimile equipment in a van used by the staff who repair power lines and gas pipes in outlying areas. The repair team no longer has to return to base to collect the information it requires on site because

it can now be faxed to the van. In addition, the team can consult its base for technical back-up, using the associated mobile telephone. For a capital cost of $5,000, and operating costs of between $150 and $200 a month, the system saves between 30 and 40 man-hours a month per team, and also enables the repair team to give customers a quicker and better service.

IMPROVED SAFETY AND SECURITY OF STAFF AND VEHICLES

Mobile communications services can also make a substantial contribution to the safety of staff, and to the security of both staff and vehicles. For example, maintenance and engineering staff working in potentially hazardous locations can use portable radio terminals to keep in continuous contact, or to call for help in the case of an accident. Police officers and other security staff can use portable radios to call for assistance; the police in the United Kingdom use open-channel technology, so that all officers can hear all communications.

Mobile communications can also improve the security of vehicles. Many of the financial institutions we interviewed have installed mobile radio terminals in vehicles used for carrying valuable documents, to provide rapid contact with base in case of an emergency. Specialist security firms carrying valuable items use mobile radio terminals as a matter of course. Vehicle-location technology will, in future, be particularly valuable in improving the security of bulk shipments of high-value goods like cigarettes, spirits, consumer electronics, and fashion goods.

AN ALTERNATIVE TO FIXED SERVICES

Mobile communications can provide a back-up to fixed services in an emergency, or where fixed-link telephone services are inadequate. For two weeks, after a fire had destroyed a local telephone exchange, one US bank used a mobile telephone in a parked car to order cash for customers and to arrange wire transfers. A Californian branch of another bank used a similar method to transact business after an earthquake had cut telephone lines. Several of the banks and financial institutions we interviewed now have pools of mobile telephones that they can call on in an emergency. Police forces, which, in the past, relied on private circuits to back up the public telephone network, now use their radio systems as a back-up to telephone circuits. They also use cellular radio for connections to emergency transportable control rooms.

Figure 2.4 A road-haulage company has saved money for itself and its customers by timely scheduling of its fleet of trucks

Frederick Transport

Frederick Transport, of Dundas, Ontario, Canada, is a road-haulage company providing general and specialised freight transport, with an annual turnover of $67 million. It runs a fleet of 600 trucks and 1,100 trailers in Canada and the United States, delivering car parts on a 'just-in-time' basis to car-manufacturing and assembly plants. One-hundred-and-fifty of the trucks are now fitted with vehicle-location and satellite-communications equipment, and the company has plans to equip the total fleet by the summer of 1989.

Frederick Transport uses the Radio Determination Satellite Service (RDSS) offered by the Geostar Corporation. RDSS System 2 uses Loran technology to define locations to within one-sixteenth of a mile; good Loran signal coverage is available throughout most of North America. The trucks are fitted with a position-finding terminal, combined with a transmit-only satellite terminal, and a terminal with a keypad and small screen in the cab to enable the driver to send simple messages to base. Information about location and other messages are sent back via a Geostar satellite to Geostar's earth station and computer centre, and hence, to Frederick Transport by telephone line.

The benefits to Frederick Transport's customers are considerable. Just-in-time plants typically carry a reserve of parts to support only a few hours of production, and the cost of stopping the production line has been estimated at US$60,000 to $100,000 per hour by one car manufacturer. Chartering a plane to get parts direct from the supplier in the event of a shortage can cost upwards of US$10,000. Knowing that a truck has been delayed enables the manufacturer to minimise these costs. Vehicle location provides better information on the status of shipments and estimated times of arrival, giving Frederick Transport greater flexibility — perhaps to redirect truckloads of parts, at the customer's request, to the plant where they are needed most urgently.

The system enables Frederick to give its customers a better service than its competitors can, and has already helped it to win a number of major contracts. It has also enabled the company to decrease the mileage covered by its trucks while unloaded, through more effective planning; the loaded mile factor (ratio of miles driven while loaded to total miles driven) has been increased by 2 per cent, equivalent to increased revenue of US$181 per truck per month. In addition, the trucks equipped with satellite units experienced a 9.5 per cent increase in miles run per month. Drivers used to make telephone calls back to base every four hours to report on their progress; the number of calls, with the attendant time wastage, has been reduced, equivalent to a saving of US$26 a month. Against these benefits must be set equipment costs of US$3,450 per truck (equivalent to US$122 per month over three years, assuming current rates of interest) and Geostar's service charge of US$45 a month.

Over the next 18 months, Frederick Transport intends to implement a computerised artificial-intelligence dispatch system to gain additional productivity. Early in 1989, a Very Small Aperture Terminal (VSAT) satellite system will be installed to replace the terrestrial data lines. This will provide for a 15-second response time from any mobile truck unit to a dispatch centre. Frederick Transport is looking forward to a 20 per cent growth in revenues in 1989, two-thirds of which will be attributable to the system.

Mobile services are also vital where the public telephone service is poor or nonexistent. We interviewed an oil company, which has 40 separate private mobile radio networks operating in the Middle East. It uses them to communicate with staff working on pipelines, construction sites, and offshore drilling platforms as well as with aircraft, marine fleets, land vehicles, and staff patrolling sites. The networks are also used for disaster recovery — for example, to back up microwave links. This company told us that the overall impact of mobile communications on its operations is very large, and that it would have great difficulty operating without them.

AN ADDITIONAL CUSTOMER SERVICE

Mobile services can be used to enhance an overall service provided to customers, either as a value-added element that distinguishes one supplier's service from its competitors', or as an additional revenue generator. Some car-rental companies have differentiated their service from that of competitors by providing mobile telephones in their more expensive hire cars. SAS, the international airline of Sweden, Denmark, and Norway, provides mobile telephones in airport limousines, as a service to customers (in some cases, as part of an inclusive service package). Mobile telephones can now be fitted in taxis, trains, and civil aircraft. In all cases, they attract customers and generate additional earnings for the transport operator.

MOBILE DATA SERVICES PROMISE EVEN GREATER BENEFITS THAN VOICE SERVICES

The use of mobile data communications is in its infancy but they can already deliver even greater benefits than mobile voice communications. (We are concerned here with full data communications, not message paging or vehicle-location technology; while the latter also have advantages over voice communications, their ability to transmit information is limited.) The main applications that have emerged so far for mobile data communications are:

- Dispatching more detailed messages than would be possible with mobile voice communications or message-paging.
- Communicating data that has to be input to or accessed from a computer system.
- Communicating information not suitable for voice transmission, such as graphical material or medical data.
- Communicating via an unattended terminal.

Mobile data systems can, in principle, provide users with access to a range of computer systems both within and external to the company concerned. Mobile users can thus be provided with a similar level of computer-systems support and access to information that they enjoy in their offices. In a pilot trial, currently in progress, the French national police have installed mobile data terminals in their vehicles. Police can use the terminals to access the police national database from their cars. For example, a patrolman can check the record of an offending motorist whom he has stopped for speeding; for any but the first offence, the on-the-spot fine can be appropriately increased. When a suspect is picked up, the police can access the database immediately to check his or her credentials. The trial has already shown that the mobile link can greatly increase the effectiveness of police operations.

Few organisations have yet explored the implications of the development of mobile data systems in any depth, however. While there are still some technical problems (discussed on page 20), the long-term implications are likely to be far-reaching, in terms of business opportunities and operations, and more significant than the benefits provided by other forms of mobile communications. The main types of advantages of mobile data communications over mobile voice systems are described below.

DATA TRANSMISSION REQUIRES LESS AIR TIME

In most applications, a data message can be sent substantially more quickly than the equivalent voice communication. Comparisons for a range of applications are shown in Figure 2.5. The voice message may take up to 20 times as long as the data message. This is particularly important where the charges for air time are high, as for cellular telephony, or where channel capacity is strictly limited and has to meet an increasing volume of use, as on many private radio systems. In the traffic-police application listed in Figure 2.5, the costs of the data and voice calls are 7.5p (13.5c) and £1.15 ($2.10) or more, respectively. Faced with major congestion on the radio channels used by police officers to call in for information from its computer systems, a US police department recently spent $3 million on a mobile data system; the alternative was to change to another frequency band and spend between $20 and $25 million replacing 3,000 items of equipment.

Figure 2.5 A data message can be sent more quickly than the equivalent voice communication

Application	Voice message	Data message
Traffic police	4.5 minutes	Less than 20 seconds
Service engineers (gas utility)	3 to 4 minutes	Less than 10 seconds
Courier service	20 seconds	1 second

MOBILE DATA APPLICATIONS CAN IMPROVE THE SPEED AND QUALITY OF RESPONSE

In dispatching applications, mobile data systems give a faster response than mobile voice systems. Voice dispatching systems require drivers to respond before they can be given instructions; where the airwaves are congested, it can take a long time to establish contact with mobile staff. With data systems, a message can be received in as little as five seconds from the keying of the order. The more rapid response possible from using mobile data systems in dispatching operations can create a competitive advantage for organisations such as taxi operators. US taxi companies installing mobile data communications, in conjunction with computer dispatching systems, report that they handle up to 30 per cent more business with the same fleet of cars and drivers. The experience of a Danish taxi company, illustrated in Figure 2.6, shows how the use of mobile data communications has helped it to maintain its level of business in a declining market. Mobile data communications can also improve the quality of the response. For example, computer-service engineers can have all the information they need about a customer's installation sent to terminals in their cars as they drive to the site.

MOBILE DATA REQUIRES FEWER, AND LESS-SKILLED, DISPATCHING STAFF

In dispatching applications, the same workload can be supported by fewer staff when computerised mobile data systems are used. Moreover, the staff do not need to be so skilled (and hence, are less expensive to employ). In one dispatching application, a team of 12 operators was reduced to four when a mobile data system was introduced. One UK organisation, which uses teams of mobile service engineers, recently computerised its dispatching operation; skilled dispatchers were replaced by office staff with no formal qualifications, at salaries more than 30 per cent lower than those paid to the skilled dispatchers. Conventional dispatchers take several years to reach full proficiency, whereas staff on the new system take only eight hours to train.

MOBILE DATA REDUCES ERRORS

Mobile data systems can greatly reduce errors. Voice communications over radio links of variable quality give plenty of opportunity for errors, and further errors arise when the information relayed over the voice link is transcribed, rekeyed, or memorised. In one application, requiring the transmission of 4,000-character messages from mobile units for entry into a computer system at base, even trained staff made a minimum of eight errors per message when voice transmission was used; the errors were virtually eliminated with mobile data communications. In general, errors are greatly reduced when messages are keyed into a mobile terminal that can access the relevant computer systems directly over mobile communications links, or when messages from a dispatching centre are printed out by the mobile unit to give a permanent record.

MOBILE DATA CAN PROVIDE EXTRA SERVICE CAPABILITIES

Electronic data capture and direct interaction with computer systems enable additional facilities

Figure 2.6 A quicker response to calls has helped a taxi company to remain competitive in a declining market

København Taxa

København Taxa is a company operating 820 taxis in Copenhagen. Sixteen months ago, it had a computerised dispatch system supplied and installed by Mobile Data International (MDI) of Canada. The systems integration was done by MDI on the advice of some Canadian taxi companies that had experience of developing systems and warned against 'do-it-yourself'.

Prior to the installation of the system, a large group of operators took telephone calls and passed orders to a dispatcher. The dispatcher gave instructions over a voice radio link to the taxi driver; it took between one and five minutes to pass on each order because taxi drivers did not always respond immediately. Now, the operators take an order and type it into a terminal. The computer finds a free taxi in the district concerned and sends the order to a terminal in the taxi. The whole process takes about five seconds from the keying of the order.

The MDI terminal in the taxi is linked to the radio and to the meter, so that the computer knows when the taxi is free. The pick-up address is transmitted to the terminal, and the driver can acknowledge it with a single key. As the taxi driver enters each district, he registers his whereabouts. Customers can also book directly.

København Taxa has between 8,000 and 9,000 customers who book this way, leaving the operators free to take other calls.

København Taxa's market share has increased as a result of the system. The taxi business in Denmark has declined by 20 per cent overall in the last year; København Taxa's business has increased by between one and two per cent. The number of operators taking calls has been reduced by 30 per cent, to 35. Other costs have been reduced, and instructions are sent out more quickly. The system cost Dkr25 million ($3.6 million); payback is expected to take two to three years.

As a next step, the company is working with a printer manufacturer to get printed receipts directly from the meter. In conjunction with the computer dispatch system, this will give the company a daily printout of all work, with indications of the distance travelled and the time for each trip, and between each trip. This will enable the company to offer a better service to customers, and provide evidence to support drivers should any dispute arise about the choice of route or delays in the delivery of parcels.

to be provided by mobile data systems. In one service-engineering application, invoices are printed and domestic (as opposed to business) customers pay on the spot. This contrasts with the normal time of between 30 and 60 days for receiving payments from domestic customers. Additional services can be provided automatically in dispatching applications — for example, the ability for customers to dial the computer of a taxi company directly and use a pre-arranged code to obtain a rapid response. In addition, mobile data communications can provide extensive management information that can be used to improve the quality of service (listing of jobs not completed on time, for example) or to monitor staff performance (printouts of mileage for specific trips, and between fares, for example).

MOST ORGANISATIONS CAN OBTAIN BENEFITS FROM MOBILE COMMUNICATIONS

Some organisations, especially those in the field of transport, public utilities, emergency services, and organisations providing maintenance services and technical support on customers' premises, are particularly dependent on mobile communications. Even those that are not, however, will usually have applications where the use of mobile communications could be a great advantage to them. Senior managers, for example, often spend a lot of time out of the office; salesmen spend most of their time on the road; staff concerned with site management, building facilities, and building maintenance spend little or no time at their base office or desk; key staff may have to be called in, outside normal working hours; drivers of goods or passenger vehicles are constantly on the move. All these staff can increase their responsiveness or productivity with mobile communications services, to the benefit of their organisation.

Mobile communications services will become increasingly important as customers demand higher levels of service, and as organisations become less tolerant of being unable to contact staff who are on the move. There are already some areas of business where it is now difficult to be competitive without the use of mobile communications; the number of businesses to which this applies will continue to increase in the future. Our research shows that many of the organisations that have not yet begun to use mobile communications are holding back because they perceive the costs to be too high.

COSTS CAN BE HIGH BUT ARE FALLING

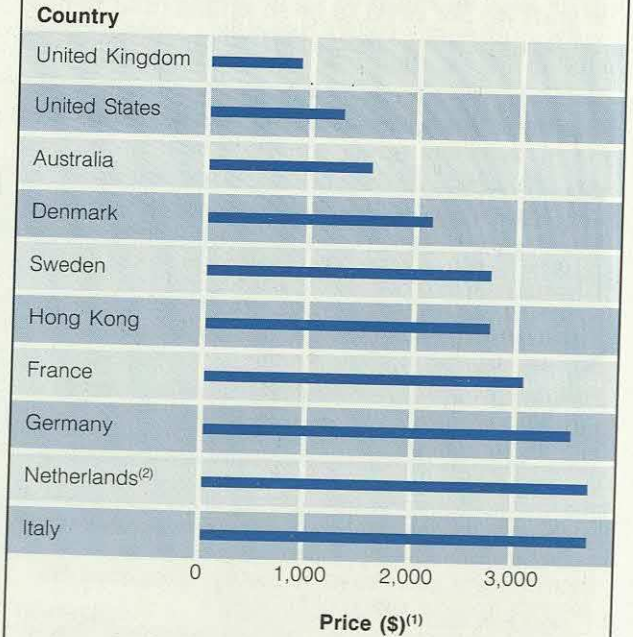
In response to the questionnaire sent out to Foundation members at the beginning of the research, members indicated that cost was by far the greatest perceived barrier to the use of mobile communications. Indeed, the costs of installing and using mobile systems can be substantial, but they can often be justified in view of the benefits that can be gained. Typical costs for cellular telephones, private mobile radio, and vehicle-location systems are discussed below. The general trend is that costs of mobile communications equipment are falling.

