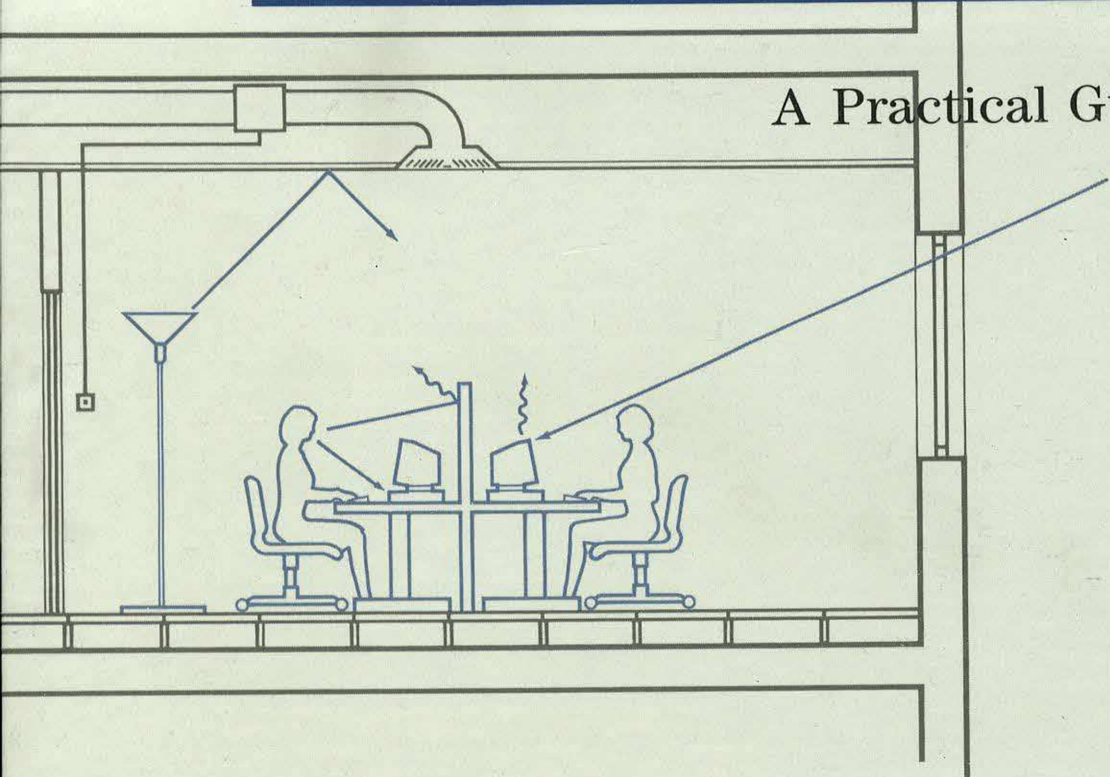
A Practical Guide for Designers



BUTLER COX

This Guide was Sponsored by
AT&T (UK) Ltd, British Telecom plc,
Digital Equipment Company Limited,
and IBM United Kingdom Limited

Architectural Advisor: Dr Francis Duffy

Published by Butler Cox plc
Butler Cox House
12 Bloomsbury Square
London WC1A 2LL
England

Acknowledgements

The development of these guidelines and the publication of this handbook were sponsored by:

AT&T (UK) Ltd

British Telecom plc

Digital Equipment Company Limited

IBM United Kingdom Limited

Butler Cox extends its thanks to all those who assisted with the research, suggested guidelines, or reviewed the text. We are especially grateful to our architectural adviser, Frank Duffy of DEGW, and to the following:

Bob McIntyre and Nick Cogelia of AT&T (UK) Ltd

Chris Shaw and Jacqueline O'Rourke of British Telecom plc

Lee Cooper of Digital Equipment Company Limited

John Harvey and Colin Jackson of IBM United Kingdom Limited

John Lane, Roger Camrass, and Alan Robinson of Butler Cox plc

We are grateful to the following who gave their time to share their experience or discuss the issues at various stages of the project:

Brian Amey, Electrical Installations
Tim Arnold, Anderlyn Group
Peter Bacon, Butler Cox
Paul Ballinger, IBM
John Beattie, Training Agency
Mick Bedford, DEGW
Colin Bromley, Legal & General
Tony Buchan, Legal & General
Ian Buxton, BT
Michael Carver, SVM
Les Chalton, BT
Carole Cobham, DEGW
David Corley, CCTA
Ken Crowhurst
Mel Dance, BT
Humphrey Day, GMW Partnership
Richard Eastwood, First Architecture
Peter Forsdike, Anderlyn Group
Brian Gearing, DEC
Maggie Hall, DEGW
David Hand, IBM
Tony Hare, IBM
Andrew Harrison, DEGW
Steven Hunter, DEGW
Dean Hopper, AT&T
Ron Humphreys, BT
Bill Jones, Thames Water
Adrian Leaman, Building Use Studies
Brian Lloyd, Butler Cox
Anthony Lopinto, JBB
Ray Lucas, Philips
Chas Mackenzie, AT&T
Dr James McMurray, ICI
Ron Martell, DEC
David Miller, BT
Malcom Mitchel, Glaxo Group Research
Chris Nunn, Marks & Spencer
Bill Nowlan, Irish Life
Gavin Peacock, Walfords
John Peel, Thames Water
Graham Pengelly, IBM
Alan Pepper, Ove Arup & Partners
Steve Pillinger, IBM
Jim Reed, Ove Arup & Partners
Bill Rees, BT
Francis Reynolds, Abbey National
D Rigg, J Roger Preston
Derek Rogers, Derek Rogers Consultancy Services
Terry Rook, J Stinton Jones & Partners
Eric Simons, IBM
Alan Smith, Training Agency
Ziona Strelitz, DEGW
Tony Thompson, DEGW
Gerry Thorning, BT
Clive Thurston, Mathew Hall
Steven Tipton, BP Oil
David Trench, Trench Farrow and Partners
John Turner, LEB
C Turton, Midland Bank
Amend Van Eppinghaven, Rybka Smith Ginster & Battle
Mike Warner, Richard Ellis
Alison White, DEGW
Dave Whitely, BT
Eddie Wilson, J P Morgan
Howard Wood, Butler Cox
Martin Yates, Lloyd's of London

Foreword

The United Kingdom has a considerable claim to being in the vanguard of advanced thinking on the design of office buildings for information technology (IT). No-one would have predicted this 10 years ago. Indeed, so bad was the reputation of British office development — mean, retrograde, unlovely, underserviced — that to expect the opposite would have seemed much more reasonable.

The reason for this sudden qualitative shift is now obvious. It is because British office buildings were so bad by international standards that they had no alternative but to improve in response to the sudden explosion of IT in the early eighties. Britain is fortunate in being so centralised: when sudden growth occurred in the use of IT in offices, especially in the electronics and financial services industries, a handful of farsighted developers understood immediately that a dramatic improvement in office-building performance was essential if they were to succeed as developers. The ORBIT report, published in 1983, succeeded in capturing and broadcasting the significance of this moment of change when a new level of specification for office design had to be worked out.

The first ORBIT study defined, in general terms, the case for new, more permeable, more finely zoned and controlled, simpler, and easier-to-plan office buildings. ORBIT 2, carried out in 1985 in North America, confirmed these recommendations and developed them into an operational method of evaluating building performance against IT-driven organisational priorities. Meanwhile, in Britain, both user clients and developers began to procure, surprisingly rapidly, new kinds of high-performance office buildings, designed for a variety of different kinds of users in the City, on the M25, and in cities like Glasgow and Birmingham.

Why, then, is a further study required? What more could it possibly contribute to office design?

This Butler Cox study is particularly well timed: it comes at the top of a steep learning curve. Five years after the initial realisation that IT *was* an important and dynamic factor in office design, a new kind of certainty is emerging. We now know, from bitter experience and shrewd forecasts, more or less exactly the design implications of a fully networked office composed entirely of intelligent workstations. For the first time, it is possible to step back from the novelty and wonder of the rapid introduction of IT into the world of office work, and to prescribe not only coherent strategies, but detailed guidelines to help architects as well as data and telecommunications managers.

Many of our recommendations are specifically practical — dimensions for ducts and cabling rooms, heights of access floors, types of cabling, configurations of 'presentations' — in other words, data on the design of *all* the interfaces where data and telecommunications come into direct contact with the physical working environment. This is exactly the type of information that teams working on new building projects or renovations of existing buildings must have at their fingertips if they are to avoid waste and save time.

Other recommendations that are less specific are even more practical. These recommendations are intended for those senior managers in both the public and the corporate sector who do not yet realise that *they* must insist that architects and other members of building design teams must cooperate with IT specialists from the earliest stage of the development of a new project. Equally, the IT team must collaborate with the building team. Without such strong leadership, it is inevitable that building designers and data specialists will go their own separate and suboptimal ways — leading to accelerated obsolescence and exorbitant occupancy costs. By insisting on the sharing of information and insights between professional disciplines, senior managers responsible for large office accommodation projects can manage the risks so much more effectively.

A broad view is vital for senior management. After all, office buildings, in the age of artificial intelligence and global communications, are practically and operationally harder and harder to distinguish from the computer.

The word 'architecture' has been borrowed by the computer industry to describe the underlying structures of information systems. This is hardly a coincidence: every large system has its own structure, and it is essential, if major systems as large and complex as building construction, mechanical and electrical services, telecommunications and data are to be coordinated, that their underlying logic should be understood by everyone involved.

These guidelines are intended to make such coordination not just possible, but also much easier than ever before. The benefits will not only be to the design teams but to all those who use office buildings (these days, the majority of the working population), and of course, to all those organisations whose commercial success, and even survival, increasingly depends upon using IT and environmental resources intelligently to achieve their corporate goals.

Francis Duffy

Introduction

This handbook started from our awareness, based on practical experience, of the problems that organisations often encounter in installing computers and communications equipment in office buildings. Seeing the need for a handbook to assist building developers and designers, and recognising the considerable amount of work needed to prepare it, Butler Cox obtained sponsorship from four leading suppliers of computers and communications.

Our sponsors, AT&T (UK) Ltd, British Telecom plc, Digital Equipment Company Limited, and IBM United Kingdom Limited, brought to our work their considerable expertise and experience in cabling, computer-room design, building services, and office design. We also benefited from the assistance of our architectural adviser, Dr Francis Duffy of DEGW Ltd. We have therefore been able, for the first time, to produce practical guidelines that are underwritten by a significant part of the IT industry.

The main purpose of this handbook is to provide practical guidance to the architects, engineers, surveyors, and space planners who design, fitout, and refurbish buildings. Since much of our guidance is concerned with objectives, rather than particular architectural and engineering solutions, the handbook is also relevant to developers, commercial estate agents, and the prospective purchasers and occupiers of office buildings, including their IT managers.

In view of the breadth of this readership, we have deliberately attempted to build bridges between disciplines by writing in generally familiar, rather than specialist, terms. Since the use of some specialist terms has proved essential, we have included a glossary at the end.

The Executive Summary (Chapter 1) draws out the main lessons of our work for management.

In Chapter 2, we explain, in a very general fashion, the likely developments in IT over the next 20 years, and the principles that must be applied in building design. These chapters, in particular, serve as a bridge between disciplines, and we hope that all readers will read them both.

Chapters 3 to 7 form a detailed technical handbook of design guidelines. They cover office buildings, including those associated with non-office facilities, such as factories, warehouses, and hospitals. They do not cover purpose-designed data centres, but they do provide information on installing a substantial computer suite in an otherwise ordinary office building. They address the issues of building location, structure, services, and fit-out.

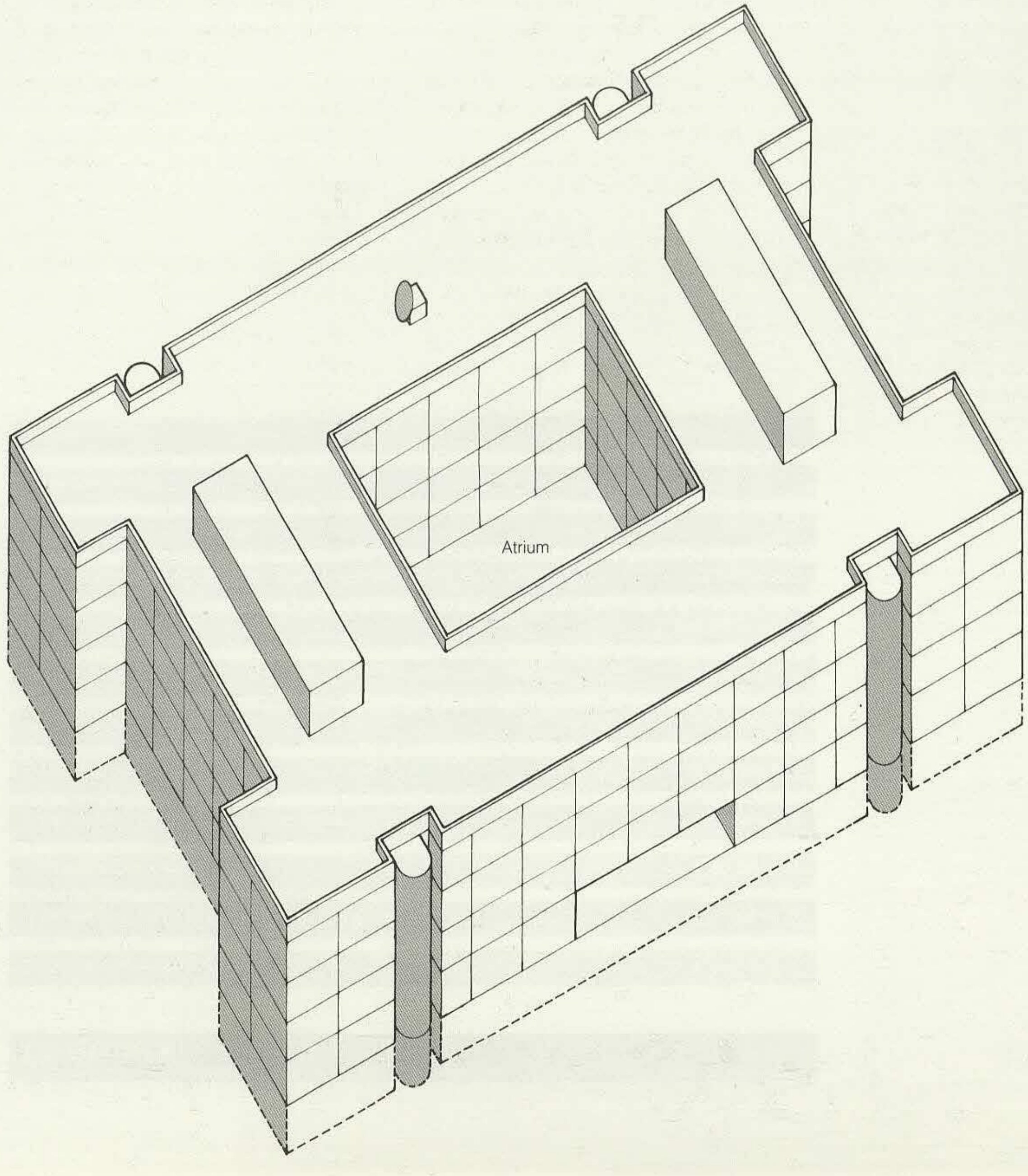
Chapter 8 provides guidance on the management of the building after commissioning. These chapters are intended as a reference work, although they may, of course, be read consecutively.

The Appendix extends Chapter 2, with further information about IT developments.

The guidelines are not offered as a complete and universal solution to the problem of IT in buildings. Considerable scope exists for designs that depart from our guidelines because of local circumstances, or the intending occupant's commitment to work within more restrictive standards. However, our guidelines define a substantial degree of adaptability, which need not be expensive, and which will benefit many building owners and occupants in the long term.

David Flint

Contents


Atrium

Computers have been important in business for 30 years, but, until the early 1980s, they were generally found in specialised data centres and data-entry areas. Only a minority of staff had any direct contact with them. During the past five years, however, the position has been transformed. Computers have entered ordinary offices in great numbers. Today, in more and more organisations, almost every employee is a computer user to some extent.

This unprecedented expansion in the deployment and use of computers and communications (information technology) has placed demands on office buildings that they were never intended to meet. Computers require space. They require power, and are sensitive to electrical interference. They generate heat, and so require cooling. Data communications between computers and desktop terminals and workstations require cables and other equipment in large amounts.

Some information technology (IT) systems have been designed with little thought to the physical requirements associated with installation in buildings. As a result, buildings have very often been unable to meet their occupants' needs for IT systems. In the City of London, for instance, many buildings are being completely refurbished, or even demolished, for this reason.

The construction industry's attempts to meet these emerging needs have been hampered by a number of difficulties:

- IT is advancing extremely rapidly.
- The use of IT varies greatly between occupiers.
- IT systems from different suppliers make different demands on buildings.
- Few IT specialists are able to foresee their organisations' future requirements for IT beyond the short term, or to present them in ways that are useful to the construction industry.

As a result, even some recently completed office buildings presented their occupants with serious difficulties when they came to install IT.

This handbook has been written to help bridge the gap between the IT and construction industries. In it, we show how the design of office buildings should take account of the increasing requirements of IT in offices.

We have found that clear guidelines for many aspects of building design can be derived from considering the way in which IT systems, and their use, are developing. We present these, often quite detailed, guidelines in the handbook. In our view, success in reconciling the requirements of IT with the other requirements in actual building projects rests on the achievement of effective interdisciplinary cooperation. Our analysis of the requirements of IT, and experience of actual building and refurbishment projects, reveals a close relationship between IT, engineering, architectural, and space-planning issues. The design team must achieve a building design that provides a high degree of adaptability to future requirements, at an acceptable cost. The requirements also come together in the field of space planning, where we find that adopting predetermined furniture and partition layouts can deliver benefits in ways that are both practical and aesthetic.

None of these issues can be addressed effectively if the specialists fail to understand one another. Achieving this understanding between design teams is a key management responsibility in both developer and occupant organisations.

Much of the future impact of IT can now be foreseen

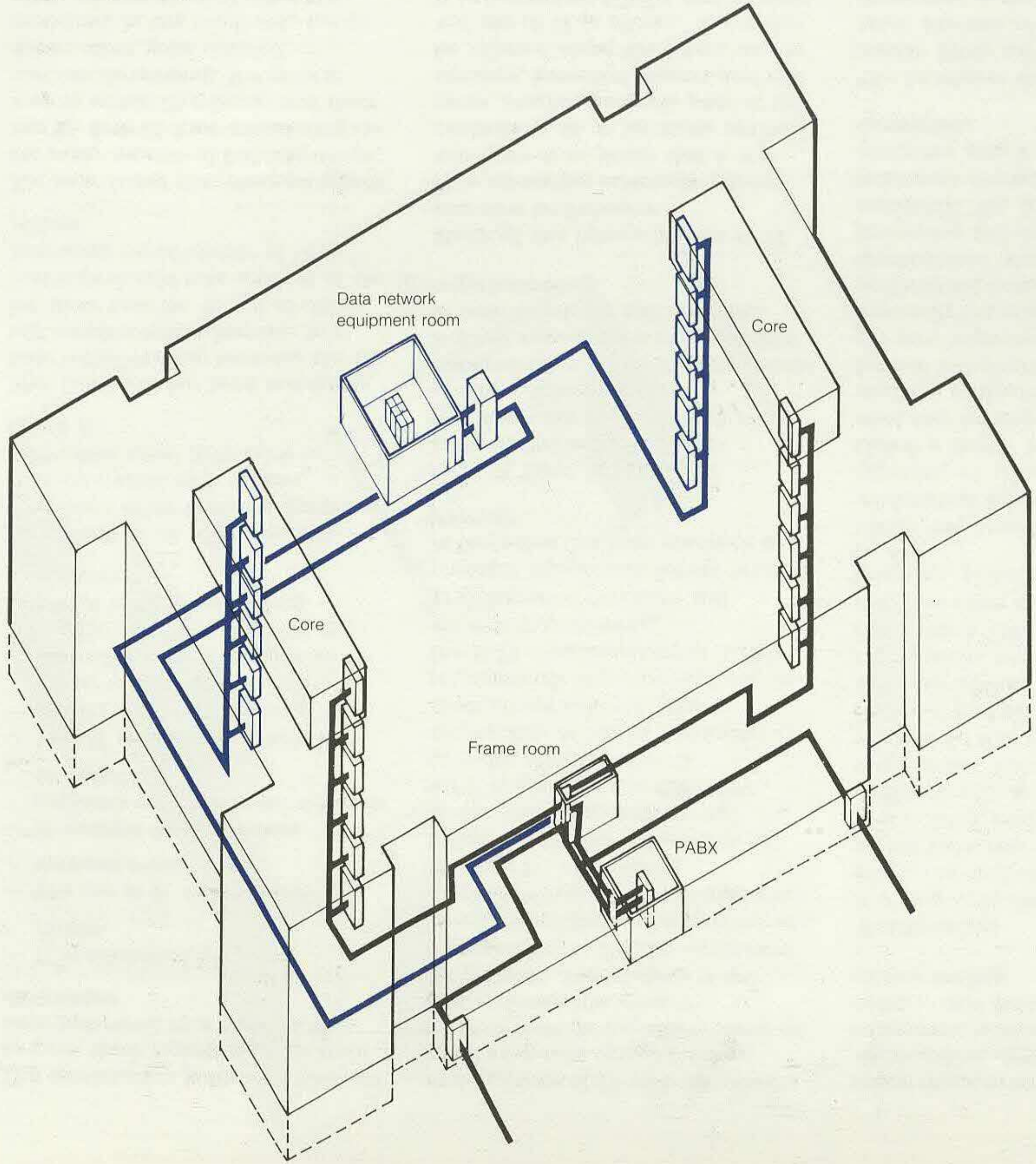
IT is advancing extremely rapidly, and there is no doubt that it will continue to do so for many years to come. Despite the rapid pace of this advance, however, a great deal can be inferred about the future nature and use of IT in offices. To see this, it is convenient to look first at some major components of IT in offices — workstations, departmental computers, and central computer suites — and then at communications cabling.

Workstations

It is now clear that, within a few years, and well within the planning period for a new building, almost every office worker will be equipped with an intelligent desktop workstation. With this device, he or she will be able to retrieve, examine, and manipulate information from any place in the organisation, local or remote. This information will, in general, comprise some mixture of words, diagrams, pictures, and speech.

Today, the typical desktop workstation has no processing capability or data storage of its own. Called a 'dumb' terminal, it can be used only in conjunction with a separate computer, which is often located elsewhere. Dumb terminals are now beginning to be replaced, especially for managerial and professional users, by 'intelligent workstations' that have their own processing and data-storage capability. The commonest kind of intelligent workstation is a personal computer with a network connection.

The intelligent workstation of the middle 1990s and beyond will look much like one of today's personal computers — though it may possibly


Data network
equipment room
Core
Core
Frame room
PABX

feature an attached telephone and a larger screen, and it will certainly be very much more powerful. Although cellphones and laptop portables will be used increasingly in business, radio and infra-red communications will be unable to provide the data transmission speeds needed by these workstations. Estimating the space, cabling, power, and cooling implications of such workstations, as we do in Chapters 2 and 5 of this handbook, is now a practical proposition.

Departmental computers
New office buildings should be designed to allow for at least some of an occupant's computers to be installed on-site. This is because most people in offices work in groups — in teams, departments, and divisions — and computers are being used increasingly to support such groups by storing the information they share and helping group members to communicate and cooperate.

The use of graphics and pictures in business systems is growing and this is likely to encourage the installation of departmental computers on the same sites as their users.

Central computer suites
A growing proportion of office buildings will need to include a substantial computer suite. Compared with ordinary office areas, computer suites require much higher levels of services, notably power, cooling, cabling, and security. Although not every building will need to accommodate such a suite, it is impossible, during design, to identify those that will. Designers should therefore ensure that office building designs are sufficiently adaptable to allow an occupant to install a central computer suite if necessary.

Communications cabling space
Building designers should therefore provide space for structured voice and data cabling systems, together with spare space to accommodate successor systems, probably made from optical fibre, that will be needed later in the life of the building.

The inadequacy of the spaces for communications cables has been one of the commonest problems found in installing IT systems in buildings. In part, this has resulted from an undisciplined proliferation of data communications cables, each able to support only a single kind of workstation.

Structured cabling systems, such as those offered by AT&T, British Telecom (BT), Digital Equipment Company Limited (DEC), and IBM United Kingdom Limited, provide the means of solving this problem. Structured cabling systems allow a wide range of office IT equipment to be supported on a single kind of cable, at least until the limits of copper cables have been reached.

Since all structured cabling schemes require cables to radiate from telecommunications closets to users' desks, this topology is stable and building designers may now rely on it. This stability also allows them to calculate the space required. Detailed guidance on this appears in Chapters 6 and 7.

The power and cooling demands of IT equipment in offices will continue to rise
Just as it is possible now to infer a great deal about the future nature and use of IT in offices, so the power and cooling demands of IT equipment in offices can be predicted with some certainty.

Penetration of data terminals and personal computers
The penetration of data terminals and personal computers is rising very rapidly and will reach one per desk in many organisations by the mid 1990s. In addition to this growth in desktop IT equipment, there is a corresponding growth in the number of shared printers and other peripherals which also contribute to the power and cooling demands in office areas.

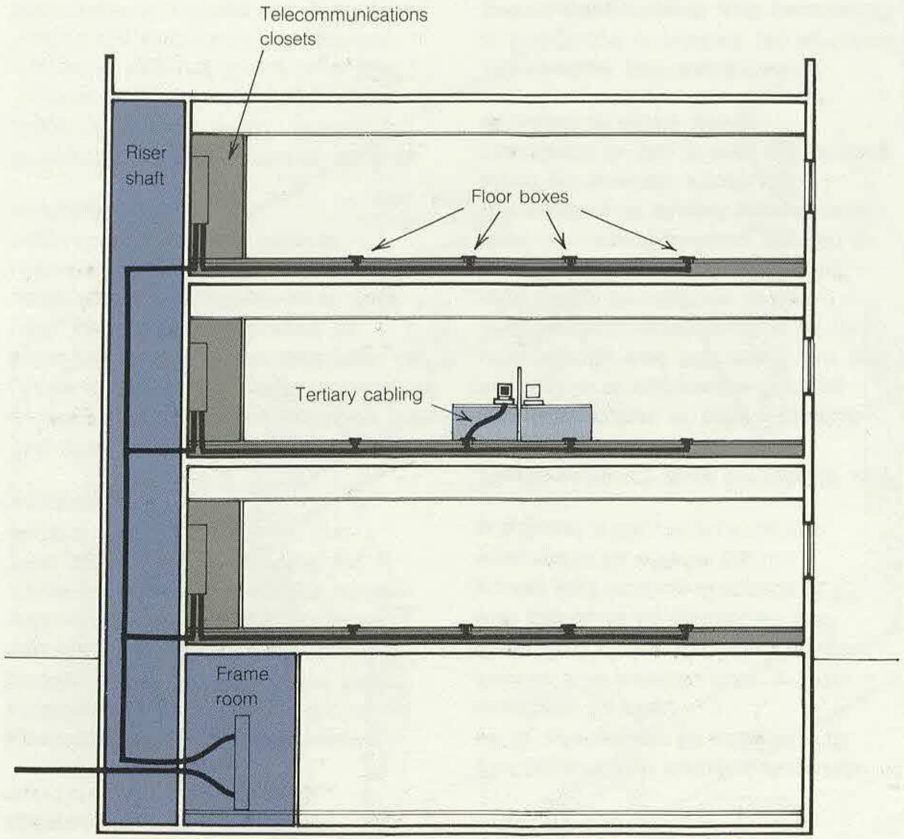
Dissipation per workstation
It is difficult to predict the electrical power requirements and corresponding heat dissipation of individual workstations. The trends towards larger screens, with higher resolution colour displays and greater processing power, which increase electrical power consumption, are offset to a certain extent by improved technology and efficiency in more recent products.

However, a personal computer with a colour screen requires two or three times as much electrical power as a data terminal with a monochrome screen, and a laser printer requires four or five times as much electrical power as a dot matrix printer. So power demand and cooling load per desk will rise as these technologies are adopted.

Diversity
Electrical engineers use a diversity factor in estimating the total electrical load for an office building to allow for the fact that not all equipment will be in use at the same time. When personal computers were first introduced they rarely had a network connection and were left switched off for much of the day, so a low diversity factor could be used.

However, as office staff begin to do more and more of their work on a computer, and particularly when networked applications such as electronic mail and electronic diaries are in use, they will leave their personal computers on all day. This will result in the need to allow a higher diversity factor in electrical power calculations.

Taking these factors together, we believe the small power load for IT equipment could increase from


Telecommunications
closets
Riser
shaft
Floor boxes
Tertiary cabling
Frame
room

typically less than 10 W/m^2 of net lettable area (NLA) today to as much as 40 W/m^2 of NLA in a few years time. The cooling load will rise to correspond with this electrical power dissipation. Some of the best office buildings are already able to provide this level of electrical power supply and cooling. Not all of the capacity needs to be provided initially. Ideally, the building services should be able to meet immediate requirements efficiently, and be able to be enhanced economically when required.

Some rigidity in office layout is beneficial in space planning
The design team should address the practicalities of servicing and lighting office areas as part of the design process. IT affects the servicing issue both in a direct sense, because of the need to accommodate cables, and indirectly, through its power and cooling demands. Workstations present particularly strict requirements for lighting, and thus for interior design. In the future, the use of voice recognition systems is likely to create acoustic requirements, which will also bear upon interior design.

Requirements of this sort are difficult to meet if building occupants are free to move their desks and other equipment around within the office. Predetermined partition layouts, based on the building construction module and standardised furniture configurations, result in a higher-quality working environment at lower cost than does flexibility that is uncontrolled. However, organisations should consider the degree of control they wish to exert over their staff before limiting individual freedom in this way. At present, only a few companies have reached the stage where internal moves involve only the movement of staff rather than the movement of furniture and floor boxes.

IT requirements should be considered at an early stage
The impact of IT on building space, layout, power, and cooling requirements is now such that its requirements should be considered at the outset.

IT makes substantial demands on buildings
Information technology now makes very substantial demands on office buildings in space for central and departmental computer rooms, telecommunications equipment rooms, wiring closets, and on the desk top. Furthermore, prewiring every desk with telephone and data cabling requires considerably more space for cables and cable patching than was needed for telephone wiring alone.

IT demands are the main variable in services design
The basic human requirements for heating, ventilation, and air conditioning are well understood, so this leaves information technology as the largest variable factor in building services design.

IT affects the 'shell-and-core' as well as the fitting out of office buildings
IT requirements for power and cooling are reflected in the design of building services. The space allowed in plant rooms and service cores will reflect the ultimate level of electrical power supply and cooling needed. These space allocations need to be considered in the earliest stages of a building design and certainly at the 'shell-and-core' stage in any speculative development.

To ensure a good overall design, it is essential that IT specialists are involved at an early stage. Their contribution may affect the selection of the site (to obtain access to suitable telecommunications services), total size (to reflect the impact of IT on space usage and work patterns), and the allocations of space, power, and cooling for IT equipment, amongst other things. Although IT is usually not the largest component of these allocations, it is generally the least predictable.

Management must insist on multi-disciplinary cooperation
The design and construction of a building is an extremely complex undertaking, involving people from many different professional backgrounds having different commercial interests. Each party is likely to give primacy to certain aspects of the whole. Developers seek to minimise non-lettable space, architects emphasise aesthetics, engineers stress the servicing, space planners focus on workflow, adjacencies, and furniture layout, and the ultimate occupant will probably want a building that is attractive to staff and visitors, and convenient to use, yet economical to occupy.

Each discipline has a valuable contribution to make to the overall design, but it is important to achieve a balance between the various aspects of the finished building.

Many of the problems of today's buildings are due to ineffective communication between different disciplines. So the developer and the occupier's management alike should insist upon the involvement of IT specialists in building projects, and on effective interdisciplinary cooperation. We discuss the management arrangements that will be needed to achieve this in the chapter that follows.

Of all the advances that are affecting the shape of business in the closing years of the 20th century, it is widely agreed that information technology (IT) has the potential to cause the most convulsive changes of all. IT will change what office workers do, how they do it, and even where they work.

IT is causing fundamental rethinking in office design, because of the impact that IT has on people and their work, and because of the accommodation demands made by IT equipment on office space, lighting, and power.

Until recently, probably the most certain feature of IT in the office has been uncertainty. No wonder architects and office planners have had such difficulty in coming to terms with the issues. Today, however, it is possible to see the future forms of IT and their impact upon businesses. That is not because IT's acceleration is set to decline. Rather, it has reached a point at which predicting the future is suddenly less uncertain than has been the case before.

In this chapter, we describe the key developments in IT as they will affect office buildings and their design. We begin with an overview of the technology itself, before going on to describe IT's impact on the organisation of people, its requirements for space, the need for adaptability in building design, and some of the key design consequences.