CELLULAR TELEPHONES

The total cost (including equipment and usage) of a cellular telephone can vary between about $1,000 and $6,000 a year depending on country and level of use. Assuming that the cost of the equipment is written off over three years, the total annual cost (including usage) for one Swedish organisation is about $1,500, which is similar to the median costs incurred by Australian organisations. For a UK organisation, the total annual costs for two different users are $1,200 and $5,800, which illustrates that, even in the same organisation, the level of use can vary significantly.

Figures 2.7 and 2.8 show how both the purchase prices of cellular telephones and the tariffs for their use vary from country to country. When applications are considered that require, say, a

Figure 2.7 Prices of mobile cellular telephones vary from country to country



(1) Prices specified are lowest prices available to the private individual (that is, excluding bulk purchase deals) for mobile (in-car) cellular telephones
(2) Based on three years' rental

fleet of 1,000 vehicles to be fitted with mobile terminals, or a national salesforce of thousands to be provided with cellular telephones, the investment can be daunting. There are, however, few 'hidden' costs with mobile systems; some administrative effort may be required, but the costs will not be significant compared with purchase and usage charges.

PRIVATE MOBILE RADIO

The capital cost of private mobile radio systems consists of equipment costs and operating costs, which include such items as landline and transmitter-site rentals, and operating and maintenance staff. A full list of the main cost items is given in Figure 2.9 overleaf. Equipment costs are discussed in this section. Other costs vary widely, depending on the scale and complexity of the system in question and its particular characteristics. Private mobile radio services may provide voice communications alone, or data communications, usually with voice as well.

Voice communications

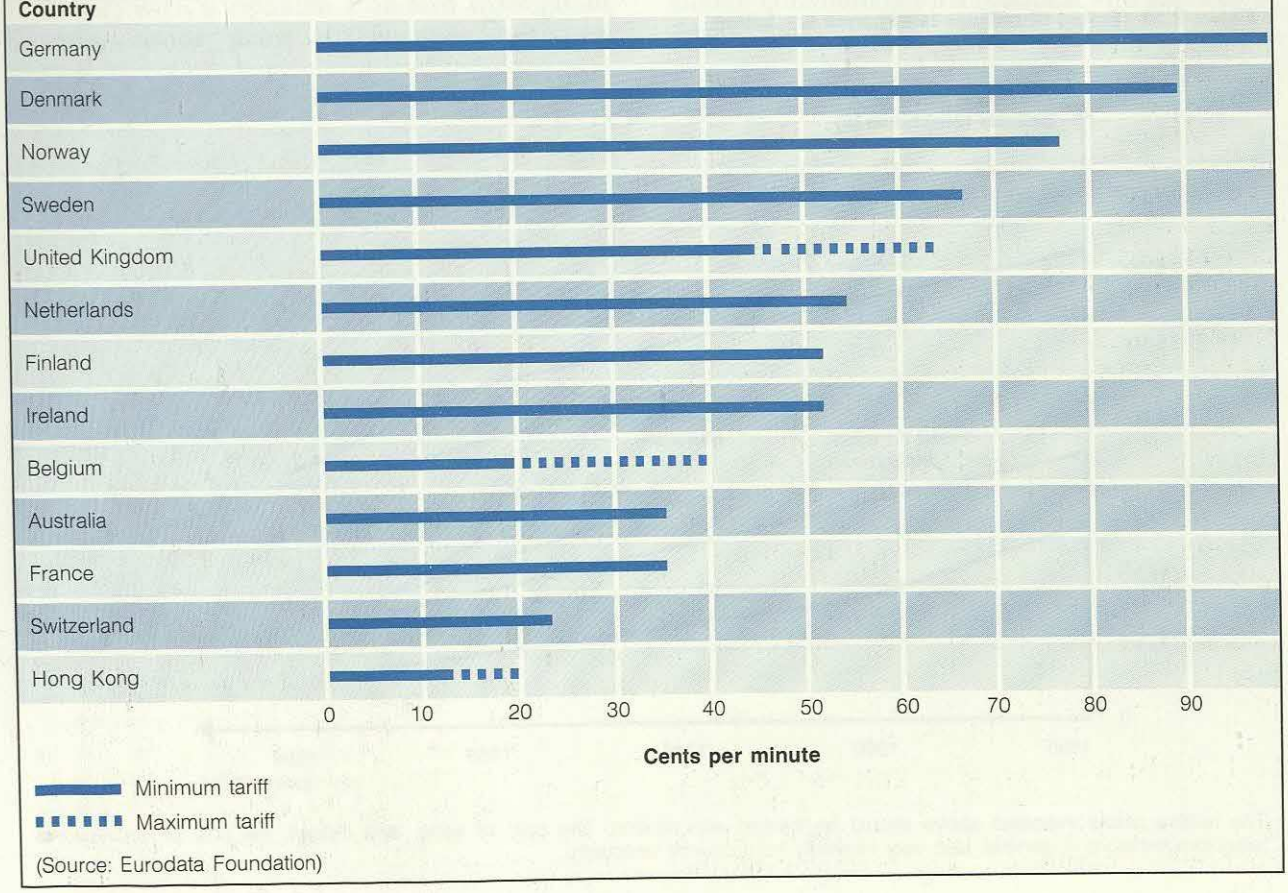
The simplest private radio system in the United Kingdom, with the aerial located on the same site as the base station, will cost about £2,000 ($3,600) for the base transceiver, £800 ($1,450) for a desktop control unit, and between £200 and £400 ($360 and $720) per vehicle for the mobile units. The cost rises sharply if the aerial is to be located at a remote site: the landline to connect it to the base station will cost in the order of £10,000 ($18,000) to install.

Private mobile radio services are also provided by third-party operators offering the shared use of trunked mobile radio systems. The tariffs for these public systems are structured differently from those for cellular telephony. Typically, the user purchases a terminal and then pays a service charge that includes all calls. In the United Kingdom, a terminal will cost about £700 ($1,300), and service charges start at £15 to £25 ($27 to $45) a month, depending on the coverage required.

Data communications

The most common application of mobile data communications systems is data dispatch, where data communications are used to schedule the activities of a vehicle and its crew. A basic private mobile data communications system for data dispatch typically requires equipment similar to that used in a private mobile voice communications system, but with additional data equipment to

Figure 2.8 Peak-rate cellular tariffs vary from country to country



(Source: Eurodata Foundation)

interface with it at the base station and in the vehicle. The communications control unit and radio transceiver cost between £1,000 and £2,000 ($1,800 and $3,600). In addition, a personal computer and a special software package costing about £500 ($900) will be required to provide the control interface on the user's premises. Each vehicle will need a radio costing between £500 ($900) and £1,400 ($2,500), depending on the transmission technology used, and some form of data terminal; printers start at about £300 ($550), and displays at £400 ($700). Thus, a complete system for a fleet of eight vehicles can be obtained for under £10,000 ($18,000).

The costs of larger-scale data dispatching systems are substantial, ranging from $2.7 million for a US taxi company with 650 mobile units, to $5.4 million for a US police department with 3,000 mobile units. Software accounts for a substantial proportion of these figures. A radio terminal for the Mobitex data service in Sweden, which is designed specifically to provide a private mobile data communications service, costs about Skr15,000 ($2,400) excluding printer or display. (Mobitex is discussed in more detail on page 21.)

Figure 2.9 The cost of a private mobile radio system includes both capital and operating costs

Capital costs	Operating costs
Base station(s)	Landline to transmitter
Mobile units	Site rentals
Control unit	Operators
Installation costs	Maintenance staff or maintenance contracts
Licence	

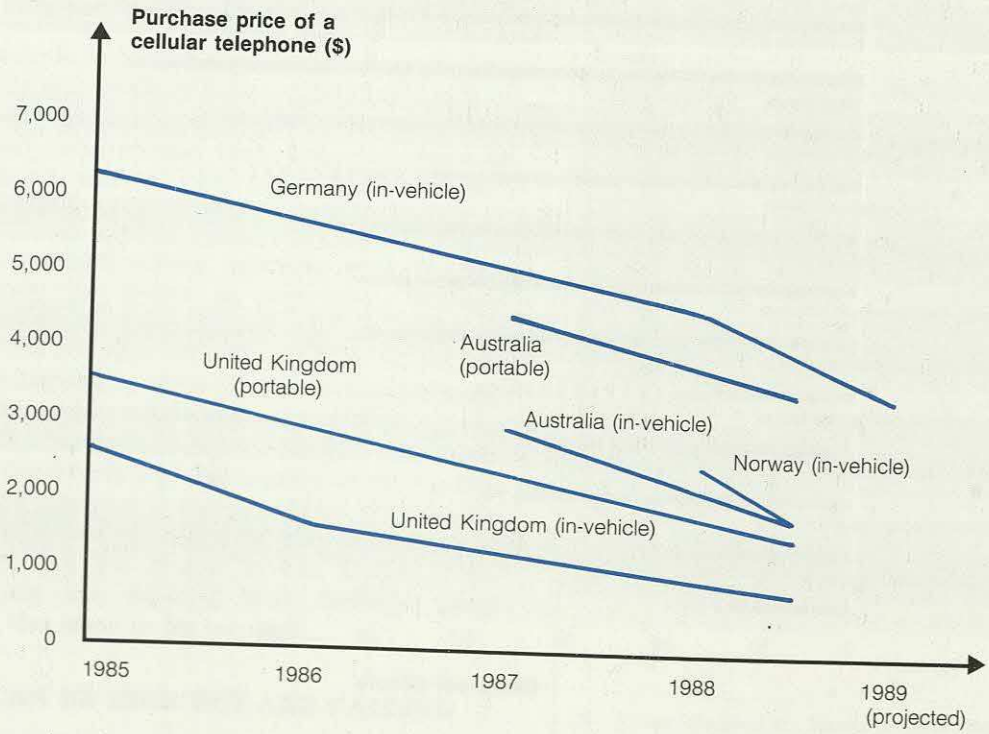
VEHICLE-LOCATION SYSTEMS

Equipment for vehicle-location systems costs between $2,100 and $3,500 per vehicle. Monthly service charges range between $45 and $70 per vehicle. In addition, a control room will cost between $9,000 and $45,000 to equip. Alternatively, an additional service charge may be payable to the service provider for a bureau service, which removes the need for a control room. As these services are only just becoming available, prices may be expected to change.

PRICE TRENDS

The typical costs discussed above demonstrate that the investment required to install and run mobile communications systems can be high. However, as we discussed earlier in this chapter, the benefits are considerable in a wide range of applications. Furthermore, the prices of many types of mobile equipment have fallen considerably as a result of progress in integrated circuit technology, growing equipment production

Figure 2.10 Prices of cellular telephones are falling



The relative prices indicated above should be treated with caution. The cost of living, and indeed, the cost of conventional telecommunications in general, also vary markedly from country to country.

volumes, and greater competition. Reductions in the prices of cellular telephones in several countries over the last few years are a case in point (see Figure 2.10). Retail prices have fallen by more than 60 per cent in some markets since cellular services were first launched.

Prices of existing analogue cellular telephones are unlikely to decline much further in those countries where they are now the least expensive. In these countries, prices have fallen to a level where retailers are left with little or no margin for further discounts. Nor are any major new breakthroughs expected to reduce the cost of manufacture because the manufacturers are now putting all their effort into the development of the next-generation digital instruments. A secondhand market is, however, developing in the United States, and will keep prices low in other countries where such a market is permitted.

A lot of speculation surrounds the pricing of digital cellular telephones to work on the new GSM (Groupe Spécial 'Mobile') service. (GSM is the standard to be used for the new pan-European digital cellular radio system, which is scheduled to begin operation in 1991; it is described in more detail on page 19.) In the opinion of one industry expert, GSM cellular telephones will have to be priced within 5 per cent of their analogue equivalents if a mass market is to develop. However, with a common standard throughout Europe, major price differences between countries will not be sustainable, and prices will tend to level down. This, in conjunction with the impending obsolescence of analogue technology, is likely to reduce the prices of analogue cellular telephones in European countries where they are at present expensive, in the years before the launch of the digital system.

Where a new service is introduced alongside an equivalent existing one, as has occurred with cellular services and the previous generation of mobile telephone service, for example, the new service is typically less expensive. Variants of an existing service — for example, the NMT-900 service in Scandinavia — have typically been introduced at the same price as, or at a slight discount to, the existing service to encourage people to use the new service. As regards the new pan-European digital system, the Managing Director of Cellnet in the United Kingdom has already stated that he expects usage tariffs to be the same as those currently charged for the existing analogue service.

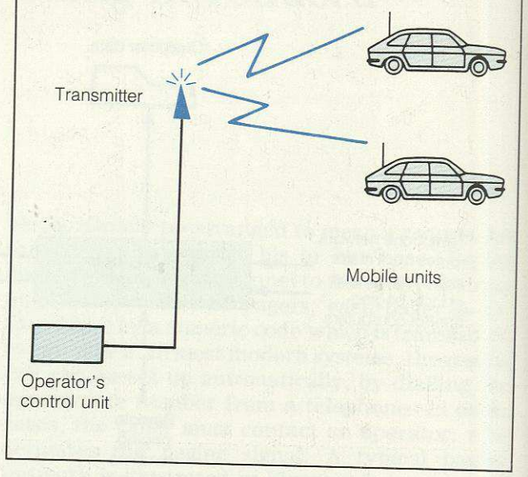
Thus, although many organisations currently perceive price to be the main barrier to using mobile communications, we believe that the substantial benefits, coupled with falling prices, will mean that many more organisations will begin to use mobile products and services. We turn, now, to examine the way in which the market for mobile communications products and services is developing.

speeds will be required to cater both for longer messages and for the expected high volumes of system usage. (Some countries have already had to increase the transmission speeds they use for RPC 1 systems.) The projected launch date for the service is 1992, but industry observers are not optimistic that this objective will be met. Finally, the international maritime satellite organisation (Inmarsat), and service providers in several countries are studying the possibility of providing message-paging services over a wide geographical area — for example, the whole of Europe — via satellite.

PRIVATE MOBILE RADIO

The earliest commercial radio communications systems were private mobile radio systems, and they are still in widespread use. Private mobile radio systems are usually implemented and operated by companies for their own use. In most countries, the construction and use of radio systems is controlled by law, so operators need to obtain the appropriate licences. They are also likely to have to agree with the authorities on the radio frequencies that they will use. The simplest systems are controlled by an operator with a radio transmitter/receiver linked to an aerial on the roof of a building. The operator communicates with mobile units over an open communications channel; every mobile unit can hear all transmissions from the operator. Usually, the mobile units talk only to the operator, not to each other, although sometimes, they can be heard by other mobile units. Private mobile radio systems of this kind are typically used in a limited geographic area by taxi services and other dispatch operations. A simple private mobile system is illustrated in Figure 3.3.

Figure 3.3 Private mobile radio systems can be very simple



For coverage of a wider area, the aerial may be located on a hilltop away from the operator's building and be linked to it by a landline or another radio link. For still wider coverage, a number of aerials on different sites, linked to the common control point, may be required; for a nationwide network, such as that operated by the police in many countries, multiple control points may be used.