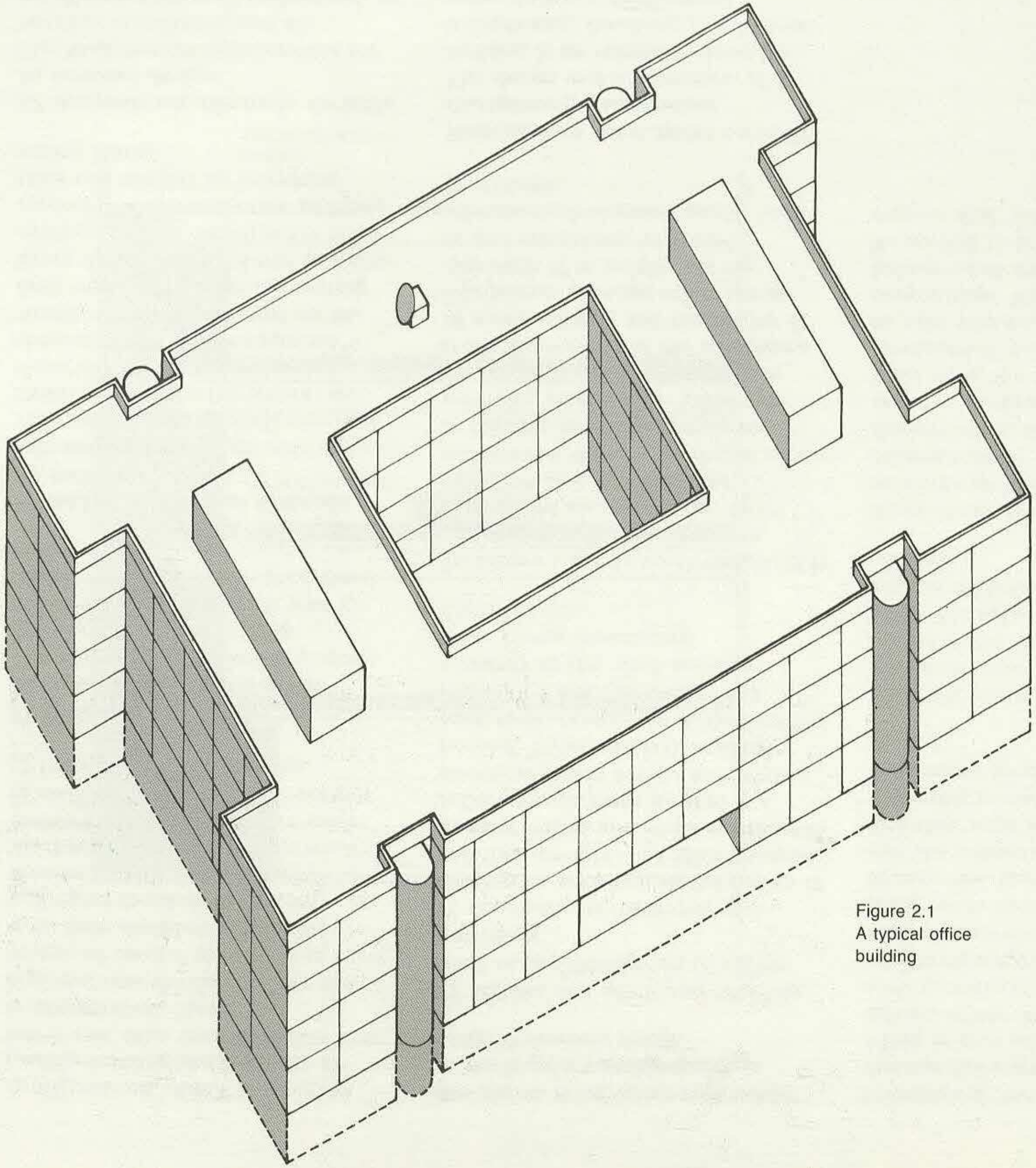


Figure 2.1
A typical office building

Contents

The most significant advances in IT are occurring at the desktop, within departments, and at the level of the mainframe computer suite.

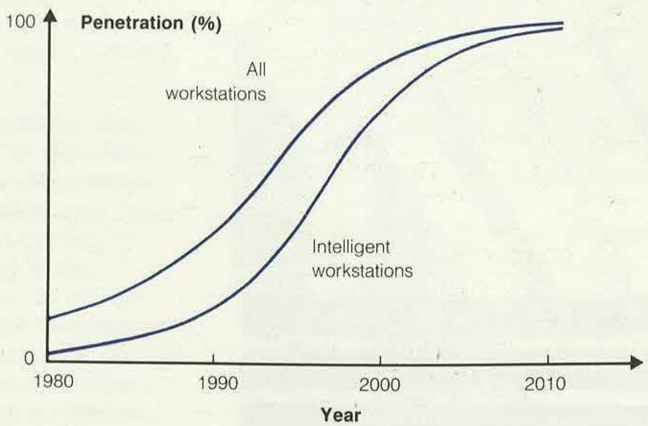
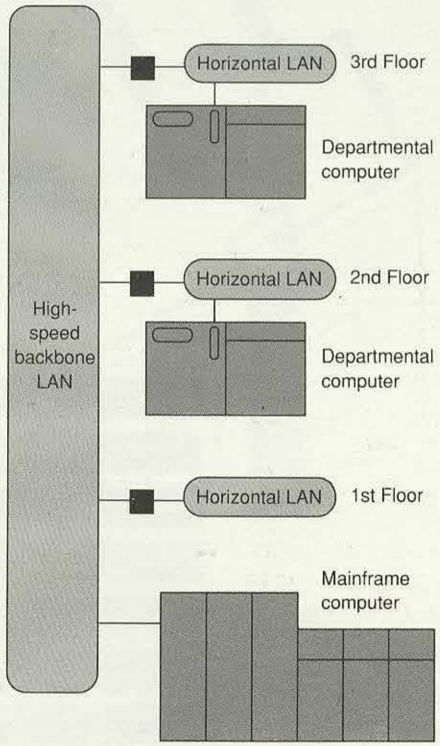


Figure 2.2
The increasing penetration of workstations
The penetration of computer terminals and networked personal computers is growing rapidly. In the future, dumb terminals will tend to be displaced by intelligent workstations.

Figure 2.3
A typical LAN configuration
A configuration with a local area network (LAN) on each floor and a high-speed backbone LAN is expected to become a common arrangement for office building data networks.



The desktop
The most obvious change that has occurred within offices in recent years is the proliferation of the desktop personal computer.

The personal computer has its own data processing and data storage capability so that, given appropriate software, it can be used for a wide variety of tasks such as word processing, financial analysis, accounting, and graphic design. Recent technical developments have focused on ease of use. The next generation of personal computers will be able to process more information much faster.

The penetration of personal computers is rising rapidly from one in three or four office workers at the end of the 1980s, to one per desk in the mid-1990s, as is shown in Figure 2.2. At present, personal computers are used mainly by professional staff. However, they will replace the conventional computer terminals now widely used for routine clerical functions. In order to support the growing number of these more powerful workstations, it will be necessary for office buildings to provide more electrical power, more cooling facilities, and better lighting. In Chapter 5, we provide an estimate of the level of electrical power supply and cooling required for IT in offices.

The department
The power of the personal computer and its widespread deployment has led its users to look for ways of sharing information within a department, and for linking to the organisation's central computers. Local area networks (LANs) have been developed to meet this demand.

The first LANs required special cables installed between desks in a linear or ring configuration. Now, however, products are available that allow each desk to be directly wired to a wiring closet. In the wiring closet, cable patching facilities and small electronic units connect the simple radial wiring to form the necessary LAN configuration.

This structured type of data cabling may be used for a mixture of conventional computer terminals and workstations with LAN connections, eliminating the need continually to replace the data cables in office buildings. The significance of this development is that data cables can now be considered a part of the building rather than part of the computer system.

Data cables suitable for LANs and the associated cable patching facilities and electronics take up much more space than before. Wiring closets need to be larger and these closets need a small amount of electrical power and cooling. In Chapters 6 and 7, we give guidelines for the design and sizing of these closets.

Optical-fibre data cables provide high data transmission rates and are immune to electrical interference. They will often be used in the data communications backbone between central computer rooms and wiring closets. However, fibre cables will not replace copper cables between the wiring closet and the desk for some time. There are two reasons for this. First, the majority of optical-to-electrical signal convertors needed at each desk are relatively expensive. Second, the majority of optical-fibre cables and connectors are not yet sufficiently rugged for use between the floor box and the desk.

Central computer suites
Despite the growth in the use of personal computers, central computers will continue to be an essential part of business operations.

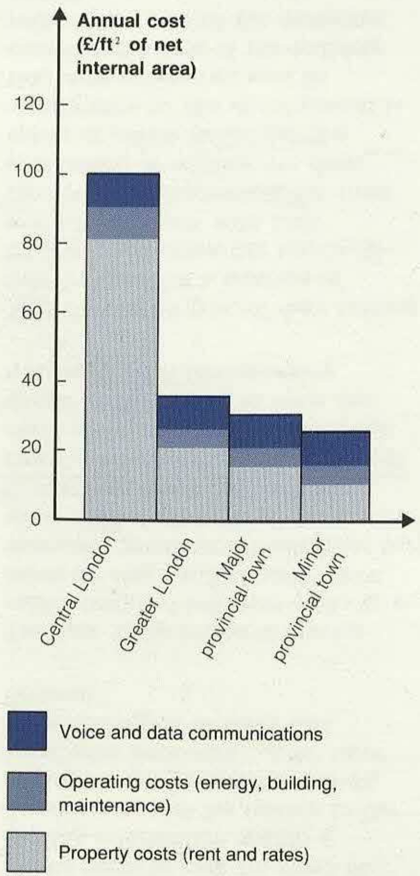
Many organisations are seeing a growth in demand for central processing power and data storage of 40 per cent or more a year. The manufacturers of large central mainframe computers are achieving rapid improvements in processing power and storage capacity per square metre of floor space and per kilowatt of electrical power required. Despite these improvements, many businesses find themselves continually expanding their central computer suites, and building additional facilities.

To avoid paying high rents and to allow for easier expansion, mainframe computer suites are often located out of town. Telecommunication links have adequate capacity and are cheap enough to make this remote operation economically viable. In the future, however, this convenient arrangement will be upset by the introduction of electronic document image technology.

Electronic images of documents are set to replace paper. However, an A4 sized image needs 1,000,000 bits of information to display it on a screen with acceptable resolution. That compares with 16,000 bits for a full screen of text. It is unlikely that telecommunications links will be fast enough or inexpensive enough for organisations to store document images at a remote site, when they have to be accessible virtually instantaneously. So businesses will need to have at least some of their central computing facilities on site. If the document image systems cannot be accommodated on site, space will need to be found within a kilometre or two so that direct wideband communication links can be provided economically.

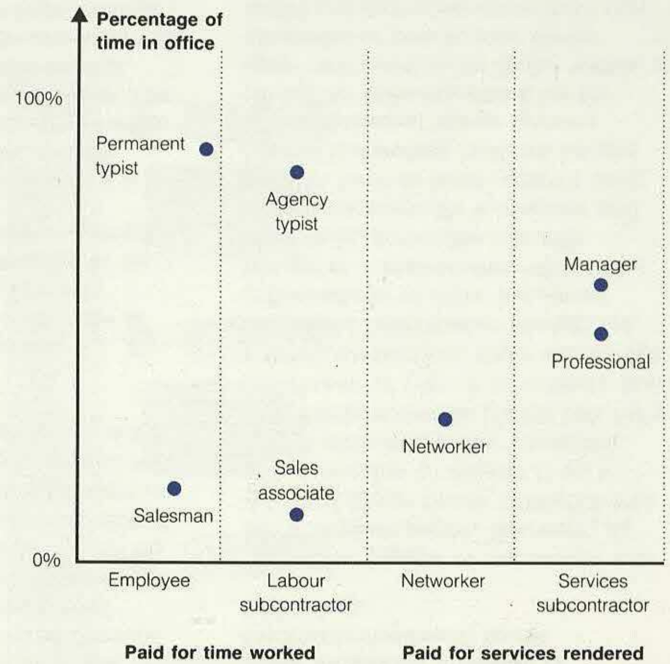
Information technology has already changed the way in which organisations are structured. These changes will certainly continue. They are likely to alter the role of the office building over the next 20 years, increasing its significance as a meeting place and reducing its primary role of providing accommodation for office workers and their desks.

Figure 2.4
A breakdown of office costs in four locations
Communications costs are relatively independent of location. They become an important part of overall costs outside central London



(Source: Bernard Williams)

Figure 2.5
Changes in pattern of employment
Over time, a reduction in the time staff spend in offices will be accompanied by moves away from standard employment



Current situation
Traditionally, British companies and public bodies were organised around such familiar principles as full-time employment, hierarchy, attendance at office buildings, and standardisation of terms and conditions. Each of these is now under pressure.

Flexible employment
The last decade has seen substantial increases in the number of part-time rather than full-time workers. Although reducing the employer's costs has been a major driving force, the trend has provided work opportunities for people, mainly women, unable to accept full-time employment. There has also been an increase in the use of consultants and subcontractors. As the long-predicted shortage of skilled staff becomes more apparent, employers will be obliged to do more to meet the needs of their workers for flexibility. As a consequence, employers will increasingly find themselves with a variety of employment patterns, even if this was not their intention.

Homework
Employment has required attendance at a place of work, a factory, or an office, both because the materials and tools were there, and because the work needed to be supervised. (Of course, people attend offices to work for a variety reasons, of which social contact is not the least.) The advance of IT means that the 'material' for most office work — information — can be transmitted electronically, although only with the introduction of digital networks and document image processing will this become really convenient. The tools of office work are increasingly a telephone and a workstation, both of which can be installed at home. Supervising work done at home raises some difficulties but, in many office jobs, there is little moment-to-moment supervision anyway — and the telephone and workstation can be used to share and resolve problems.

The advantage to the employer of encouraging people to work at home is that substantial savings are possible. The advantages to employees are less clear, however. They lose social contact, which is an important motivator. Early experience suggests that work from home is attractive only to a minority of staff.

When staff work at home, they will tend to be paid for results rather than for effort. (This will, of course, require managers to decide what results are required and what standards of work are acceptable.) This relationship is at least as close to customer-contractor as it is to manager-employee, and it will tend to evolve towards the former. Staff who do not work at home will be affected, because the habits of setting and demanding clear objectives are likely to prove contagious. As the ties of employment are replaced by the links of contracting, the organisation will come to seem more like a network and less like a pyramid.

The organisation of the future
The organisation of the future is likely to comprise three parts, which may be clearly differentiated:

- A core group, including senior management and their immediate support staff.
- Trusted subcontractors, based at their homes or their own offices, but treated as part of the organisation for many purposes. They may be paid for the time worked or for the work done.
- Subcontractors, whose relationship is more distant.

The role of the building
The traditional role of the office building is to accommodate people and their (largely paper) files. It has also provided a meeting place for customers, suppliers, and consultants, as well as other staff. To these traditional roles, developments in technology have added the need to accommodate a wide variety of office equipment.

Information technology is changing the role of the office building. On the one hand, computers are increasingly automating the more routine business functions, reducing the need for clerks, typists, and data entry staff. On the other, computers make it possible for an increasing proportion of the remaining staff to work away from the office.

These changes have implications for the location and aesthetics of a building. There are other implications too. For instance, there is likely to be an increased emphasis on travel outside the usual rush hours. Furthermore, buildings will need to provide a higher proportion of meeting rooms, and a lower proportion of ordinary office space. At least some of the office space will need to be allocated to staff on a temporary rather than a permanent basis.

References
Judkins, Philip; West, David, & Drew, John. *Networking in organisations: the Rank Xerox experiment*. Aldershot: Gower, 1985.

Toffler, Alvin. *The third wave*. London: William Collins & Co Ltd, 1980.

Long-term Perspectives Group. *IT futures ... IT can work*. London: National Economic Development Group, 1987.

Usable space is the space in which an occupant can install staff, machines, and furniture. In practice, the usable space must also include some space, known as secondary circulation, for people to move between desks.

Figure 2.6
Use of space as a proportion of the gross internal area

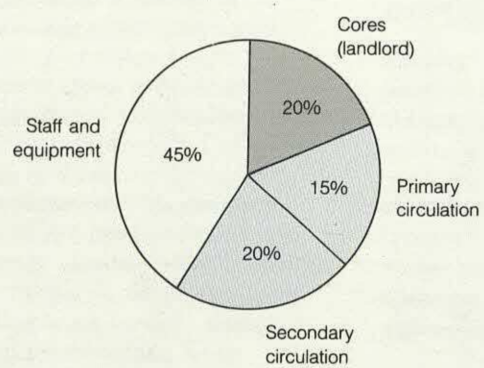
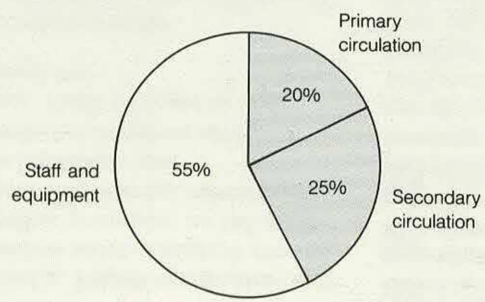


Figure 2.7
Use of space as a proportion of the net lettable area



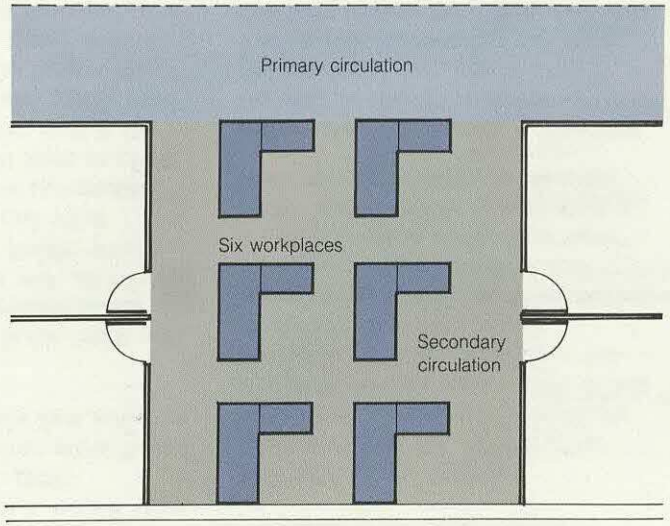


Figure 2.8
A typical office area
The space required for primary and secondary circulation cannot be used for desks and equipment.

Figure 2.9 Typical space allocation

Use of space	**Proportion of NLA (%)**
Meeting rooms	10
Photocopying	2
Stationery	2
Mail rooms	2
Telex/fax/PABX operations	4
Computer hardware	4
Computer printing, etc	2
Computer stationery	2
Computer operations	2
Total	30

In most buildings, usable space amounts to about 65 per cent of the gross area. The remainder is unavailable space, which cannot be freely used. It includes lifts, stairs, landings, corridors, plant rooms, toilets, and service cores. Where the occupier is not the owner, the unavailable space is divided between the landlord and the tenant, as shown in Figures 2.6 and 2.7. The landlord's space, on which the tenant is not charged rent, usually includes plant rooms, service cores, and toilets, but not the primary circulation on each floor.

Most buildings need to accommodate areas such as meeting rooms, dining rooms, filing areas, and so forth, which are not permanently occupied by people. Figure 2.9 shows a typical space allocation for these functions.

The effects of technology

During the last 20 years, there has been a continuing increase in the amount of space allocated to each office worker. This increase seems to be due to the shift from clerical to professional work rather than the use of technology. More recently, IT equipment has entered the workplace in increasing quantities. Most substantial organisations have seen the number of computer terminals and PCs rise from one per 100 staff to 70 or more per 100 staff over the past 10 years. In many cases, these terminals and PCs have been accompanied by printers, modems, disc drives, stationery, and manuals, requiring additional desktop space to accommodate them. So far, the IT equipment has done little to displace either paper or previous equipment, so a significant demand for extra space has been created.

In the future, the proportion of people with workstations will continue to increase, reaching 100 per cent within five years in most organisations. Some ancillary items, such as modems, will be absorbed into the workstation. In addition, fewer people will have their own printers and disc drives. They will share devices of larger size and higher performance over high-speed LANs. The desk space required by each workstation will therefore get smaller. In the long term, optical discs and more powerful intelligent workstations will make it feasible for computer systems to replace paper in many offices. The space required for paper filing could therefore also decline.

The implications for building design

The automation of routine work and increased flexibility in patterns of employment will increase the requirement for meeting rooms and other 'social' areas at the expense of ordinary offices. People will spend less time in their 'normal' offices, although they may spend time in other offices or neighbourhood work centres instead. Increasingly, these staff will be expected to share space when they are present.

In selecting an office building, and more especially when specifying or designing a new building, the possibilities of a significant change of use should be considered. Changes in the pattern of use may require the building to be let to multiple tenants, or to be sub-let by the main tenant.

In planning power supply, cooling, and cabling, the building design team should consider the highest staff density that is feasible. The relevant Act requires each employee to have not less than 400 ft^3 (11.5 m^3) of air space. With a ceiling of normal height, this implies an area of 45 ft^2 (4 m^2). In practice, this density is used only in very exceptional circumstances or small areas. An allocation of as little as 5 m^2 of usable space per person is possible, although not usual. This corresponds to about 8 m^2 of lettable space, when due allowance has been made for circulation space and other areas in which people cannot be located.

When allowance is made for areas that are not continuously occupied and for spare space to facilitate moves, the space per person is likely to be raised to a minimum of 10 m^2 for a whole building. Some buildings outside cities may provide as much as 20 m^2.

Reference

Debenham, Tewson and Chinnocks Holdings plc. *Office needs: the occupier's view.* London: 1988.

Although the main trends in the deployment of IT are clear and common to all organisations, there are likely to be significant differences between organisations in the sizes of their computer systems, and in the balance between centralised and decentralised computing. To the designer, this means providing sufficient space to accommodate both central and local computers and adequate local networks, and to install sufficient capacity to meet initial needs for power and cooling services (say, for the first five years), plus sufficient infrastructural capacity to meet the highest rates of growth that seem plausible.

Figure 2.10
Lifetime costs for buildings with various levels of adaptability and initial provision

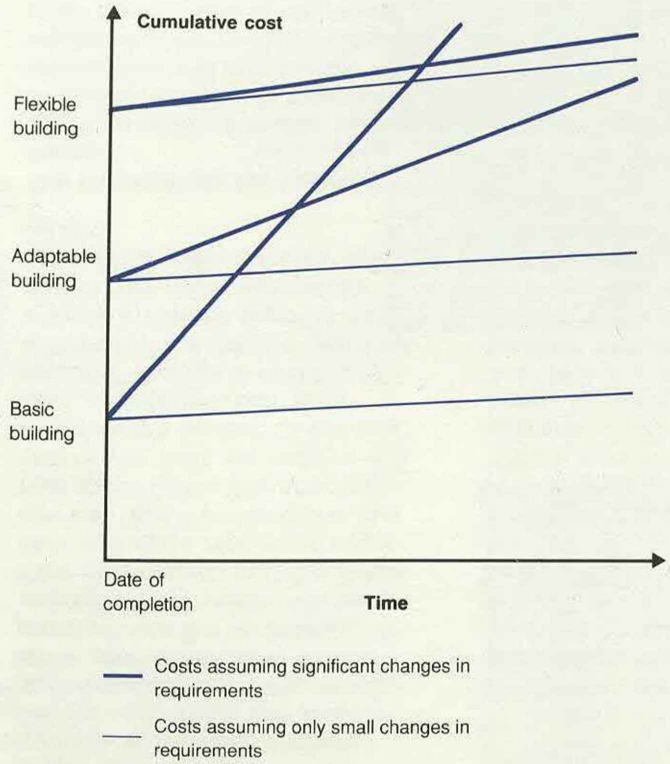


Figure 2.11 The design and size of spaces should be adaptable

Duct space for additional power cables, power control panels, air movement, venting of air from generators, and so on, must be dedicated during construction although it need not be used initially for these purposes.

Plant room space for additional uninterruptible power supplies (UPS), back-up generators, and switchgear. The space need not be used as plant rooms initially. It may, for instance, be an area of car park adjacent to the plant rooms.

Space on roof or adjacent land for additional cooling towers.

Some *building space* should be available for use as a computer suite.

Some office space should be designed as *heavily serviced zones* in which equipment rooms can be constructed.

The problem
Because buildings are designed to last for decades rather than years, they will have to meet many changing requirements over their lives. In particular, many will need much higher levels of electrical power in the future than when built. Providing at the outset all the facilities that could ever be required, at the highest conceivable levels, is obviously uneconomic. So design teams may be tempted to consider only the immediately foreseeable requirements.

Even foreseeing the occupants' needs as far as seven years ahead still covers only a small fraction of the building's useful life. Changes beyond that will create needs that the building will be unable to support without additions to the fabric, or replacement of services, or both. The alternative is to demolish the building. Many 20-year-old buildings are now being demolished for these reasons. The cumulative costs of both basic and highly flexible buildings are shown in Figure 2.10.

The solution
The solution to this problem is for the design team to distinguish clearly between the initial requirements and the capability that should be built into the infrastructure to enable it to meet future requirements. Initial requirements may be defined as those needed in the first few years of the building's life. These requirements will vary, both between industry sectors and according to the policies of the organisation using the building. The potential long-term requirements can be defined by assessing the kinds of demands that the future may bring. (In this handbook, we have done so for the limited, but important, range of issues affected by IT.) The design team should not attempt to design a building that meets them all, but rather one that can be adapted to meet them all. This adaptability is expressed through the design and sizing of spaces and the services infrastructure, as shown in Figure 2.11.

In Chapter 4, we deal with those spaces that are specific to IT, while in Chapter 5, we discuss the highest foreseeable levels of demand for IT power and cooling services. The demand levels should be combined with corresponding figures for non-IT components to produce total numbers, and thus to estimate the required sizes of plant rooms and service ducts.

The second element is the services infrastructure. The main fixed elements, such as chilled water pipes, main electrical cables, and vertical busbars should be sized to meet the highest foreseeable requirements, and should extend throughout the building. Although this approach provides considerable adaptability, the costs are likely to be acceptable because such equipment as standby generators, uninterruptible power supplies (UPS), and heating, ventilation, and air conditioning (HVAC) plant need to be provided only to meet immediately foreseeable demand.

A central theme in this guide is the importance of considering the IT requirements at an early stage in the design of a building. IT systems require space, power, cooling facilities, and fire detection and prevention equipment. In most cases, there will be both central IT facilities and distributed departmental facilities, as well as cabling between them and throughout the building. In this section, we describe the project-management organisation needed to ensure that the IT requirements are considered in the design of a typical building project.

Figure 2.12
Organisation of the project team — speculative development

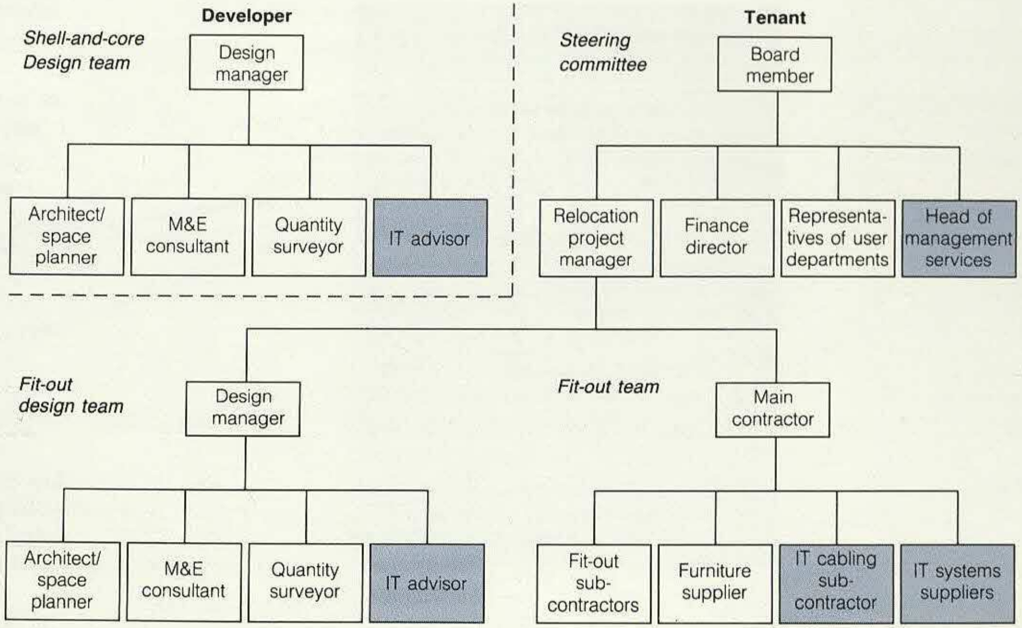
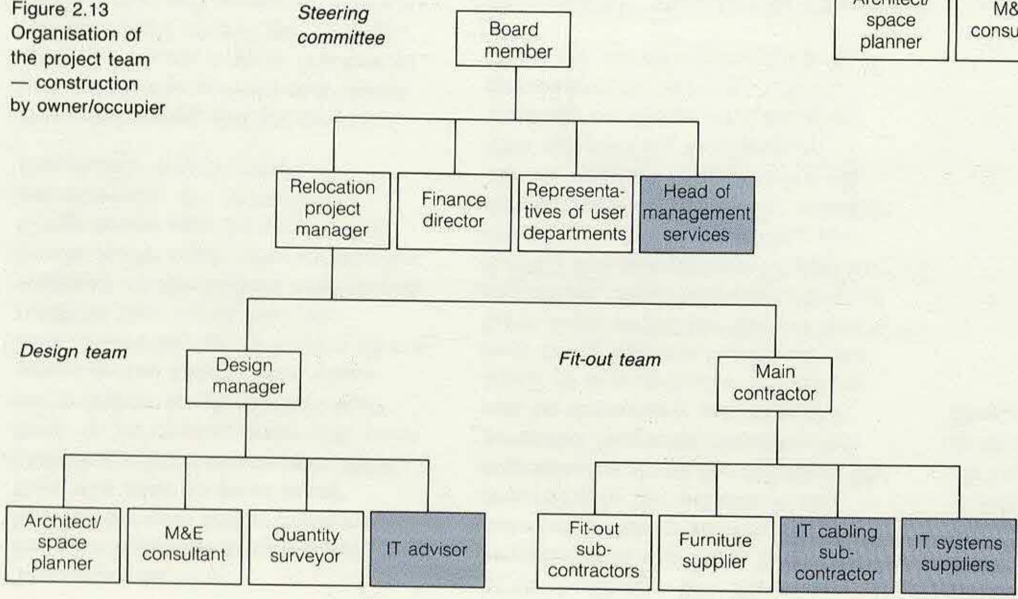


Figure 2.13
Organisation of the project team — construction by owner/occupier



There are two approaches to the construction of a new building. In a city centre, and especially in London, most new office buildings are speculative developments. The developer does not usually know who the tenant, or tenants, will be when the building is being designed. Often, in these cases, the developer completes only the basic structure of walls, roof, and floor slabs, and the central services such as power, HVAC, lifts, and building-management systems. The landlord's areas, such as toilets, lift lobbies, and reception areas, are often completed too. (This is termed the 'shell-and-core' stage.) The tenant, or several tenants if the building is to be a multiple occupancy, then completes the sub-let areas in a separate 'fit-out' stage. The fit-out usually includes access floors, ceilings, air-conditioning ducts, electrical distribution, and voice and data cabling. The other approach to building design and construction is the more straightforward one in which the owner-occupier commissions an architect to design and build an office to meet specific requirements.

In both cases, IT requirements must be considered in varying degrees of detail at each stage of the design and construction process. We have considered the speculative shell-and-core approach in this guide because it is the more complex of the two. The main difference between the speculative development and the owner-occupier development is that, in the latter case, there is usually only one design team. However, the type and timing of the IT requirements that must be fed into the design process are broadly similar.

Figure 2.12 shows the project-team organisation appropriate for a speculative shell-and-core project. The developer's design team takes responsibility for meeting the requirements of the developer's brief. The design team should include an architect, a mechanical and electrical (M&E) engineer responsible for the design of the extension of the building services from the landlord's provision in the core into the tenant's area, and a quantity surveyor.

The design team should also include an IT consultant capable of understanding the potential tenant's business and likely IT requirements.

Often, the tenant will have a steering committee that is responsible to the board for the fitting out and relocation project. This committee might be chaired by a board member, and include the relocation project manager, the finance director, a senior representative of each user department that will be moving into the building, and the head of management services. The main functions of this steering committee will be to appoint the project manager and the fit-out team, approve the design brief, agree on the budget, and take ultimate responsibility for the project.

Figure 2.13 shows the appropriate arrangements where the building is developed by an organisation for its own use. The functions are similar to those required in the first case, but a single design team is usually responsible for all aspects of the project.

The fitting out is usually awarded to a management contractor, who will subcontract most of the work — for example, the M&E work, furnishing, and the IT cabling. We have shown the IT cabling contractor as part of the fit-out team, although, on many projects, the reporting line for IT cabling contractors is unclear. In our view, the cabling contractor should report on-site to the management contractor. The management contractor should control all activities on-site during fit-out, including IT cabling, and should be able to call on the design team during fit-out to resolve any design queries that arise. The client's project manager may also wish to employ the members of the design team to inspect the works on-site and to issue completion certificates.

The design and construction of a building is a complex process involving many stages. In order to manage a building project successfully, it is essential to be aware of the critical design decisions that must be made, and of the timing of those decisions.

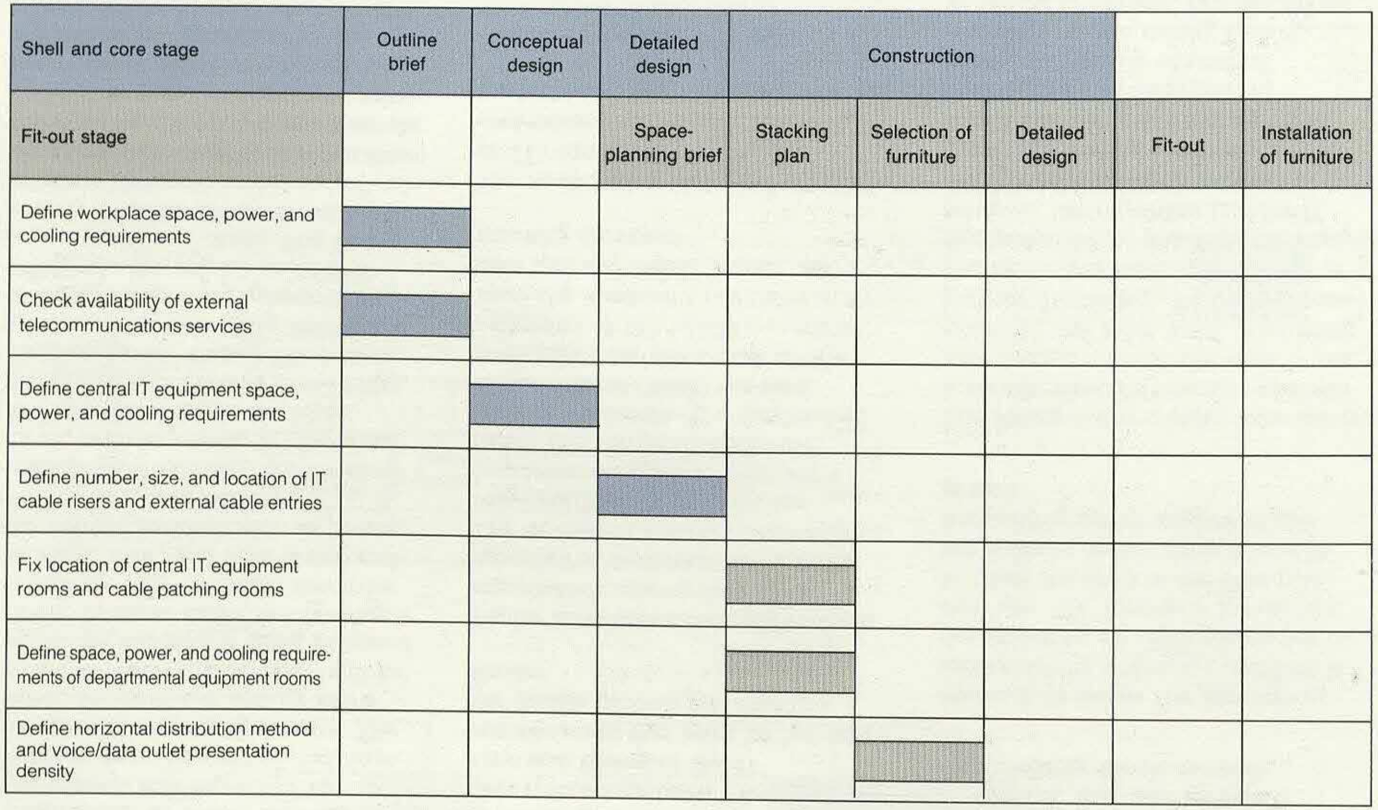


Figure 2.14
Timing of key IT decisions in relation to the overall development and fit-out programme

Figure 2.14 shows the main IT-related decisions and their timing. It shows the shell-and-core design and construction overlapping the fit-out stage. Three of the main IT parameters relate to the shell-and-core design and must therefore be addressed at an early stage:

- *Workplace space, power, and cooling requirements:* these will affect the size of the plant rooms, and must therefore be considered in the outline brief.
- *Space allowance for central IT equipment:* this space allowance implies a significant power and cooling load, which will again affect the size of the plant-room space, and must be agreed during the conceptual design stage.
- *The size, number, and location of the IT cable risers and external cable entries:* these affect the design of the building cores, and should therefore be fixed during the detailed design of the shell and core.