The basic service can be enhanced in several ways

The basic private mobile radio service can be enhanced in various ways. Calling can be made selective so that only the mobile unit for which the communication is intended receives it. Simple status messages can be sent from the mobile units. Mobile units can be connected by the operator, via the company PABX, to conventional telephones within the organisation, although in most countries, connection of private mobile radio systems to the public telephone network is forbidden.

In some countries, notably Sweden and the United Kingdom, aerial sites and transmitters are often operated by third parties who can provide a service to local organisations needing private mobile radio facilities. Operations of this kind are known as community repeaters.

Trunked mobile systems make better use of the available spectrum

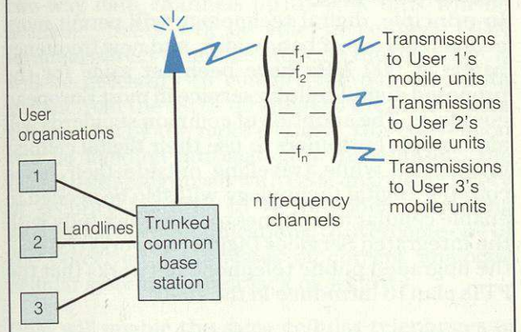
In many regions, the usable frequencies allocated for private mobile radio are very congested. Users often have to share their frequencies with others in the same area, and those who make heavy use of mobile communications find their channel allocations barely adequate to support their requirements, particularly if their use of radio is growing. There is therefore considerable pressure for more efficient use of the radio spectrum.

Trunked mobile systems have been developed in response to this pressure. In simple private mobile radio systems, mobile units are assigned to a single frequency band, or channel, on which all their communications take place. In trunked systems, a user's equipment can access several channels, and when a call is initiated, the system assigns it to whichever channel happens to be free. This sharing of frequencies means that all channels are better utilised. This principle of trunked mobile systems is illustrated in Figure 3.4.

In several countries, trunked common base stations are also operated by third parties to provide a service for several users over the area served by a single transmitter. In Sweden and the United Kingdom, services have been launched that potentially provide regional or national coverage

Figure 3.4 Trunked mobile systems make better use of the available radio spectrum

Transmissions from a user organisation to its mobile units use any one of the frequency channels, depending on which is free. The equipment in the mobile units automatically tunes to the frequency being used.



by linking trunked systems, and similar services are being implemented in other countries. In the United Kingdom, two national service providers, Band Three Radio and GEC National One, are expanding their systems to provide national coverage, and other service providers have been licensed for regional networks. The technology is analogue, frequency modulation (FM). The MPT 1327 protocol, which is being proposed as a European standard, is used for signalling. These systems are designed primarily to provide voice services, although Band Three Radio now offers its 'Radiotext' service for sending data messages. By contrast, the Swedish Mobitex system is designed primarily as a data system, although it also supports voice.

CELLULAR TELEPHONY

Mobile telephone services have been quite widely available for many years. They connect into the public telephone network and permit normal two-way conversation, like a conventional telephone. Early services made extravagant use of the radio spectrum, so that the number of channels available was very limited. This made mobile services expensive and gave a low grade of service, because users had to search for a free channel and sometimes wait a long time before obtaining one.

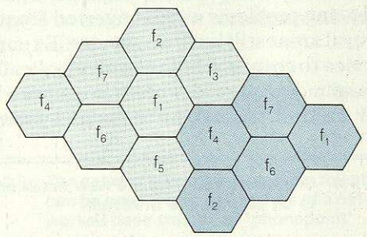
Cellular radio technology has allowed these problems to be overcome by using a network of small, low-power transmitters to cover areas of small and predictable size, called 'cells'. The same frequencies can be re-used, not in adjoining cells, but in cells separated from each other by another cell. System capacity for a given geographical area depends on the bandwidth or total number of channels available, and on the number of cells into which the area is divided — that is, the number of times the bandwidth can be re-used. Capacity can therefore be increased by splitting cells into families of smaller cells, each with its own transmitter operating at lower power than that of the transmitter in the original cell. These concepts are illustrated in Figure 3.5.

Vehicles on the move are likely to drive out of one cell and into another, during the course of a conversation. Cellular networks are therefore equipped with control systems to detect when a calling mobile unit is passing out of the range of a given transmitter, to establish which cell it is passing into, and to switch the call from one transmitter to the other without losing the call. The mobile terminal switches automatically to the new frequency.

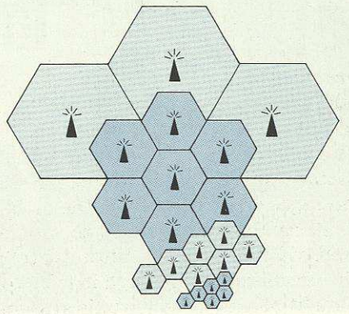
The original cellular telephones were installed in vehicles and could not be removed. Similar equipment is now packaged as relatively heavy units to be carried over the shoulder or with a built-in carrying handle. More recently, units small enough to carry in a briefcase have become

Figure 3.5 Cellular radio technology enables many of the problems of early mobile telephone services to be overcome

The same frequencies can be re-used in non-adjacent cells



Capacity can be increased by splitting cells into families of smaller cells with lower-power transmitters



speeds will be required to cater both for longer messages and for the expected high volumes of system usage. (Some countries have already had to increase the transmission speeds they use for RPC 1 systems.) The projected launch date for the service is 1992, but industry observers are not optimistic that this objective will be met. Finally, the international maritime satellite organisation (Inmarsat), and service providers in several countries are studying the possibility of providing message-paging services over a wide geographical area — for example, the whole of Europe — via satellite.

PRIVATE MOBILE RADIO

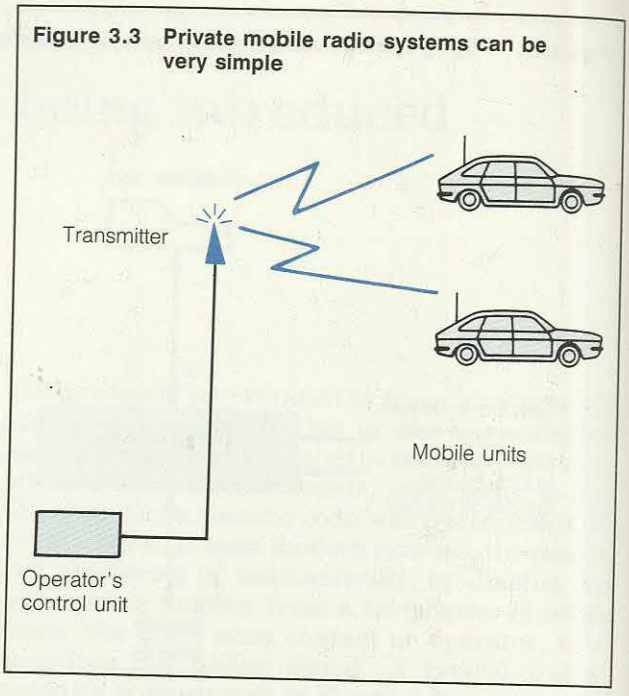
The earliest commercial radio communications systems were private mobile radio systems, and they are still in widespread use. Private mobile radio systems are usually implemented and operated by companies for their own use. In most countries, the construction and use of radio systems is controlled by law, so operators need to obtain the appropriate licences. They are also likely to have to agree with the authorities on the radio frequencies that they will use. The simplest systems are controlled by an operator with a radio transmitter/receiver linked to an aerial on the roof of a building. The operator communicates with mobile units over an open communications channel; every mobile unit can hear all transmissions from the operator. Usually, the mobile units talk only to the operator, not to each other, although sometimes, they can be heard by other mobile units. Private mobile radio systems of this kind are typically used in a limited geographic area by taxi services and other dispatch operations. A simple private mobile system is illustrated in Figure 3.3.

For coverage of a wider area, the aerial may be located on a hilltop away from the operator's building and be linked to it by a landline or another radio link. For still wider coverage, a number of aerials on different sites, linked to the common control point, may be required; for a nationwide network, such as that operated by the police in many countries, multiple control points may be used.

The basic service can be enhanced in several ways

The basic private mobile radio service can be enhanced in various ways. Calling can be made selective so that only the mobile unit for which the communication is intended receives it. Simple status messages can be sent from the mobile units. Mobile units can be connected by the operator, via the company PABX, to conventional telephones within the organisation, although in most countries, connection of private mobile radio systems to the public telephone network is forbidden.

Figure 3.3 Private mobile radio systems can be very simple



In some countries, notably Sweden and the United Kingdom, aerial sites and transmitters are often operated by third parties who can provide a service to local organisations needing private mobile radio facilities. Operations of this kind are known as community repeaters.

Trunked mobile systems make better use of the available spectrum

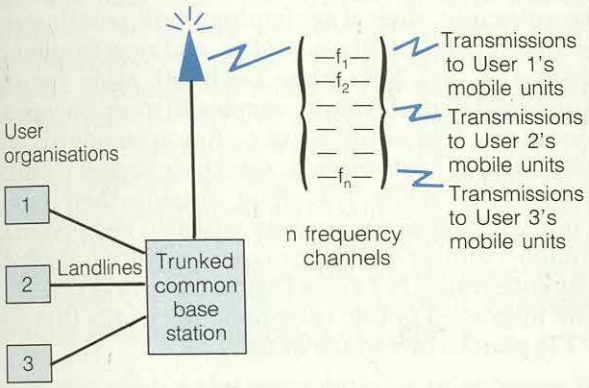
In many regions, the usable frequencies allocated for private mobile radio are very congested. Users often have to share their frequencies with others in the same area, and those who make heavy use of mobile communications find their channel allocations barely adequate to support their requirements, particularly if their use of radio is growing. There is therefore considerable pressure for more efficient use of the radio spectrum.

Trunked mobile systems have been developed in response to this pressure. In simple private mobile radio systems, mobile units are assigned to a single frequency band, or channel, on which all their communications take place. In trunked systems, a user's equipment can access several channels, and when a call is initiated, the system assigns it to whichever channel happens to be free. This sharing of frequencies means that all channels are better utilised. This principle of trunked mobile systems is illustrated in Figure 3.4.

In several countries, trunked common base stations are also operated by third parties to provide a service for several users over the area served by a single transmitter. In Sweden and the United Kingdom, services have been launched that potentially provide regional or national coverage

Figure 3.4 Trunked mobile systems make better use of the available radio spectrum

Transmissions from a user organisation to its mobile units use any one of the frequency channels, depending on which is free. The equipment in the mobile units automatically tunes to the frequency being used.



by linking trunked systems, and similar services are being implemented in other countries. In the United Kingdom, two national service providers, Band Three Radio and GEC National One, are expanding their systems to provide national coverage, and other service providers have been licensed for regional networks. The technology is analogue, frequency modulation (FM). The MPT 1327 protocol, which is being proposed as a European standard, is used for signalling. These systems are designed primarily to provide voice services, although Band Three Radio now offers its 'Radiotext' service for sending data messages. By contrast, the Swedish Mobitex system is designed primarily as a data system, although it also supports voice.

CELLULAR TELEPHONY

Mobile telephone services have been quite widely available for many years. They connect into the public telephone network and permit normal two-way conversation, like a conventional telephone. Early services made extravagant use of the radio spectrum, so that the number of channels available was very limited. This made mobile services expensive and gave a low grade of service, because users had to search for a free channel and sometimes wait a long time before obtaining one.

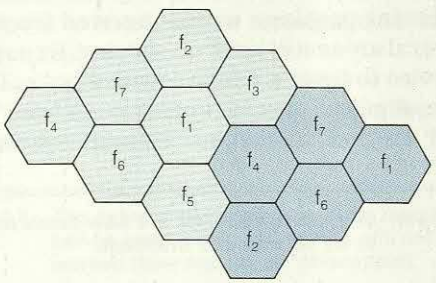
Cellular radio technology has allowed these problems to be overcome by using a network of small, low-power transmitters to cover areas of small and predictable size, called 'cells'. The same frequencies can be re-used, not in adjoining cells, but in cells separated from each other by another cell. System capacity for a given geographical area depends on the bandwidth or total number of channels available, and on the number of cells into which the area is divided — that is, the number of times the bandwidth can be re-used. Capacity can therefore be increased by splitting cells into families of smaller cells, each with its own transmitter operating at lower power than that of the transmitter in the original cell. These concepts are illustrated in Figure 3.5.

Vehicles on the move are likely to drive out of one cell and into another, during the course of a conversation. Cellular networks are therefore equipped with control systems to detect when a calling mobile unit is passing out of the range of a given transmitter, to establish which cell it is passing into, and to switch the call from one transmitter to the other without losing the call. The mobile terminal switches automatically to the new frequency.

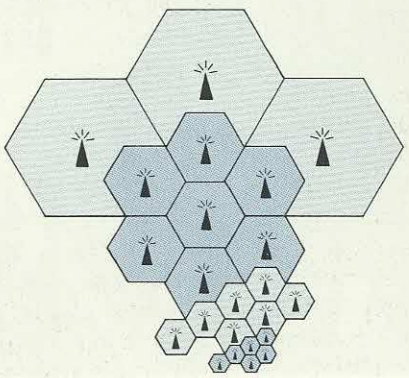
The original cellular telephones were installed in vehicles and could not be removed. Similar equipment is now packaged as relatively heavy units to be carried over the shoulder or with a built-in carrying handle. More recently, units small enough to carry in a briefcase have become

Figure 3.5 Cellular radio technology enables many of the problems of early mobile telephone services to be overcome

The same frequencies can be re-used in non-adjacent cells



Capacity can be increased by splitting cells into families of smaller cells with lower-power transmitters



available. They have lower-power transmitters and are suitable for use in city centres (where there are small cells) and other locations near to a cell transmitter. Photographs of modern cellular telephones are shown in Figure 3.6.

Analogue systems will not be developed further

Existing cellular systems and services use analogue technology. Unfortunately, the cellular systems currently available in different countries work to different technical standards, and terminals suitable for use in one country will not work in another, except in a few cases. The main types of cellular technology and the countries using them are listed in Figure 3.7.

Many of today's cellular telephone systems in Europe and elsewhere are already reaching maximum capacity. In many countries, and particularly in major cities, the allocations of suitable frequencies are insufficient to meet demand. There is heavy competition for the same frequencies from other types of users, like television broadcasters and the military, and public services may therefore be congested and offer a poor grade of service, or be very highly priced in order to control demand. Increased demand is generating political pressure for the reallocation of bandwidth to mobile communications, and for frequencies assigned to obsolete technologies, such as UHF television, to be reassigned to cellular systems.

Further, while many highly populated areas are experiencing problems with congested frequencies, some rural areas still have no service. Expansion of the service to cover a whole country typically takes years, and public perception of the service lags yet further behind. Analogue cellular systems will therefore still be installed in areas, and indeed, countries, that do not yet have them, but they are unlikely to be developed technically much further. Manufacturers are now investing in digital technology.

Figure 3.6 Cellular telephones are now small enough to be carried in a briefcase

(Source: Philips Radio Communication Systems Ltd)

New cellular services will use digital technology

In principle, digital technology will permit more economical use of bandwidth, and new frequency bands at 900 MHz have been set aside for the proposed digital cellular service in most European countries. The adoption of common standards will also enable customers to use their digital cellular telephones while travelling outside their home country. Digital technology will also be needed to enable cellular telephones to interwork fully with the Integrated Services Digital Networks (ISDNs), the upgraded public telephone networks that the PTTs plan to introduce in the 1990s.

The GSM pan-European digital cellular system is scheduled to be launched in 1991. The plan is for coverage of large cities and airports in most countries to be achieved by 1993, and of main roads by 1995. Despite scepticism in many quarters, it is likely that a timely launch will be achieved, at least in some countries. Competition between the potential systems suppliers is acute, and many of the cellular service providers will be pressing for early delivery to ease the congestion problems on their existing analogue systems.

Figure 3.7 Different countries use different types of cellular systems

In different countries, cellular systems have been developed independently of each other, and are therefore incompatible. Because the systems are based on different technical standards, telephones designed for use with one type of system cannot be used with another. In fact, even when the same system is used by different suppliers in different countries, it may not be possible to use telephones interchangeably.

System type	Countries using the system
AMPS (Advanced Mobile Phone Service	United States, Australia, Hong Kong (Hutchison)
NAMTS (Nippon Automatic Mobile Telephone System)	Japan
NMT-450 (Nordic Mobile Telephone System)	Austria, Belgium, Denmark, Finland, Luxembourg, Netherlands, Norway, Spain, Sweden
NMT-900	Denmark, Finland, Norway, Sweden, Switzerland
TACS (ETACS) (Total Access Communications System; E(Extended) TACS)	United Kingdom, Ireland
C-450	Germany, Portugal
Radiocom 2000	France
RTMS (Second-generation Mobile Radio Telephone)	Italy
UNITAX	Hong Kong (CSL), China
Comvik	Sweden

The GSM will be able to deliver a range of voice and data services. Voice will be transmitted at 13k bit/s; good-quality speech will be achieved at this low data transmission speed by taking advantage of the regularities in human speech in its encoding. (The technique used to achieve this is called linear predictive coding.) Synchronous and asynchronous two-way data channels up to 9.6k bit/s will be available. Users will be able to connect ISDN terminals direct to mobile units. At the interface, it will be necessary to convert the 64k bit/s data stream from the ISDN terminal to the slower data stream used by the radio channel; this conversion will be handled automatically. In addition, the digital technology used with GSM enables a variety of security features to be provided, including encryption of communications, to overcome one of the perceived weaknesses of current analogue cellular systems — their lack of security.

GSM will enable the same cellular telephones to be used throughout Europe, and will provide additional features and facilities for the minority of customers who need them. It is likely to provide better-quality service in areas where analogue systems are congested. The coverage will not, however, be as good as that of analogue systems until the late 1990s, and the two systems are likely to continue to exist side by side for the foreseeable future.

The concept of the 'personal number' will be developed

The developments described above will inevitably lead to a demand for mobile terminals based on a personal number that will identify an individual rather than a telephone instrument. Any convenient telephone instrument could then be programmed to receive calls directed to this number, and instructions could be given to bill outgoing calls to the number, regardless of the instrument used to make the calls. This concept will not be implemented fully until well into the next century, but many of the required features are available today, or will be by about the end of 1990. Individuals can now increase their chances of receiving incoming calls by using their cellular telephone number as their main number, and diverting calls to an appropriate conventional telephone, in their home or office, for example. (It should be remembered however, that calls from a conventional telephone, which are diverted from a mobile to a fixed-link telephone, are usually charged at mobile rates.)

Unified billing of outgoing calls made from various telephones is already available with the C-Netz system in Germany. This system has an authorised credit-card facility that allows subscribers to insert their cards into the telephone being used for the outgoing call. The subscribers are then billed on their own numbers, regardless of whether the terminal is their own or a public one. CT2 handsets, for use with 'phonepoints' (see below), will also have to have some means of declaring their identity so that users can be billed regardless of where they are using their handsets.

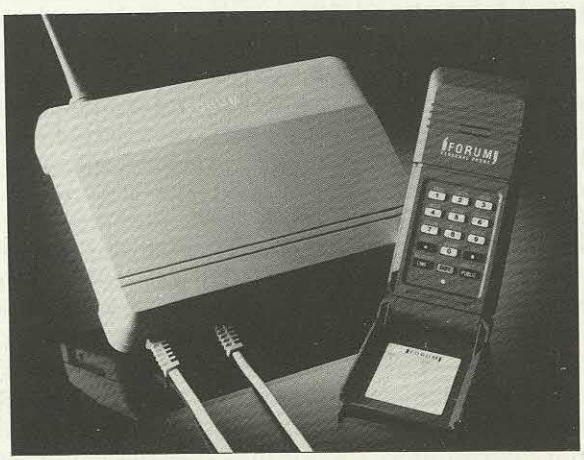
WIDE-AREA CORDLESS TELEPHONY

Cordless telephones have been available for use in homes or offices since the early 1980s. They allow the user to make and receive calls from a portable handset, within 150 metres of a base unit connected to the telephone line. Second-generation cordless telephones using digital technology (also known as CT2) have now been developed. They can be used as conventional cordless telephones, but they can also provide an inexpensive form of mobile communications if networked base stations, or phonepoints, are sited in public places. A user with a CT2 handset can make a call within 150 metres of a phonepoint. For billing purposes, the user is identified by an identification and authorisation code transmitted by the handset, and by a personal identification number (PIN), entered by the user. A CT2 handset and phonepoint are shown in Figure 3.8.

CT2 handsets cannot receive incoming calls, but they could be fitted with a pager that would indicate when someone was trying to get in touch. CT2 is seen as a potential competitor to cellular telephony; it is expected to be much less expensive because it does not provide the facility for transferring calls from one transmitter to another (a process known in the industry as a 'hand-off'). Nor does it have to track where terminals are, in order to receive calls.

CT2 technology has been pioneered in the United Kingdom by Ferranti Creditphone. In total, five UK

Figure 3.8 **The second-generation cordless telephone can be used within 150 metres of a networked base station, or 'phonepoint'**



(Source: Shaye Communications)

manufacturers have developed equipment, although current designs are not mutually compatible because each requires a different interface (known as the air interface) between the handset and the phonepoint. The manufacturers have agreed on a common standard but equipment conforming to this standard is not likely to be developed before 1990. At the end of January 1989, the UK Department of Trade and Industry licensed four operators of phonepoint systems — a consortium comprising British Telecom, STC, France Telecom, and Nynex; Ferranti; a consortium comprising Shaye Communications, Motorola, and Mercury Communications; and a consortium comprising Philips, Barclays Bank, and Shell. Most plan to start their services by the early summer of 1989. Initially, proprietary systems will be allowed, but by the end of 1990, a standard air interface will have to be provided.

There is interest in the provision of phonepoint services in other countries in Europe — most notably in France, where trials are planned — and elsewhere. The European Commission is interested in establishing a European standard, but no definite service plans have been announced, as yet, outside the United Kingdom.

MOBILE DATA COMMUNICATIONS

Mobile radio is a hostile medium for data. Interference, fading, screening by man-made objects, the voice-channel signalling used on many radio systems to maintain the communication path, and on cellular systems, hand-offs, all conspire to increase errors. On the public telephone network, the norm is one error in 100,000 bits; with analogue cellular telephony, the uncorrected bit error rate can be as high as 1 in 50. A lot of effort has therefore been spent on the development of effective mobile data communications technologies.

Very basic data systems, without any form of data correction, have been implemented using slow transmission speeds (300 bit/s); at these speeds, little data is lost, and if the connection is lost, it is re-established manually. This approach may be suitable for the simplest applications. For anything more ambitious, error-correction protocols must be used. Protocols designed for high-grade land-based data transmission have been employed, but many major suppliers have developed special protocols. These rely on two principles — forward error correction and automatic request retransmission. With forward error correction, sufficient redundant information is sent for data to be reconstructed even if individual bits are corrupted during transmission. The penalty is a reduction in the effective data-transmission speed for a given link; typically, the effective transmission rate is half the nominal transmission speed for the link. Automatic request retransmission uses block-check coding or cyclical-redundancy checking to detect errors in transmission; if an error is detected, it requests retransmission. The two techniques are often used together, when forward error correction compensates for minor errors, and automatic request retransmission compensates for major disruptions in transmission.

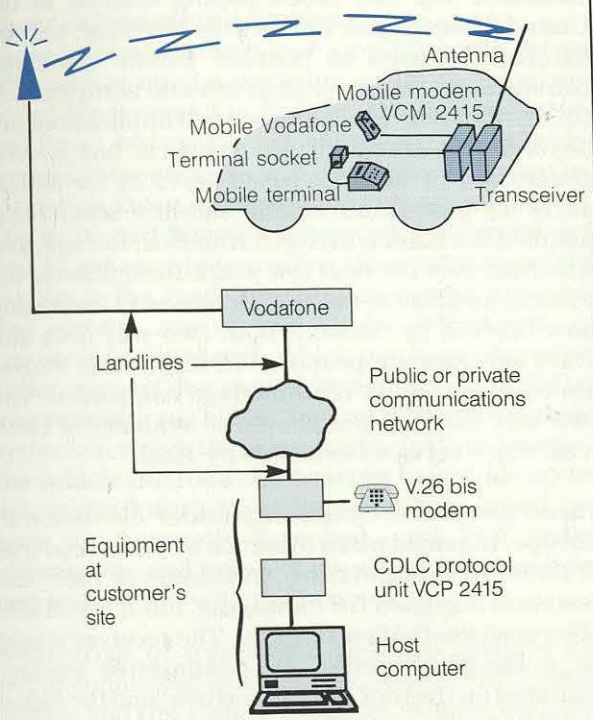
Equipment providing data communications over private mobile radio voice links is now in use in many countries. Figure 3.9 shows such equipment installed in a vehicle. Major suppliers include Mobile Data International of Canada, recently acquired by Motorola, Spectronics Micro Systems, Dowty, and Gandalf for taxi data dispatch systems. The emphasis is on the provision of complete systems. Data transmission speeds of up to 4.8k bit/s, with an effective throughput of 2.2k bit/s, are claimed.

In the United Kingdom, cellular telephony service providers actively support the use of their services for data transmission, and equipment for data communications over the cellular telephone network is available in other countries. The UK cellular operators have taken different approaches to data communications, however. Racal has developed a special cellular data link control (CDLC) protocol for sending data over its Vodafone cellular telephone network (see Figure 3.10). CDLC is based on the high level data link control (HDLC) protocol, but with additional error-correction capabilities; it is described in more detail in the appendix. CDLC requires a special, car-mounted modem with a V.24 terminal interface. Vodafone provides a standards-conversion service for access to a range of equipment and protocols. Cellnet, on the other hand, provides public telephone network interfaces direct to its cellular telephones — that is, without a modem — leaving the choice of modem to the customer. For

Figure 3.9 Equipment providing data communications can be installed in vehicles

(Source: Spectronics Micro Systems Limited)

Figure 3.10 Data transmission over the Vodafone cellular telephone network uses the CDLC protocol



(Source: Racal-Vodata Limited)

the simplest applications, the integral modems in personal computers can be used to communicate over the Cellnet network.

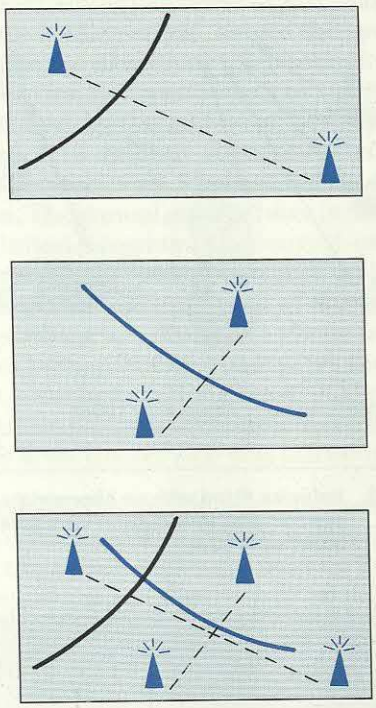
A public mobile data service, Mobitex, is operating in Sweden and is being implemented in Norway and Finland. Mobitex handles data in store-and-forward mode, as packets of up to 512 characters. Direct connections are established for voice. Mobitex is operated as a national, switched service; it is intended primarily for closed user groups and dispatch applications, but access to public networks is available as an optional extra.

VEHICLE LOCATION

Attempts to develop vehicle-location technology have a long history, and some of the solutions proposed have been bizarre. Vehicle-location services of the accuracy required for commercial use are, however, now available in the United Kingdom, the United States, and Australia. These services typically use the Loran, or radio hyperbolic, approach to establishing the location of a vehicle. A network of longwave radio transmitters, broadcasting a synchronised pattern of signals, creates an interference pattern; each pair of transmitters creates an hyperbola of points at which a given signal could be observed. A second pair of transmitters creates a different hyperbola, and the point at which the two hyperbolae intersect is the unique

Figure 3.11 Vehicle-location services typically use the Loran, or radio hyperbolic, approach

The signals from each pair of longwave transmitters create an interference pattern consisting of a set of hyperbolae. By detecting the peaks and troughs in the interference pattern, the in-vehicle unit is able to relate its position to two hyperbolae — one from each pair of transmitters. The point at which the two hyperbolæ intersect identifies the position of the vehicle.

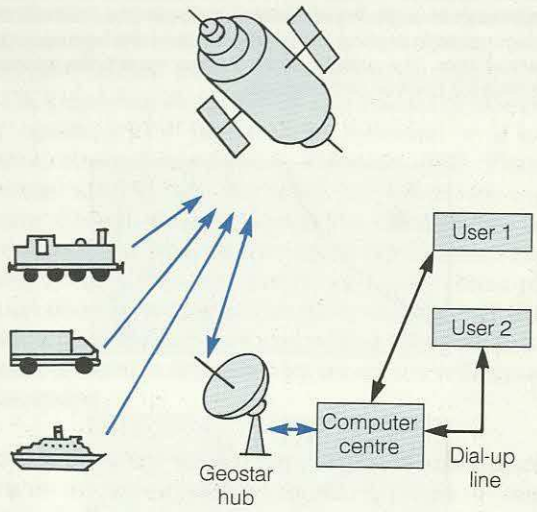


(Source: Datatrak)

position of a locator unit detecting both signals. The Loran approach is illustrated in Figure 3.11. The UK service, operated by Datatrak, a joint venture of the Securicor Group and the construction company, George Wimpey, claims accuracy to within 50 metres; it is now available in the south-east of England and is being extended to the rest of the country. The US service, operated by Geostar and illustrated in Figure 3.12 overleaf, claims accuracy to within one-sixteenth of a mile, anywhere in North America. Figure 3.13, overleaf, shows a truck fitted with an aerial for use with Geostar's vehicle-location service.

The services differ in the method used to relay the signal to the operator. On the Geostar system, the information is relayed by satellite to Geostar's satellite earth station, and from there, to the customer by telephone. Datatrak uses two UHF channels to relay the information back to radio base stations, from which it is sent on to the customer over Datatrak's own data network. Both systems have the capability for the driver to send predefined status messages back to base.

Figure 3.12 The Geostar system enables information from mobile units to be relayed via satellite to transport operators' headquarters



(Source: *Communications News*, May 1988)

Figure 3.13 Vehicles fitted with an appropriate aerial can transmit information via a satellite to their home base

(Source: Frederick Transport)

OTHER SERVICE DEVELOPMENTS

In the next few years, continuing advances in technology will make available still more mobile communications services which are, as yet, in the early stages of development. Satellite-based mobile services, for example, will make long-distance, two-way data and voice communications feasible in the early 1990s, and advanced in-car information services will become a reality at about the same time if current trials and pilot schemes are successful.

Satellite-based services

The vehicle-location application described above is one example of a mobile service being delivered via satellite. Most of the services described so far in this chapter use terrestrial transmitters. Satellites are, however, an attractive option where service coverage of a wide geographical area is required. Satellites link city-based paging systems in the United States to give nationwide coverage, and are extensively used to provide mobile communications services for ships at sea and aeroplanes in flight. Maritime and aeronautical applications are beyond the scope of this report, but a new generation of satellite-based services for mobile users on land (land mobile satellite services) is planned for launch in North America, Europe, and Australia over the next few years. In addition to the vehicle-location service with one-way messaging now offered by Geostar, both two-way data and voice services are proposed in the United States, aimed primarily at road-haulage companies. The two-way data services should be available in 1989, with voice services available by 1993.