In addition, IT factors should be considered in deciding on the location of the building, as we explain in Chapter 3.

Before selecting a speculative building, or commencing the design of a commissioned building, the occupier must identify his space requirements. This space-planning brief should cover not only the requirements of the office area, but also all the central space requirements, including IT equipment rooms, and so on. This leads on to a stacking plan in which the organisation's space requirements are matched to the net lettable area available on each floor of the building. The stacking plan should identify the floor of the building on which the central IT facilities are to be located, and the amount of space required on other floors for cable patching rooms and any departmental equipment rooms.

The other major IT parameter in the fit-out design is the horizontal distribution method and the quantity or density of presentations needed. The whole design team must work together on this issue. The electrical, telephone, and data presentations must be coordinated and decisions made on the degree of flexibility to be achieved. The design could be flexible enough to accommodate any reasonable furniture layout, or it could rely on desks being fixed. Cables could be terminated below the floor, at floor level, or in the furniture.

In addition to the timing of the design decisions, it is important to plan the installation of the cabling and IT systems to fit in with the building works:

- Vertical voice/data cables should not be installed until cable patching rooms are finished, termination frames installed, and the complete route free from debris.
- Horizontal underfloor trays/trunking should be installed after the raised floor has been laid, but before it is finally levelled.
- Underfloor horizontal voice/data cables are best installed immediately after the small power, while the floor tiles are still up.
- Overhead voice/data cables should be installed before any false ceiling is installed.
- Reliable power supplies are essential for testing and commissioning computer and telecommunications systems. All electrical systems, including distribution switchgear, generators, and UPS equipment, must be completely tested and handed over before computer/telecommunication testing begins.
- If air-conditioning, fire detection, and fire prevention systems are provided, they must be fully tested and accepted before the computer/telecommunications equipment is commissioned. If the air-conditioning system is controlled by a building-management system (BMS), this must also have been tested and accepted.

Designing a building involves a series of choices to provide a cost-effective solution to the requirements defined in the design briefs to the architects, engineers, and space planners. Although we have stressed the need to provide flexibility and adaptability, these provisions will inevitably be limited, and will not necessarily exceed those specified in the briefs. It is important that both the managers responsible for the facilities and those responsible for the staff and equipment be aware of these design limits.

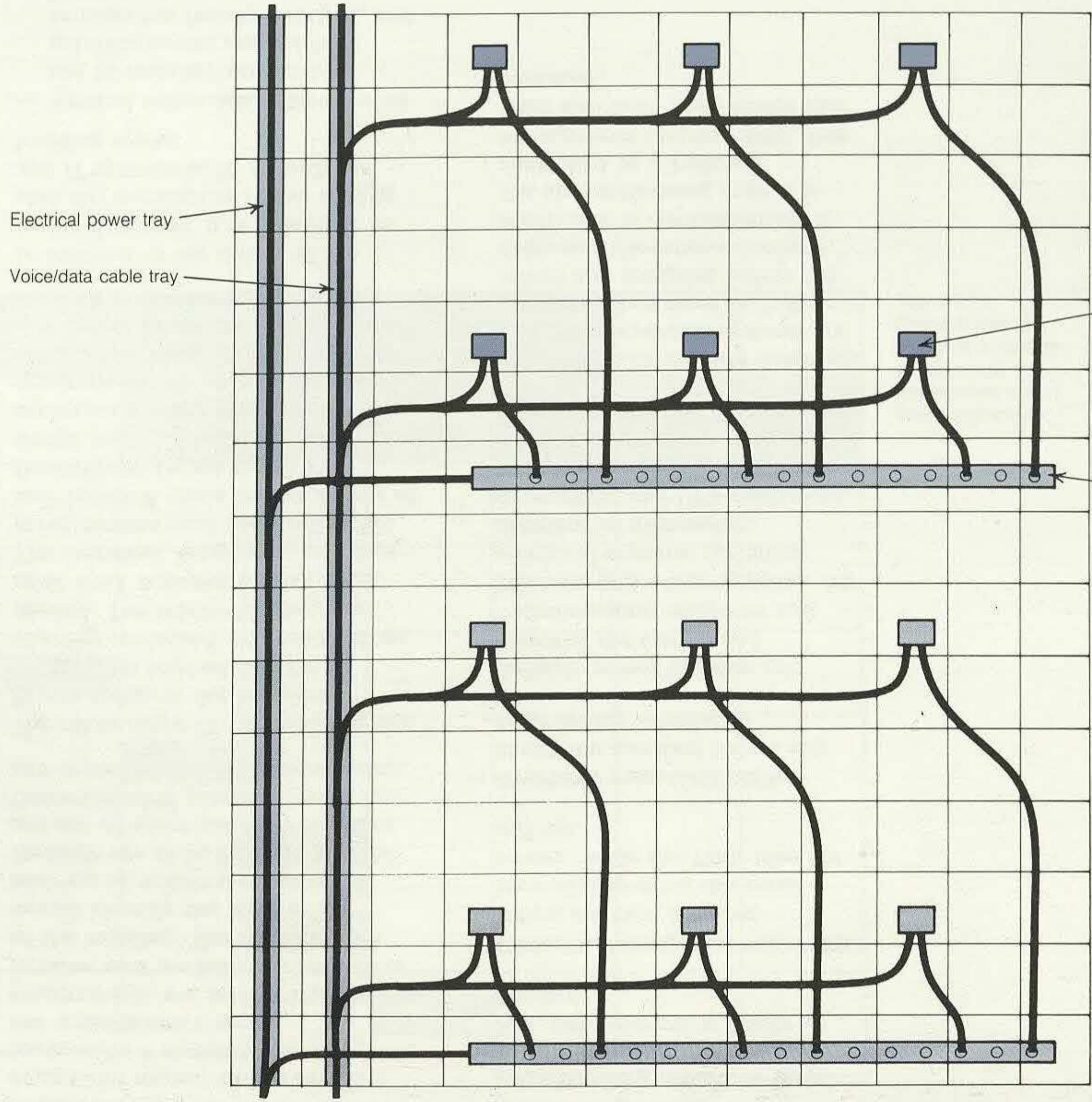


Figure 2.15
A typical underfloor cable layout
CAD drawings can show cable routes in relation to the floor tile grid.

In the past, building designers were unable to foresee the revolution in the use of IT which has made many office buildings obsolete. Much of today's practice is significantly better. In some cases, the design brief does specify required levels of adaptability, while in others, the design teams have built them in as a matter of course.

Once a building or refurbishment has been commissioned and handed over to the occupants, it passes out of the control of the design teams. There is therefore a need for the occupant to stay within the design limits of the building. In turn, this requires that the occupant knows what they are. Both the initial designs and their rationale must be passed to the occupant's facilities-management staff. This may require some training of those concerned, to enable them to understand both the arguments involved in the rationale, and the nature and implications of the design decisions that have been made.

Like any other complex construction, every new building should be accompanied by an 'owner's manual' explaining, in terms intelligible to facilities-management staff, the design principles and expected performance of the building, and the maintenance and operating disciplines required to ensure that the expected performance is achieved. This manual should clearly state the limitations of the design, and may include examples of changes of use that should be avoided.

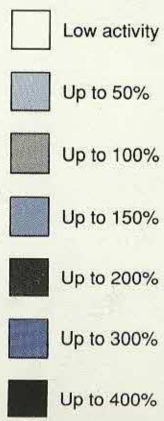
GUIDELINES

The developer should provide every building with an 'owner's manual', suitable for use by the occupant's facilities-management staff. Failing that, the developer's brief, designs, engineering reports, and so on, should be passed to the owner, who should keep them safely. They should be available to facilities-management staff for reference.

To both the developer and the occupant, location is a critical issue. Location has the largest single influence on the value of a building, and thus on the cost of occupation. City sites are generally more valuable than rural sites and, within cities, central sites are more valuable than others. These relative values are, in part, a reflection of fashion. They are also indicative of the proximity of sites to other businesses, and to facilities such as shops, parks, and railway stations. Amongst the list of facilities, two that are growing rapidly in importance are telecommunications services and a clean radio environment.

Figure 3.1
Industrial land values as a percentage of the average for England and Wales, 1977
There are wide variations in land values.

Figure 3.2
Industrial land values as a percentage of the average for England and Wales, 1988
Land values have risen rapidly in the South-East and along the M4/M5 corridor.



Contents

The physical location of a building has always been an important issue for its occupants and developers. Many factors influence the choice of location — notably, the cost of land, and the proximity of customers and suppliers.

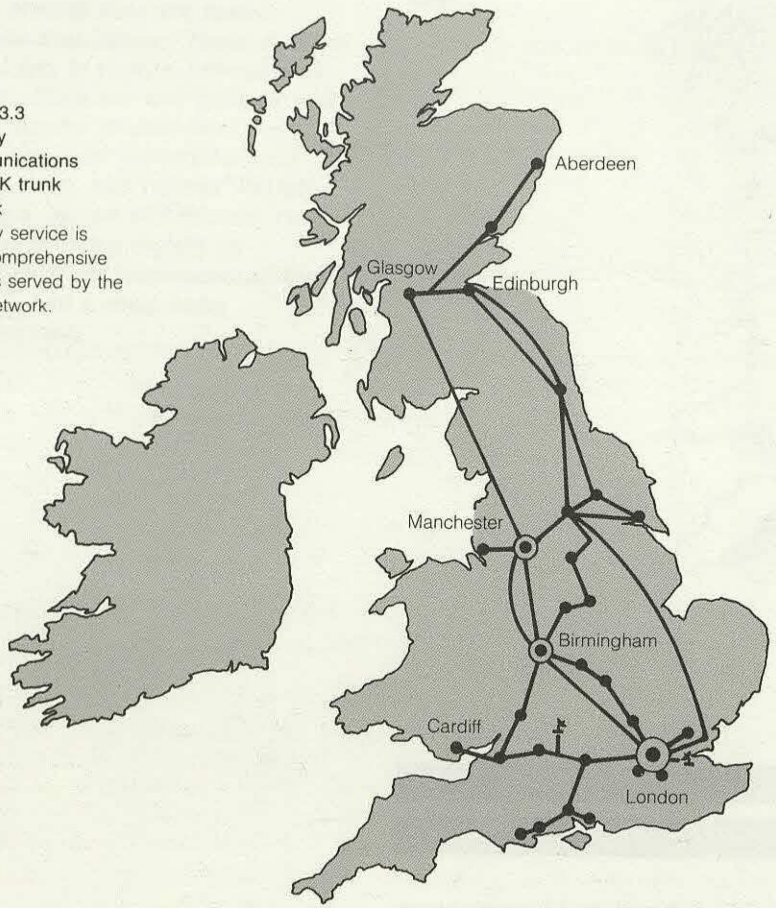
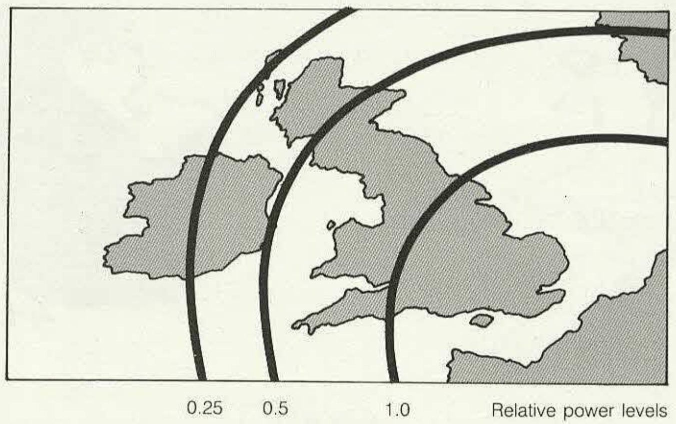


Figure 3.3
Mercury Communications Ltd's UK trunk network
Mercury service is most comprehensive in areas served by the trunk network.

Figure 3.4
Satellite coverage
The power of the signal available from the TELECOM 1 communications satellite varies across the United Kingdom. Within the shaded area in the south-east of the United Kingdom, an antenna of 3.5 m is sufficient. Larger antennae are needed in other areas.



As discussed in Chapter 2, organisations are increasingly dependent on their computers and other IT systems, and on telecommunications in particular. It is therefore important that the suppliers of such systems should be able to provide the necessary levels of engineering and other support. It should not be assumed that every supplier will be able to provide a high-quality and responsive service at every place within the United Kingdom.

Although telecommunications service was broadly uniform throughout the country in the past, this is no longer true. The services of Mercury Communications Ltd (MCL) are, as shown in Figure 3.3, fully available only in some areas. The more advanced of British Telecom's (BT) services are also geographically restricted at present, because access to BT's integrated services digital network (ISDN) is available only via System X and System Y digital local exchanges. Service from these exchanges was available to 40 per cent of business lines in March 1989, and will be available to 75 per cent by March 1992.

Access to the services of other providers, such as local cable companies, also varies from place to place. As Figure 3.4 illustrates, the use of communications satellites requires larger antennae in some parts of the country than in others.

This geographical variation is likely to continue; as today's services become more widely available, so new services will appear, initially in limited areas.

In addition, the provision of certain facilities may be difficult in some areas. For instance:

- The very large private-circuit networks needed by money-brokers cannot be provided economically outside London's Moorgate exchange area.
- The presence of rivers and motorways may make the provision of alternative routes from the site to the main network difficult.

Even where no very unusual facilities are needed, the provision of telecommunications services may take many months. A delay of three years has been known for a major development. The developer should therefore start discussions with telecommunications providers at the earliest possible stage, preferably before becoming committed to the site. Such discussions should include the following topics:

- Diversity of routeing.
- Multiple service accesses to the site.
- Range of services available.
- Timing of new services.
- Support arrangements.

GUIDELINES

The availability of telecommunications services and of maintenance support for all IT and office equipment should be considered in deciding on the location of a new building, or in selecting a building for occupation.

Discussions should be held with BT and, where appropriate, other service providers, as early as possible to establish their willingness, or even ability, to provide the required telecommunications facilities in a timely manner.

Modern computers operate at high frequencies and emit small amounts of radio-frequency radiation. Powerful sources of electromagnetic radiation, such as radar transmitters, are likely to interfere with nearby computers, causing them to malfunction. Radar systems are found near seaports and airports and, occasionally, in less obvious places. Less powerful sources, and sources of lower-frequency waves (such as power lines), will not generally cause interference unless they are very close to the computer. The radiation emitted by computers carries information about the processes within them, and might, in principle, be received and decoded illegitimately.

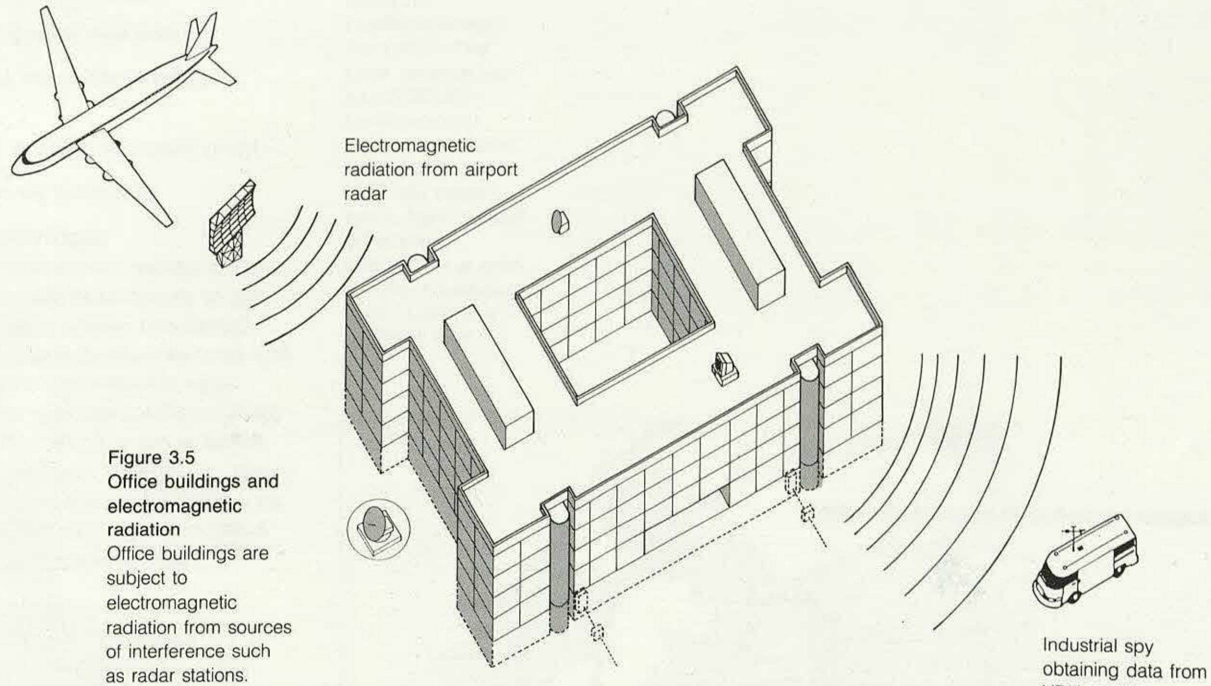


Figure 3.5
Office buildings and electromagnetic radiation
Office buildings are subject to electromagnetic radiation from sources of interference such as radar stations. Equipment within an office also emits radiation, which can be intercepted by industrial spies outside.

The development of faster computers is likely to result in machines that are more sensitive to interference than those available today. Powerful sources of radio waves will therefore be an increasing threat to computer installations, which should not be sited near them if possible. If a computer must be operated in the presence of such sources, it will be necessary to build a screen between the source and the computer, or perhaps, a complete electromagnetic screen around the computer.

Experience shows that the signals emitted by mainframe computers are too complex to be decoded without resources equal to those of a major national security agency. This is not, however, true of the signals emitted by visual display units. They can be captured at distances of a few hundred metres with easily available electronic equipment, and used to reconstruct the display. There is also evidence that radiation from ISDN basic-rate connections can be detected and decoded easily. On sites with many visual display units, a 'radiation eavesdropper' is likely to have difficulty distinguishing the important business information from the rest. However, it is possible that eavesdroppers will be able to find technical solutions to this problem.

One way of circumventing this problem is the construction of a complete electrical screen around the whole building. A less expensive alternative is to use displays, such as those based on liquid crystals, which radiate less energy. Neither of these steps could normally be justified by a civilian commercial organisation, however.

Reference

Recommendations for the accommodation and operating environment of computer equipment. IST 22. (Draft).) Milton Keynes: BSI Committee, 1989.

GUIDELINES

Installing a computer in line of sight to sources of radio-frequency interference, such as radar transmitters and TV stations, should be avoided if possible.

If a computer must be installed near a radio or radar installation or an industrial or medical site, an electromagnetic survey should be conducted by an appropriate testing service to determine the degree of risk. The field strength should not exceed 1V/m.

When drawing up a brief for a building, it is essential to specify the levels of flexibility and adaptability that the design team should achieve. It is possible to provide a great deal of flexibility and adaptability by the definition, sizing, and connectivity of the various spaces that comprise the building.

The ability to accommodate IT systems depends on the existence and sizes of the IT service spaces — that is, computer suites, risers, frame rooms, telecommunications closets, and local computer rooms. It also depends upon the existence of sufficient and appropriate plant-room space for the power supply and air-conditioning equipment that will be required. (Service levels are dealt with in Chapter 5).

As discussed in Chapter 2, IT will have a wide-ranging impact on the role of a building over its life. Every part of the building has to be adaptable to accommodate change.

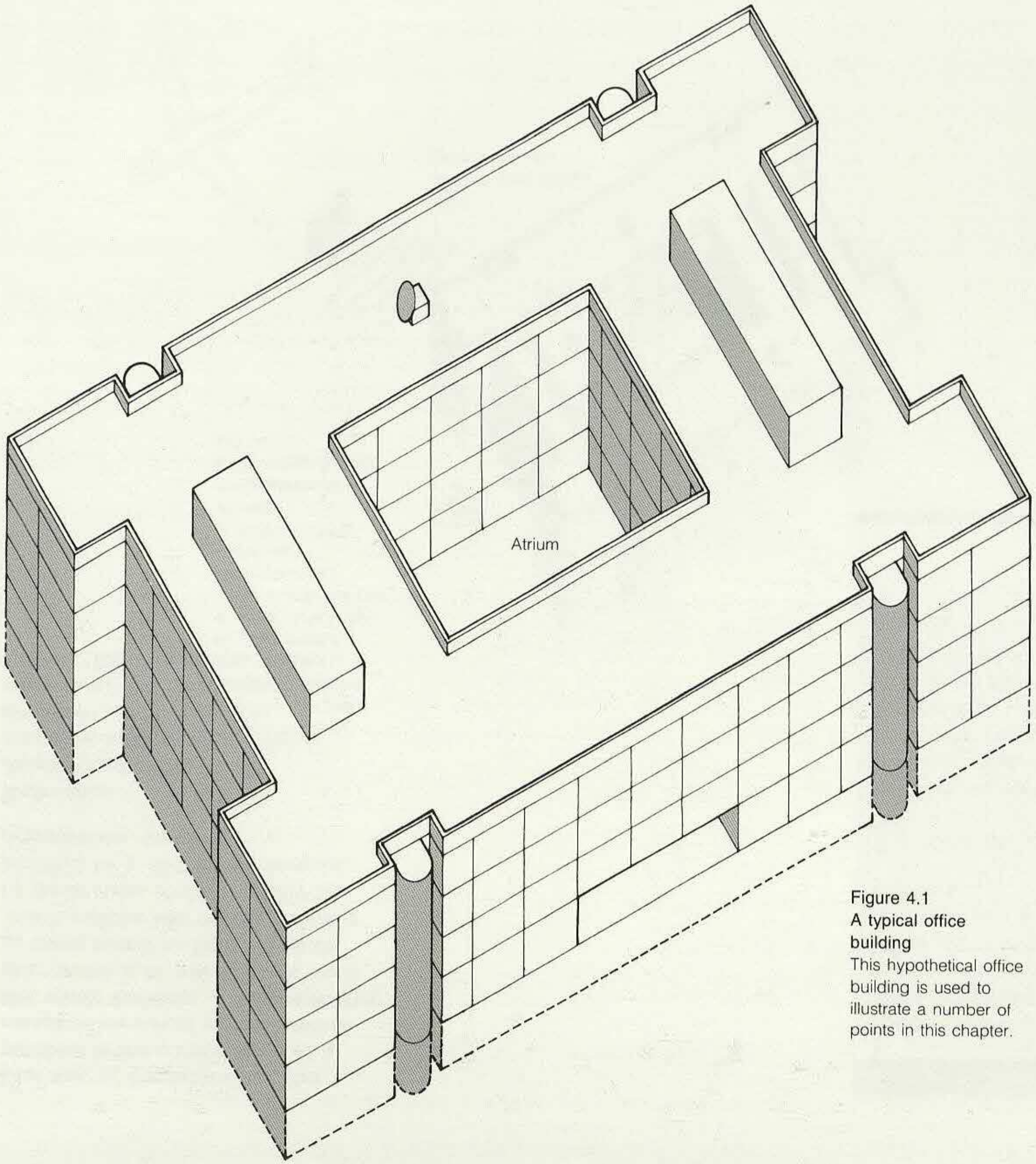


Figure 4.1
A typical office building
This hypothetical office building is used to illustrate a number of points in this chapter.

Contents

BUTLER COX

The 'depth' of an area of office floor is its distance from the nearest window. This is significant because only positions fairly near to windows benefit from natural light and a sense of outside space. The windows may look onto an internal atrium rather than to the outside, and need not have an attractive view.

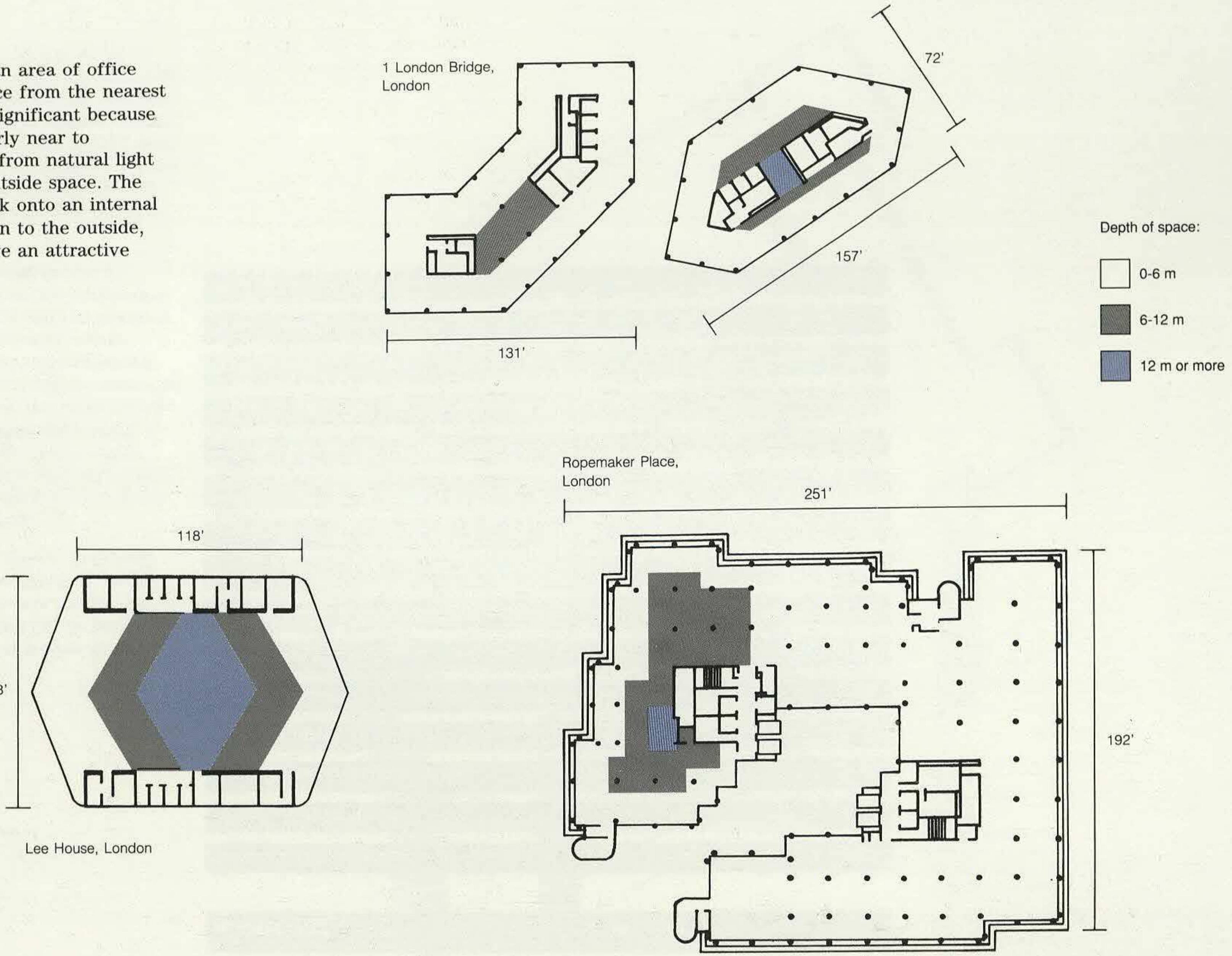


Figure 4.2
Floor plans of three office buildings
These three examples show typical variations in the proportions of deep space available in actual buildings.

It is convenient to distinguish three depths of space:

A Space within 6 m of a window, which is good for cellular offices and can also be used for open plan.

B Space within 6 to 12 m of a window, which is unsuitable for cellular offices and acceptable, although less satisfactory, for open plan.

C Space more than 12 m from a window, which is unsuitable for office accommodation, although it may be used for meeting rooms and machine rooms. It is convenient for machine and storage rooms because environmental control is easier.

Current situation
Traditionally, Depth A space has been preferred for offices because it provides natural illumination (although often not enough) and an open outlook. Open-plan offices can be arranged more easily if there is a mixture of space of Depths A and B (or even C). Deregulation and acquisitions by traders in the financial markets have created a demand for very large, open-plan trading floors. Buildings with a relatively high proportion of Depth C space are desirable for these floors.

Future requirements
Many factors influence the style of office organisation, including technology, staff preferences, the state of the labour market, lighting efficiency, and legislation. Most of these may change in unforeseeable ways, and designers therefore need to provide a high degree of adaptability.

Both long-term occupants and owners will benefit from a high degree of adaptability in the buildings they commission and use. Clearly, occupants will benefit if the building can be adapted to meet their changing needs. Owners will benefit because an adaptable building will retain its value for longer. However, because adaptability costs money, occupants may need to consider the lifetime costs of making a building highly adaptable. They may find it advantageous to lease a less adaptable building at a lower rent and accept higher adaptation costs later in the life of the building.

In the financial sector, the requirements for large, open-plan office areas are unlikely to grow significantly. In fact, they are likely to decline in the longer term as information on the state of the market and on the positions taken by other dealers becomes available online.

Nor will other sectors follow the pattern set by the financial sector. Research shows that productivity on computer-intensive tasks such as programming and graphic design is higher when people are given individual or small team offices. As these tasks become more common, and the benefits better understood, we expect to see moves away from open-plan towards smaller offices. Buildings should therefore be planned with a high proportion of shallow space to allow for the possibility of a high proportion of cellular offices in the future.

Implications for information systems
Open-plan areas generally have higher occupation densities, and thus higher servicing requirements, than cellular offices. They are also subject to more changes in furniture layout, and often require (as discussed on page 6.03) a different approach to the provision of services. Because of these implications, IT designers need to know which areas will always be used for cellular offices and which might become open-plan.

GUIDELINES

The design team should discuss the planned use of space with the IT specialist.

Office buildings should be planned to facilitate division into separate parts for sub-letting.

A highly serviced zone is a part of the usable office space that is either provided with much higher-than-average levels of building services, or in which those higher levels can easily be achieved.

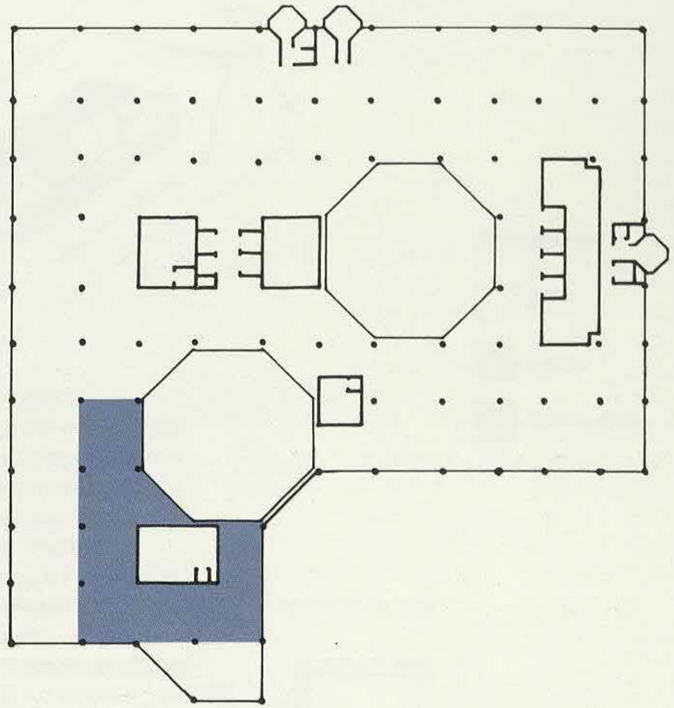


Figure 4.3
Broadgate 2, London, showing the highly serviced zones
The extent of highly serviced zones should be defined for future use.

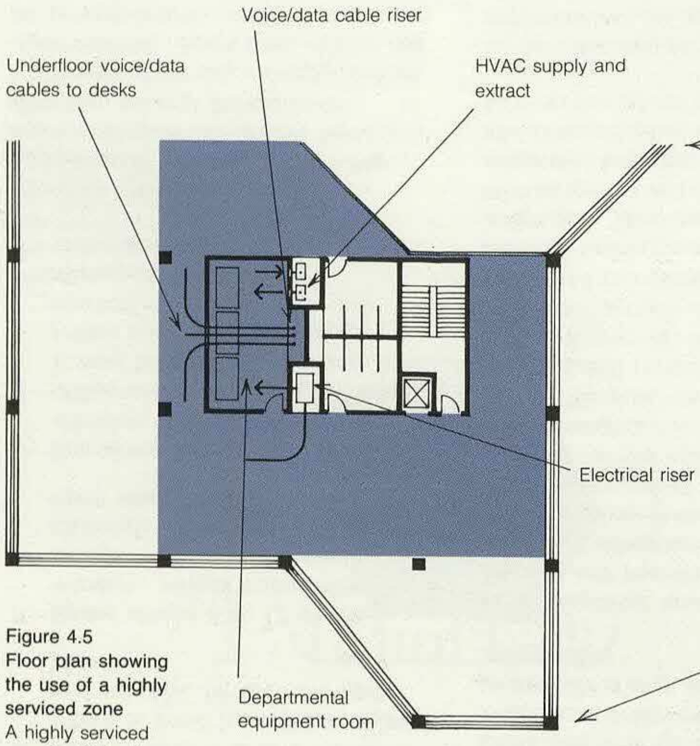


Figure 4.5
Floor plan showing the use of a highly serviced zone
A highly serviced zone facilitates the introduction of departmental computer rooms in the future.