Three services are currently under discussion in Europe. Inmarsat plans to launch a commercial trial of its service, Standard-C, in Europe in 1989; the system is designed for messaging, but it could also offer position-finding facilities. The receiver would be a flat-plate aerial, 10 centimetres square, mounted on the roof of a car or truck, and the signal could be fed to an ordinary message pager, a small printer, or a more specialised terminal. Locstar, a consortium including Geostar and some PTTs, plans to offer a position-finding facility with the capacity to relay short messages, probably two-way (in contrast to the one-way service currently offered in the United States); the service would be available in 1991/92. The European Space Agency is also proposing a service, Prodat, in the same timeframe. Aussat, the Australian satellite operator, is also considering services for the early 1990s, and is expected to be the first to offer voice services.

As an alternative to satellite technology, high-frequency radio technology may make a long-distance mobile voice service possible in the near future. High frequency (3 to 14 MHz) technology is being used by British Telecom International for trials of a long-distance mobile radio service for voice communications. The service would provide relatively low-grade voice communications over a wide area — for example, across Europe — and be suitable for road-haulage operators and other specialised applications. It could meet the demand for pan-European voice services until the digital cellular network is available, and would be suitable for use in other parts of the world.

The final example of emerging satellite-based mobile communications is the air-to-ground telephony services on trial with several major airlines. These services are relayed via satellite, and provide access to terrestrial telephone networks.

Teleglobe plans to introduce a similar service in Canada in 1990, suitable for corporate and private aircraft.

In-car information services

In-car information services, providing the driver with advice on the optimum route to take, are under development in Europe, the United States, and Japan, but are not yet commercially available. Some of these services will make use of current information about congestion and road conditions. The estimated benefits are savings of between 6 and 10 per cent in travelling time, with potential savings in the road construction programme too. The systems are of two kinds: standalone, or 'autonomous' systems, which use maps stored on either compact disc read-only memory (CD-ROM) or magnetic-storage media; and infrastructure-based systems in which there is communication between the vehicle and road-side beacons to provide up-to-date traffic information. Infrastructure-based systems are currently favoured, and VHF radio, microwaves, and infra-red are all being assessed for communication with the beacons.

Small trials of infrastructure-based systems are being conducted in Germany, Japan, the United States, and the United Kingdom. A pilot with 250 beacons and 900 vehicles is being implemented in Germany, and a licence for a pilot of a similar size in London is expected to be granted in mid-1989. Full-scale operational systems for traffic management in major cities are likely to begin to appear in the early 1990s.

Microwave technology is also being used in automatic toll systems; the first operational system, developed by Philips, has been installed at the Aalesund tunnel in Norway. Drivers purchase an identity plate with memory capability, which entitles them to use a toll route for a specified period of time or a predetermined number of journeys. When they drive past the toll system, a burst of low-power microwaves is fired at the vehicle and reflected back off the plate with information about the subscriber. The requisite fee is then charged to the driver's account. If the identity plate is not in order, the driver is warned by a red light to stop at a manned checkpoint. The system allows three times the traffic flow of a fully manned system.

THE MARKET WILL CONTINUE TO GROW RAPIDLY, BUT WILL VARY FROM COUNTRY TO COUNTRY

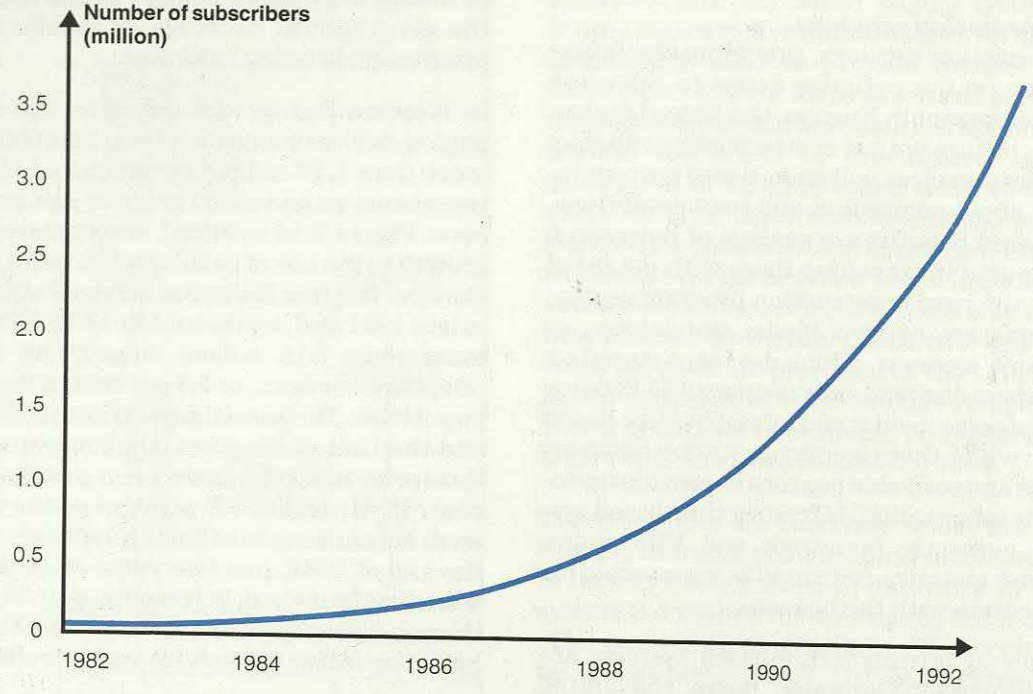
Over the past five years, the use of mobile communications services has grown very rapidly. Cellular telephone and message-paging services have been made available in most developed countries. The newest mobile technologies, such as trunked mobile radio services and vehicle-location services, are being implemented in the countries most advanced in mobile communications, and will be available in others shortly. Within each country, the geographical coverage of mobile services is progressively being extended.

In Western Europe, for example, the number of paging devices has grown from 200,000 in 1983 to more than 1.25 million at the end of 1988, which represents an annual increase of just under 50 per cent. Figure 3.14 overleaf, shows the spectacular growth in the use of cellular telephones in Western Europe. The first European services were launched in late 1981 and, by the middle of 1988, there were more than 1.15 million subscribers to cellular telephone services, or 0.3 per cent of the European population. The annual growth rates in Scandinavia and the United Kingdom, the longest-established European markets, have been just under 50 per cent. In Australia, 0.3 per cent of the population were subscribing to cellular telephone services by the end of 1988, just two years after the services were first launched; in Hong Kong, 0.55 per cent of the population use cellular telephones three-and-a-half years after the service was introduced.

Large organisations are amongst the heaviest users of mobile communications technologies. The extent to which the technologies are used by Foundation members is shown in Figure 3.15 on page 25. The spread of mobile services throughout their organisations is shown in Figure 3.16, also on page 25. Of those Foundation members who use cellular telephones, over a third have more than 50 users. Of those using paging services, over 50 per cent have more than 100 pagers. The use of private mobile radio services divides sharply into small systems with up to 20 users, and very large systems with more than 500 users.

The status of the mobile communications market does, however, vary far more widely between developed countries than the fixed-link communications market. There are quite marked differences between countries in the range of services available (as shown in Figure 3.17, on page 26). There are also major differences in the levels of usage of mobile services. In Hong Kong, there are more than 16 pagers for every 100 people, whereas in Italy, only 0.03 per cent of the population use pagers; in other words, adjusting for the population difference, there are 500 pagers in Hong Kong for each one in Italy. In Norway, over 3 per cent of the population have cellular telephones; in Spain, it is just 0.02 per cent. The numbers of pagers and cellular telephones per 100 inhabitants in a range of countries are shown in Figures 3.18 (on page 26) and 3.19 (on page 27), respectively. The variations apparent from these figures are due to differences in the tariffs that apply to the various services, and to

Figure 3.14 Spectacular growth in the number of subscribers to cellular telephone systems in Europe is expected to continue



(Source: *European Mobile Communications Report* and Dataquest)

differences in the regulatory environment, which determine the extent to which there is competition in the provision of mobile communications services.

The use of mobile services is likely to continue to grow over the next few years at similar rates to those of the past, as shown in Figure 3.14. These growth rates and levels of use represent a substantial increase in the importance of mobile communications in the telecommunications environment as a whole. Moreover, there will be a similar increase in the use of 'wireless' technologies within individual sites. One industry expert we interviewed estimated that, by the end of the century, 30 per cent of all network connections would not be wired, including wide-area mobile terminals, cordless telephones, and mobile terminals using infra-red technology. We would not disagree with this assessment.

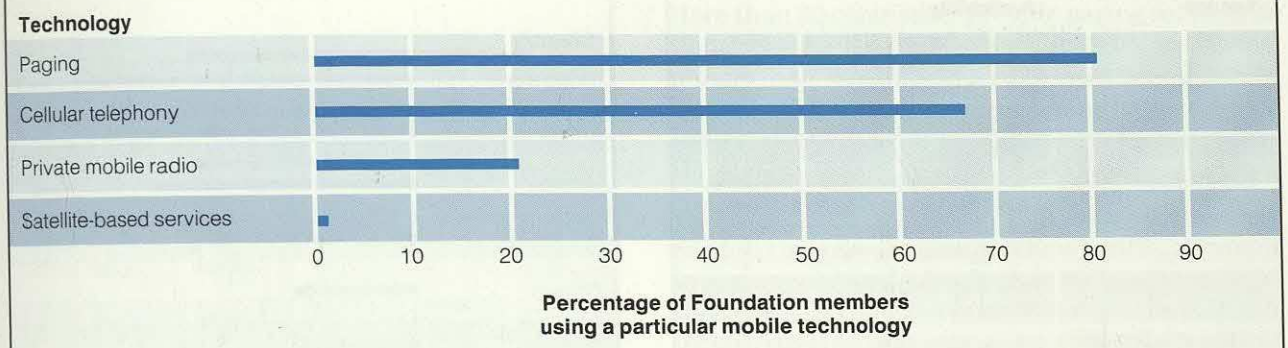
PRODUCTS AND SERVICES ARE ACCESSIBLE TO A GROWING RANGE OF CUSTOMERS

Until recently, organisations with a requirement for mobile communications were forced, in most cases, to implement and operate their own private radio systems, assuming that they could obtain a licence and a frequency allocation. This required a substantial investment in expertise, infrastructure, and management effort that not all potential users were in a position to make. Over the past few years, a range of public mobile services, which offer an alternative to private systems in an increasing range of applications, has been made available in many countries; they open up new possibilities that would be uneconomical or impracticable for most organisations to address with private systems. Specifically:

- Community repeaters now provide a service that is equivalent to a local private radio system.
- Message-handling services provide a more complete service for organisations with modest mobile communications requirements; as well as providing the radio-transmission facilities, they also supply equipment (on a rental basis) for installation in vehicles, provide staff for control rooms, and offer a complete range of secretarial and telephone-answering services.
- Networked private mobile radio services from a third-party operator can now be used as an alternative to more extensive private mobile communications systems.

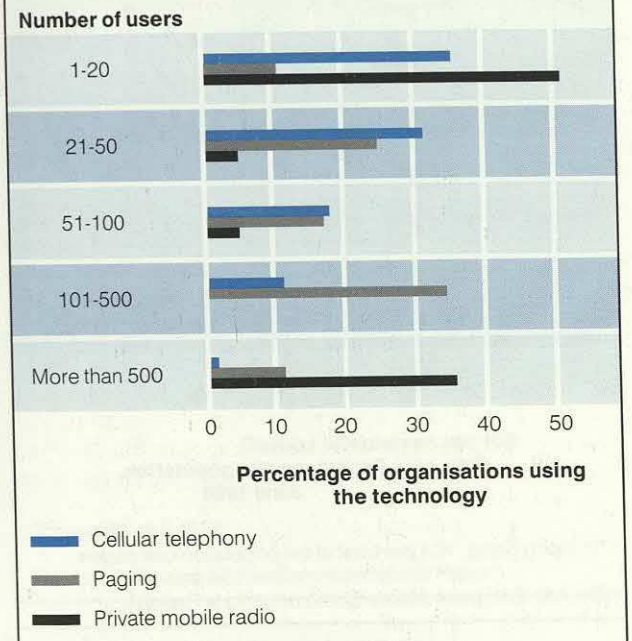
In addition, cellular telephones have access to the public telephone network, a facility not available with private systems in most countries.

Figure 3.15 Paging and cellular telephony are the mobile technologies used most extensively by Foundation members



(Source: Butler Cox survey of Foundation members)

Figure 3.16 Mobile communications services are used extensively by Foundation members



(Source: Butler Cox survey of Foundation members)

New services that will make it easier to set up mobile communications systems are also becoming available. Operators of shared transmitter sites, for example, will sometimes handle licence applications and provide the expertise necessary to start transmissions. There are even facilities-management companies that will take over and manage an organisation's relations with suppliers of mobile communications services. All these services reduce the amount of specialist expertise and management effort required to install a mobile communications system.

These services make mobile communications much more widely available than formerly; they can support more customers, and they are packaged and marketed in a way which makes them practical for use by a wider range of customers.

NEW SYSTEMS OFFER GREATER CAPACITY AND CAN SUPPORT MORE CUSTOMERS

Developments in the technologies on which mobile communications are based will provide greater capabilities. Faster signalling speeds are increasing the capacity of paging systems. The adoption of cellular technology, which permits the re-use of frequency channels within relatively short distances, has greatly increased the capacity of mobile telephone systems, and digital technology promises to do so again. Trunking can increase the effective capacity of private mobile systems.

PRODUCTS AND SERVICES ARE BECOMING EASIER TO USE

Mobile communications services are being packaged and marketed in increasingly attractive ways. Cellular telephone services, for example, can now provide all the special features that modern electronic switching equipment can provide. (In fact, the facilities available on mobile systems exceed those available on the public telephone network in most countries.) However, there are three particular features of modern services that make them a practical proposition for a wider range of organisations — greater portability, better transmission quality, and the facility for integration with other systems and services.

Greater portability

Mobile communications terminals have steadily decreased in size and have become more portable. The equipment for the earliest police mobile communications systems filled the luggage compartment of a police car. Today, however, radios are small enough to be carried by a policeman on foot patrol. The earliest mobile telephones were

Figure 3.17 The availability of mobile communications varies widely between countries

Service	Availability
Paging	Western Europe, Australia, United States, New Zealand, Hong Kong, Singapore, and others
Private mobile radio	All countries, subject to national regulations
Trunked mobile radio	Public systems available in the United States, the United Kingdom, Sweden, and Australia; to be implemented soon in many other countries
Cellular telephony	As for paging, but not yet available in Greece
Wide-area cordless telephony	Service planned for the United Kingdom in 1989; for other countries soon after
Mobile data communications	Public services available in the United States, the United Kingdom, and Sweden
Vehicle location	Public services available in the United States, the United Kingdom, and Australia
Satellite-based mobile services	Commercial services available in the United States; planned in other countries
Air-to-ground telephony	Under trial with US, UK, and Australian airlines
In-car information services	Trials in several countries

usually fixed in vehicles, but portable cellular telephones are now available. Paging devices are now the size of a pen, and there are reports of a combined wrist-watch and paging unit being developed by AT&E, Seiko, and Plessey. These developments mean that mobile communications can now be used for a much wider range of applications.