Highly serviced zone

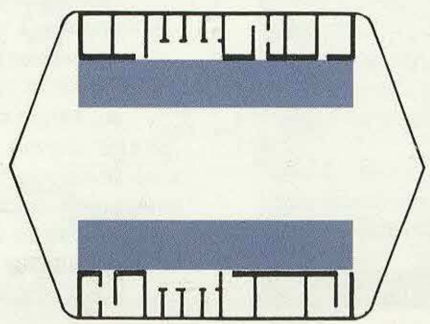


Figure 4.4
Lee House, London, showing the highly serviced zones

Current requirements
Modern offices need to be able to support IT equipment outside dedicated computer suites. Apart from workstations and their peripherals, this equipment may include communications multiplexors, minicomputers, laser printers, and disc stores. It is often desirable, in the interests of security, environmental control, and noise management, to segregate this equipment from the rest of the office space.

Suitable local equipment rooms may require lockable doors, a dedicated power supply, uninterruptible power, cooling for 300 W/m^2 for 24 hours per day, and many telecommunications connections. Cooling is probably the most critical requirement and can be achieved by a supply of chilled water to in-room coolers, or by the installation of self-contained air-cooling units. The telecommunications connections will generally be provided from the riser (or cable patching room where this is separate) and this requires a suitable route. Although suitable rooms can be built almost anywhere, it is generally best to build them near service cores, since this requires the shortest cable and pipework runs. Because they do not require windows, they can be placed in deep space.

The space near the cores is also required for other facilities, particularly kitchens, which often need a fresh air supply and extract ducts. It is important to plan the use of space in the highly serviced zones to ensure that current and future requirements for duct work and cable routes are not compromised.

Future requirements
As discussed on page A.06, the impact of today's trends in IT is ambiguous. On the one hand, the increasing deployment of workgroup systems (especially for image handling) increases the need for satellite equipment rooms. On the other hand, the high cost of office space in cities militates against the use of such rooms, and encourages the use of high-speed LANs.

Because the future requirements for local equipment rooms cannot be estimated accurately, the design team should provide zones that can be used economically either as offices or as equipment rooms. Because the provision of extra services for highly serviced space increases costs, the amount of space provided should be limited to the maximum foreseeable requirement.

Supporting arguments
Workgroups — that is, groups of staff who interact mainly with one another, and who work on a shared task — generally consist of 10-20 staff. The shared equipment for small workgroups can generally be accommodated in ordinary office space (provided the cooling system is satisfactory). The shared equipment for four large workgroups (say, 80 people in total) might sensibly be accommodated in a single departmental computer room requiring a high level of services. Such a room should be located in a highly serviced zone. Given that 80 people typically occupy about 800 m^2 of lettable space, there should clearly be some highly serviced space for every 800 m^2 of office space.

A middle-range minicomputer with associated equipment requires about 20 m^2. Although 80 people are unlikely to require more than two such machines today, the growing demand for computing and the development of document-management systems based on optical discs are likely to increase this. An area of 80 m^2, 10 per cent of the office area, would be enough to accommodate four such machines.

G U I D E L I N E S

There should be some highly serviced space for every 800 m^2 of net lettable area (NLA).

There should be the potential for at least 10 per cent of the net lettable office space to be much more highly serviced than ordinary office space. Such space should provide:

- Three-phase power.
- Power to 300 W/m^2.
- Cooling for the above power.
- A cable route to a communications riser.
- Physical access for heavy and bulky equipment.

Telecommunications entries are the places at which telecommunications services can be brought into the building from outside.

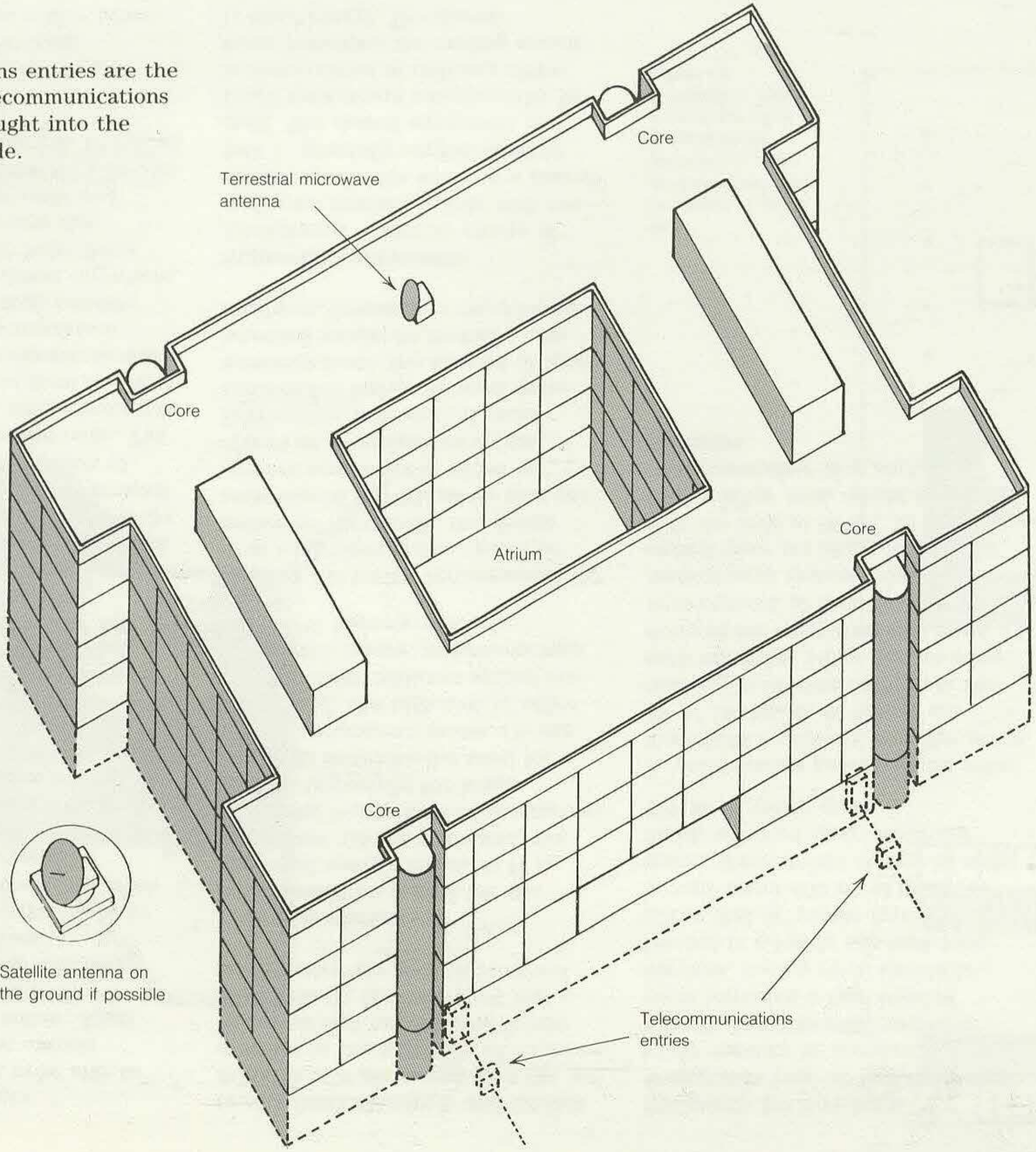


Figure 4.6
An office building showing telecommunications service entries
Occupiers are likely to need two telecommunications cable entry points at street level, and space for satellite dishes.

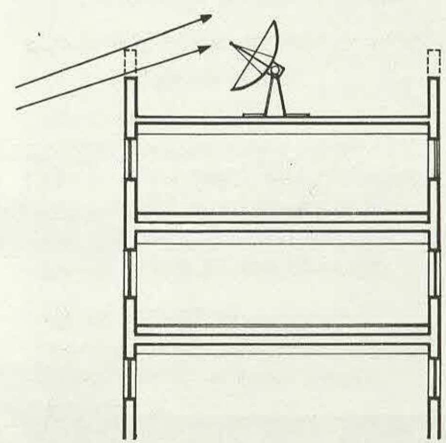


Figure 4.7
Concealed roof-top satellite dish
Satellite dishes often need to be located on the roof-top, but it is possible to hide them from view.

Dish concealed from ground level

Organisations are becoming more dependent on telecommunications services. For many of them, telecommunications provides their principal, and sometimes their only, contact with customers. As their dependence on telecommunications increases, more and more organisations will want the security provided by 'diverse routeing' — that is, multiple, independent access to services. This diversity may be provided in one of several ways — for instance, by:

- Multiple cables to the nearest British Telecom (BT) exchange. (The exchange will itself have multiple routes to the rest of the BT network.)
- The use of services from more than one provider — BT and Mercury Communications Ltd (MCL) at present.
- A mixture of terrestrial cable and microwave links to the national network.
- A mixture of terrestrial and satellite connections.

A variety of access routes will also be advantageous for the reception of new services that may not be available through existing facilities. Places for satellite antennae are a case in point because satellite communications are finding increasing use for video-conferencing, business television, and the distribution of information to widely distributed locations, such as retail outlets.

In future, most large buildings will require this range of options, especially if they include computer centres. Every building will need multiple entries: small buildings may, of course, need fewer than large ones. Small buildings are also unlikely to need the large satellite antennae that are used for the more sophisticated high data-rate services.

Satellite antennae are best placed on the ground, to facilitate servicing, and to avoid interference from signals from terrestrial sources (via side lobes of the antenna). If this is impossible (as is often the case in cities), the developer should consider providing a roof space on which antennae can be placed. (The planning authorities are more likely to grant permission for this if the antennae are not visible from the ground.)

GUIDELINES

All sites
The site should provide more than one entry route for telecommunications cables. (If all entries are to be occupied by cables from the same service provider, careful negotiation will be needed to ensure that the cable routes remain independent once they leave the site.)

Care should be taken in the positioning of antennae to ensure that stray radiation from terrestrial microwave antennae does not impinge on the (highly sensitive) satellite antennae, thereby causing interference.

Buildings over 2,500 m² and computer centres
Areas should be provided where terrestrial microwave dishes can be placed. (These areas should be strong enough to take antennae.)

Sites should include at least one area on which a satellite antenna with a diameter of at least 5 m can be located, and which has unobstructed lines of sight to geosynchronous orbit. These antennae are best placed on the ground.

In cities, developers should consider providing roof space on which antennae may be installed so as not to be visible from the ground.

The southerly arc between south-east and south-west of the planned antennae should be kept free of obstructions.

Small buildings
Buildings should provide places at which 1.5 m diameter satellite antennae can be installed.

A service-entry cupboard is a room within a building in which telecommunications cables from outside are terminated.

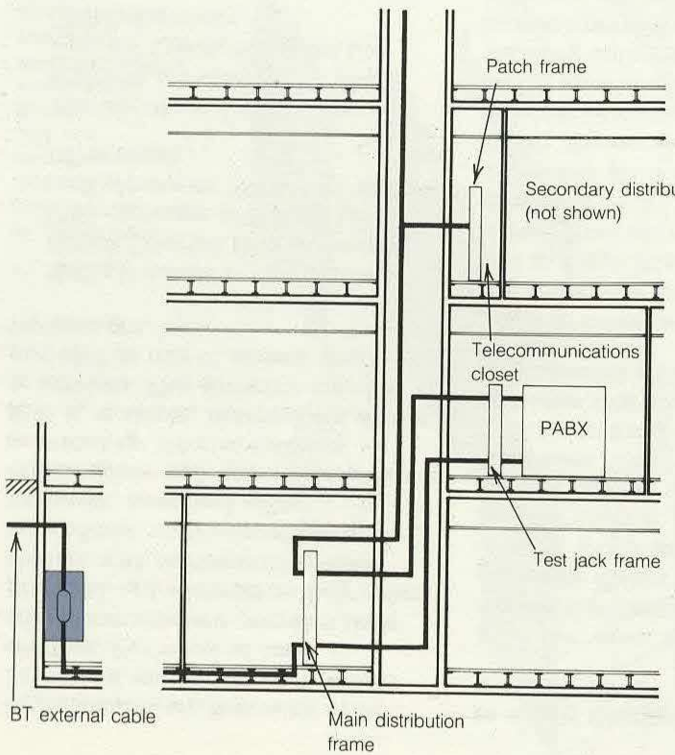


Figure 4.8
Schematic diagram of building wiring
The main (or building) distribution frame (MDF) provides a termination and interconnection point for internal and external cables. The PABX test jack frame (TJF) must be in the same room as the PABX, but it need not be adjacent to the MDF.

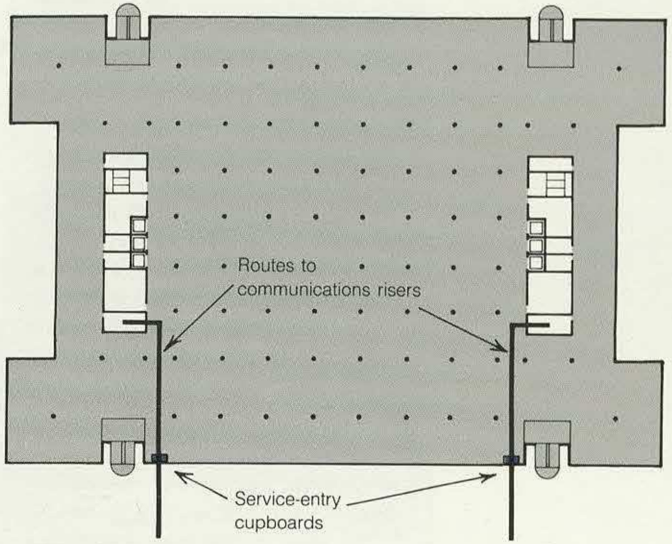


Figure 4.9
Plan of a typical building basement showing cable routes
Diverse routeing of external cables is often considered essential. Within the building, route separation is also desirable.

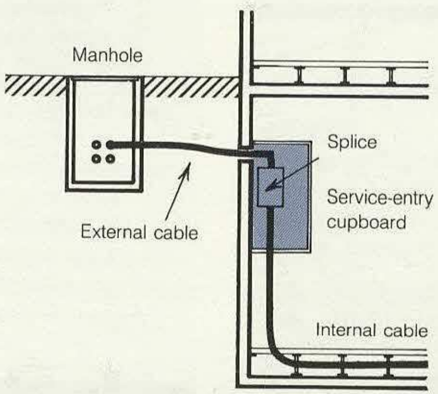


Figure 4.10
A telecommunications cable entry
A service-entry cupboard is required to accommodate a splice between outside- and inside-grade telecommunications cables.

Current situation
In the past, a single frame room has often been installed to accommodate the terminations of external cables, building distribution cables, and cables to the private automatic branch exchange (PABX). External communications cables are generally filled with petroleum jelly to make them waterproof. They constitute a significant fire load and should not therefore extend into the building any further than is necessary. Frame rooms are usually, therefore, located close to the external accesses. However, with the increasing need for multiple, independent, telecommunications entries, this traditional multipurpose frame room is no longer a sound approach.

Future requirements
Traditional passive spaces must be provided to terminate incoming copper and fibre cables close to the cable entry points. Since the spaces needed are much smaller than has been typical, we shall call these 'service-entry cupboards' rather than frame rooms. This requirement exists even when the building is located on a campus with shared access to off-site telecommunications facilities. The service-entry cupboard should be designed to provide termination of external connections only, and not to provide the base of the building cabling scheme.

GUIDELINES

There should be as many service-entry cupboards as there are external cable entries.

A frame room is a room within a building in which connections are made between telecommunications cables, including cables connected to external services.

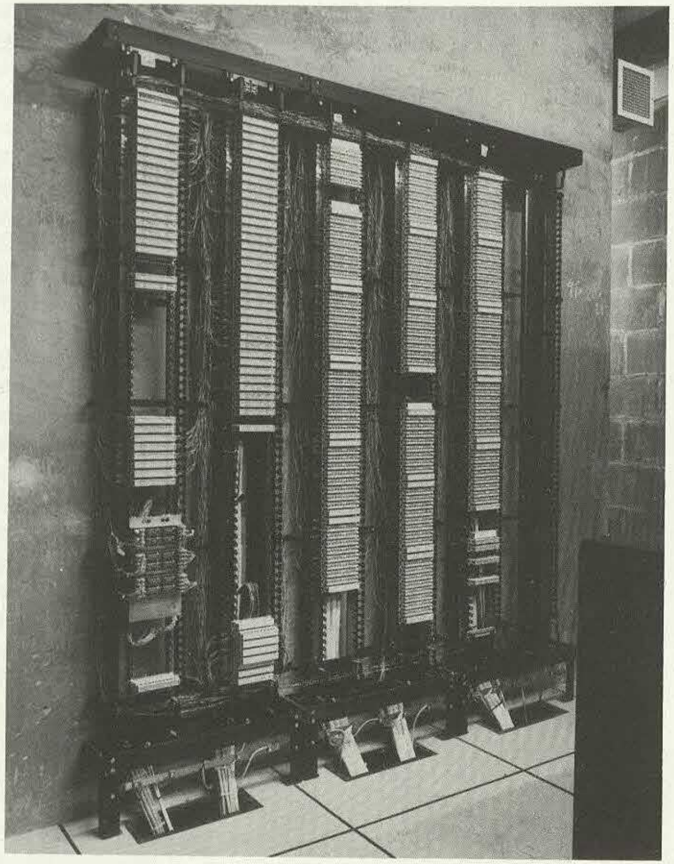
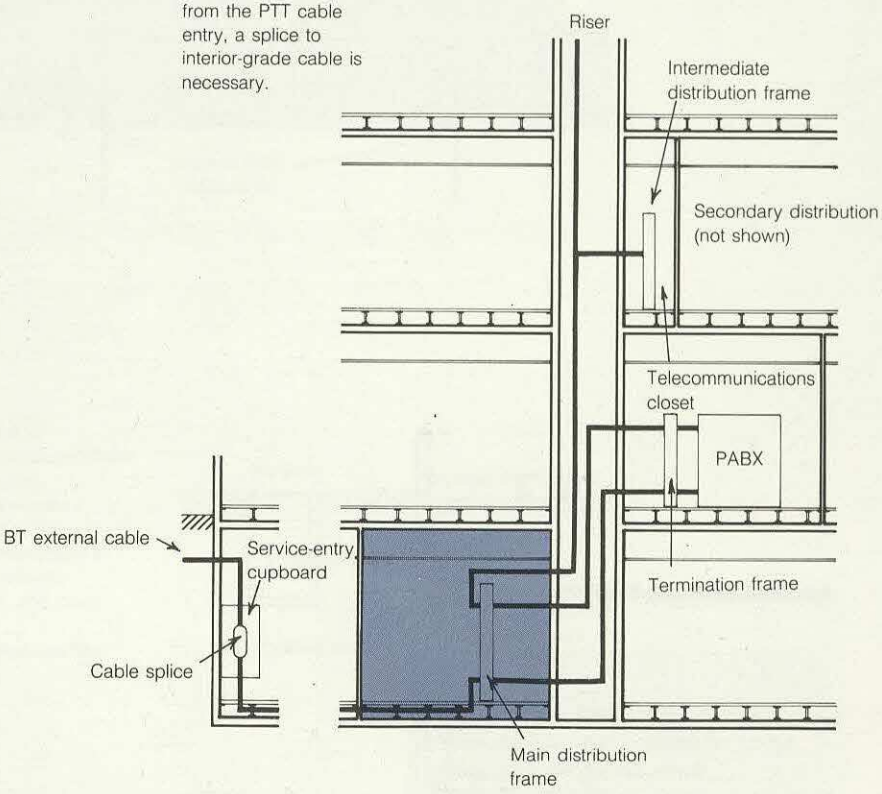


Figure 4.11
A typical main distribution frame
A main distribution frame (MDF) provides a termination and interconnection facility for internal and external cables.

Figure 4.12
Diagram showing position of the main distribution frame
The main distribution frame (MDF) is located between the external service cables and the primary building distribution cables. If the MDF is more than a few metres away from the PTT cable entry, a splice to interior-grade cable is necessary.



Current situation
PTT telephone technology has traditionally relied heavily on multipair telephone cables in which many twisted pairs are contained in a single protective sheath. These cables are relatively compact, but each pair has to be terminated on a distribution frame, as shown in Figure 4.11. Occupants have traditionally installed a Main Distribution Frame (MDF) in each building to serve as the base of the internal telephone wiring scheme and the point at which the PABX is connected to that internal wiring. Because of the termination technology used, frame rooms have traditionally contained little or no active electronics and have not therefore required dedicated power or cooling.

Future requirements
Despite the many advances in local communications, the need to install large amounts of copper wire in buildings will continue for many years to come. Because building wiring lasts much longer than the electronic equipment connected to it, and because it may, at any one time, be used to support a variety of types of communications, it is appropriate to manage the wiring as a separate resource and to have separate rooms for cable termination and interconnection. In addition to the telecommunications closets on the office floors, a central frame room is needed to provide flexible connections between those closets, and connection to various external services (as shown in Figure 4.12). This frame room should be located in a place with convenient routes to all the communications risers and to the various service entries.

GUIDELINES

There should be a central frame room with suitable cable routes to the risers and service entries.

Figure 4.14
A small frame room
In smaller buildings, a single-sided MDF will be adequate.

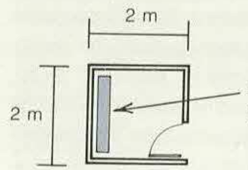
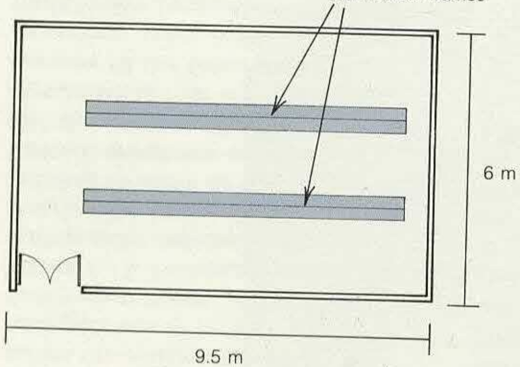


Figure 4.15
A large frame room
In larger buildings, double-sided MDFs are more space-efficient.



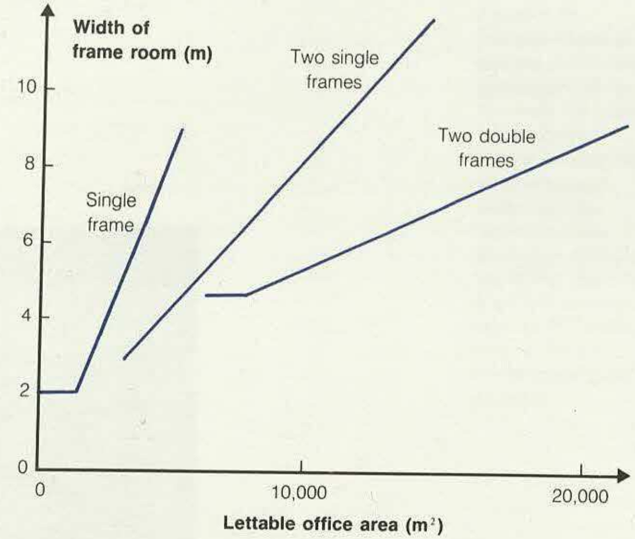


Figure 4.13
Recommended frame-room size
This graph indicates the recommended size of a frame room. It is based on frames having 1,200-pair capacity per metre width of single-sided frame.

Cable type	Pairs per circuit	Circuits per 100 m² of NLA	Double for rewiring?	Pair allowance on frame
Riser cables:				
— For PABX extensions	2	17	Yes	68
— For PSTN instruments	2	8	Yes	32
PABX cables:				
— For extension ports	2	17	Yes	68
— For trunks[1]	2	3	Yes	13
External services accesses:[2]				
— BT circuits	1	11	No	11
— MCL circuits	1	1	No	11
				203

(1) Allowing one trunk to every five PABX extensions.
(2) PSTN circuits plus PABX trunks.

Figure 4.16
Frame-room space requirements
This table indicates the recommended size of the MDF in terms of pair termination capacity in relation to net lettable floor area.

Current situation
In addition to terminating external cables, frame rooms have also served as the hub of the building cabling system. Today's frame rooms are generally sized to accommodate an MDF with at least one connection for every telephone instrument, telex machine, or other terminal using a line pair, one for every outside line, and some provision for data.

Future requirements
The frame room should be kept separate from the PABX accommodation and from the accommodation used for the equipment that terminates any incoming circuit because:

- The PABX will be replaced several times over the life of the cabling scheme.
- The MDF is part of the cabling scheme, not the PABX. Maintenance is likely to be separate.

The frame room should be large enough to accommodate the terminations of the internal voice cabling and of the cables leading to the service-entry cupboards, but not to accommodate the electronics needed to terminate modern, high-speed networks. Figure 4.13 shows the largest number of copper pairs that will be needed for an office building outside the 'high-tech' part of the finance sector. No space needs to be allocated for a central data patching frame in the frame room, because all data patching frames may be located in telecommunications closets.

The actual size of the frame room depends on the total lettable area to be served. We have assumed that the highest possible staff density in the building is one person per 6 m^2 of the net lettable area (NLA). Each person may need a telephone and a workstation.

The smallest size for a frame room that is convenient is 2 m by 2 m. When laid out as shown in Figure 4.14, it is large enough for a building of 600 m^2. Since a changing mixture of PABX and Centrex operations may be needed over the life of the building, the largest requirement should be allowed for. Financial organisations may need very much larger numbers of connections — as many as 25 per employee in some cases. The guidelines are not intended to cover these exceptional circumstances.

Voice and network services
The frame room should be planned to last the life of the building and should therefore provide sufficient space to allow for recabling at some stage. As shown in Figure 4.16, the frame room must terminate cables from the external services to the PABX and to the building risers. Because the PABX will be replaced several times during the life of the cabling, enough space must be left to terminate a second set of PABX cables during the conversion. The figure shows the pairs that may be needed on the MDF for each 100 m^2 of NLA. Each 100 m^2 of NLA requires MDF space for 120 pairs of cables to be terminated. A popular design of frame accommodates 1,200 pairs in a width of 1 m. So a 1 m width of frame will support the requirements of 600 m^2.

Data cables
Data cables should be terminated in the central computer suite or data communications equipment room and not in the frame room. The space required for data communications cable termination depends on the choice of media and type of network and varies a great deal.

GUIDELINES

A frame room should be at least 2 m deep and 2 m wide.

The frame room should be sized to accommodate 170 mm width of single-sided frame or 85 mm width of double-sided frame for each 100 m^2 of NLA.

A computer suite is a set of rooms accommodating one or more computers, their ancillary equipment, and supervisory staff. It may also include data communications equipment. A computer suite may be located in a purpose-built building, called a computer centre, or within an ordinary office building. Computer centres may accommodate staff other than operations staff, most commonly those engaged in systems development and support.

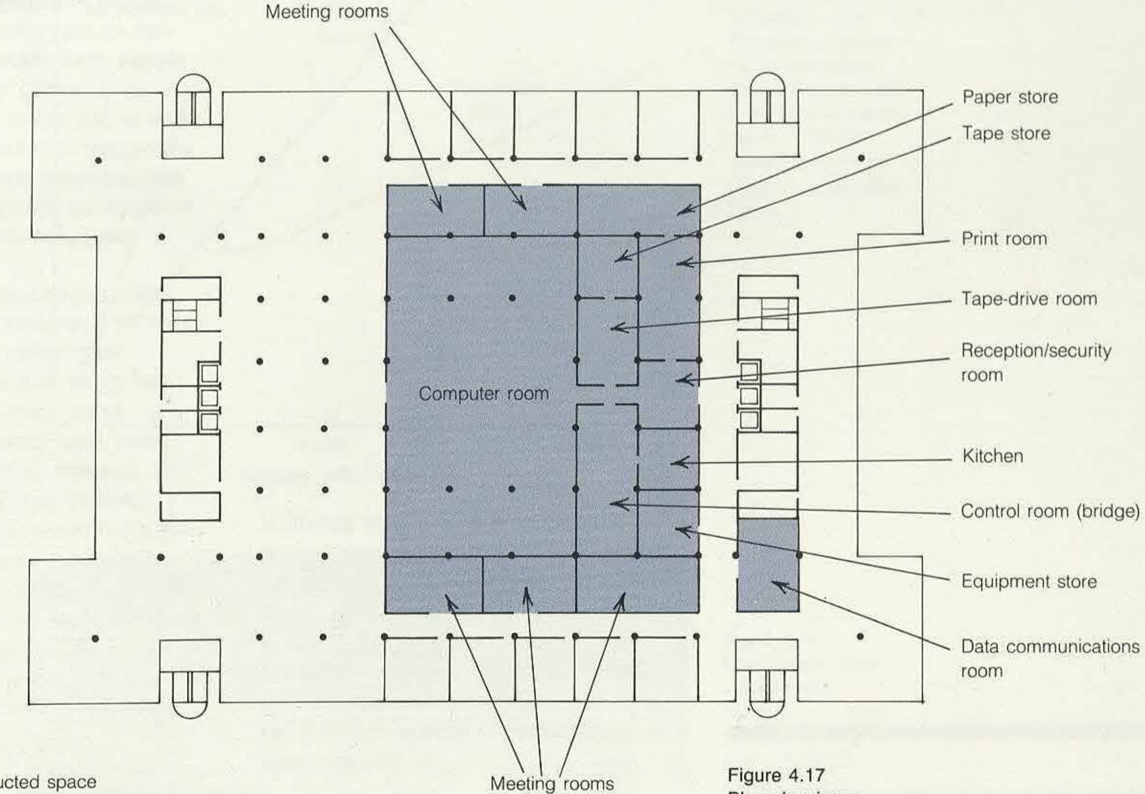
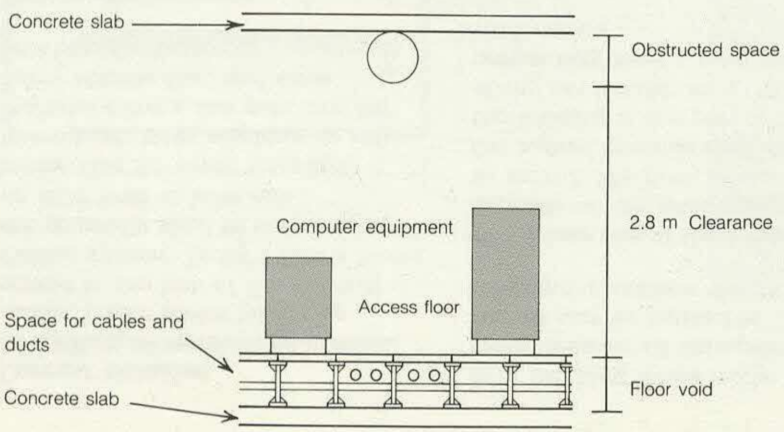


Figure 4.17
Plan showing a possible layout for the computer suite in a typical office building

Figure 4.18
Vertical space required for a computer room
Computer suites for large mainframe computers may need a deep floor void for cables, chilled water, and other services.



Current situation
In the past, computers have often been installed in purpose-built computer centres. Because these centres have been in out-of-town areas, they have been economical to build and run. Developers have not therefore included any space in office buildings suitable for the construction of computer suites. The majority of today's computer applications require relatively modest data communications capacity between the central computer site and the users' terminals.

Future requirements
In the future, new applications, such as those involving document images, will require much higher communications bandwidths than is the case today. The cost of high-speed data communications over long distances may then force users to locate at least part of their computer facilities within 1 or 2 km of the users. Because the future requirements for computer suites in office buildings cannot be estimated reliably, the design team should provide, at a minimum, the space to accommodate a computer suite large enough to service the staff in that building. At least 10 per cent of the area of the building should be set aside for this purpose. It will require:

- A slab-to-slab height of at least 3.5 m, and preferably 4.5 m. This will be sufficient for an access floor of 300-600 mm and will provide sufficient clearance for the computers.
- Adequate capacity for power and data cables and other building services between the allocated space and the service cores.
- A heavy goods access route (for deliveries). The route should be large and strong enough to take a mainframe central complex, an air-handling unit, or an uninterruptible power supply (UPS) module, and ideally, should not be essential to normal office work.
- Space for associated plant rooms.

Modern office buildings usually have a storey height of about 4 m. This is sufficient for the installation of a computer suite. The space should be protected from environmental hazards, especially floods. It should not be adjacent to heavy machinery or stores of inflammable or noxious gas. Some locations pose specific threats:

- Near lobby — vandalism, sabotage.
- Basement — flooding (the flooding risk depends on the level of the water table, which is higher, for instance, near rivers).
- Top floor — air crash, fire.

For these reasons, a good location is between, say, the second and middle floor of a tower block. On a campus, the computer suite should be fairly central to the whole site to reduce cabling costs.

GUIDELINES

At least 10 per cent of the net lettable area (NLA) should be usable as a computer suite.

There should be an access route at least 2 m wide from the loading bay. Any lift on this route should be of at least 1,200 kg capacity and should measure at least 2 m by 3 m.

A communications riser is a space connecting the floors, in which communications cables can be installed.

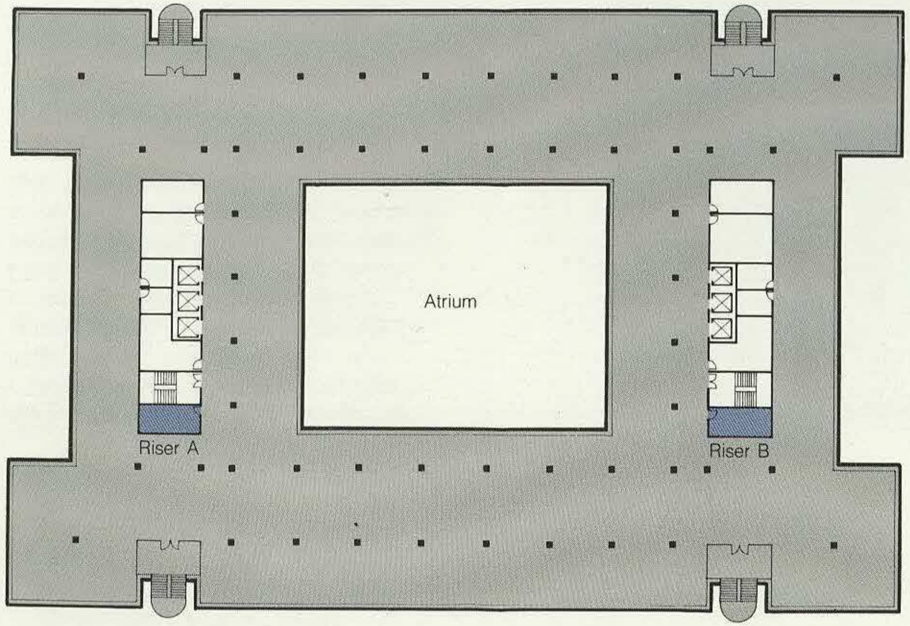


Figure 4.19
A typical office building showing positions of risers
More than one communications riser will be required in larger buildings.

Current situation
Older buildings generally have risers for water (fire sprinklers, waste, and drinking water), and power, but often do not have separate risers for communications. Communications cables have to be installed in existing risers, usually the electrical risers. Modern buildings usually have more riser space, but even buildings being completed today do not always have enough.

Future requirements
Communications cables need separate risers, which should be located in the landlord's space. It is usually convenient to serve each closet on a floor from a separate riser, so the locations of risers and closets depend on one another and should be planned together. (The planning of telecommunications closets is dealt with on pages 4.13 and 4.14.)

Risers are usually located, together with lifts and emergency stairs, in service cores. The regulations concerning the maximum distance between emergency stairs will usually result in enough service cores to provide the number of risers needed.

Communications and power, and sometimes cooling water and air, will have to be distributed to the floors from their respective risers and/or plant rooms. Because the secondary distribution spaces are likely to be limited, it is helpful to keep these risers and plant rooms separate and, in particular, to keep communications risers away from risers of other kinds. Since telecommunications services may be brought into the building in a number of places, cable routes should be planned from the risers to each of the cable entries and to any site reserved for terrestrial microwave or satellite antennae.

Even when structured cabling systems are in use, it will sometimes be necessary to install additional cables. It should be possible to do this without disrupting the normal work of the organisation. This may be achieved conveniently either by providing access to risers from landings or primary circulation areas (but taking care that the doors do not interfere with escape routes), or by making the riser large enough to accommodate workmen.

GUIDELINES

Communications risers should not be combined with those for water, air, or power.

Communications risers should be located away from other risers and plant rooms.

The riser locations should not be decided until the locations of wiring closets and highly serviced zones have been decided.

Risers or other communications ducts should connect to the places intended for microwave and satellite antennae.

Risers should be accessible without disturbing normal work.

The size of a riser is the area in which cables may be run between floors.

Figure 4.20
A crowded riser

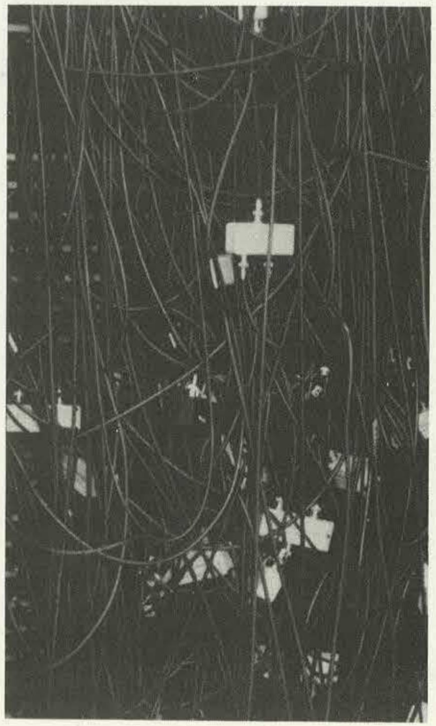


Figure 4.21
A typical communications riser
The smallest communications riser allows space for, and access to, one 300 mm-wide cable tray and an intermediate distribution frame for voice cables.

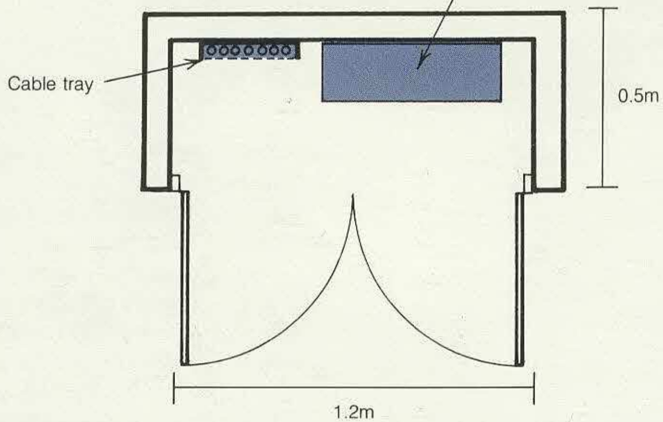


Figure 4.22 Sample calculation of communications riser size

Cable space

Consider a building with five floors of 1,000 m² net lettable area (NLA) each, and two communications risers.

To allow for asymmetric division of the floors for sub-letting, each riser should be able to serve 750 m² on each floor, a total of 3,750 m².

Applying the guideline, the cross-sectional area allowed for cables in each riser should be:

$$\frac{3{,}750}{6} \times 36 \text{ mm}^2 = 22{,}500 \text{ mm}^2$$

Sufficient space should be provided by:

— A slot 600 mm long by 40 mm wide (24,000 mm²).
— Three holes of 100 mm diameter (23,550 mm²).

Between floors, the cables would usually be tied, at a depth not exceeding 40 mm, to cable trays of a suitable width.

Use of space

Initially, each floor will require cabling for about 250 circuits. Assuming that two pairs are provided for each, and allowing for some excess because of the use of standard-size cables, the area needed would be about 6,000 mm² — that is, no more than 26 per cent of the available space would be used initially.

Current situation
Older buildings generally have risers that are too small. Modern buildings usually fare better, although some recently completed buildings in the City of London have insufficient riser space for the many cables needed for the specialised information services used in the financial markets.

In a modern office building, the risers will need to take cables for telephony, terminal support, local area networks (LANs), and building-management systems, and possibly an intercom, paging system, television, and security system, amongst others. Separate telephony cables may be needed for British Telecom (BT) services, Mercury Communications Ltd (MCL) services, and PABX extensions. Several different sorts of data cable may be needed.

The dealing rooms of financial institutions present an extreme case because staff are usually packed tightly into the available space, and they often require additional specialised services, such as:

- A number of direct telephone lines to other dealers.
- 'Hoot 'n holler' — a type of intercom system.
- Financial market information services. (These services are generally run over coaxial cables and, since some are in colour and many dealers have several information screens at their desks, each desk may need as many as 18 cables.)

With today's technology, dealing rooms need much more riser space than other offices.

Future requirements
Most buildings are sub-let, or become multitenanted, at some stage in their lives. The space will not necessarily be divided in ways that are convenient for cabling. The risers should therefore be sized on the basis that they may have to serve up to 75 per cent of the space to the next riser rather than the half that might be assumed.

Experience shows that the number of telephones, both PABX extensions and direct lines, rarely exceeds 1.5 times the number of staff. Although most telephones are supported on single pairs of wires, this will not be sufficient for some future telephony systems (including some uses of ISDN), and space for two pairs per circuit should be provided. A space of 4 mm^2 is sufficient for a twisted pair in a high pair-count cable, so that the riser space needed to accommodate these services is 12 mm^2 per person. Given that the staffing density might rise to one person per 6 m^2 in some cases, this is also the space required for each 6 m^2 of net lettable area (NLA).

Every building is likely to need recabling every 10-20 years, and it is desirable to be able to do this without disrupting the existing cabling. The riser should therefore provide as much space again, in order to accommodate the replacement cabling system. The space requirement is therefore 24 mm^2 per 6 m^2 of NLA. A 50 per cent reserve is prudent for unforeseen developments.

The overall requirement for voice and network cabling is therefore 36 mm^2 per 6 m^2 of NLA. It is sometimes more convenient to express this as 15 mm of tray width per 100 m^2 of NLA. This approach is quite conservative as it ignores:

- The likelihood that future PABXs will concentrate many telephone calls onto a single, probably optical-fibre, cable. (A few modern PABXs already work this way.)
- The integration of PABX and network service wiring. The Office of Telecommunications (OFTEL) is currently reviewing the regulations that prevent this.

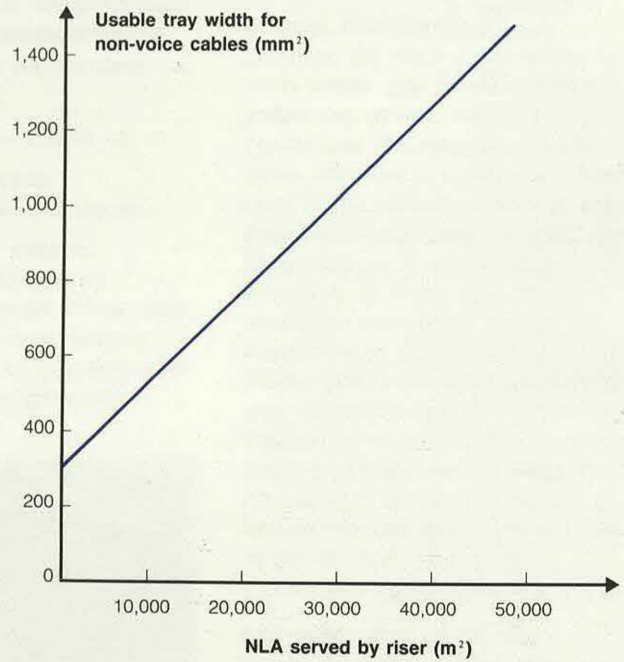
GUIDELINES

Risers should be sized to allow for the possible division of the floor space for sub-letting.

A communications riser should provide 600 mm^2 of area for each 100 m^2 of NLA that it might need to serve for voice and network services.

A communications riser should provide 15 mm of tray width for each 100 m^2 of NLA that might be served for voice and network services.

Figure 4.23
Usable tray width for non-voice cables as a function of building area served



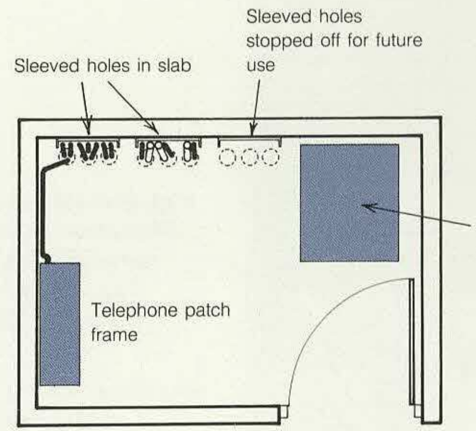


Figure 4.24
A typical wiring closet

Current situation
In many buildings, risers have become congested owing to the proliferation of cables dedicated to particular IT services. As explained in Chapter 2, offices of all kinds will experience the migration to LAN-supported intelligent workstations, and the integration of building services.

Financial institutions will also be affected by the migration of video services onto digital LANs; they are also beginning to investigate the use of optical fibre to reduce their space requirements.

Future requirements
In principle, the trends in network technology should lead to a reduction in the requirements for cabling, and therefore for riser space. In practice, three factors are having an influence in the opposite direction:

— It is generally troublesome to remove cables when they are no longer needed and the cables for structured cabling schemes are deliberately retained for future use. The cables for the new LANs may therefore be additional to any cables needed previously.

— Future network technologies may, in practice, require more space than now seems reasonable.

— There are always likely to be some individual staff and groups who require particular information services with unusual requirements.

In the future, therefore, the risers should be sufficiently large to accept all the cables envisaged initially, plus the largest system that can reasonably be foreseen.

In a small building, the riser space required is greatest if optical fibres are installed in a star topology from a central frame room or computer suite to each work location. The further advantage of this approach is that it makes few assumptions about the services that each user will require. The fibres can be used for data communications at a variety of speeds and under a variety of protocols, or television, or speech.

Because every office worker is likely to need an intelligent workstation, it is prudent to provide enough space to run a dedicated cable to each one. The size of the largest cable in common use is 80 mm^2, to which we add 40 mm^2 for a replacement system, and 40 mm^2 for reserve. The total requirement is therefore 160 mm^2 for each 6 m^2 of NLA. This is more conveniently stated as 67 mm of tray width per 100 m^2 of NLA.

This is a reasonably generous approach (except where large numbers of financial traders have to be accommodated), because many data circuits can be concentrated onto a single cable. A further 300 mm of riser tray should be allowed as a general provision for services such as television, broadband networks, and leaky feeders for pagers.

To ensure that the space provided remains adequate, and is not used up by inefficient technologies, cable management must continue to be effective after occupation. This is discussed further in Chapter 8.

GUIDELINES

A communications riser should provide space for 2,700 mm^2 of non-voice cables for every 100 m^2 of NLA that might be served by the riser. This will require 67 mm of cable tray width for every 100 m^2 of NLA.

The riser should provide an additional 300 mm width of tray for other services.

NB:
(1) These guidelines should not be used for buildings of more than 10 storeys. These buildings require detailed study by the design team.
(2) Extensions of the riser ducts to cable entries and micro-wave antennae may be much smaller than indicated above.

The usual practice in the United Kingdom today is to build risers as open shafts whose floors are filled in later. Slots are left in the floor for the vertical cable trays and cables.

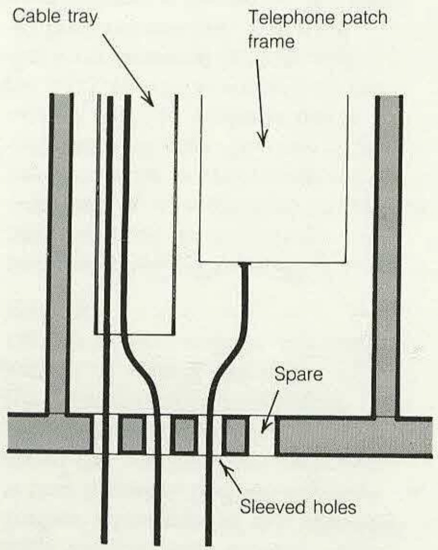


Figure 4.25
Section of floor penetrations in a riser shaft
Cables may be routed through sleeved holes in the floor slab.

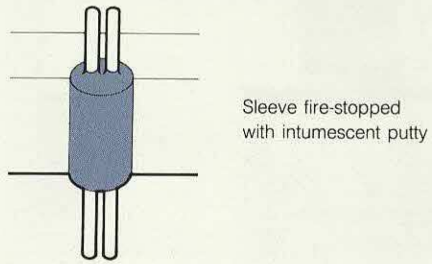


Figure 4.26
Detail of sleeve and fire stopping
Cable sleeves cast *in situ* provide a convenient arrangement for fire barriers between floors.

Current situation
An alternative to the British approach, common in the United States, is to leave fairly small holes, typically 100 or 150 mm diameter, between wiring closets, and to install ceramic sleeves. These are firestopped and brought into use only when needed. The advantages are that:

- There is no risk of workmen falling.
- They are easy to firestop.
- They keep cable bundles in line.
- They provide a framework for space management.

Future requirements
Most buildings are sub-let or become multilet at some stage in their lives. These situations create problems that the design team should address:

Telecommunications access: Each occupant is likely to require his own BT and/or MCL access cables. To prevent one occupant depending on the favour of another, the landlord should provide ducts for public network cables, both copper and fibre.

Frame rooms: Occupants will need to establish frame rooms, probably in their own space.

Connections between floors: If an occupant has multiple floors that are not contiguous, these will need to be linked through secure riser space.

GUIDELINES

Communications risers should be continuous vertical shafts, wherever possible.

The minimum size for a communications riser should be 1,200 mm wide by 500 mm deep.

The space for cables between risers, wiring closets, and secondary distribution space should be defined in the brief to the builder.

A number of sleeved holes, rather than open shafts, should be used.

To allow the building to be let to multiple occupants, or to be sub-let, there should be provision for individual security of an occupant's riser space.

A telecommunications closet is a room in which the backbone network is connected to the horizontal distribution.

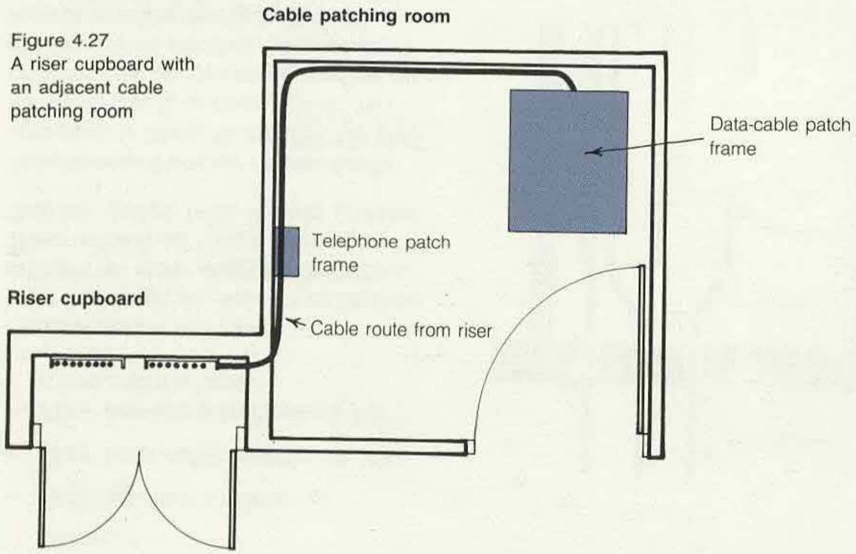


Figure 4.27
A riser cupboard with an adjacent cable patching room

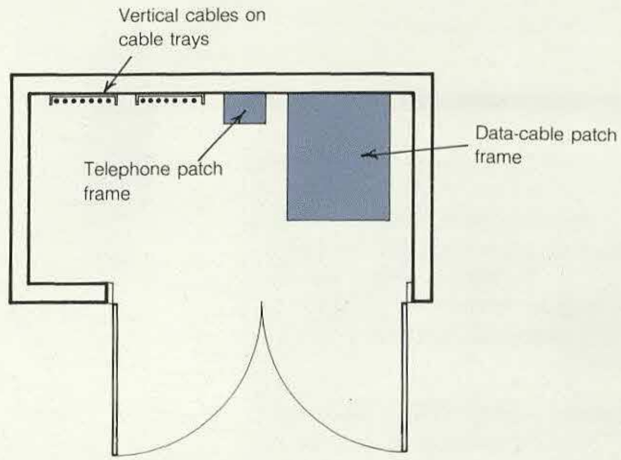


Figure 4.28
A typical wiring closet
A wiring closet should provide space for voice and data patching frames.

Current situation
Riser cupboards were introduced in the United Kingdom to accommodate the patch frames in telephone block-wiring schemes. They were originally small and unserviced, as shown in Figure 4.21 on page 4.10. The requirements for riser cupboards have gradually increased to accommodate data communications cables, patching frames, and electronics. Structured data-cabling schemes have been based on larger components. This has increased the pressure on space in riser cupboards, requiring them to be supplemented by separate cable patching rooms or to be substantially increased in size. To mark this change, the term 'wiring closet' has been introduced.

The move to higher signalling speeds and the introduction of local area networks (LANs) has required the installation of active electronics on the same floor as the workstations. In some environments, this trend has converged with the development of departmental computing, based on small machine rooms in office areas. Reflecting the further increase in size, and especially the new need for power and cooling, these rooms have been called 'satellite equipment rooms'.

It is helpful to distinguish between these varieties of communications and computer rooms. In practice, the size and level of servicing increases, from a riser cupboard at one end of the spectrum to a departmental computer room at the other.

There is still considerable variation between buildings in the approaches taken to telecommunications closets. Most current designs, however, leave little opportunity for changes to be made over the life of the building.

Future developments
The trend from small riser cupboards through wiring closets to even larger departmental computer rooms may continue, but this may not occur because:

— Once every worker has an intelligent workstation with a network connection, there is only limited scope for expansion in the number of connections.

— Some computer users have recognised the high direct costs and opportunity costs of departmental computer rooms, so have centralised the departmental computers and reclaimed the computer-room space for office use.

The building design team must accept that the balance between centralised and distributed processing is unstable and may swing either way, probably during the life of the first fit-out, and certainly during the life of the building. Therefore, they should provide modest telecommunications closets — either a riser cupboard with adjacent space for a cable patching room, or a wiring closet. These options are shown in Figures 4.27 and 4.28 respectively.

It is desirable to provide a clear demarcation between passive structural space and serviced space intended for active electronics, in order:

— To reduce the risk of fires spreading between floors through the risers.

— To keep heat, ventilation, and air conditioning out of the risers.

— To encourage clear demarcation of management responsibilities.

Designs should be flexible enough for the telecommunications closets to be expanded, either during fit-out or subsequently, to form satellite equipment rooms or departmental computer rooms. The areas designated for satellite equipment rooms should fall within a heavily serviced zone.

Figure 4.29
Plans showing areas of the model building that can be served from a wiring closet

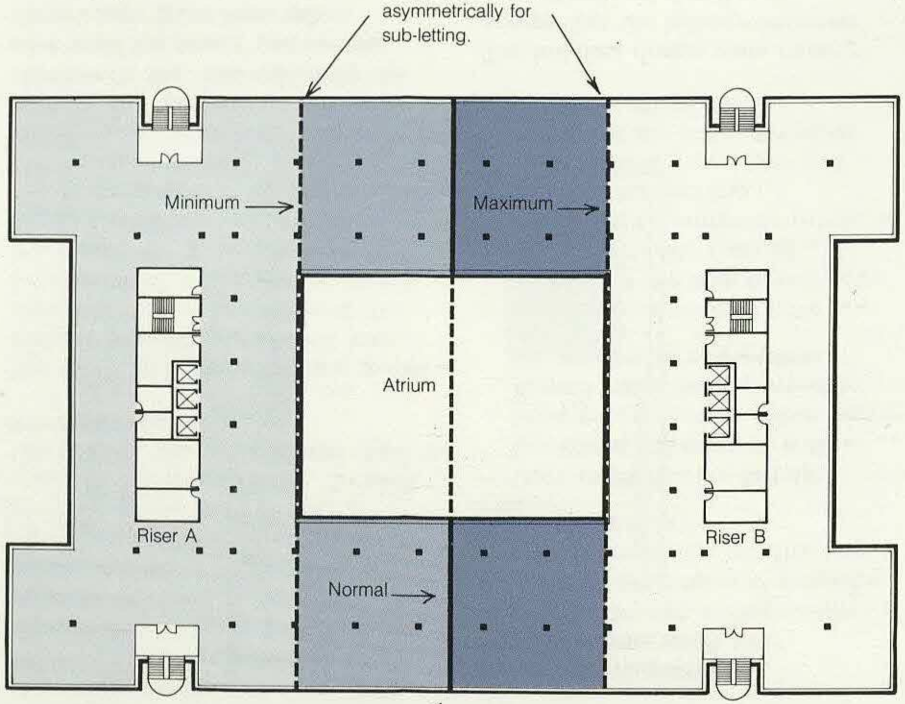
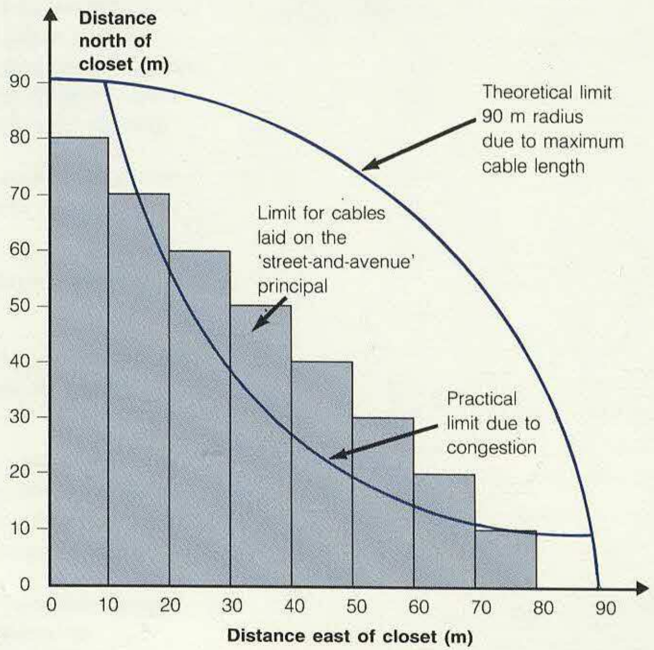


Figure 4.30
Floor area that can be served from one telecommunications closet
The shaded area represents the maximum possible area served by a closet in one quadrant. In practice, placement of building cores and cable congestion below the floor limit the area served to about 1,000 m².



The most basic limitation on the positioning of telecommunications closets is the need to keep the lengths of cables within the limits set by the structured cabling scheme that will ultimately be used. Since that scheme is unlikely to be known when the building is designed, the limit given in the emerging Electronic Industries Association (EIA) standard (90 m), should be used. This distance is sufficient for most uses of the main proprietary cabling schemes.

Four factors combine to reduce the office area that can be served from a single closet below that of a circle of 90 m radius. They are:

- The use of 'street and avenue' horizontal cable routes.
- The need to route cables around obstacles such as service cores.
- The need to avoid congestion in the areas where the cables approach and enter the closets. These areas are often densely packed with other services as well.
- The need to allow some cable length at the patch panel, and sometimes, from the service space to the presentation.

The area that can be served is further reduced when the shape of the building is considered. This often leads to the location of a telecommunications closet near a corner of the space to be served, as shown in Figure 4.29.

In practice, it is quite difficult to serve areas of more than 1,000 m^2 (lettable) space from a single closet: an area of 500 m^2 is a better guideline. If the design team wishes to support a larger area from a single closet, it should ensure that all services can be satisfactorily distributed. This may involve increasing the floor void depth from 120 mm to 150 or 200 mm (see also page 6.08).

Reference

Building standards for telecommunications media and systems. EIA PN 2072 (CSA T530). Washington DC: Electronic Industries Association.

G U I D E L I N E S

Even if the space is occupied by a single occupant, there should be at least one telecommunications closet for each 1,000 m^2 (preferably 500 m^2) of NLA.

To provide resilience, there should be at least two telecommunications closets on every floor of more than 1,000 m^2.

Figure 4.31
A typical voice and data-cable patching room layout
Some types of data-cable termination and patching frames require front and occasional rear access.

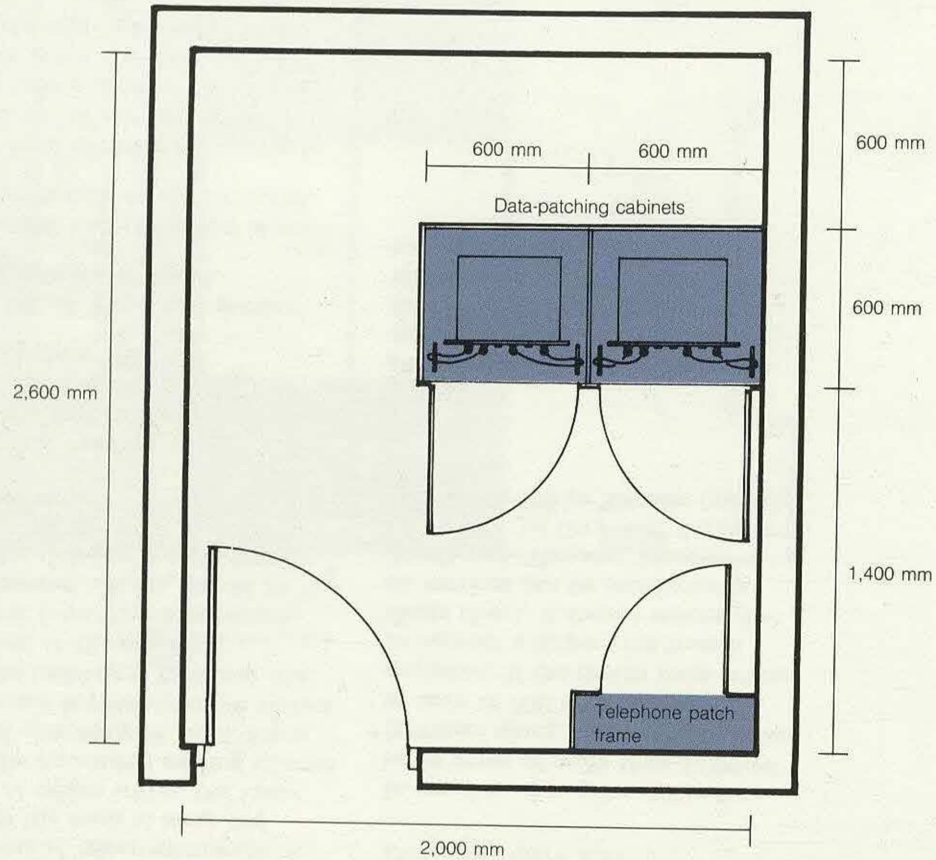
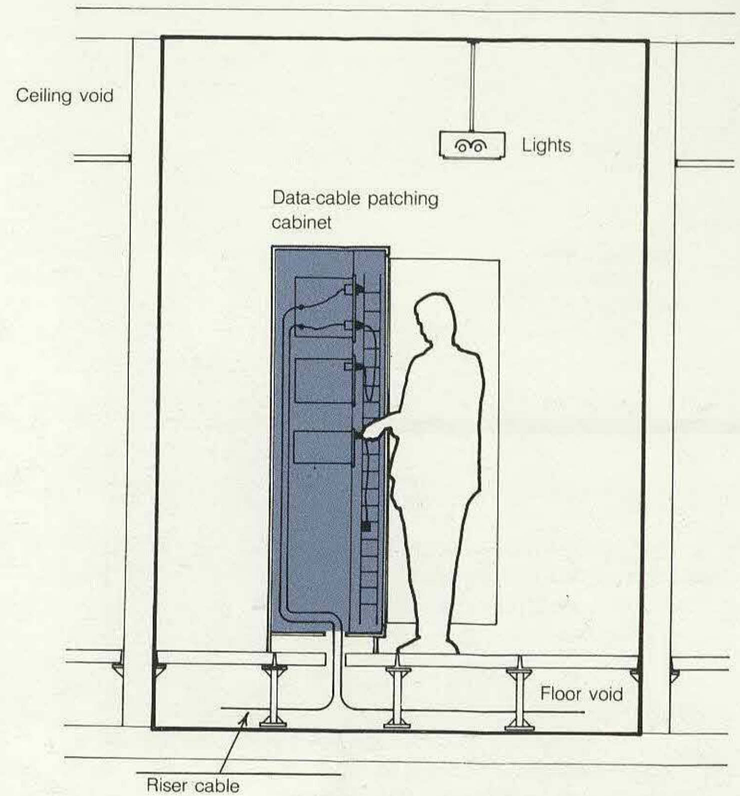


Figure 4.32
A technician working in a closet



Different minimum sizes are appropriate for the various kinds of telecommunications closet described above. A riser cupboard should be large enough to contain telephone patch panels or similar, but need not be large enough to work in. Its minimum size is therefore the minimum size for a riser.

A wiring closet or cable patching room to serve 500 m² of net lettable area should be large enough to contain two racks of patching for the largest structured data-cabling system in common use, plus a limited amount of electronics, such as multistation access units for a token ring LAN (as shown in Figure 4.31).

GUIDELINES

The minimum size for a riser cupboard should be 0.5 m deep by 1.2 m wide.

The minimum size for a cable patching room or wiring closet should be 2.2 m deep by 2 m wide.

A cable patching room to serve 1,000 m² should be 2.6 m deep by 2 m wide.

Figure 4.33
Building cross-section showing the telecommunications closets as part of the riser

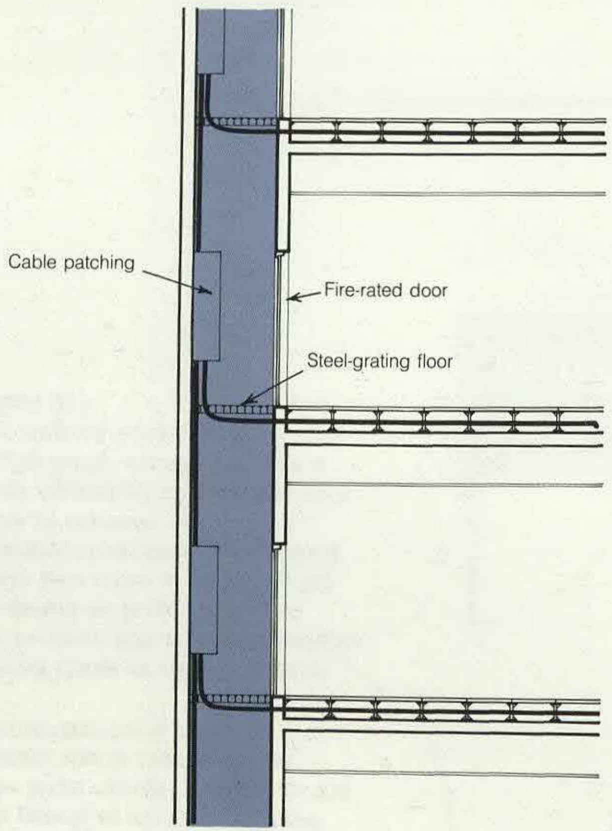
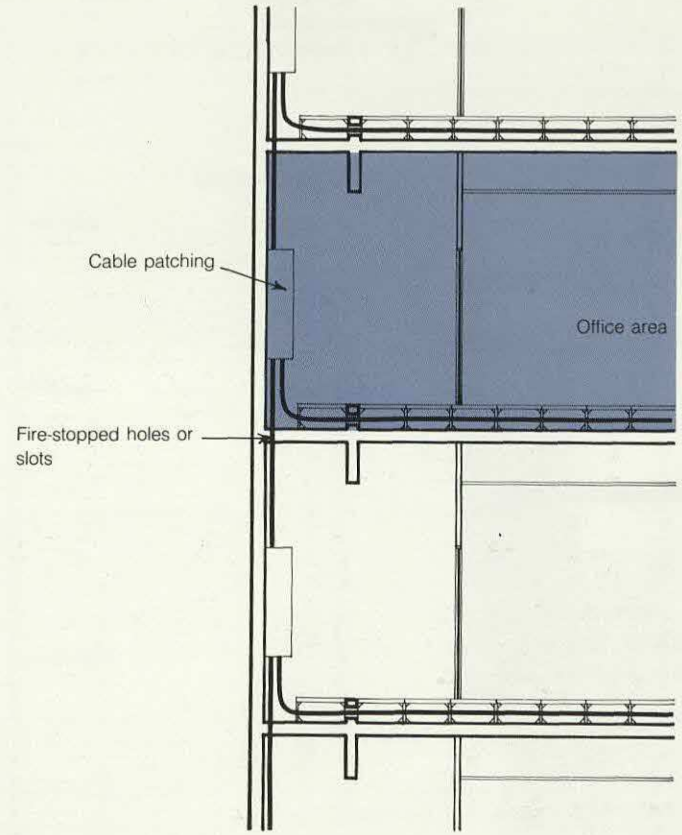


Figure 4.34
Building cross-section showing the telecommunications closet as part of each floor



As discussed above, the design team should provide either riser cupboards or wiring closets. The use of riser cupboards minimises the size of the riser but constrains the occupier either to devise a very compact cabling scheme, or to create a patching room. In the latter case, the design team should provide a knock-out panel through which a cable route between the two can be constructed.

Sufficient space should be provided to connect cable ways within the closet to those provided for secondary distribution (which is discussed on page 6.07) for the highest density of presentation and the largest number of cables per presentation that may be needed.

The design team should also decide on its approach to fire protection. It must regard the closet either as part of the riser, or as part of the floor. The latter is generally preferable since fire safety is maintained even when someone is working in the closet with the door open. In either case, the design team must take steps to ensure that fire seals are established and maintained.