Better transmission quality

The technology used for modern mobile voice services gives better transmission quality than earlier systems. Although the quality of mobile voice transmission is still variable, at its best it approaches that of conventional telephony. With the technology used on the earlier, private systems, only one party could transmit at a time. Modern, mobile, cellular telephone services offer duplex communications — that is, both parties can talk simultaneously.

Integration facilities

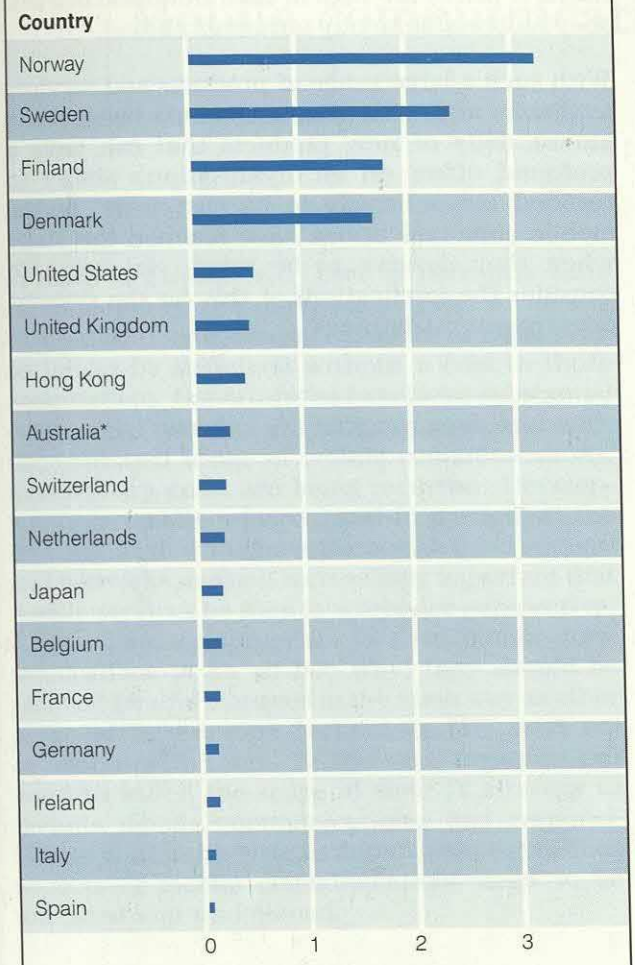
The technology and systems supporting mobile communications applications have become more sophisticated, and mobile services are increasingly being integrated with other information-technology systems and services. For example, it is now possible, in some countries, to send numeric messages to a pager direct from a telephone (as described on page 14). Some voice-messaging services can be linked to pagers, so that a voice-mailbox subscriber is paged when a message is left in his or her mailbox. A high degree of integration has been achieved between cellular telephone services and other networks, through facilities for direct connection of private networks to cellular service switches, and for call diversion from cellular telephones to other public-network connections. The technology also exists to link private mobile radio systems into a PABX so that PABX extensions can have direct contact with mobile devices. In addition, mobile data systems can now access company computer systems. The integration of mobile radio with computer systems is not straightforward, but it has been achieved by a considerable number of organisations and has yielded substantial benefits.

Figure 3.18 The use of pagers is very widespread in Hong Kong, but still limited in much of Europe

*In Hong Kong, 16.4 per cent of the population use pagers

(Source: *European Mobile Communications Report*)

Figure 3.19 The use of cellular telephones is most widespread in Scandinavia and Finland



*Projected, end-1988

(Source: *European Mobile Communications Report*)

THERE IS A WIDER CHOICE OF SUPPLIERS THAN THERE IS FOR FIXED SERVICES

Competition is far greater in the supply of mobile communications services than it is in conventional telephony services. Two cellular telephone service operators compete for business in most parts of the United States, the United Kingdom, Sweden, and Canada. In Hong Kong, there are three service providers. A second service is just starting in France, and competitive digital cellular services will be provided in Germany. The Australian authorities are currently considering whether to allow competitive cellular services. In the United Kingdom, the service operators do not sell direct to the public; they are forced, by regulation, to retail their services through independent service providers, who also supply terminals. In the United States, carriers sell cellular services through agents and resellers, as well as direct to customers.

More than 20 companies provide paging services in Hong Kong. There is also competition in the provision of paging services in Australia, France, Ireland, Sweden, the United Kingdom, and the United States, and a decision has been taken to open the market to competition in Germany.

There is little evidence that competition has reduced mobile communications tariffs, although in some countries, it has had an indirect impact on terminal prices, because retailers are given incentives to sign up new subscribers for a particular service operator. In countries that have developed cellular systems based on their own national standards, the range of available equipment may be biased towards national suppliers. This situation will change drastically when the pan-European digital system is introduced. In principle, once equipment has been approved in any country, it can be used throughout Europe. This means that users will be able to buy their equipment in any country in Europe. Indeed, some PTT sources claim that when the pan-European digital cellular system is launched, subscribers will be able to sign up with service providers in other countries to get better terms than their domestic service providers can offer. It remains to be seen whether this will be feasible in practice.

STANDARDS ARE BEING DEVELOPED

As the market for mobile communications matures, the importance of standards is more widely acknowledged, and standards are beginning to be developed. The need for standards is recognised by the suppliers, who want to be able to provide the same equipment in different countries. Users will also benefit from standards because they will be able to use the same equipment to access a range of mobile communications services. However, few truly international standards have appeared as yet, except for the RPC 1 paging standard (see page 14) that is now widely used.

The European Commission has pressed hard for the establishment of common cellular radio standards as part of the initiative to harmonise technical standards in the context of the creation of the single unified market in Europe. Common European-wide standards (GSM) have been agreed by the member countries of the CEPT for the digital cellular service, but in the United States and Japan, digital cellular technology is being developed to different standards.

Little effective international standards-setting has as yet taken place for the newer public mobile

services. The MPT 1327 protocol is now in use or chosen for implementation in several countries for trunked mobile radio systems. The CEPT has taken some preliminary decisions on a digital European cordless telephone (DECT) standard, but the standard ignores current product developments, favouring time-division multiple access (TDMA) technology at 1.6 GHz, to the frequency division multiple access (FDMA) approach at 900 MHz, used in the systems currently under development. In its present form, the DECT standard is more likely to hinder market development than assist it.

Few users have a significant requirement for mobile communications from abroad. However, international standards will enable terminal manufacturers to achieve substantial economies of scale. Competition will ensure that these are passed on to users; if prices are high in their domestic market, they will be able to buy terminals abroad.

With such a large range of products and services available, and with announcements being made almost daily of new products that can have a profound effect on an organisation's ability to respond competitively to its customers' needs, mobile communications have reached the stage when they deserve to be taken seriously. We consider the implications of this for the systems department in Chapter 4.

Chapter 4

Mobile communications must be coordinated and managed

In many organisations, there is currently little coordination of the purchase and use of mobile communications services. This state of affairs can no longer be sustained without a cost to those organisations. Opportunities to achieve substantial commercial benefits are being missed, and with the increased usage of mobile communications, unnecessary costs are being incurred. Developments in mobile services, and in particular, the growing need to integrate them with fixed systems and networks, make it increasingly important that mobile services be seen in a broader perspective. It is no longer appropriate to treat mobile communications in an ad hoc way; they should be planned for and managed in the same way as other areas of information technology (IT), and coordinated with them. To this end, organisations need to widen the scope of their IT strategy to include mobile communications, and responsibilities within the systems department for various aspects of mobile communications need to be allocated and understood.

AN UNCOORDINATED APPROACH HAS MAJOR DRAWBACKS

Organisations that fail to manage mobile communications effectively risk incurring significant penalties. Above all, an uncoordinated approach will lead to inefficient operations and a failure to capitalise on the business opportunities that mobile communications could bring. Furthermore, it will mean that unnecessary costs are incurred and that opportunities to develop the business in the future will be jeopardised because it will be difficult to integrate existing mobile communications with other systems.

A LACK OF COORDINATION WILL LEAD TO INEFFICIENT OPERATIONS

In many of the Foundation member organisations we interviewed, responsibility for mobile services was split between two or more departments, and there was often no coordination of purchasing. In one company, for example, the telecommunications manager was responsible for cellular telephony, but the site-management department looked after paging. In other companies, where responsibility for fixed-link voice and data services was divided, responsibility for mobile voice services and data services was similarly split. This is particularly unfortunate because most mobile data services are currently delivered over voice networks and in conjunction with voice services.

Such a lack of coordination of responsibilities can cause serious problems. One organisation had about 30 senior managers with cellular telephones in their company cars. The cars had been obtained from different distributors, and the mobile telephones had been fitted by the distributors, each of whom had obtained the telephones from a different equipment and air-time retailer. As a result, the company was dealing with six air-time providers; handling the billing for cellular services for the 30 units was taking half a day of administrative time per week. As a consequence, that organisation was considering employing a specialist facilities-management company to manage relations with the service retailers and to act as a single billing point.

UNNECESSARY COSTS WILL BE INCURRED

The total cost of using mobile services can be considerable, and purchase and usage of the services therefore need to be controlled effectively if unnecessary costs are to be avoided. In fact, significant cost savings can be achieved if requirements are coordinated throughout the organisation.

In many organisations, the decision to purchase cellular telephones for use by individual departments is made by senior departmental managers, without reference to any coordinating unit. Other organisations control capital purchases above a predefined value, but leave smaller purchases to the discretion of individual managers. The falling price of cellular telephones is now taking them below this threshold in many cases, and as a result, there is likely to be a large increase in the number of ad hoc purchases.

The acquisition of pagers is often subject to even less control. One organisation we interviewed allocated them on request. Another, which had no cost-monitoring system in place, found it virtually impossible to calculate its total paging costs when it eventually realised the need to do so. Both its own and its supplier's records were grossly inadequate. On the one hand, the organisation was being charged for pagers that it did not have; on the other, many of those that it was justifiably being charged for were found abandoned by staff who had left years before. Total costs were very difficult to establish because bills were submitted to 160 different individuals or departments and included charges other than those for pagers. The organisation's annual paging costs were finally estimated to amount to £160,000 ($290,000).

With centralised control of purchasing, very significant savings can be made. In countries where different suppliers compete for cellular telephony business, for example, significant discounts on terminals and air-time can be obtained by bulk purchase, whether by direct negotiation or by competitive tender. Many cases have been reported of cellular telephones being provided 'free' in bulk deals for terminals and air time. We also heard of organisations that had obtained 40 per cent discounts by competitive tendering for rentals of tone pagers.

In the United Kingdom, both Cellnet and Vodafone offer reduced call charges to customers who access the mobile service directly from their own network via a private circuit. Typical reductions are from 35p (63c) per minute for a call from London during working hours, to 20p (36c) per minute. These reductions have to be offset against the costs of the private circuit, and become more attractive as the number of cellular telephones increases; the number of users must exceed 25 for Cellnet, and 30 for Vodafone. Clearly, a co-ordinated approach within an organisation is essential to obtain savings like these.

INTEGRATION WILL BE DIFFICULT

Although Foundation members perceived the opportunities for integrating mobile services with other systems and communications services as rather limited at present, integration is, in fact, becoming more technically feasible, as we illustrated in Chapter 3. To ensure that actions taken now will not jeopardise the business in the future, consideration must be given at an early stage to the question of how mobile communications will interwork with existing computer systems and networks. Organisations can learn useful lessons from their experience with personal computers. Both personal computers and cellular telephones are relatively low-cost items that have been widely purchased by individual departments and managers to meet local needs. As usage becomes more sophisticated and more integrated with other systems and services, it is essential that coordination mechanisms be put in place, and that only a limited number of standards and equipment types need to be supported. Without such forward planning, the task of integration will be substantially more difficult in the future as equipment types proliferate.

THE SYSTEMS DEPARTMENT SHOULD BE RESPONSIBLE FOR MOBILE COMMUNICATIONS STRATEGY

Because of the growing need to integrate mobile communications with fixed networks and existing systems, and because mobile communications are likely to account for a significant and growing percentage of spending on telecommunications in most organisations in the next few years, we believe that systems departments should take responsibility for mobile communications and consider them as an integral part of their overall IT strategy. In particular, systems directors need to ensure that their organisations are aware both of the potential business threats if competitors are able to use mobile communications to gain a competitive advantage, and of the potential business benefits available from well managed mobile communications.

Sometimes, organisations may not be able to match the use of mobile communications made by their foreign competitors simply because equivalent services are unavailable, or are substantially more expensive, in their own country. In many cases, this is a consequence of the national regulations governing mobile communications, and of the frequency allocations made by the national regulatory body. Where services are not available, and where the consequences of this to the business are significant, the systems director should alert the board to the problem and encourage it to lobby the relevant political institutions or to bring pressure to bear on the PTT or other service suppliers to improve the situation. In most countries, associations of mobile radio users and suppliers exist to pursue such campaigns on behalf of their members.

Where adequate mobile services and products do exist, systems directors must ensure that their organisations can make sensible choices among the wide range of services and products now available, and that mobile communications applications are developed and managed within an overall framework. This implies the need for a strategy for mobile communications. Such a strategy should be based on a clear idea of the type of

mobile communications environment that will be required by the organisation in, say, five years' time. This, in turn, will be based on the business's requirements for mobile systems and services. Advice on how to identify these is set out on page 32. Individual applications can then be implemented in a way that is consistent with the environment that the organisation is seeking to create.

In order to implement the strategy, systems directors will need to ensure that telecommunications managers are aware of mobile communications technologies and are in a position to take responsibility for them, and that the necessary skills are available and coordinated in their departments. They will also need to define standards and guidelines for mobile communications and ensure that appropriate user support and administrative procedures are available. These responsibilities are discussed in more detail below.

TELECOMMUNICATIONS MANAGERS SHOULD ACQUIRE MOBILE COMMUNICATIONS SKILLS AND EXPERTISE

It is likely that the systems director will delegate responsibility for implementing mobile communications applications to the telecommunications manager. To date, however, many telecommunications managers have no experience of mobile communications. As a consequence, many do not know the range of products and services becoming available, or the technical possibilities, and few understand the complexities of mobile data communications. Furthermore, they underrate the significance of mobile communications. One commented to our researcher, "Paging is a long way from my main concerns with networks." Systems directors therefore need to ensure that their telecommunications managers are well informed about mobile communications and aware of their importance.

In turn, telecommunications managers must ensure that their departments are appropriately organised and have the skills required to implement mobile communications applications. Technical skills in mobile communications are usually in short supply, and are often scattered throughout the organisation. Telecommunications managers should ensure that the right mix of skills is available in their departments, and provide appropriate training in mobile communications technologies.

When mobile data applications are to be developed, which could require expertise in radio, computing, and fixed-network technologies, the dispersal of limited skills around the organisation is an even more acute problem. It may best be solved either by forming a team of people with skills in one or more of the relevant technologies, or by using specialist subcontractors. In the former case, time will have to be allowed for the team members to gain an understanding of the technologies with which they are unfamiliar, and of the particular problems of mobile data communications.

STANDARDS AND GUIDELINES FOR MOBILE COMMUNICATIONS SHOULD BE DEFINED

The systems department will also need to define standards and guidelines for using mobile communications. These should include the procedures for procuring equipment, definitions of the types of staff who qualify for particular items of equipment (those applied in practice by a range of organisations are listed in Figure 4.1), and guidelines relating to aspects of use. For example, the guidelines may specify that use is restricted to business calls only, that security considerations preclude discussion of sensitive business matters over cellular telephones, or that mobile equipment should not be used while driving.