GUIDELINES

Telecommunications closets should be protected by full-height fire walls of two-hour rating if they are part of the riser system.

They should have waterproof ceilings.

They should have no windows.

The ceiling should be at least 2.5 m high.

Doorways should be at least 1 m wide and 2 m high.

It should be possible to gain access without disrupting normal office work.

The cable entry to the horizontal distribution should have an area at least 110 mm^2 for each 1 m^2 of NLA.

Information technology equipment in buildings requires not only space for computer and cabling installation, but also an adequate level of electric power that is secure against voltage fluctuations, protection against electric interference, proper earthing, facilities for cooling, and protection from unauthorised access.

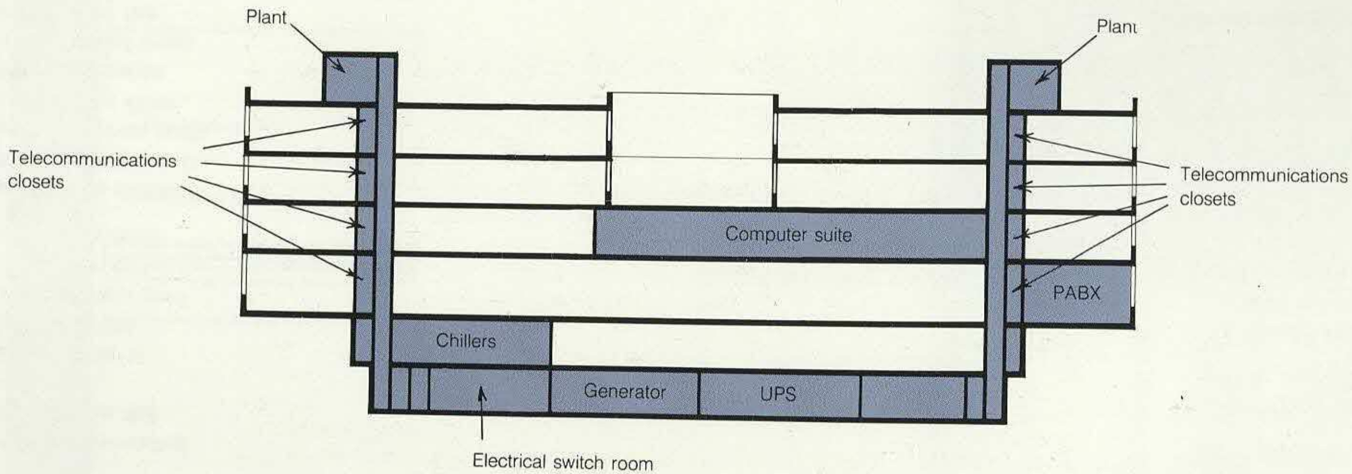


Figure 5.1
Section of a typical office building showing the space allocated to services

Contents

A computer room is a specialised room in which larger computers (known variously as super-computers, mainframes, superminicomputers, and so on) are housed. It requires a physical environment that is controlled for temperature, humidity, and dust content. Both the computer room itself and its air-conditioning system require considerable amounts of power.

Figure 5.2
Typical power flow for a mainframe computer

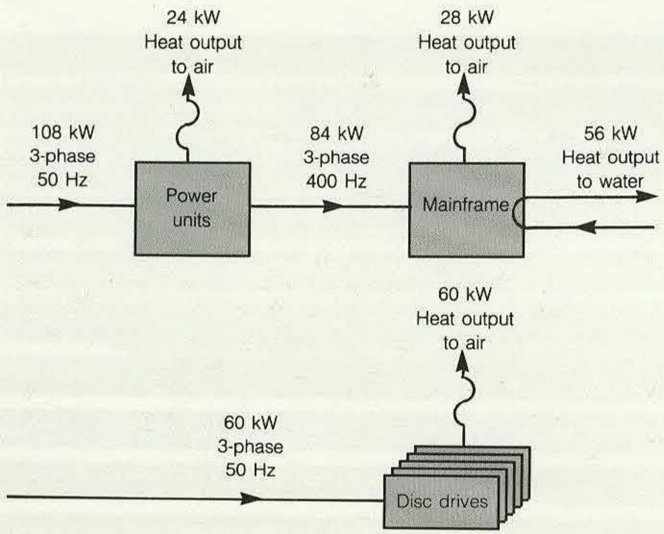


Figure 5.3 Energy conversion factors

Heat conversion factors

1 kW = 3,142 Btu/hr
1 kW = 857 kcal/h

Electrical load conversion factors

$$\text{Load (kVA)} = \frac{\text{Heat output (kW)}}{\text{Power factor*}}$$

* For most IT equipment, the power factor is in the range 0.8 to 0.95.

Figure 5.4 An example of the power-supply and cooling facilities needed to meet IT requirements

IT power requirement	kW
Computer room:	
1,000 m² at 750 W/m²	750
Offices:	
15,000 m² at 40 W/m²	600
	1,350

Power supply for cooling system to dissipate this

(The requirement depends on the ventilation and air-conditioning design but commonly adds between 30 and 70 per cent to the IT power demands.)

Assume: cooling power (50 per cent of IT demand):	675

Power supply

Assume: power factor = 0.8

So, required supply is:

$$\frac{(1{,}350 + 675)}{0.8} = 2{,}530 \text{ kVA}$$

Current situation
In many office buildings, the computer suite is a major consumer of power and source of heat. Moreover, both the size of computer rooms and the power consumption of computers have tended to increase. The growth of telecommunications networks has increased the availability required from computer systems and their power supplies, and has led to the increasing provision of back-up facilities, such as standby diesel generators, uninterruptible power supplies (UPSs), and reserve computer centres.

Initial requirements
Those aspects of the power supply and cooling systems that are expensive to provide and not very difficult to expand should be provided at the level needed for the first five years of occupation. These include standby generators, UPS units, and cooling system components such as fan coil units. Other elements should be sized for the largest load that the building is expected to need, the computer-room contribution to which is discussed overleaf.

The initial level of power required can usually be defined by the occupant (who knows the intended use of the building). This will include allowance for any computer rooms. The power supply and cooling load should be estimated on the basis of the allocated floor area rather than on the equipment that is expected to be installed initially. The IT equipment actually installed on occupation is usually different from that planned, and it will certainly change repeatedly during the life of the computer suite.

Reference
Halper, Robert F. *Computer data center design: a guide for planning, designing, constructing and operating computer data centers.* New York: John Wiley, 1985.

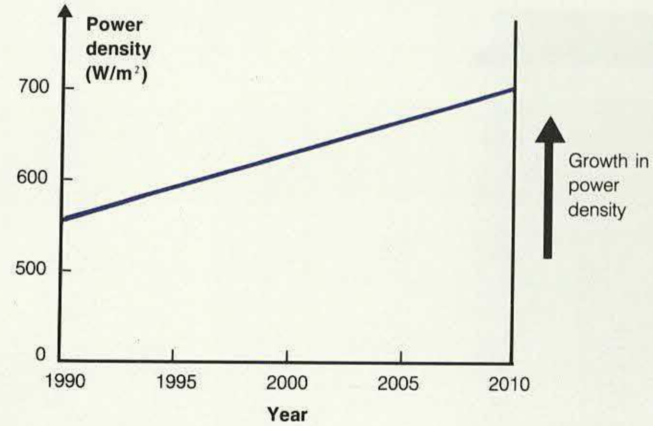
GUIDELINES

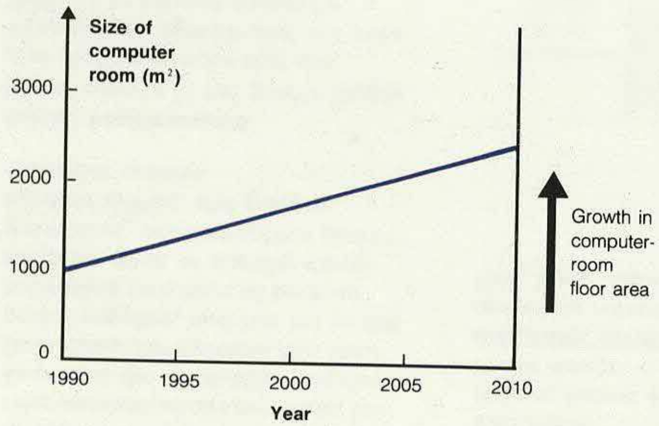
The initial computer room power demand should be estimated by the occupant. In the absence of more precise data, the following guidelines may be used:

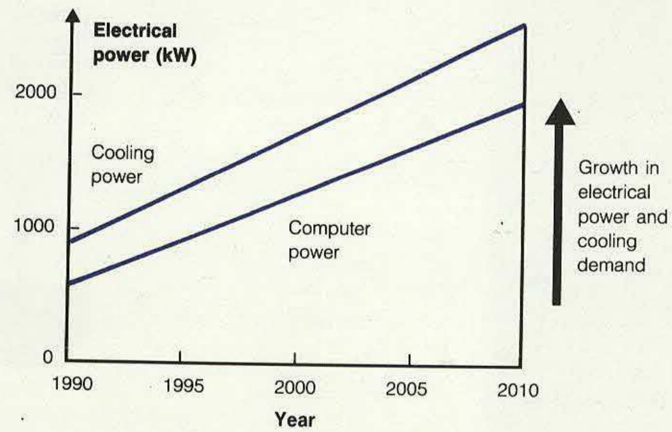
- The computer room occupies half of the space of a computer suite.
- Large computer rooms (for mainframes) require 600 W/m^2.
- Small computer rooms (for minicomputers) require up to 500 W/m^2.
- Satellite equipment rooms (for communications equipment) require 300 W/m^2.
- The power budget for the ancillary areas of the computer suite should be the same as for other offices.
- Power will be needed to cool the computer room. Cooling systems typically require one kilowatt of electrical power to remove three kilowatts of heat.

To allow for the possibility that power needs will increase over the life of the building, as is shown in Figure 5.5, the designer should provide space in which additional power supply equipment (such as standby generators and UPS equipment) can be installed. This space need not be committed for the purpose at the outset. Subject to planning permission, it might be used for car parking until needed.

Figure 5.5
A hypothetical graph showing the growth of IT power and cooling demand over the life of an office building
The combination of growth in computer room size and growth in power density can lead to a dramatic rise in total power (and cooling) demand.







Future requirements

The use of mainframes, departmental computers, terminals, and intelligent workstations will continue to increase and, as organisations become more dependent on their computers, they will be increasingly intolerant of any loss of service. Within 10 years, a high proportion of staff in many organisations will be unable to do their work unless the computers are operating. It is therefore essential to provide space in every reasonably large office building in which additional generators, power supplies, and switchgear can be installed to meet the future power needs of computer suites. There is also a trend, for which some allowance should be made, towards increasing power densities.

A reasonable space allocation for a computer suite is 10 per cent of the office space, of which half will be the computer room and half ancillary areas, such as the control bridge and media stores. Large buildings may need rooms for departmental computers as well as central computer suites. A further 3 per cent of space should be assumed to be used as minicomputer rooms.

The practical minimum size for a satisfactory mainframe computer room is about 300 m². This includes space for communications equipment and for two complete mainframe configurations, so that major upgrades can be installed without disrupting normal operations. Thus, the smallest building to which these rules can be applied is one of about 6,000 m².

Smaller buildings may still need computer rooms, but these will probably contain minicomputers rather than mainframes. They should be planned on the assumption that 8 per cent of the space will be used as departmental computer rooms.

For ultimate capacity planning purposes, it is good practice to assume that:

— The power allocation for a mainframe computer room should be 750 W/m².

— The power allocation for the ancillary areas should be the same as for ordinary office space. (This is discussed on page 5.05.)

— The power allocation for a departmental computer room should be 500 W/m².

— Power will be needed to cool the computer room. Cooling systems typically require one kilowatt of electrical power to remove three kilowatts of heat.

— UPSs will be needed for all the IT equipment.

— Standby diesel generators will be needed for the IT equipment, the lighting, and the cooling system.

GUIDELINES

Every large office building should be planned on the basis that it may have to include a computer suite at some point in its life.

The maximum power requirement should be calculated as follows:

— For buildings up to 4,000 m², allow for a computer room with a floor area of 8 per cent of the NLA and a power rating of 500 W/m².

— For larger buildings over 4,000 m², again allow for a computer room with a floor area of 8 per cent of the NLA, but in this case the power rating should be 750 W/m² for 5 per cent of the building NLA and 500 W/m² for 3 per cent of the building NLA.

The planning should take into account the guidelines given on page 5.06 for standby-generator and UPS provision.

This power requirement should be used to determine the computer-room component of the Electricity Board supply, the main supply cables, the space for power and cooling equipment, and the size of chilled water pipes.

The power supply to equipment in offices is generally known as 'small power' (sometimes as 'office power').

Figure 5.6
Increase in small-power requirements for IT equipment in offices
Small-power demand is growing rapidly because of the increasing penetration of IT equipment, and the change from dumb terminals to intelligent, networked workstations.

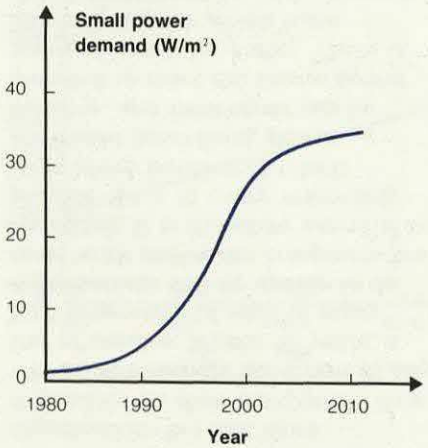


Figure 5.7
Small-power demand today
A high penetration of PCs in a city-centre office leads to a relatively high small-power demand, especially if space per person is low.

Staff	Mainly clerical	Managers/ professionals		Financial analyst/trading support
Location	City centre	Out of town		City centre
		Low use	High use	
NLA per person (m^2)	8	12	12	7
Penetration of 250 W PCs (%)	0	5	40	70
Penetration of 100 W terminals (%)	80	10	20	20
Workstation power density (W/m^2)	**10**	**2**	**10**	**28**
Shared equipment (W/m^2)	2	6	4	4
Small-power density (W/m^2)	**12**	**8**	**14**	**32**

Current situation
The power requirements of a building include small power, and the power needed for lifts, lights, and kitchen equipment. Until perhaps 10 years ago, small power was a minor element of the total requirement (see Figure 5.6). As IT equipment has spread into offices, however, small-power demand has grown substantially and has become a significant part of the total power requirement in non-air-conditioned buildings. Figure 5.7 shows a range of practical cases, based on our research.

Planning for a new building
In estimating the initial small-power demand for a new building, it is reasonable for the occupant to extrapolate from his existing usage. In doing so, he should take account of the main trends and uncertainties, discussed in Chapter 2 and the Appendix.

In the past, some occupants have greatly over-estimated their initial power requirements, basing them on the nominal power demand of their IT equipment (sometimes called the 'nameplate load'). The actual power demand of an IT device, such as a terminal for a personal computer (PC), is often one third or less of the nominal demand. Planners should base their estimates on the measured average power demands of the equipment to be used, and should never rely on the nominal loads.

The speculative building developer will generally have identified one or more commercial sectors as the likely market for a building. In deciding on the level of initial small power, he should consider the characteristics of that sector, especially the staff density, and the nature and penetration of workstations.

GUIDELINES

To define their initial power requirements for a new building, occupants should:

- Extrapolate from existing usage, taking current trends into account.
- Rely on the measured, not nominal, power demand of the equipment they intend to use.

The increased use of IT systems in offices will lead to higher levels of small-power demand in the future.

Figure 5.8
Ultimate small-power demand
Ultimate small-power demand is difficult to predict. Assumptions must be made about minimum net lettable area per person, diversity, and power per workstation, since the table shows, these affect power requirements.

Staff	Financial traders		Managers/professionals				High-tech research	
Location	City centre		City centre		Out of town		Out of town	
NLA per person (m^2)	5	8	8	14	10	15	12	20
Workstation penetration (%)	100	90	100	90	100	90	100	100
Diversity factor	1.0	0.9	0.9	0.9	0.9	0.9	1.0	0.9
Power per workstation (W)	400	200	300	200	300	200	750	400
Workstation power density (W/m^2)	**80**	**20**	**34**	**12**	**27**	**10**	**63**	**18**
Shared equipment (W/m^2)	22	8	11	4	8	4	15	5
Small-power density (W/m^2)	**102**	**28**	**45**	**16**	**35**	**14**	**78**	**23**

The future requirements for small power depend principally on five factors:

- Staffing density.
- Penetration of workstations.
- Use of workstations.
- Power consumption by workstations.
- The number of shared machines.

Staffing density
In Chapter 2 (page 2.04), we concluded that, for a single office floor, there was unlikely to be more than one person per 8 m² of net lettable area (NLA). In general, buildings in cities have higher densities that those in the countryside, and there can be even higher densities on financial trading floors (where there is also a high IT penetration) and in some specialised clerical functions (such as telesales).

A complete building will include areas such as meeting rooms, restaurants, and storerooms, which are not occupied continuously. The effective staffing density for a building is therefore typically 25 per cent lower than that for a single floor — thus, no higher than one person per 10 m² of NLA.

Penetration of workstations
As discussed in Chapter 2, the penetration of workstations is increasing rapidly and is likely to approach 100 per cent in most organisations in five years. During the same period, there will be a marked move towards intelligent workstations. The move from dumb to intelligent workstations implies a substantial increase in power demand. Today's PC consumes about twice as much electric power as a dumb terminal: a powerful engineering workstation may consume four times as much.

Use of workstations
Today's PCs are used in a rather different way from dumb terminals. While the typical dumb terminal is used by a clerk for a single application or a group of closely related applications, most PCs are used for a range of applications, often by professional staff. Thus, terminals are generally left running the whole day, while PCs are turned on only when needed. This has led to a reduction in actual demand for power, relative to the sum of the power demands of the individual machines. This reduction factor is termed the 'diversity' factor.

In the future, the intelligent workstation will combine the functions of the terminal and the PC. It will provide both local processing and access to information and systems residing on other machines. As their dependence on computer systems increases, users tend to leave their workstations running continuously. Taking into account the occasional absence of people from their offices, the diversity factor will therefore approach 0.9.

Power consumption by workstations
During the first decade of the existence of the PC, electric power demand first rose and then fell, despite a 100-fold increase in its storage and processing capability (see Figure A.4). It is impossible to predict the power demand of future workstations with any confidence, because improved technology will tend to reduce it, while increased demands for processing power and high-resolution colour graphics will tend to increase it. However, the power demand per workstation is unlikely to rise much above its present level of 300 W, and it may well fall.

The number of shared machines
For power planning, the most significant shared machine in today's office is the photocopier. The power consumption of a large office photocopier is about 1.5 kW. The increasing use of IT, and especially of document image processing, will reduce the requirement for paper copies and cause the replacement of copiers by printers. At the same time, however, the trend to intelligent workstations will increase the demand for power because they need shared facilities such as printers, communications gateways, and file stores.

These shared facilities usually run continuously, at least during the working day. The power consumption of shared file and print servers depends on the workstations they support. The power load due to these devices is typically about 20 per cent of that due to workstations.

Total demand for IT small power
Figure 5.8 shows that a wide variety of workstation power requirements can be calculated. Therefore, except for buildings constructed especially for financial trading in city centres, the ultimate demand for small power should be taken to be 40 W/m² of NLA. This figure should be used to size the power supply components on each floor.

For a whole building, or for a group of floors that includes meeting rooms, the ultimate demand for small power should be taken as 30 W/m² of NLA. The figure should be used in sizing the Electricity Board's supply to the building, the main cables and vertical busbars, and the main HVAC systems.

GUIDELINES

Designers should provide small power for IT at the following levels in new buildings:

- For a single floor: 40 W/m² of NLA.
- For several floors or a whole building: 30 W/m² of NLA.

The public electricity supply in most of Britain is of high quality and very reliable. The voltage and frequency are closely controlled, and typically only one or two supply failures occur in a year. Other disturbances, such as spikes due to switching in the supply authority's network, are much more frequent in some areas. IT systems are vulnerable to these disturbances.

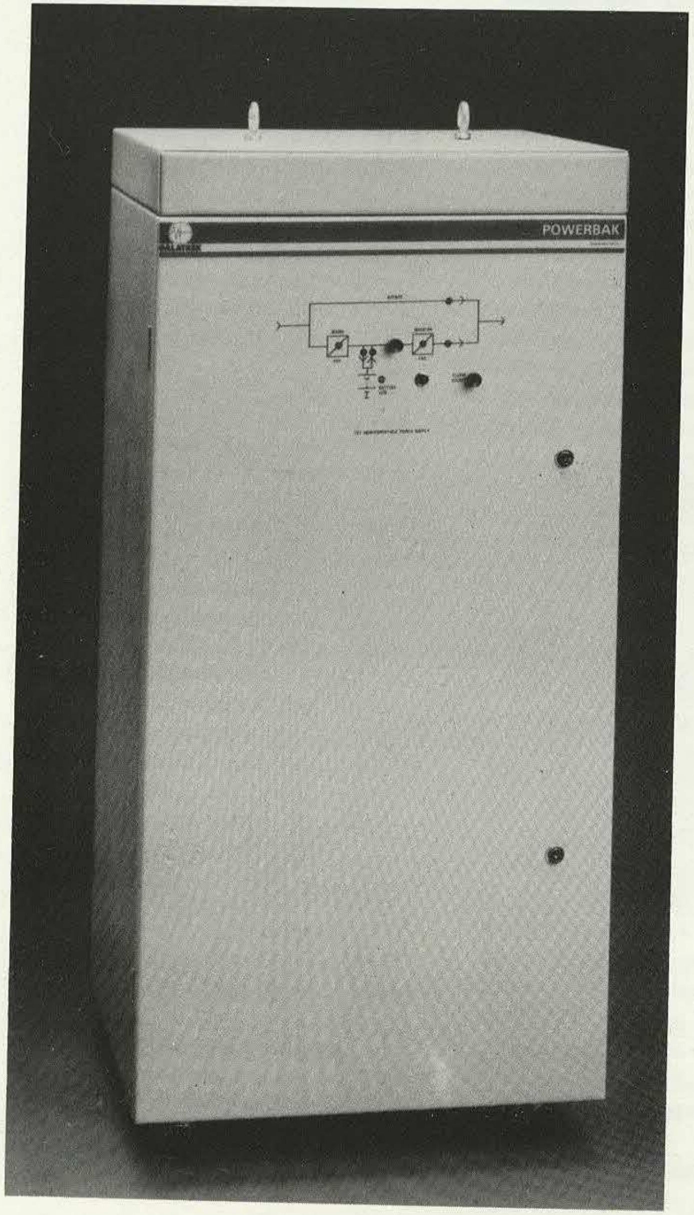


Figure 5.9
A typical UPS

Current situation
In larger buildings, the landlord often provides a diesel generator for emergency services such as lifts, emergency lighting, fire detection, and smoke extraction. However, tenants will not usually be provided with supplies that are protected against failures and disturbances. Some organisations regard these infrequent disturbances as acceptable, even for their computers. Others have decided that they must have their own standby generating capacity to enable them to operate during periods when the mains supply is unavailable, and this standby is generally provided by diesel generators. Diesel generators take 30 to 90 seconds to start, run up to speed, and deliver a stable voltage that can be connected to the main distribution board. Computers served from them will therefore stop, and complex recovery procedures may be needed to restore the files to a consistent state.

To avoid this, battery-powered UPSs, such as that depicted in Figure 5.9, are available, which completely eliminate any break in the supply to the computers. Since UPSs can provide power for many minutes, they can be used to give the operators time to conduct an orderly shutdown of the computers. They are more often used, especially for applications such as airline reservations and financial trading, in conjunction with diesel generators to make the computer room wholly independent of the mains supply. UPS units also eliminate the effects of disturbances other than complete failures in the incoming supply, and in the absence of diesel generators, are sometimes installed for this purpose.

Neither standby power nor UPS is generally provided for office areas since most electrically powered office equipment, lights, coffee machines, and copiers, are not damaged by a loss of power. The increasing use of IT equipment has altered this position somewhat, but organisations usually take the view that:

- A loss of terminal function is acceptable, provided that the computers are protected.
- Users of PCs must take periodic back-ups of their work and tolerate the effects of (rare) power disturbances.

In most cases, PCs and computer terminals in office areas can be operated from the public supply without taking any special precautions. However, in certain situations, such as airline-reservation offices and financial trading rooms, standby supplies are needed so that operations can continue in the event of loss of the public supply. If continuous operation is required, all building services, including lighting and air conditioning, must be considered.

Future requirements
The trend to distributed computer systems consisting of minicomputers or networked PCs, and the tendency to use them for operational, rather than decision-support applications, increases the impact of a power failure. There is therefore a growing requirement for secure power supplies to be available throughout the building.

The proliferation of local area networks (LANs) is creating a need for secure supplies to file servers (which are used to store departmental data). It is complicated to restart these systems following loss of power, and data may be lost. In a building that has a standby diesel generator and a battery-backed UPS, the simplest arrangement is to site these components in satellite equipment rooms on each floor, which can be fed with secure supplies and air conditioning 24 hours per day. Where there are no central secure supplies, or where the file server must be located in a work area, self-contained UPS units with integral sealed batteries can be used for each critical load. Typically, these units provide 30 to 60 minutes of power. This is long enough for staff to save current work and initiate an orderly shutdown.

It is generally neither economical nor operationally convenient to provide supplies from standby generators or central UPSs to a small proportion of outlets in office areas. A better approach is to provide the required level of standby power to all the outlets on a floor, or to a major part of a floor, accepting the costs of the additional generators and UPSs.

GUIDELINES

Where a standby diesel generator or battery-backed UPS is installed in a building, the power supply that it secures should be available in telecommunications closets and local equipment rooms to support departmental computers and file servers, and other distributed network components.

Some electrical loads in buildings, such as lift motors and air-conditioning plants, can generate voltage spikes and other electrical noise. In turn, this can be transmitted to IT equipment via the power cabling. As IT equipment is often sensitive to this type of noise, steps must be taken to control it. Some equipment is also sensitive to the radiation emitted from electrical cabling.

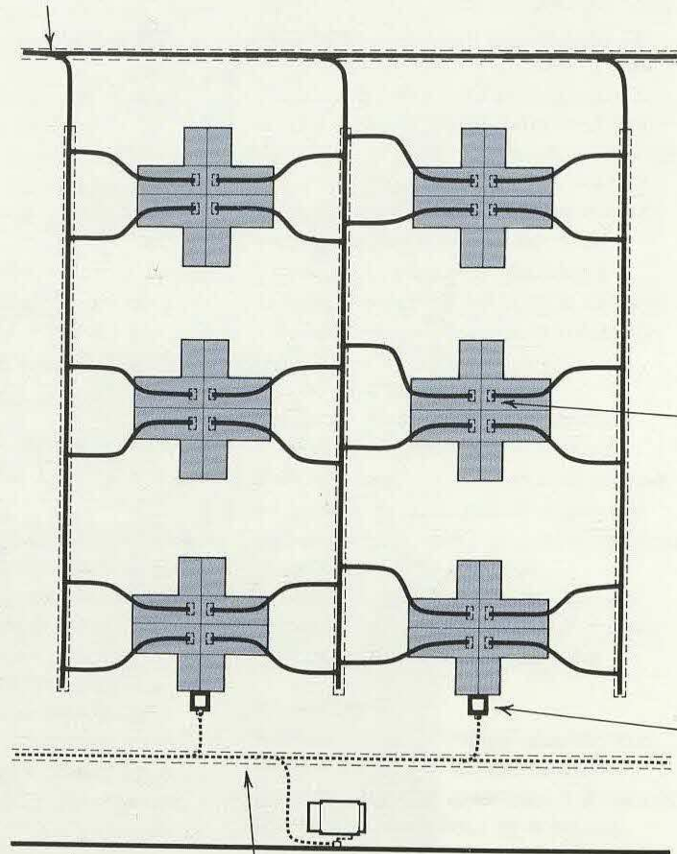


Figure 5.10
A typical cable layout plan for a floor of an office building
All desks require clean supplies. Separate circuits are necessary for electrically noisy loads such as uplighters, photocopiers, vending machines, and vacuum cleaners.

Providing clean power supplies
Good-quality IT equipment is quite tolerant of disturbances in the power supply. The 240 V ac supply is transformed to 5 V or 12 V dc inside the equipment, where it feeds a large bank of capacitors. They smooth out disturbances and can ride through millisecond interruptions.

In existing buildings, particularly sensitive IT systems may be protected by their own power conditioners. In some new buildings, desks are provided with their own clean supplies of power. This adds to the cost and makes subsequent equipment moves troublesome and expensive, because power supplies must be moved with the IT equipment. Relocation problems of this sort may be eliminated by providing a clean supply to every desk. Some designers have provided each desk with both clean and dirty supplies, using two separate power distribution systems. This approach adds yet more significantly to the installation cost.

Because every desk in a building is likely to support IT equipment, it is far less expensive to keep all desk supplies relatively clean by excluding dirty loads, and to provide separate supplies for the relatively few dirty loads such as large photocopiers and vacuum cleaners. This arrangement is shown in Figure 5.10. It may be appropriate to fit vacuum cleaners with special industrial plugs so that they cannot be plugged into the desk outlets.

Controlling radiated interference
Some IT equipment is susceptible to radiation from power cabling. Power cables that are run parallel to communications cables may induce currents in cables. Lighting circuits in which the live and neutral conductors are not run close and parallel may cause distortion on VDU screens. These problems should be controlled by segregation, screening, and good cabling practices.

Power cables should be kept away from voice and data cables, in their own ducts, where possible.

GUIDELINES

Power outlets serving desk areas should use standard 13-amp sockets complying with BS 1363.

Live and neutral conductors should be kept close together throughout their lengths.

Where power cables are run parallel to voice or data cables, they should be segregated in earthed metal trunking, or sheathed with wire braid armour that is bonded to earth.

Separate distribution circuits should be provided to wall- or column-mounted outlets for electrically noisy loads, such as large photocopiers and vacuum cleaners.

Office IT systems need to be earthed for electrical safety, for electromagnetic screening, and in some cases, for signalling. Tenants are often given conflicting advice about the earthing of IT systems by power, telecommunications, and computer-systems engineers, each of whom has a slightly different perspective and sees an incomplete picture. In fact, earthing of IT equipment is relatively straightforward. Since electrical safety must be the first priority, IT equipment usually needs to be earthed in accordance with the Institution of Electrical Engineers (IEE) wiring regulations.

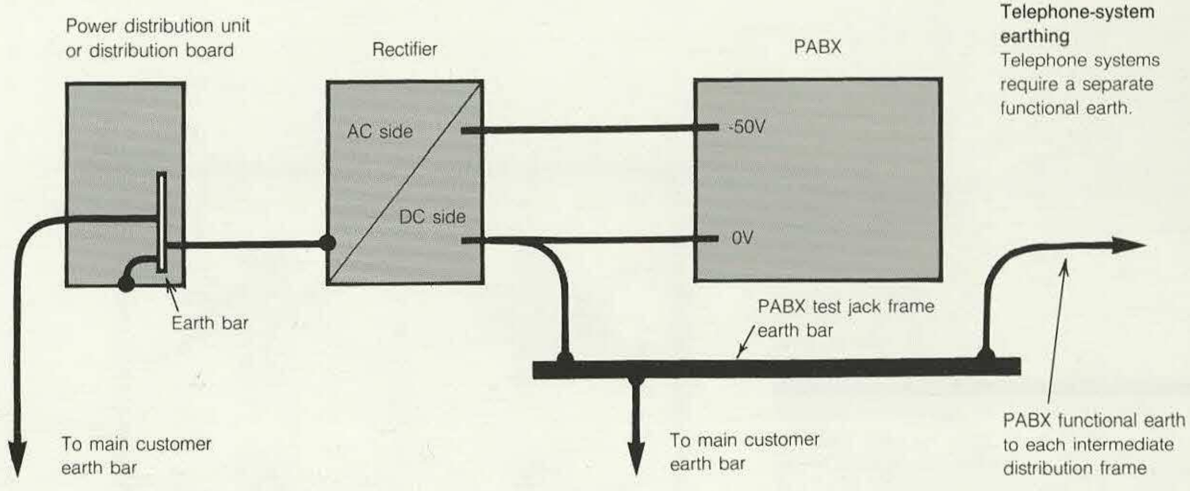


Figure 5.13 Telephone-system earthing
Telephone systems require a separate functional earth.

Figure 5.11 Computer-system earthing
Computer hall and other equipment rooms

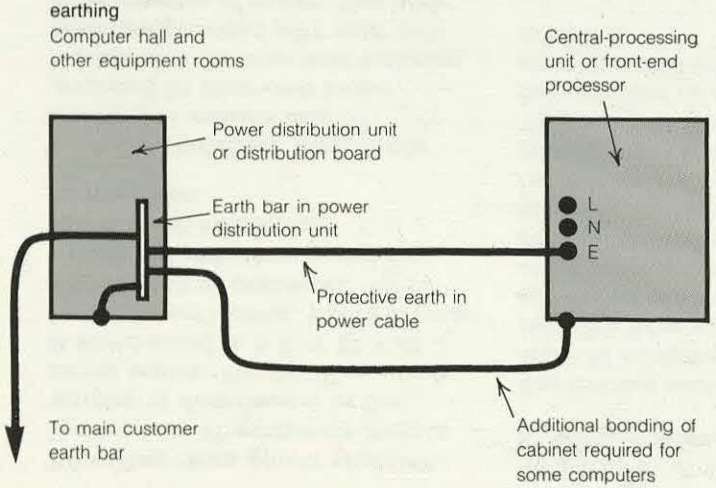
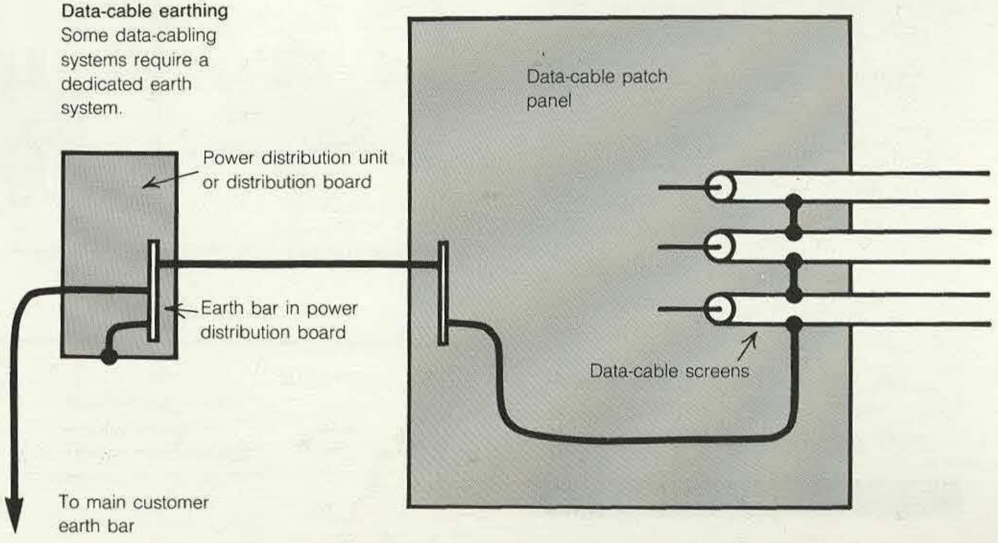


Figure 5.12 Data-cable earthing
Some data-cabling systems require a dedicated earth system.



Requirements
Most equipment should have an electrical safety earth. Desktop and small office systems will be supplied with a three-core power cable that must be fitted with a three-pin plug and connected to a standard outlet socket that provides an earth connection.

Some computer suppliers specify a relatively noise-free ('clean') earth connection. However, it is difficult to provide a completely segregated clean earth system and this should not be attempted. Instead, the systems should be connected to the main electrical earth in the building using a dedicated 3-core, or for three-phase equipment, 5-core power cable, in compliance with the IEE wiring regulations. This is shown in Figure 5.11.

Some data communications cables have a metallic screen surrounding the signal-carrying conductors. The purpose of the screen is to minimise the pick-up of electrical noise, and also, in some cases, to reduce the radiation of radio-frequency data signals from the cable. These cable screens should be earthed, but the earthing arrangements vary from one system to another. Screened cables must therefore be installed in accordance with the system supplier's instructions. Some cabling systems work best if their earths are independent of other earths in the building, and a separate earth system for cable screens, connected to the main building earth at a single point, should be installed as shown in Figure 5.12.

An earth wire is required for 'earth recall' signalling between telephone instruments and a private automatic branch exchange (PABX). PABX installations have a separate earth wire from the central equipment to each riser closet, which is connected to every telephone. It is important that this telephone system earth be kept separate from the electrical safety earth throughout the building, except at a single connection point, which is usually at the main distribution frame. This is shown in Figure 5.13.

Reference

Regulations for electrical installations. 15th edition. Institution of Electrical Engineers, 1987.

GUIDELINES

Separate earth-recall cabling for PABXs should be installed in the communications risers.

A separate earth for data cable screens should be installed in the communications risers.

Large computer installations that require a relatively 'clean' (noise-free) earth connection should be connected to the main electrical earth in the building with a dedicated cable that is part of the main electrical distribution system.

The earthing of lightning conductors should be considered as part of the overall building earthing scheme.

Figure 5.14
Electrical-equipment-room earthing

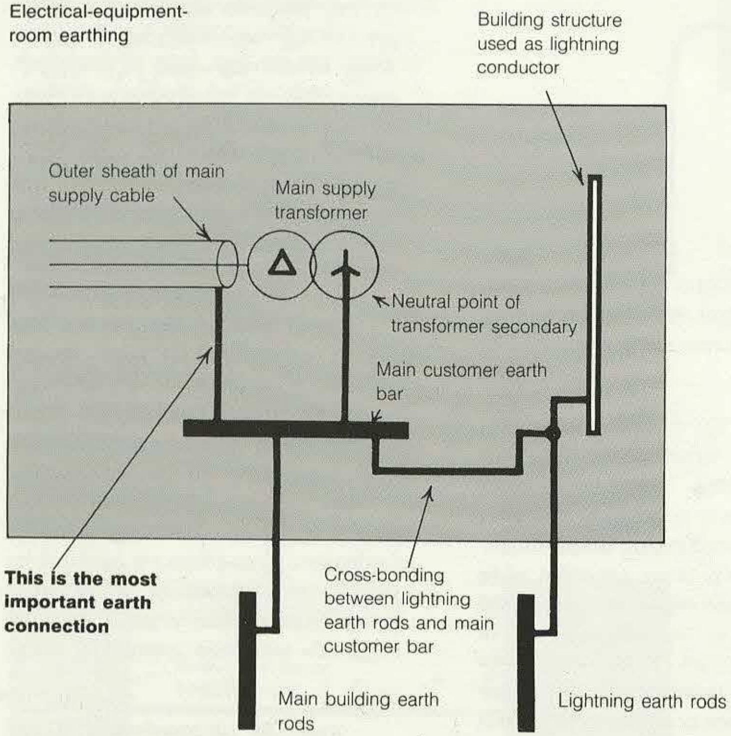
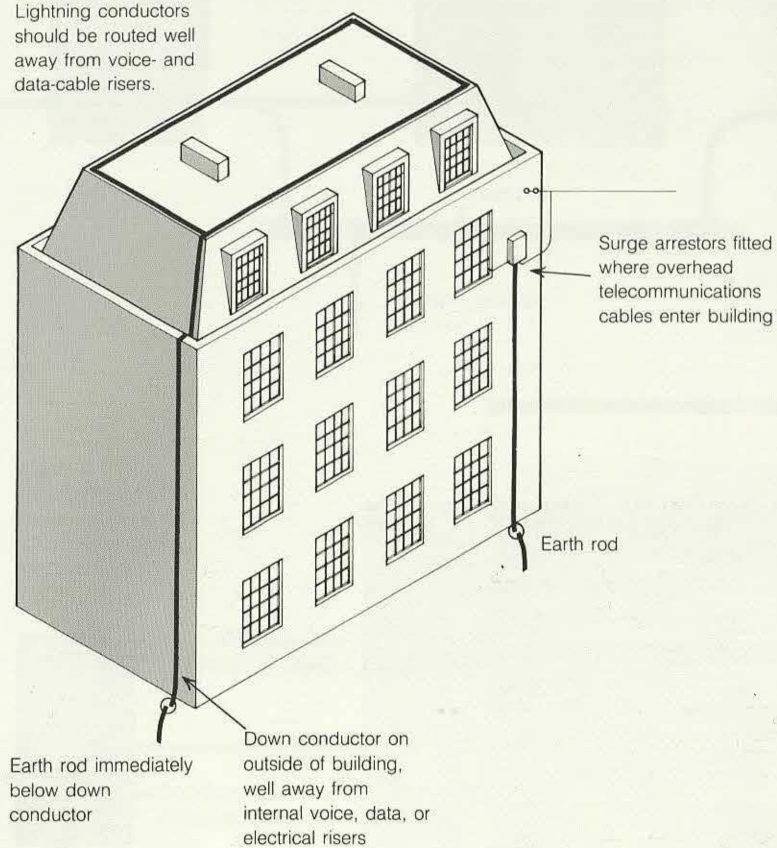


Figure 5.15
A typical external lightning conductor on an older building
Lightning conductors should be routed well away from voice- and data-cable risers.



In Britain, with its generally high soil conductivity, it is not necessary to bury large quantities of copper in the ground to achieve an adequate electrical safety earth. The most important connection is an earth return path to the Electricity Board's transformer. The worst credible event is a flash-over in a supply transformer from the 11 or 33 kV line to the transformer casing. In this event, buried copper alone will not prevent the building earth system from rising to a potential of several thousand volts, but a reasonable earth return cable to the supply authority's transformer (shown in Figure 5.14) will limit the rise to a few hundred volts. This voltage rise will not harm the occupants since the whole building will be at one potential internally.

Lightning conductors are usually run on the outside of buildings, as shown in Figure 5.15. Sometimes they are run within building risers. The latter route is unsafe, since not only may the lightning arc onto other internal cables, but the magnetic field produced by the lightning current will induce currents in other cables, which may cause damage. The British Standard on lightning conductors requires all conductors and earths to be bonded together. Unfortunately, this is likely to lead, in the event of a lightning strike, to very high voltages reaching IT equipment via its earth.

There is a risk of lightning striking communications cables outside the buildings, whether over- or underground, if they fall outside the protective zone provided by lightning conductors.

Reference

Code of practice for protection of structures against lightning. BS 6651. London: British Standards Institution, 1985.

GUIDELINES

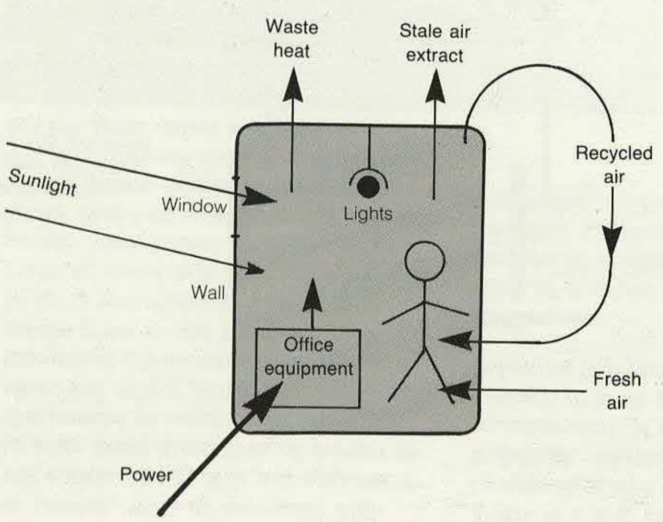
Where lightning conductors are run outside the building, they should be at least 2 m from internal voice, data, or electrical risers.

Any outside communications cable, including a buried cable that runs outside the protective zone provided by lightning conductors, should be fitted with a surge arrester.

Heating, ventilation, and air conditioning (HVAC) systems are installed in office buildings to provide an acceptable working environment. IT equipment places additional demands on the HVAC system, mainly in the requirement to remove excess heat, but also in the need to avoid extremes of low humidity which can lead to static build-up.

In city centres, where it can be noisy and dusty, it is common practice to install sealed glazing and a full variable air volume (VAV) HVAC system with perimeter heating. Out of town, where noise levels are often lower and opening windows are practical, partial HVAC systems provide 'comfort cooling'.

Figure 5.16
Energy flows and air circulation in an office environment
Removal of excess heat is one of the major functions of an HVAC system in a modern office building.



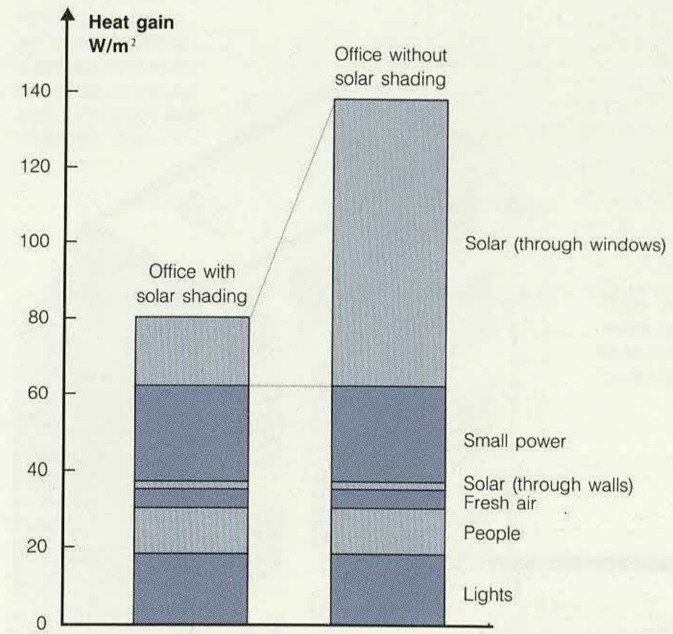


Figure 5.17
Heat gains in two typical office buildings in Europe
Heat from IT and office equipment is only a part of the excess heat to be removed.

Current situation
In older buildings, only heating was provided, and this was most commonly achieved by circulating hot water through radiators. Fresh air was provided simply by opening windows. More recently, the emphasis has switched from heating to cooling, because of the use of large sealed windows, and the installation of increasing amounts of IT equipment. So far, the solar gains have been more significant, but as shown in Figure 5.17, the heat gain can be reduced by providing external shading, in the form of projecting sunshades, blinds, or some more advanced technology (the term 'intelligent skin' is sometimes used).

The deployment of IT systems has already increased the heat gain by as much as 10 W/m² in many buildings. In the admittedly atypical case of financial dealing rooms, the heat gain may be as high as 75 W/m².

Future requirements
Occupants should demand high adaptability in their HVAC systems. The systems should be able to provide satisfactory working conditions even when the nature and amount of IT equipment changes. This adaptability can be provided in a variety of ways. In a chilled water system, the pipes may be made larger than required initially, at modest cost. Additional heat loads may then be met by adding cooling units, as necessary. If these heat loads are moved, the units may be turned off, or even relocated.

Designers should consider two factors, in particular:

IT heat dissipation: As discussed on pages 5.04 and 5.05, the power requirements, and therefore the heat output, of office IT systems are likely to increase progressively towards a maximum several times higher than today's levels. In many offices, however, this increase will not be a steady progression as the balance between workstations and central computers moves to and fro (as discussed on page A.06).

IT systems are not the largest source of heat within the office but they may be the largest sources in particular areas. IT systems will be the most uncertain element since other elements are functions of location, building structure, and lighting design, all of which are known during fit-out.

Serviceability: As IT becomes more vital to the normal functioning of organisations, the cooling systems also become more vital. It will therefore be more and more important to ensure that these do not fail. HVAC systems should be designed with some redundancy in the primary plant and circulation components.

References
Traffic noise and overheating in offices. BRE 162. Watford: Building Research Establishment, 1979.

CIBSE guide: design data: internal heat gains. Volume A, Section A7. London: Chartered Institution of Building Services Engineers, 1986.

GUIDELINES

The HVAC systems should cope with the heat dissipation implied by the power planning numbers.

The HVAC systems should be able (possibly by physical adjustment) to maintain acceptable conditions following any of the following equipment moves (providing that the total heat dissipation remains within the design limit):

- A 1 kW workstation in any office of 6 m².
- A 1 kW printer in any office of 25 m².
- A 2 kW photocopier or similar machine in any office of 100 m².

The HVAC central plant should be designed on a modular basis to provide flexibility.

The HVAC systems should include sufficient redundancy to ensure that cooling for all the computer-room and communications-closet equipment, and at least 66 per cent of the office equipment, can be restored within 30 minutes following any failure of a single HVAC component.

The function of an HVAC system is to maintain the physical environment within certain specified limits, most usually of temperature, fresh-air flow, and occasionally, humidity. The HVAC system is dynamically controlled in response to measured or calculated conditions in the building. In most office buildings, the HVAC control zones are too large; often, the HVAC is on or off for the whole building at once. As a result, the building is uncomfortable to work in outside normal working hours, and within working hours when solar gains affect one area more than another.

Figure 5.18
A typical office interior
The penetration of IT equipment is reaching 100 per cent in some offices.

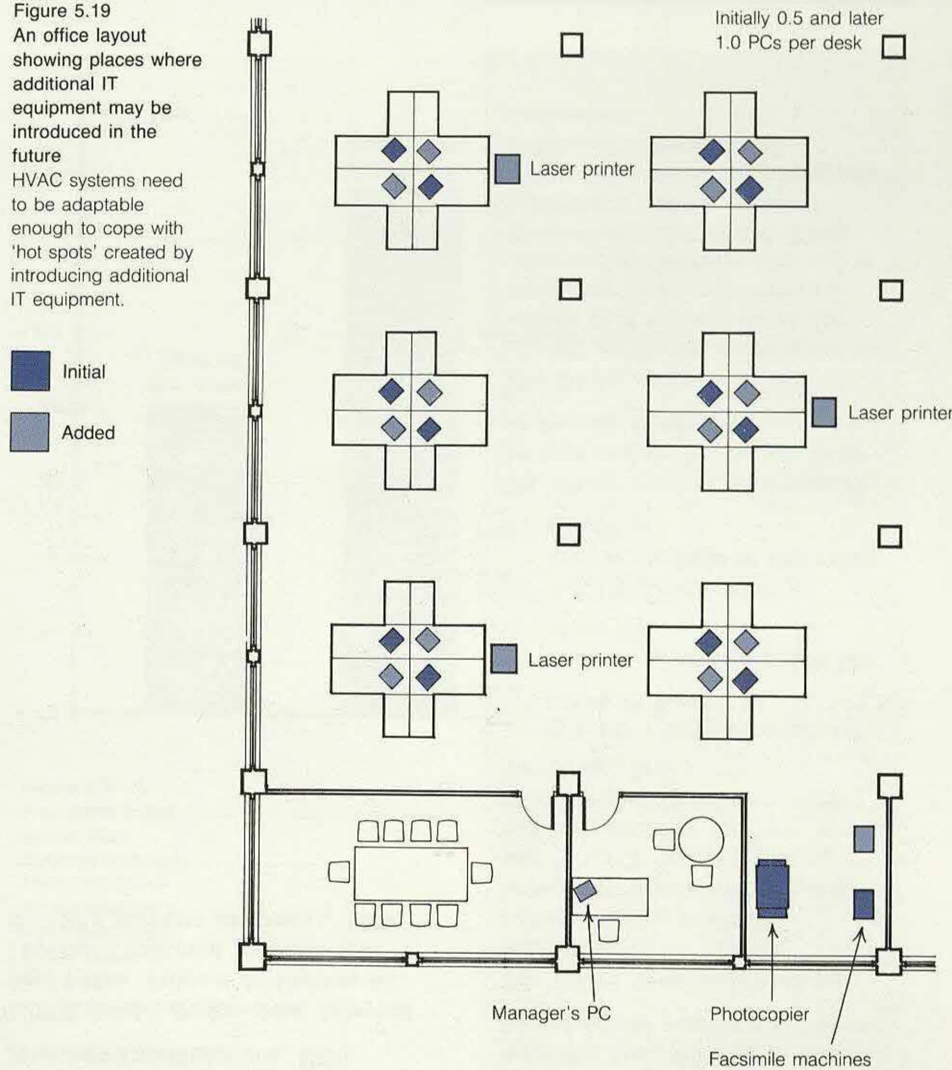


Figure 5.19
An office layout showing places where additional IT equipment may be introduced in the future
HVAC systems need to be adaptable enough to cope with 'hot spots' created by introducing additional IT equipment.

Future developments
The past few years have seen a progressive extension of working hours. In many offices, staff may be found working earlier, or later, or over weekends, either to meet deadlines or for their own convenience. These habits are likely to grow more common, especially as the use of word processing and electronic mail replaces the need for secretaries and meetings. At the same time, there are likely to be mounting pressures to maintain, or improve, the quality of the office environment. These pressures will come from staff and, less certainly, from government.

In some parts of northern Europe, there are already laws requiring every office worker to have his or her own window, individual control over lighting, temperature, and ventilation, and even the ability to open the window. While there seems no immediate prospect of the adoption of such laws by the British government, both the example set in European offices and the desire to raise working standards through the European Community are likely to have some impact. This impact is likely to become effective only slowly, but may be significant over the life of the HVAC systems being installed today.

Some recently completed offices already provide control at the level of offices or individual work areas. This may be provided in the form of direct control of the apparatus, or infra-red control units, or via the telephone and a link to a building-management system.

It should be possible to provide staff with satisfactory working conditions outside normal working hours, without excessive costs. This can generally be achieved by providing separate HVAC controls for each floor, or for smaller areas where the floors are particularly large.

The requirements for smaller control zones, and the savings available from integrated energy management, indicate a need for an integrated building-management system in all but the smallest office buildings.

Reference

Code of practice for design of buildings: ventilation principles and designing for natural ventilation. BS 5925. London: British Standards Institution, 1980.

Ventilation requirements. BRE 206. Watford: Building Research Establishment, 1981.

GUIDELINES

The HVAC system should:
- Provide economical partial operation out of normal working hours and at weekends.
- Provide control for each individual office or small group of desks in open-plan areas.

A variety of building control systems, relating to power, lighting, HVAC, access control, surveillance, and emergency procedures, may be found in office buildings. In most cases, these systems are not integrated, and each runs on dedicated cabling.

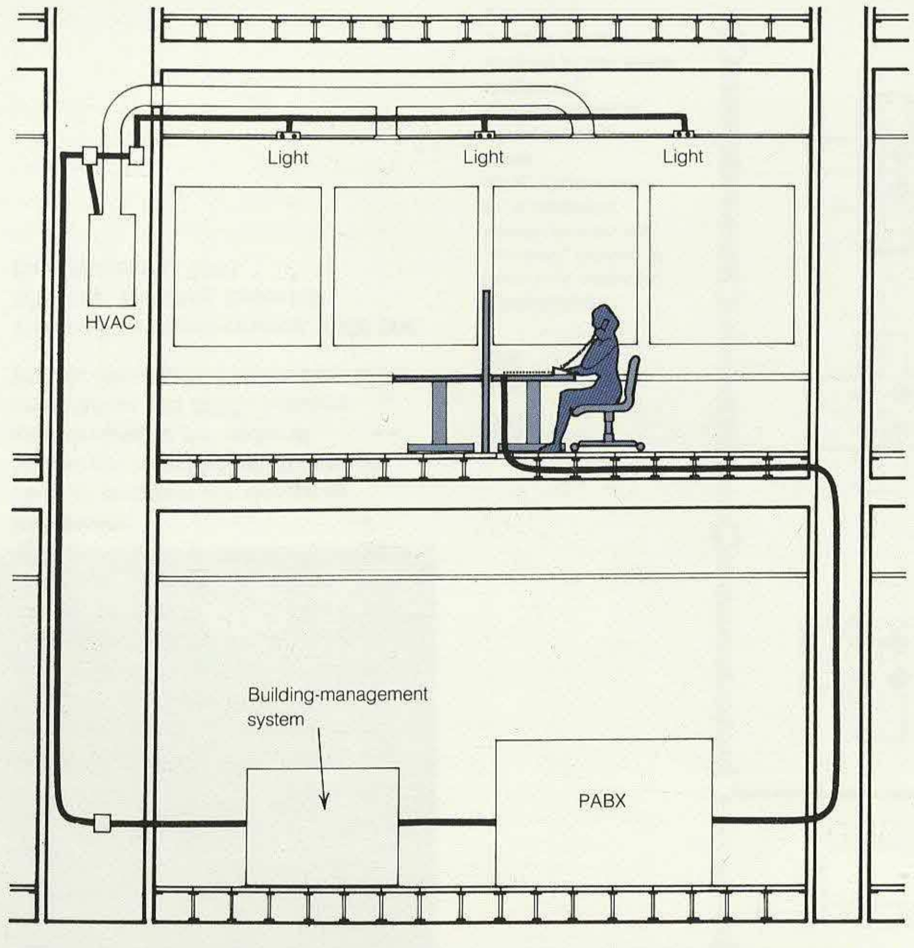


Figure 5.20
A diagram showing how office telephone equipment can be used for local control of lighting and HVAC
A link between the PABX and the building-management system enables the individual user to control his environment without loss of central monitoring or pre-emptive control.

Current situation
The various elements of building management have developed independently because of their differing origins and requirements. In each area, there is a mixture of common and proprietary standards, as a result of which equipment from different suppliers is often unable to interwork fully.

Recently, the belief has grown that, in the future, 'high-tech' or 'intelligent' buildings will become economically viable and widespread. A common theme of these concepts is the complete integration of all information and control systems including those that support the occupier's business.

Business-oriented systems
Business-oriented systems will generally be controlled by the tenant. They should not be integrated with building-oriented systems because:

- The point of delivery is different (that is, they need to be delivered to desks rather than to plant rooms and other building spaces).
- They are subject to frequent changes in response to changing business requirements.

It may, however, in owner-occupied buildings, be possible to link these systems in order, for example, to provide telephone access to the public address system, to use the telephone as a control device for the HVAC and lighting, as shown in Figure 5.20, or to provide user access to facility management systems.

Some owner-occupiers may benefit from the use of common components in their building- and business-oriented cabling systems.

Building-oriented systems
All building-oriented systems are linked quite closely to the structure and services of the building and should therefore be treated as part of facilities management. In the case of a landlord-operated building, it is often appropriate for the landlord to take responsibility for these systems.

Building-oriented applications include heating, ventilation, and air conditioning (HVAC) plant controls, fire alarms, security, public address systems, and automatic lighting controls. (In some cases, these may be related to a campus rather than to a single building.) Building-oriented systems are often designed and implemented separately. The benefits of integrating these systems include:

- Lower energy and water costs.
- Better information during fires.
- More appropriate responses to changing circumstances and patterns of use.

In the future, these advantages will outweigh the advantages of procuring discrete subsystems. However, there are, at present, very few suppliers of integrated systems.

GUIDELINES

The cabling needed for building-oriented systems, such as energy-management systems, public address, and security, should be part of the building design and should be installed by the developer.

At least in multi-occupied buildings, the cabling for building-oriented systems should be maintained by the landlord.

Voice and data cabling is required to support business-oriented systems. It may include telephony, data communications for terminals, personal computers (PCs) and workstations, electronic mail, facsimile, and teleconferencing.

Figure 5.21
A DECconnect faceplate
Separate sockets are provided for voice, video, terminal support, and Ethernet communications.

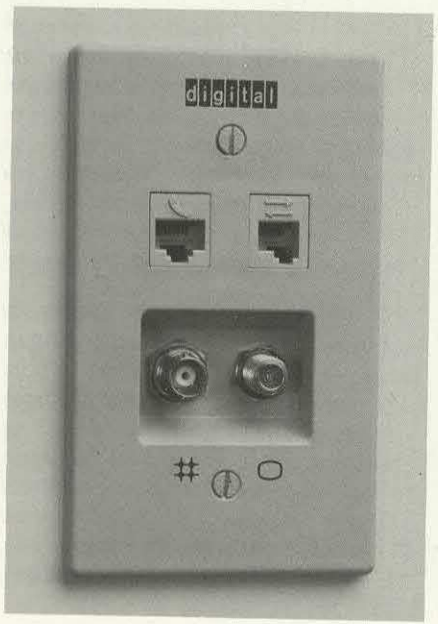
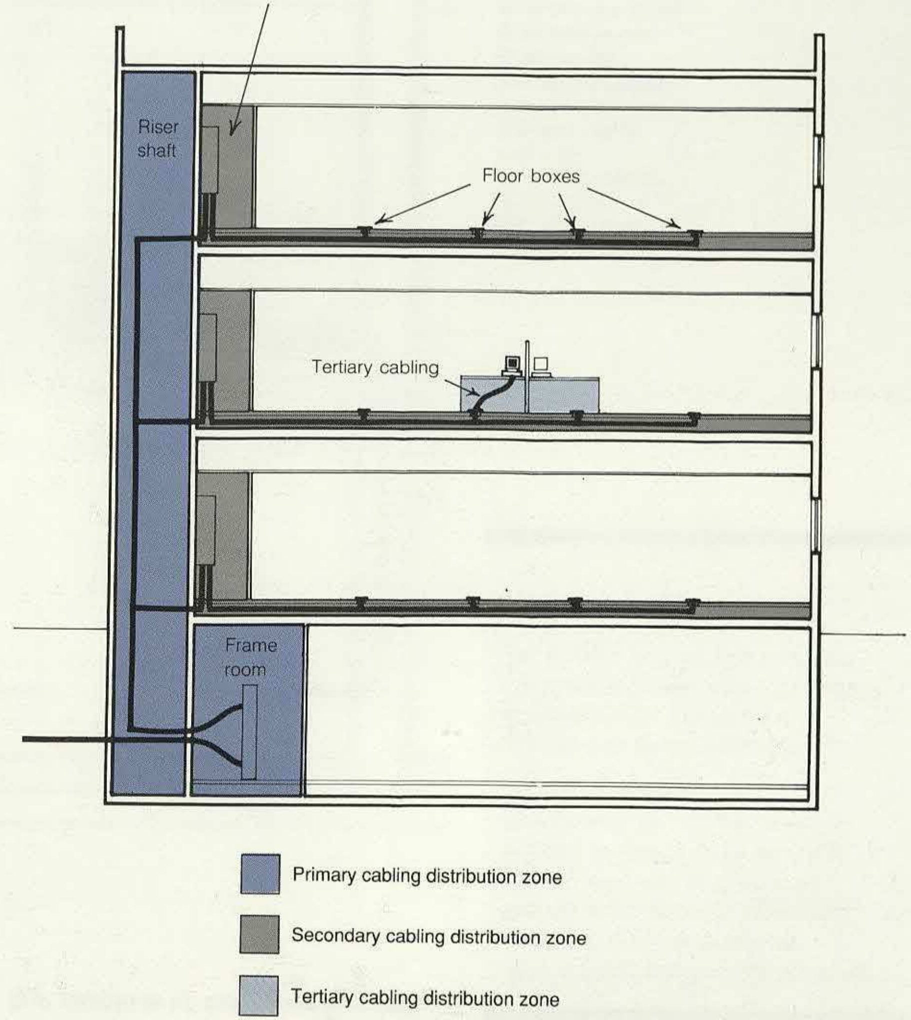


Figure 5.22
Cabling distribution zones in a typical office building



Current situation
Organisations vary greatly in their approach to telecommunications. For instance, they require different levels of availability, leading to different relationships with their suppliers, and they also use different computing and communications architectures, which often lead them to install different kinds of building cabling. Because of these differences, developers rarely install voice cabling, and almost never any cabling for non-voice services.

Business-related telecommunications are only loosely linked to the building, but are quite strongly linked to the business and to its other IT systems. Computer data transmission exists largely as an adjunct of computer systems, and this is so even when the data network is operated as a separate utility. Applications such as electronic mail and electronic data interchange (EDI) depend at least as much on the compatibility of data formats as they do on networking, and each is increasingly closely linked with other computer applications.

Future requirements
Voice systems are usually supported by copper cables installed in a standardised star configuration. It is reasonable to plan on the basis that this will continue, although multipair riser cables may be replaced by fibre in some cases.

Schemes such as AT&T's Premises Distribution System (PDS), BT's Open Systems Cabling Architecture (OSCA), DEC's DECconnect, and the IBM Cabling System (ICS) define the cables that should be used in both the primary and secondary distribution, as shown in Figure 5.22. Electronic interface units (known as 'baluns' or convertors) are used to enable a wide variety of IT equipment, including terminals, PCs, workstations, printers, and facsimile transceivers, to operate over the specified cables. With these schemes, the choice of cable is not determined by the architectures and protocols used by the attached IT equipment.

Therefore, voice and data cabling schemes can both now be treated as building utilities.

At present, there are a number of proprietary cabling schemes, but no common standard. This difficulty has not been resolved in the draft (North American) Electronic Industries Association (EIA) standard, which defines three different kinds of copper cable for horizontal distribution rather than a single type.

The IT industry is, however, converging on a single standard for optical-fibre cables. This will serve to define a single, widely accepted, standard for communications 'cabling'. A cabling scheme installed to this standard would form a building utility, and this is likely to become economically feasible in some buildings within the next five years.

GUIDELINES

Telecommunications cabling should be installed during fit-out. In the case of a 'shell-and-core' development, responsibility for this stage will naturally fall to the occupant.

Where the developer controls the fit-out, he should liaise with the first occupant, and especially with that occupant's IT department.

If no initial occupant has been identified, the developer should follow the guidelines given in Chapters 6 and 7.

Security systems are used for surveillance and to control access to and within a building. Systems include closed-circuit television for internal and exterior surveillance, intrusion detectors, security gateways, and identification cards.

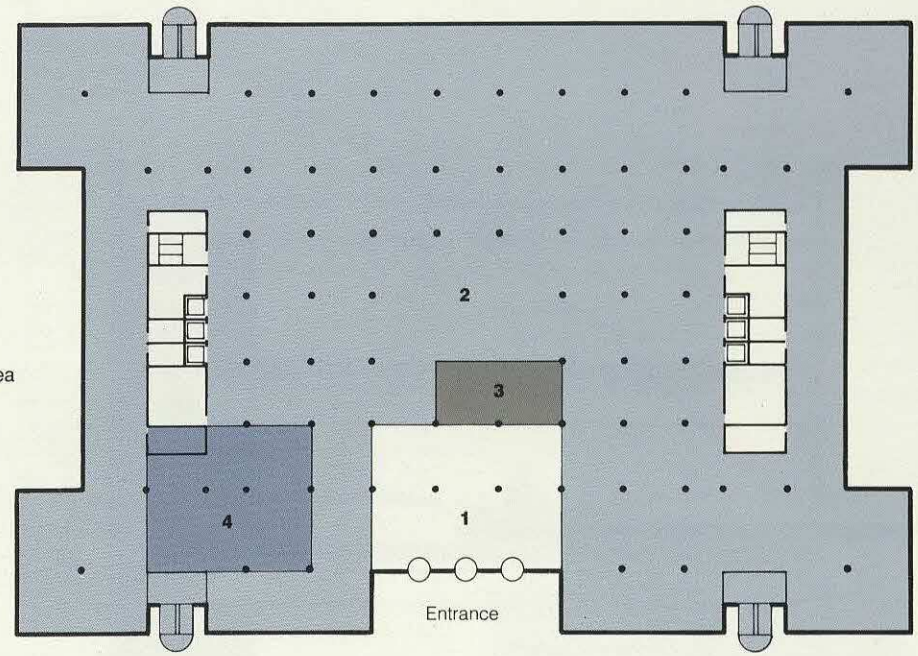


Figure 5.23
Plan of an office building showing typical security zones and security-control office
Security zones should be considered when planning circulation routes.

Zone 1: Lobby

Zone 2: General office area

Zone 3: Security office

Zone 4: Machine room

Figure 5.24
A typical CCTV camera for security surveillance

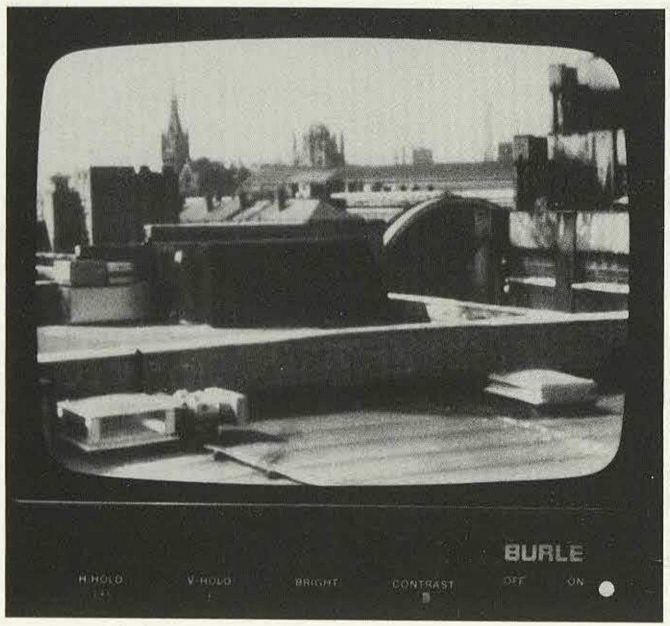


Figure 5.25 Some building-security measures

CCTV surveillance of:
- Car park.
- Building exterior.
- Reception area.
- Goods entrance.
- Computer room.
- Corridors.