Equipment standards may also be specified. One UK company, for example, has specified that all new cellular telephones must be compatible with the ETACS standards (ETACS equipment can use an additional range of frequencies made available in the London area in response to severe congestion on the original frequencies), and must be capable of hands-free operation. The standards might, indeed, specify that particular models of terminal be used, so that bulk discounts can be obtained.

Figure 4.1 Rules should define who qualifies for mobile communications equipment

These are the rules applied by a variety of organisations

Type of organisation	Qualifying rules for cellular telephones
Bank	Any manager spending more than one day per week out of the office
Airline	Senior managers above a defined level, and certain other specified categories of staff — for example, service personnel
Public utility	Staff with an urgent requirement to contact other organisations while they are out of the office

Type of organisation	Qualifying rules for pagers
Public utility	Anyone who requests a pager
Retailer	Operations staff who are on call
Insurance company	Security and service staff — for example, maintenance staff and furniture movers
Government department	Staff whose jobs are not office-based — for example, building inspectors and park keepers

USER-SUPPORT AND ADMINISTRATION PROCEDURES MUST BE AGREED

One of the most important aspects of support for mobile communications is adequate training, both for the equipment users themselves and for control-centre operators. Although the training effort need not be extensive (groups of users can be trained in simple dispatch applications, for example, in about three hours), it is essential if the mobile system is to be used effectively. One computer supplier, for example, provided its salesmen with cellular telephones to improve their responsiveness to customers, only to find that few of them gave their mobile telephone numbers to their contacts.

After a mobile system has been implemented, continuing support for users is as essential as it is for any other IT system, but it is more difficult to provide because the users are dispersed and constantly on the move. Some organisations have found that the existing procedures for supporting these types of staff are also the best means of providing mobile communications support. Thus, an insurance company that is considering providing its sales agents with mobile data terminals has decided to support them through the district offices that already manage the agents.

The administrative procedures for managing mobile communications also have to be designed carefully, particularly those concerned with taking a mobile telephone out of service when someone leaves. Some Foundation members also told us that substantial administrative effort is required where mobile communications users can access several computer centres. The problems lie in ensuring that access paths are well defined, that the procedures for accessing different centres are similar, and that users are kept fully informed of any changes.

REQUIREMENTS FOR POTENTIAL APPLICATIONS MUST BE IDENTIFIED AND DEFINED

In most organisations, the systems department has a responsibility to help identify IT applications that are likely to be of commercial benefit. With mobile communications, it will need to play a bigger role than usual, because of the general lack of awareness both about the products and services available, and about the benefits to be gained from them. It can do this either by identifying the applications itself, or by promoting awareness of specific information technologies in user departments to enable them to identify their own applications. In one major construction company, for example, the systems department circulates a newsletter every two months to update business managers on the range of IT services and facilities available; mobile services feature prominently in the newsletters. Systems directors should ensure that the functions in their own departments responsible for identifying and defining applications for users are sufficiently well informed about mobile communications to be fully aware of their potential, and include them in the range of technologies they consider.

The requirements for mobile applications should be defined in terms of the needs of the business, and the characteristics of the communication that will take place. The requirements for mobile data applications will need to be considered separately.

BUSINESS NEEDS

Two complementary approaches might be taken to identifying business needs and opportunities for mobile communications. One is obviously to look for major applications. The other is to identify users who are likely to have a significant requirement for mobile communications, and in this context, it is useful to classify different types of staff in terms of their mobility and the importance to the organisation of being able to get in touch with them quickly. One way of classifying staff for this purpose is illustrated in Figure 4.2. Staff who score highly on both counts are likely to have the greatest need for mobile communications. Combining these two approaches — finding major applications, and identifying the main users — will lead to an overall definition of the business needs for mobile communications within the organisation.

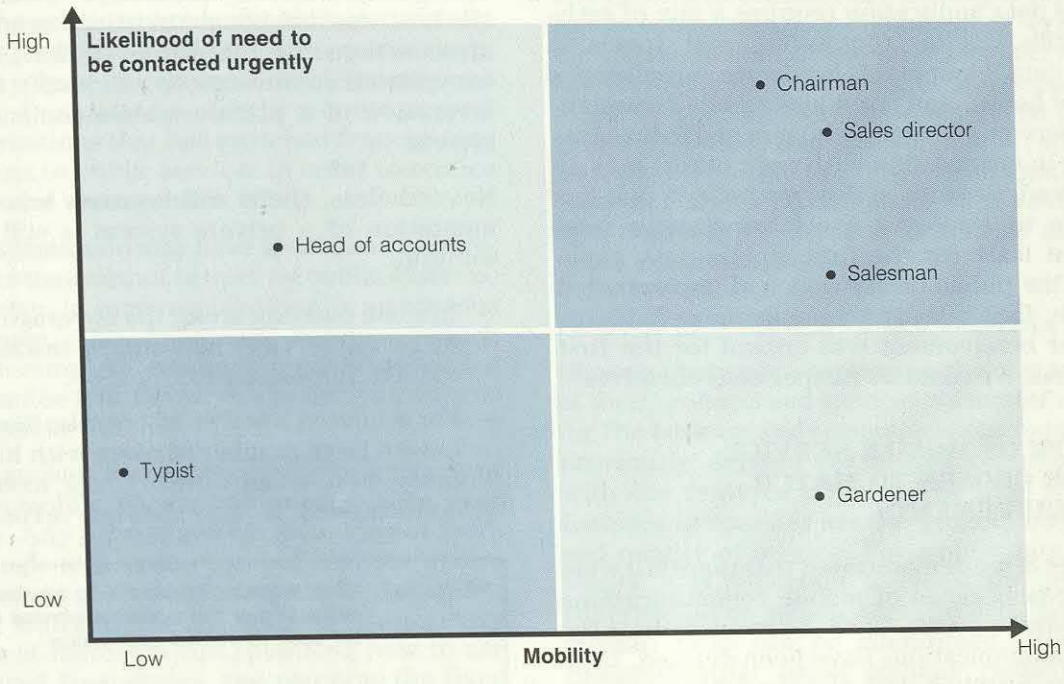
When a specific application for mobile services is proposed, the first step is to identify the kinds of business benefits that will be achieved, and if possible, to quantify them in financial terms. The costs of implementing the application should be estimated, so that the business case for the application can be made. The estimated costs will depend on the characteristics of the communication for which the application will be used.

COMMUNICATIONS CHARACTERISTICS

The costs of mobile services vary widely, depending on the type of service used and the geographical coverage required. It is therefore particularly important to define the communication characteristics of a proposed application precisely, in order to avoid incurring unnecessary costs. The main questions to ask are:

- Who needs to communicate? How many potential users of the mobile service are there?
- Is communication with other organisations essential, or will communication within the organisation, or even to a single point within it, be sufficient?

Figure 4.2 The need for mobile communications varies according to people's mobility and the need to contact them at short notice



- Is it necessary to establish immediate communication with the people on the move, or is it enough to alert them so that they can call back? Will they need to call back over the mobile link? Are data communications required so that detailed information can be transmitted accurately? How long will the messages or conversations be? (Many trunked mobile radio systems for dispatch applications break the connection after a minute or two). Will users need to communicate while actually on the move, or will they stop to do so?

- Geographical coverage is a major determinant of mobile communications costs. Within what geographical area will individual users need to operate? Although the organisation as a whole may need national coverage, it is likely that individuals will need to use mobile communications only in a predefined region.

- Is complete coverage required, even in areas where radio transmission and reception is difficult, or is it acceptable for the individual to move a few hundred metres to obtain better reception?

- What quality of service is required? Does it matter if it takes users 20 minutes to establish a connection, or if they lose it in mid-conversation when they drive under a bridge? (Some of the congested cellular and community repeater services available today provide this level of service.) Will fading be a problem? For data communications, what error rates can be tolerated?

- What level of security is needed? It is easier to tune-in to cellular telephone conversations than to conversations on a conventional telephone. If a conversation on the mobile link were accidentally overheard, would it damage the organisation? What are the risks of deliberate eavesdropping?

DATA REQUIREMENTS

For data applications, the requirements should be defined as part of an overall systems design, and should take account not only of the way that mobile communications interface with conventional networks and computer systems, but also the administrative procedures that will be required to make the most of mobile communications. The Cheltenham and Gloucester Building Society application described in Figure 2.2 is an excellent example of the benefits that can be gained when mobile data requirements are considered as part of a wider system.

The impact of mobile data communications on existing systems and networks must also be assessed. In the same way that some large-scale end-user computing applications have caused severe capacity problems, mobile data communications may require the number of access ports or

the processing power of existing systems to be increased.

We have already pointed out that implementing a mobile data application requires a mix of technical skills. Radio, computing, and specialist mobile data equipment hardware suppliers, a software house, and fixed and mobile communications service suppliers (who may see themselves as being in competition with each other) may all be involved. Because of this, we believe that it is advisable to employ a specialist systems integrator, at least for the first mobile data application. One public utility that had implemented a mobile facsimile system commented to us: "Supplier involvement was critical for the first installation. We could do further ones ourselves".

THE TYPE OF MOBILE SERVICE MUST BE CHOSEN TO MATCH THE REQUIREMENTS

In Chapter 3, we demonstrated that there is a wide and increasing range of mobile communications products and services. Once the requirements for mobile communications have been defined, they need to be matched with the available products and services to determine which are, and which are not, suitable. Figure 4.3 shows how some of the main types of mobile communications services may, or may not, match the requirements of the more common types of application.

It is important to remember, however, that communications with mobile staff do not always require mobile communications services. For example, home-based staff can use a portable terminal during the day to input orders as they visit clients' premises. On returning home, they can connect the terminal to their telephone and download the orders to the company's computer system. Fixed-link alternatives to mobile services for a given application should therefore be identified, and their cost should be compared with that of the mobile options. Often, the fixed-link alternatives will be less expensive because of the lower cost of conventional telephone calls, but they may not provide the same degree of responsiveness as the mobile options. Assuming that a mobile communications solution is required, the most important factors to consider are whether to use a public service or to develop a private system, and whether the chosen service or system will be able to provide the enhancements that may be required at a later date.

PUBLIC SERVICES CAN NOW MEET MOST REQUIREMENTS

Many existing private mobile communications systems date from a time when no suitable public services were available. The spread of community repeaters, cellular services, and public trunked mobile radio services make it increasingly likely that public services will, today, be able to meet the business and communications needs of most organisations. By the middle of the 1990s, only exceptional circumstances will justify the implementation of a private mobile communications system.

Nevertheless, there will be cases where implementation of a private system is still the best solution:

- In some outlying areas, the coverage provided by public services may still be inadequate, or indeed, nonexistent.
- For a limited number of organisations, which have a large number of users with high usage rates, and which already use mobile communications, it may be less expensive to

Figure 4.3 Each organisation needs to assess the suitability of the available service options for each identified application

Service	Application				
	Top management: contact with customers and office	Scheduling and dispatch of customer-service engineers	Account managers: contact with customers	Computer operations staff: call-out in emergency	Building maintenance staff: contact
Mobile telephone					
Wide-area cordless telephoney	✓	✓	✓	✓	✓
Cellular, voice and data	—	✓✓	—	—	—
Cellular, voice only	✓✓	✓	✓✓	✓✓	✓
Private mobile radio					
Public network/data	—	✓✓	—	—	—
Public network/voice	—	✓	—	✓	✓
Own system/data	—	✓✓	—	—	—
Own system/voice	—	✓	—	✓	✓
Paging					
Alphanumeric	✓	✓	✓	✓✓	✓✓
Numeric	✓	✓	✓	✓✓	✓✓
Tone	✓	✓	✓	✓✓	✓✓

✓✓ Highly suitable for most applications of this type
✓ May meet some of the requirements for most applications of this type
— Usually not appropriate for this type of application

continue to operate a private system because many of the costs (such as the acquisition of transmitter sites) have already been incurred. However, organisations considering upgrading existing systems should look carefully at the available public services, particularly if they have a relatively small number of users. During our research, we met several organisations that had switched from private systems to public services in order to reduce costs and management effort.

- An organisation may have specialised requirements that cannot be met by public systems. Security, in some applications, is an obvious example. The emergency services, which need complete geographic coverage and a guarantee that the service is always available for use, is another.

Those organisations that do decide to implement a private mobile system will need to plan very carefully. Any private system consisting of more than a single transmitter located near the operations centre is potentially complex. In particular, locating transmitters to achieve satisfactory coverage at minimum cost, planning how to use the assigned frequencies, and planning the fixed networks that connect the transmitters to the control centres, all need detailed attention. Few organisations have the necessary skills and expertise in-house. Where a private system is unavoidable, it may be sensible to employ the services of a specialist firm that can plan and manage the implementation as a turnkey job.

LIKELY SERVICE DEVELOPMENTS NEED TO BE CONSIDERED

Choosing which type of mobile service to use depends not just on how well the service matches the proposed requirements. It depends also on how the use of mobile communications is likely to develop in the future and on the service provider's future plans for the service. For example, if the plan is to add mobile data communications to an initial voice-only capability, or to extend coverage nationwide from a start-up in one region, will the service provider be able to support these developments? Considering these types of issues at the outset will reduce the chances of having to scrap all the equipment and start again at a later date.

Another consideration is whether a service is likely to be withdrawn in the foreseeable future, and it may be necessary to choose a more expensive service because of this. In some cases, old-fashioned mobile telephone services are now cheaper than cellular services, at least for use within a specific region. However, usage of these services is falling in many countries, following the introduction of cellular services, and some are likely to be withdrawn in due course.

SUPPLIERS MUST BE CHOSEN WITH CARE

The factors to consider in choosing a supplier of mobile communications equipment or services are the characteristics of the product or service, the full life-cycle costs of using it, the support provided by the supplier, the commercial arrangements proposed, and the supplier's capabilities and past record. For any significant mobile communications requirement, it is advisable to seek competitive tenders, as it is for any other major communications contract.

PRODUCT AND SERVICE CHARACTERISTICS

Choosing between suppliers on the characteristics of their products and services is a matter of matching the business and communications requirements previously defined for mobile communications with the features offered. The most important features to consider are the geographic coverage and quality of service. For mobile data requirements, it is important to check the geographic coverage over which the claimed data transmission rates can be guaranteed. Mobile data communication using cellular radio is in its infancy, and the data service may not be as widely available as the voice system upon which it is based.

FULL LIFE-CYCLE COSTS

It is tempting to choose the supplier who provides the cheapest equipment, but it is important to compare the full life-cycle costs of alternative equipment and services. The initial cost of buying the equipment, or the equipment leasing cost, is likely to be a small proportion of the total costs, once usage costs have been taken into account. When comparing the usage costs of alternative services, it also important to ensure that equivalent service levels are being evaluated. Suppliers of paging services, for example, use different charging zones. One organisation we interviewed found that it could save £15,000 ($27,000) a year, a third of its paging bill, by switching to a paging-service supplier with a different zone pattern. Moreover, the alternative supplier provided more attractive service features.

In countries where several suppliers are allowed to market cellular equipment, cellular telephones are frequently offered at highly discounted prices, in particular to bulk buyers. Where the telephones are retailed as part of a service that includes the provision of air time, the low equipment prices may be accompanied either by higher service usage charges, or by a tariff structure that leads to higher costs because of the time intervals used

for charging purposes; alternatively, the customer may be locked into a long-term contract. Low equipment prices may also be coupled with minimal support.

For mobile data communications, comparisons of operating costs may not be simple because different service suppliers may use different communications protocols. This can mean that call-duration times (and therefore costs) can be substantially different, even where the data transmission rates are nominally the same. The main fact to establish is the cost of a *typical* data-transmission session. It is the error-correction components of the protocol that add to the transmission overhead and slow down the effective data-transfer rate. Shorter call times can be achieved with simpler protocols but at the cost of higher error rates and more failed calls. For major mobile data communications requirements, it may be necessary to implement a pilot application in order to identify the true costs.

LEVEL OF SUPPORT PROVIDED

The level of support offered is a critical factor in choosing a mobile communications supplier. The highest levels of support will be required when an organisation has decided to implement a private mobile communications system and wants a service provider to plan and manage the project. In this situation, the service company must be able to demonstrate expertise in setting up a private radio system, leasing transmitter sites, obtaining a suitable frequency allocation and the necessary licences, and setting up communications links from the user's site to the transmitter.

Organisations planning to implement a mobile data system may need support from the chosen supplier in integrating mobile communications with conventional systems and networks. The selected supplier may also be required to maintain the equipment and provide software support. User organisations should ensure that suppliers have the capability to deliver the level of support they claim to offer, and that they will service the equipment reliably.

Other aspects of support that can be important in specific cases are training of users and operators — for example, dispatchers in dispatch systems, the quality of system documentation, and the ability to supply statistics about the volume of communications traffic. The latter may be needed to ensure that private network links have sufficient capacity to transmit information generated by the mobile system.

COMMERCIAL ARRANGEMENTS PROPOSED

The contracts proposed by potential suppliers, and their arrangements for billing and account management, may affect the choice of supplier. There is a lot of 'small print' in the standard contracts of some mobile communications suppliers, and this needs to be scrutinised very carefully. In particular, organisations should be aware of the duration of the commitment they are entering into and the respective obligations of customer and supplier. Some user organisations have, with hindsight, regretted not specifying a higher level of after-sales service in the contract.

Coordinating and managing the use of mobile communications services can be very difficult where the supplier's billing arrangements and account-management approach does not match the user organisation's requirements. For example, the service provider may insist on submitting several invoices covering the same period, or may want to include charges for mobile services in invoices for fixed-network services.

SUPPLIERS' RECORD

In a rapidly changing industry like mobile communications, it is particularly important to assess the past record of potential suppliers. The best indication of whether equipment is suitable for a particular purpose is to see it working satisfactorily in similar circumstances. This is especially relevant in the newest applications such as mobile data communications. Potential purchasers should therefore ask to be referred to existing users of the products or services.

In those countries where competition in the supply of mobile communications terminals (particularly cellular telephones) is permitted, many companies are setting themselves up as equipment retailers. The competition is acute, however, and not all the new entrants will stay in business. Indeed, several have already gone out of business. Purchasers of mobile terminals usually have a support contract with the retailer, and perhaps a contract for air time as well, so they need to be confident of the long-term viability of their suppliers, or at least to ensure that arrangements can be made to guarantee the provision of support and air time for the duration of the contract.

The competence of the staff who will install the equipment should also be checked. Problems have been caused by insufficiently skilled installers: we heard of one case where the technician installing a cellular telephone drilled 15 holes through the centre console of a car, looking for the right position; the console subsequently had to be replaced and the car's electrical system rebuilt. Cellnet in the United Kingdom claims that up to 20 per cent of failed calls can be attributed to incorrectly mounted antennae. Correct positioning

of the antenna is also important for other mobile communications applications such as vehicle location.

The skills of the installer are even more important for mobile data equipment. Facsimile machines, modems, and other equipment all need to be configured correctly, and in many cases, will need to be set up in a different way from equivalent machines attached to the public telephone network. Implementing a mobile data communications system also requires the suppliers to have systems-integration skills and the ability to manage large projects. A record of successful similar projects is the best way of evaluating suppliers' capabilities in these areas.

Wherever possible, we recommend that the selected suppliers and installers should be recognised by a certification scheme such as the Land Mobile Radio Quality Assurance Scheme (LMRQAS) that has been introduced in the United Kingdom for suppliers and installers of land mobile radio equipment.

REPORT CONCLUSION

Mobile communications have reached the stage of maturity when they need to be taken seriously by the business community. Pagers and mobile telephones can no longer be dismissed as playthings, nor should they be regarded simply as rewards for good performance. Mobile communications can bring significant benefits to most organisations, in terms of greater responsiveness, and hence, competitive advantage, and in many cases, quantifiable cost savings. They must therefore be treated as a competitive weapon, and deployed in support of the objectives set for the business as a whole. Where their purchase and use is coordinated as part of an overall information technology policy, the benefits will be even greater.

We believe that it should be the responsibility of the systems department to plan for the purchase and use of mobile communications. The systems manager should be responsible for ensuring that the required knowledge and skills are available, and for coordinating the use of mobile communications throughout the organisation. In a broader context, where the legislative environment is inhibiting the use of technologies that might further enhance an organisation's ability to compete in the market, systems managers should see that their boards lobby those in a position to fight for further liberalisation. This may all seem a daunting prospect for the systems department, but failure to take up the challenge will mean a loss of competitive advantage for the vast majority of organisations.

Appendix

Cellular data link control (CDLC) protocol for mobile data communications

Racal-Vodata's cellular data link control (CDLC) protocol is based on the high-level data link control (HDLC) protocol — CCITT's X.25 network-access protocol. However, CDLC differs from HDLC in four major ways that make it more suitable than HDLC for transmitting data over cellular radio:

— It has modified synchronisation fields.

— It provides forward error correction.

— It provides bit interleaving.

— It makes use of selective retransmission.

SYNCHRONISATION FIELDS

Data for communication is allocated to an 'information field' and transmitted in frames. The structure of a CDLC frame before forward error correction and bit interleaving is shown in Figure A.1. The synchronisation field identifies the start of the frame and specifies its length. The address field carries information about the routeing of the frame. The control field provides for communications-link management functions, including requesting retransmissions. The frame-check sequence is generated according to a mathematical formula and is used to check each frame for errors. Specifying the length of the frame in the initial synchronisation field makes a second synchronisation field at the end of the frame unnecessary, and reduces errors caused by loss of synchronisation.

FORWARD ERROR CORRECTION

All fields within the CDLC frame contain a multiple of 8 bits. Each 8-bit group is coded into a 16-bit codeword, using a complex mathematical algorithm. The coding is such that even if some of the bits are corrupted during transmission, the error-correction procedures can identify that corruption has taken place. If one or two bits are corrupted, the errors can be corrected without retransmission. If more than two bits are corrupted, retransmission is requested.

BIT INTERLEAVING

When data is transmitted via cellular radio, errors are not distributed evenly in the bit stream. When transmission is broken for a few milliseconds, several errors may occur consecutively. For forward error correction to be fully effective, these errors need to be split up so that only one or two errors occur in any one codeword. This is achieved by 'bit interleaving', as illustrated in Figure A.2, which shows that the data from 16 consecutive codewords is reconstructed into 16 new codewords before it is transmitted. The first codeword contains the first bit of each of the original 16 codewords. The second new codeword contains the second bit from each of the original 16 codewords, and so on.

The selection and interleaving of bits from succeeding codewords has the effect of distributing the errors that occur together evenly across the reconstructed codewords. This reduces

Figure A.1 Structure of a CDLC frame

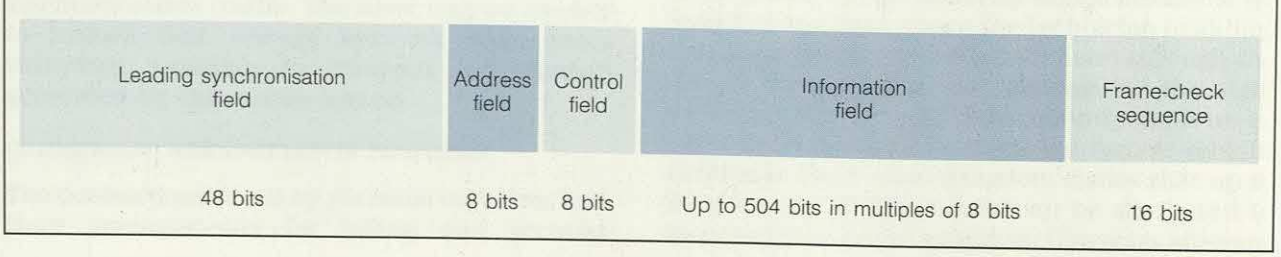
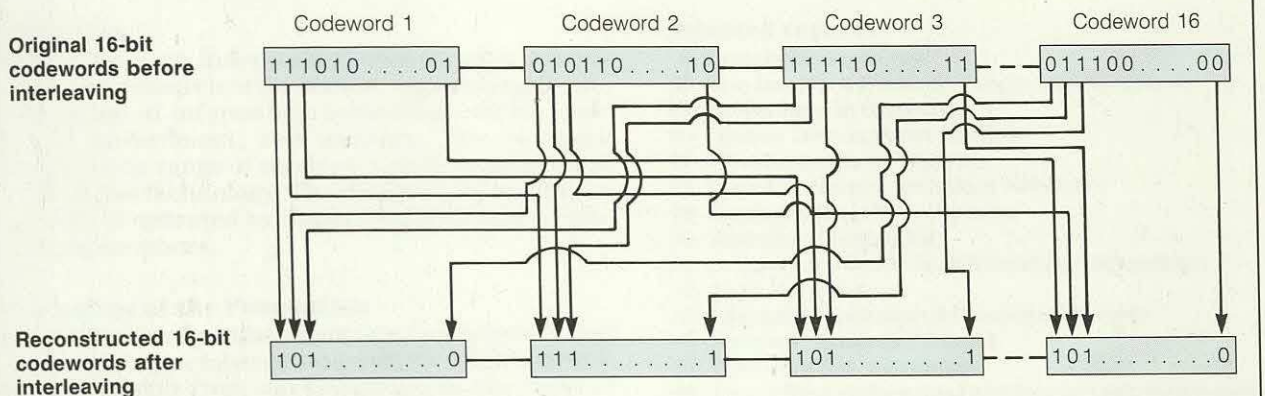


Figure A.2 Bit interleaving

Sixteen consecutive 16-bit codewords are reconstructed so that each codeword used for transmitting the bit stream contains 1 bit from each of the original 16 codewords.



the number of errors in any one codeword, and hence, the number of retransmissions that are requested.

SELECTIVE RETRANSMISSION

When more than two errors occur in a 16-bit codeword used for transmission, retransmission is requested. Retransmission is selective — that is, only corrupted or missing frames are retransmitted. The use of selective retransmission maximises throughput; typically only 10 per cent of frames have to be retransmitted.

BUTLER COX FOUNDATION

Butler Cox

Butler Cox is an independent management consultancy and research organisation, specialising in the application of information technology within commerce, government, and industry. The company offers a wide range of services both to suppliers and users of this technology. The Butler Cox Foundation is a service operated by Butler Cox on behalf of subscribing members.

Objectives of the Foundation

The Butler Cox Foundation sets out to study on behalf of subscribing members the opportunities and possible threats arising from developments in the field of information systems.

The Foundation not only provides access to an extensive and coherent programme of continuous research, it also provides an opportunity for widespread exchange of experience and views between its members.

Membership of the Foundation

The majority of organisations participating in the Butler Cox Foundation are large organisations seeking to exploit to the full the most recent developments in information systems technology. An important minority of the membership is formed by suppliers of the technology. The membership is international, with participants from Australia, Belgium, France, Germany, Italy, the Netherlands, Sweden, Switzerland, the United Kingdom, and elsewhere.

The Foundation research programme

The research programme is planned jointly by Butler Cox and by the member organisations. Half of the research topics are selected by Butler Cox and half by preferences expressed by the membership. Each year a shortlist of topics is circulated for consideration by the members. Member organisations rank the topics according to their own requirements and as a result of this process, members' preferences are determined.

Before each research project starts there is a further opportunity for members to influence the direction of the research. A detailed description of the project defining its scope and the issues to be addressed is sent to all members for comment.

The report series

The Foundation publishes six reports each year. The reports are intended to be read primarily by senior and middle managers who are concerned with the planning of information systems. They are, however, written in a style that makes them suitable to be read both by line managers and functional managers. The reports concentrate on defining key management issues and on offering advice and guidance on how and when to address those issues.

Selected reports

8 Project Management
20 The Interface Between People and Equipment
24 Investment in Systems
25 System Development Methods
27 Developments in Videotex
28 User Experience with Data Networks
29 Implementing Office Systems
30 End-User Computing
31 A Director's Guide to Information Technology
32 Data Management
33 Managing Operational Computer Services
34 Strategic Systems Planning
35 Multifunction Equipment
36 Cost-effective Systems Development and Maintenance
37 Expert Systems
38 Selecting Local Network Facilities
39 Trends in Information Technology
40 Presenting Information to Managers
41 Managing the Human Aspects of Change
42 Value Added Network Services
43 Managing the Microcomputer in Business
44 Office Systems: Applications and Organisational Impact
45 Building Quality Systems
46 Network Architectures for Interconnecting Systems
47 The Effective Use of System Building Tools
48 Measuring the Performance of the Information Systems Function
49 Developing and Implementing a Systems Strategy
50 Unlocking the Corporate Data Resource
51 Threats to Computer Systems
52 Organising the Systems Department
53 Using Information Technology to Improve Decision Making
54 Integrated Networks
55 Planning the Corporate Data Centre
56 The Impact of Information Technology on Corporate Organisation Structure
57 Using System Development Methods
58 Senior Management IT Education
59 Electronic Data Interchange
60 Expert Systems in Business
61 Competitive-Edge Applications: Myths and Reality
62 Communications Infrastructure for Buildings
63 The Future of the Personal Workstation
64 Managing the Evolution of Corporate Databases
65 Network Management
66 Marketing the Systems Department
67 Computer-Aided Software Engineering (CASE)

Forthcoming reports

Software Strategy
Electronic Document Management
Human Resources for the Systems Function
Managing Multivendor Systems
Future Information Technologies

Availability of reports

Members of the Butler Cox Foundation receive three copies of each report upon publication; additional copies and copies of earlier reports may be purchased by members from Butler Cox.

Butler Cox & Partners Limited
Butler Cox House, 12 Bloomsbury Square,
London WC1A 2LL, England
☎ (01) 831 0101, Telex 8813717 BUTCOX G
Fax (01) 831 6250

Belgium and the Netherlands
Butler Cox BV
Burg Hogguerstraat 791,
1064 EB Amsterdam
☎ (020) 139955, Fax (020) 131157

France
Butler Cox SARL
Tour Akzo, 164 Rue Ambroise Croizat,
93204 St Denis-Cédex 1, France
☎ (1) 48.20.61.64, Télécopieur (1) 48.20.72.58

Germany (FR)
Butler Cox GmbH
Richard-Wagner-Str. 13,
8000 München 2
☎ (089) 5 23 40 01, Fax (089) 5 23 35 15

United States of America
Butler Cox Inc.
150 East 58th Street, New York, NY 10155, USA
☎ (212) 891 8188

Australia and New Zealand
Mr J Cooper
Butler Cox Foundation
3rd Floor, 275 George Street, Sydney 2000, Australia
☎ (02) 236 6161, Fax (02) 236 6199

Ireland
SD Consulting
72 Merrion Square, Dublin 2, Ireland
☎ (01) 766088/762501, Telex 31077 EI,
Fax (01) 767945

Italy
RSO Futura Srl
Via Leopardi 1
20123 Milano, Italy
☎ (02) 720 00 583, Fax (02) 806 800

The Nordic Region
Statskonsult AB
Stora Varvsgatan 1, 21120 Malmo, Sweden
☎ (040) 1030 40, Telex 12754 SINTABS

Spain
Associated Management Consultants Spain SA
Rosalía de Castro, 84-2°D, 28035 Madrid, Spain
☎ (91) 723 0995