Burglar alarms on windows and doors.

Pass-card-operated doors and gateway to car park.

Figure 5.26 Some computer-suite security measures

Physical access controls for access to and between zones:
- Computer room.
- Control bridge.
- Reception area.
- Remainder of building.

CCTV surveillance of computer room from the control bridge and/or security office.

Occupancy sensors in computer room.

Current situation
In the design of many existing office buildings, little attention has been paid to security. In practice, therefore, it has been necessary to add security measures, such as those listed in Figure 5.25, after occupation and in response to changing circumstances.

Most computer users have already recognised the potentially disastrous consequences of damage to mainframe systems. The corruption or theft of business data could create severe embarrassment to an organisation and might damage its business performance. They have therefore introduced tight security in that area. (This point is discussed further in connection with computer-room design.) The requirements for computer-suite security are unlikely to decline. The security required will usually comprise access controls, and surveillance from both the computer suite bridge and the site security office. Some computer-suite security measures are listed in Figure 5.26.

Organisations have, however, been slower to recognise the risks associated with personal and departmental computers. Personal computers (PCs) are themselves valuable, and attractive to thieves. In addition, both PCs and departmental computers are now used to run important business systems that might previously have been developed for mainframes.

There are trends for PCs to have their own hard discs and to use shared file servers for their data. In both cases, the discs themselves will be in the general office areas, or perhaps in small equipment rooms, rather than in the main computer centre. These trends in IT will require better security to be provided to office areas generally, and to small departmental computer rooms.

References

Goldblum, Edward. *Computer disasters and contingency planning.* London: Amdahl and Butler Cox, 1982.

G U I D E L I N E S

The building should provide a basic security system, controlled from a central security office.

Information technology affects office space requirements, and the design of functions and fittings. An important design consideration is the density and positioning of service presentations, the points at which staff can gain access to IT services. The trend towards installing an intelligent workstation at every desk is leading to a proliferation of structured cabling systems, for which a space allowance can be made per presentation. Although copper cables to the desk will begin to give way to optical fibres in the 1990s, precabling with optical fibres in secondary distribution is unlikely to be economic today. Finally, the use of VDUs in offices has changed significantly the requirements for office lighting.

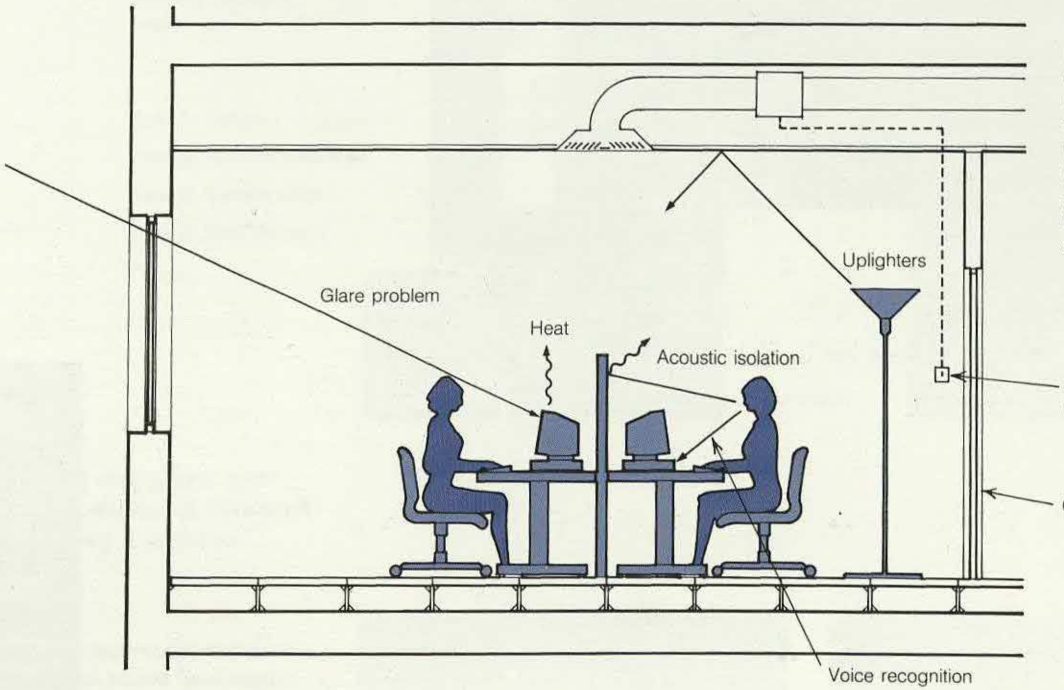


Figure 6.1
Influences on office scenery
Office scenery is influenced by the occupier's requirements for privacy, acoustic isolation, security, and so on.

Contents

Space planning is the process of designing or selecting and configuring furniture, carpets, wall coverings, and lighting to meet a particular occupier's requirements.

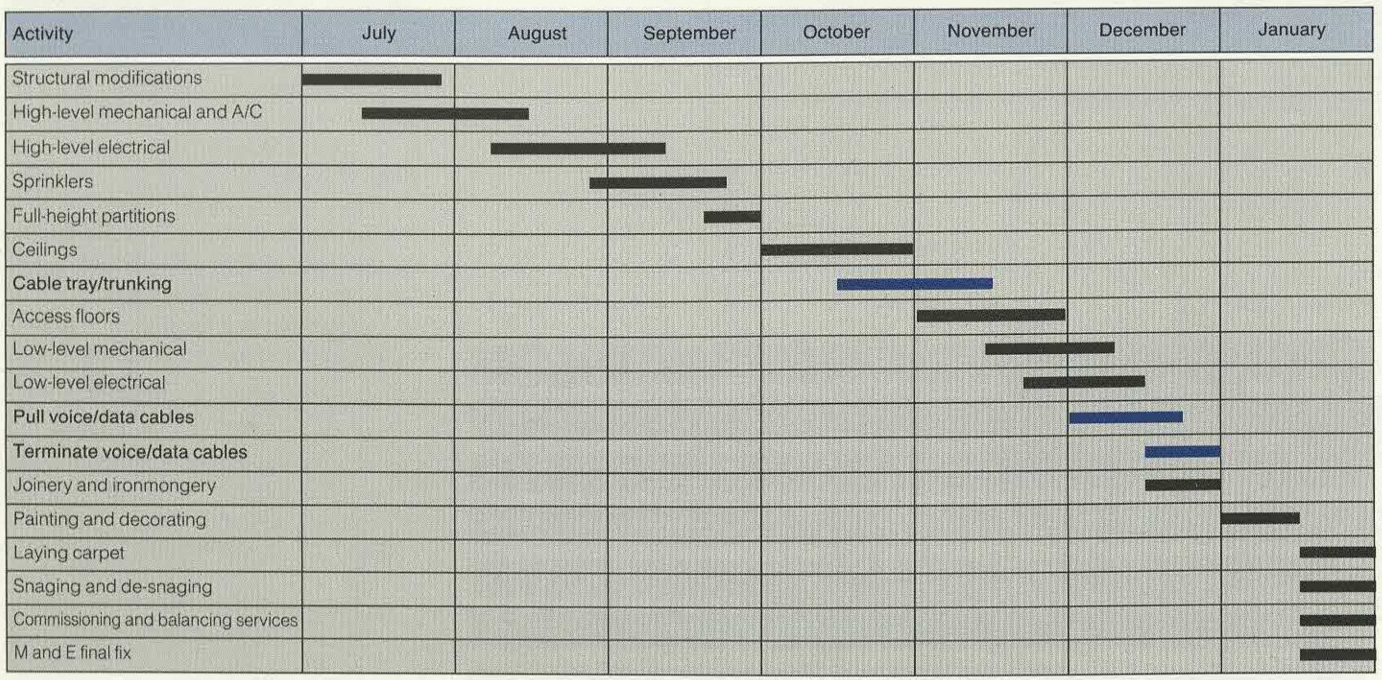


Figure 6.2
A typical programme for fitting out an office
Voice and data cabling activities should be included in the fit-out programme.

Design options
At one extreme, the landlord fits out the building before knowing the identity of the occupant, and the occupant moves existing furniture into otherwise completely prepared offices. At the other extreme, the occupant takes the building at the 'shell-and-core' stage and finishes it from that point. In the first case, many of the important fit-out decisions have been made by the developer and the occupant independently of one another. In the second case, the decisions are taken together during an extended fit-out stage.

Interiors are best designed on behalf of a particular occupant because:

- Their character and culture can be considered by the planners.
- The specific requirements of the occupant can be met.
- Over-provision can be avoided.

The dilemmas
Interior design presents several dilemmas:

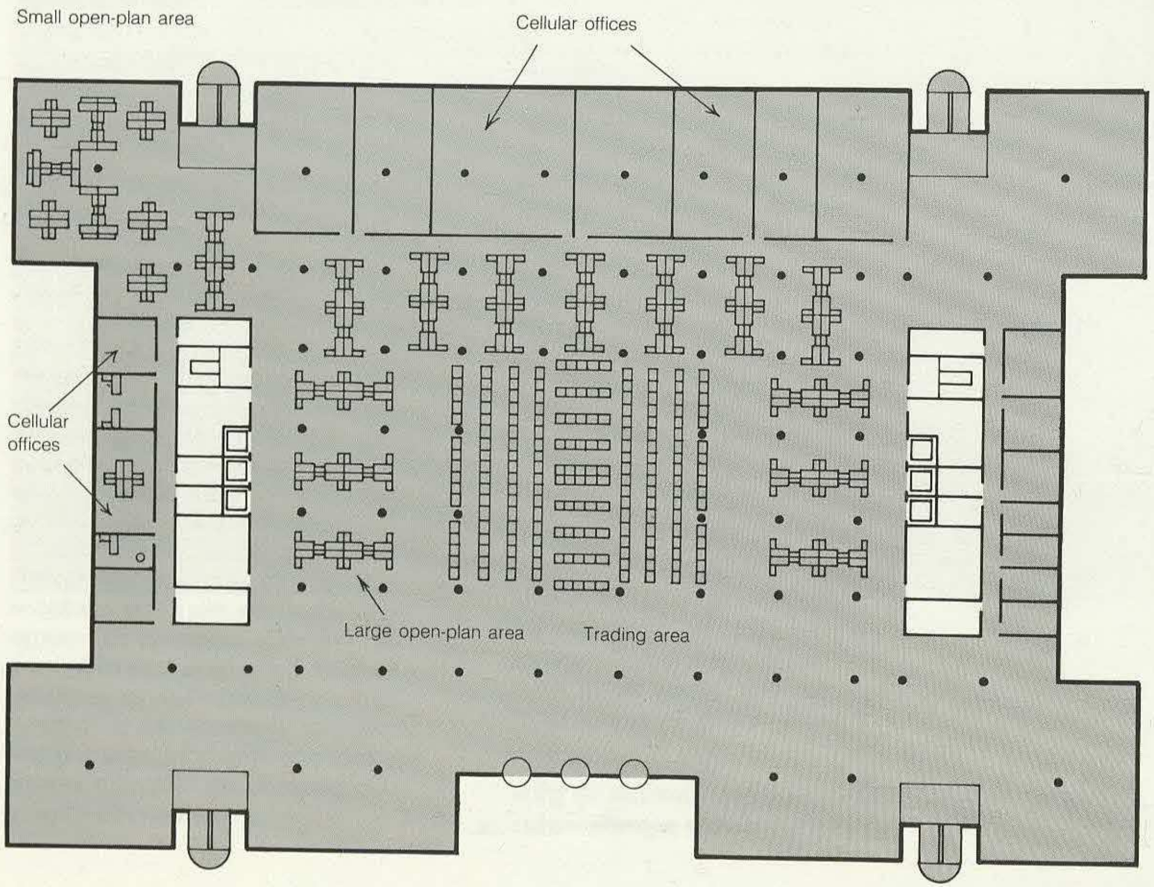
- The best results are obtained when the working groups to be accommodated are known. However, the results may not be suitable for other working groups that will subsequently use the space. Large organisations are therefore often obliged to design to fixed standards, and then get workgroups to accept the result.
- Office space is expensive, but staff do not generally like to be crowded together.
- Staff like to be free to move their desks, chairs, and any other furniture within the space allocated to them. However, if desks are fixed, lighting and service distribution can both be improved, and at lower cost.
- Open-plan offices provide economies in space, lighting, and air conditioning, but staff generally prefer cellular offices or offices that accommodate small groups.
- Staff generally prefer to have personal control of their environments. Conceivably, these desires may be backed by legislation in the future (as has already happened in some other European countries). This is most easily achieved in cellular offices.

GUIDELINES

Interiors should be designed to be used by a specific organisation, but not with particular working groups in mind, unless their requirements are incompatible with normal office practice (for example, financial dealing floors, or laboratory clean rooms).

Figure 6.3
A typical office layout showing open-plan space and several sizes of cellular space

Office layouts usually include a mix of cellular and open-plan space. If flexibility of layout is to be maintained, the electrical, voice, and data services designers must be informed of the degree of flexibility to be achieved.



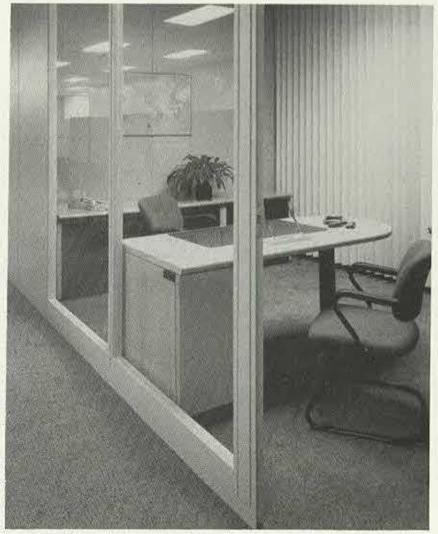


Figure 6.4
An office interior capable of providing individual cellular space

Figure 6.5
An office interior providing mostly open-plan space

Figure 6.6
An office interior arranged as a trading floor

Different approaches will be needed depending on the nature of the space to be planned and the stage at which the space planner becomes involved. The options might range from cellular offices, to open-plan areas to be divided into cells by furniture, to genuine open-plan spaces.

In each case, the space planner must take account of the requirements of the IT systems for services, and of their implications for the design of furniture, finishes, and lighting. Because space planners and IT planners have little experience of working together, the occupant's management will often have to take responsibility for seeing that there is collaboration.

Cellular offices, such as those shown in Figure 6.4, are the easiest to deal with. There is often perimeter trunking through which services are provided to the office. The distribution of cables within the office may be achieved by loose lay around the periphery of the office, or via wall conduit, or using cable management in acoustic screens (if the office is big enough to warrant their use).

Open-plan offices, such as those shown in Figure 6.5, are the most difficult to deal with. In some cases, the open-plan area is used purely for dividing into cells. The individual cells are divided by systems-furniture partitions that may, in practice, be quite difficult to move (especially if they are used for service distribution). This is best viewed as an alternative means of producing cellular space, although it shares with genuine open plan the advantages of economies in lighting and cooling, and flexibility in re-organisation.

If the open-plan area is intended to be used with a higher degree of flexibility, it is still worth considering the use of a fixed layout. Both the initial and operating costs of the facilities can be reduced significantly if layouts are fixed during fit-out. This has been proven to be acceptable in a wide variety of cases. In many of these cases, fixed layouts were not the first choice of either staff or management.

If the fixed layout is acceptable, space planners may:

- Choose the office furniture and interior decoration to complement one another.
- Choose a density of service presentations fixed by the layout.
- Place the lighting to illuminate the work surfaces and avoid reflections in VDU screens.

Otherwise, they must plan for a higher density of presentations, probably delivered via an access floor, and they may need to allow for supplementary task lighting.

References

Eley, Peter and Worthington, John. *Industrial rehabilitation: the use of redundant buildings for small enterprises.* London: The Architectural Press, 1984.

Draft British Standard recommendations for ergonomics requirements for design and use of visual display terminals (VDTs) in offices: work environment. Part 6. Document number 87/40679. London: British Standards Institution, 1987.

GUIDELINES

The approach to space planning should be defined before the distribution of services is designed.

Wherever possible, the potential distribution of cellular and open-plan space should be defined at an early stage of fitting out.

There should be an IT input to interior design, provided either by the occupant's information systems department, or by consultants, or both, to enable the designer to take full account of the IT aspects.

Wherever possible, office layouts should define the location of desks (although there need not be people, or even desks, in all such positions at all times).

'Office furniture and finishes' includes carpets, curtains, wall coverings, and all office furniture and non-IT equipment.

Figure 6.7
Traditional furniture designed for use in cellular offices

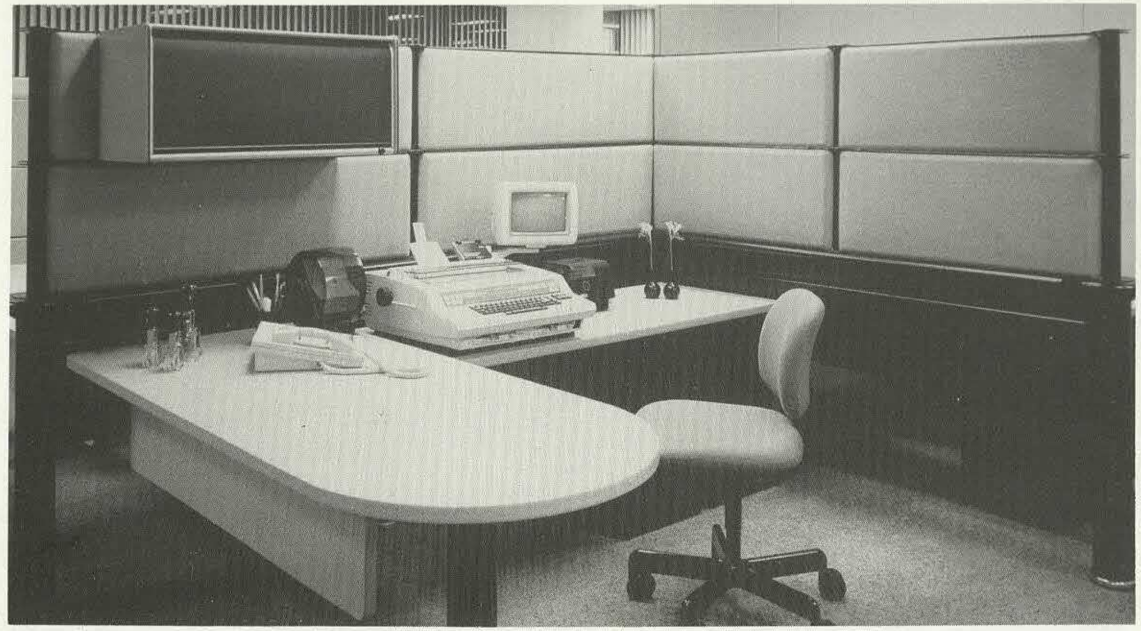


Figure 6.8
Modular furniture designed for use in open-plan offices

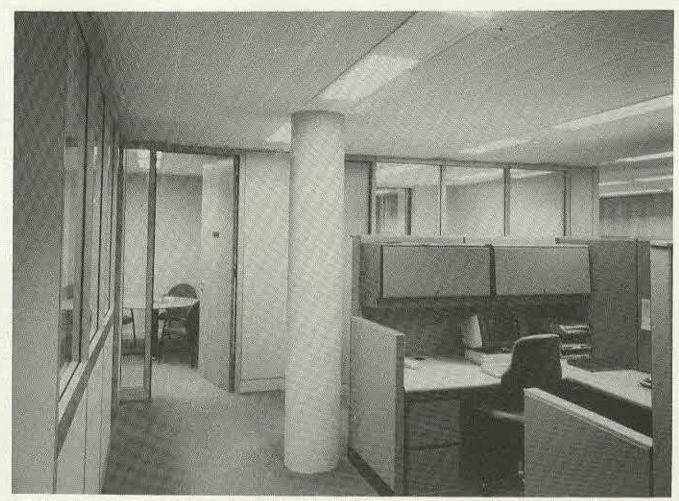


Figure 6.9
Modular furniture hung from screen partitions for use in open-plan offices

As IT is used more and more in offices, so office furniture is required that can both support the equipment and carry services to it. With the proliferation of workstations, lighting must be designed to avoid the problems of glare on screens. This affects the choice of colours, textures, and materials for carpets, screens, and wall coverings. The advance of voice recognition and its integration into office workstations increases the importance of acoustics and may favour cellular over open-plan layouts. This will also affect the choice of textures and fabrics used in offices.

Office furniture must meet a variety of needs and is subject to many disparate influences, both aesthetic and functional. The main requirement here is for design by multidisciplinary teams. The design team should produce a mock-up of its design showing size, appearance, service delivery, and lighting, for evaluation by users, facilities managers, and the project team.

Furniture systems should be selected to allow for the quantity of cables and the size of the plugs that need to be passed through the cable ways.

References

Worthington, John, & Konya, Allan. *Fitting out the workplace.* London: The Architectural Press, 1988.

Code of practice for internal non-loadbearing partitioning. BS 5234. London: British Standards Institution, 1975.

Specification for performance requirements and tests for office furniture: desks and tables. BS 5459: Part 1. London: British Standards Institution, 1977.

Office furniture: specification for design and dimensions of office workstation, desks, tables and chairs. BS 5940: Part 1. London: British Standards Institution, 1980.

Draft British Standard recommendations for ergonomics requirements for design and use of visual display terminals (VDTs) in offices: VDT workstation design. Part 5. Document number 87/40678. London: British Standards Institution, 1987.

GUIDELINES

The design team should build a mock-up of the office space in order to test the practicality of the design, and to obtain constructive comments from the potential users.

A service presentation is the point at which staff may obtain access to a service. The main services are data communications, voice communications, and power, but staff may also have some measure of control over their local environments. The density of presentations is the number of presentations divided by the net lettable area (NLA) that is served by them.

Figure 6.10
Access floor with nomadic floor boxes
Movable (nomadic) floor boxes permit a lower density of service presentations.

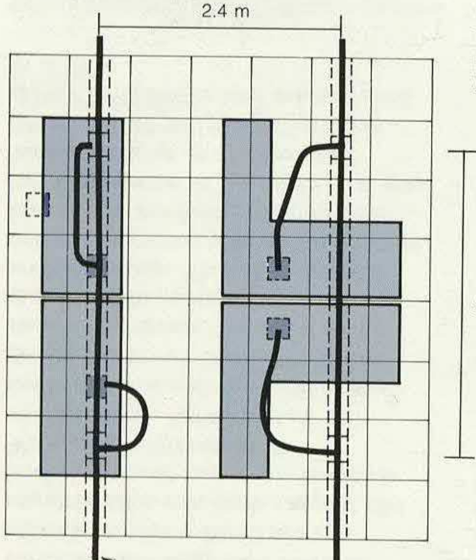
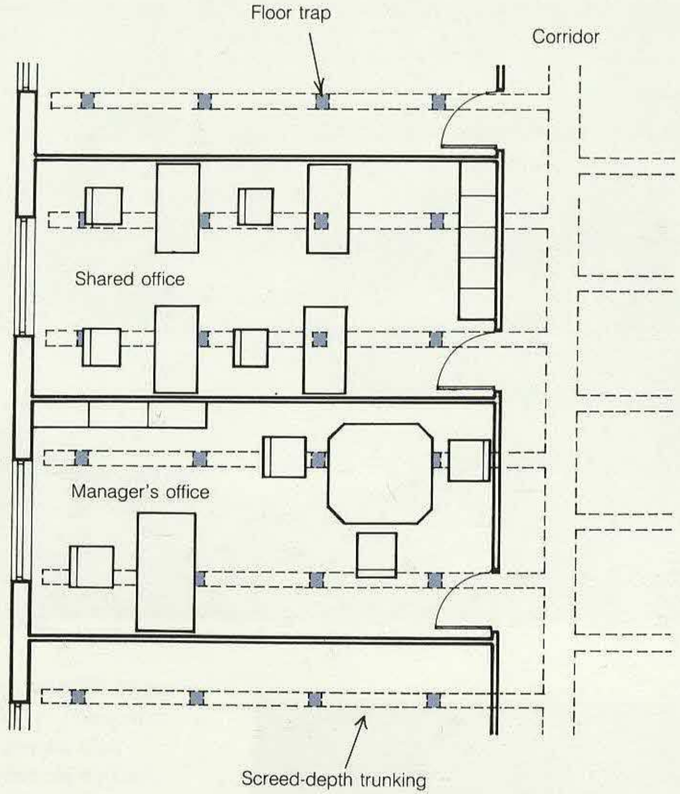


Figure 6.11
Typical screed-depth trunking layout showing floor-trap positions and furniture layout
A rigid screed-depth trunking system requires a very high density of outlets to provide presentations to suit different furniture layouts and avoid trailing cables.



Nature of outer space	Planned space per person (m^2)	Presentations required per 100 m^2 of NLA
Cellular	8	14
Open-plan with fixed furniture layout	10	12
Open-plan with fixed service presentations	6-12	25
Open-plan with movable service presentations	6-12	17

Figure 6.12
Service presentation densities
A very high number of service presentations is needed if the flexibility of an open-plan office floor is to be maintained.

Current situation
The density of service presentations varies considerably, and is often inadequate, especially in open-plan offices. It is usually expressed on a per person basis, reflecting assumptions about the number of people who will occupy the office. These assumptions often prove to be incorrect when the office is occupied, and sometimes even before.

Considerations for the future
The main consideration is the density of presentations. It is convenient to have enough presentations so that there is always one within reach. However, if the staff are to be free to move their desks where they choose, a large number of presentations will be required, perhaps as many as one per 4 m^2 of NLA. (Given the expense, especially for an office that is planned to provide 8, 10, or even 12 m^2 of area per person, this is not often done.) Lower densities result in trailing cables or restrictions on the positions of desks.

Floor plans for access floors with nomadic tiles and with screed-depth trunking are shown in Figures 6.10 and 6.11. The way in which the required service density depends upon the nature of the space and the service distribution system is shown in Figure 6.12.

GUIDELINES

In cellular and fixed-layout open-plan areas, the number of actual presentations may be restricted to the number of desks, plus an allowance of 20 per cent for shared equipment.

In open-plan areas, the outlet density should be set according to area; one presentation per 6 m^2 of NLA will be appropriate if the presentations are movable, and one per 4 m^2 if they are not.

Figure 6.13
A typical floor-box service presentation
Despite their limitations, floor boxes are the most commonly used type of service presentation in new buildings.

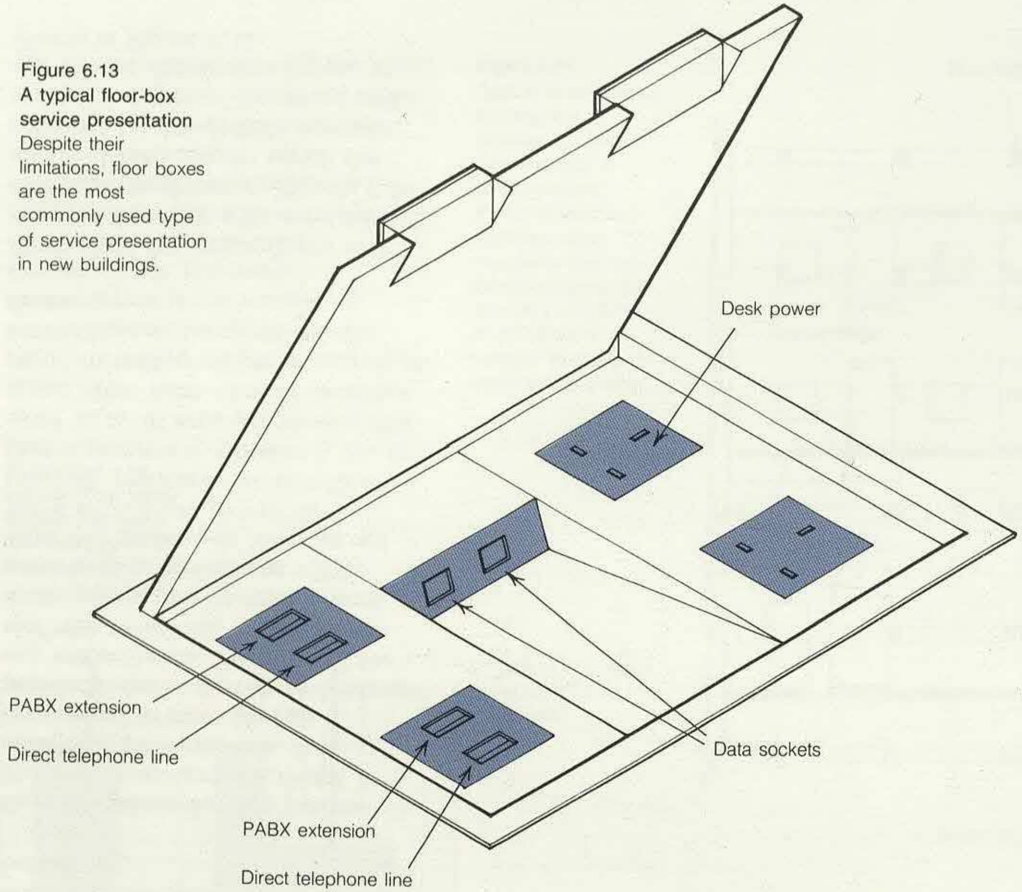
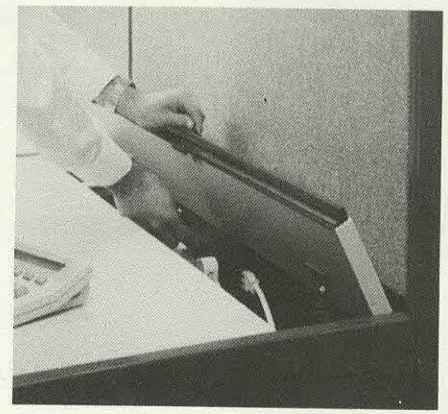


Figure 6.14
A service presentation in furniture



Current situation

In the past, a variety of forms of presentation have been needed because of the many different cables and local communications systems. Now, the tendency is to provide a single point of presentation for power, voice, and data. In cellular offices, presentations are often wall-mounted. Because this is not possible in open-plan offices, a variety of means have been used instead, including access boxes in the floor, columns, and ceilings. None of these has won universal approbation. The moves towards structured cabling schemes will reduce the need for such a variety of forms of presentation, and the move to optical fibre will reduce it further.

Future requirements

Utility power (for coffee machines, cleaning equipment, and so on) is generally needed in or near circulation spaces. Generally, data and voice services are not required in conjunction with utility power although there may be some needs for data and voice service in circulation spaces. Other services are generally required at the user's desk, and all services are likely to be needed at each presentation. The ideal presentation is therefore one that is closely associated with each desk. This has been impractical in the past because of the complete separation of furniture design from service planning. However, the increasing use of IT, with its numerous cables, has brought about a change of practice, marked by 'cable-management furniture'.

The direct termination of voice, data, and power cables in presentations mounted on the desk has several disadvantages:

- The installation of new cables is more troublesome than conventional arrangements.
- Desks cannot readily be moved.
- The cables connecting the equipment to the presentations are often longer than necessary and create clutter on the desk.

Good solutions to this include:

- Furniture systems that include a separate service beam that carries the cables, and that is not moved until the office is refurbished. Changes in requirements are accommodated by changing work surfaces and their associated storage units.
- Spaces at the rear of the work surfaces into which excess cables can be dumped.

GUIDELINES

The following service outlets should be provided at each presentation:

	Minimum tolerable	Best
Power	1	6
Data	1	2
Telephone	1	2
Fibres	0	2

Cable dump space should be associated with each desk.

The secondary distribution of services is the means used to carry services from the building risers to the places where they are needed. In the case of power and telecommunications, this will generally be at or near desks. Lighting and environmental control systems are sometimes accessible from individual desks.

Figure 6.15
Horizontal cable space for each potential workplace
A space of 30 mm × 10 mm will often be sufficient for data and voice cabling to each workplace.

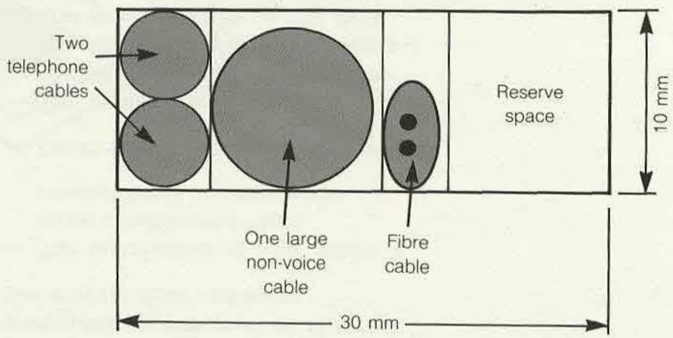


Figure 6.16 Calculation of the default cable-space requirement

A floor of 500 m² is served by one telecommunications closet.

Space is allocated for voice and data cabling before the cabling schemes have been chosen. We assume that there will be one presentation per 6 m² NLA.

	Area (mm²)
Voice:	
167 cables @ 25 mm²	4,200
Add 50% for rewiring	2,100
Non-voice:	
83 cables @ 100 mm²	8,300
New system: 83 cables @ 50 mm²	4,150
	18,750
Installation allowance @ 50%	9,400
Total cross-section of voice and data cable ducts at entry to closet	28,150

Current situation
Power and telephone wiring are installed during fit-out. Until recently, other wiring was installed at this stage only to meet definite needs, and cable installation often continued over the life of the building. As developers and others have appreciated, the increasing quantity of IT systems and their associated cables is an important consideration for building design. Even so, some new buildings still provide inadequate space for this, especially in the area where the cables from the horizontal distribution enter the telecommunications closet.

Future requirements
The space needed for horizontal cabling will be determined by the nature and density of the service presentations, as discussed previously. As shown in Figure 6.15, the space required will exceed that needed for the initial cabling because rewiring will be needed eventually, and because it is impractical to fill trays or ducts more than about two-thirds full. Further space, not covered by these guidelines, will be required for electrical power distribution.

Voice communication
In most offices, the majority of staff require a single telephone, although some may need a separate direct line. An area of 25 mm² is sufficient for each telephone cable, and it is good practice to allow enough space for two per presentation.

The trading floors of financial institutions generally provide each dealer with many speech circuits. These requirements are specific to the financial sector, and depend upon the dealerboard system adopted for the trading floor. They are not therefore considered in this handbook.

In the future, less space will be required for voice-only cables because:

— The Office of Telecommunications (OFTEL) is likely to permit schemes that integrate private automatic branch exchange (PABX) and network-services wiring.

— More advanced telephone switching equipment will make it possible for an intelligent telephone and PABX to replace a large number of directly wired circuits.

The space for a single telephone cable should be sufficient for recabling.

Non-voice requirements
As discussed in Chapter 2, the trend is to install an intelligent workstation on every office desk over the next five years. Each workstation will require a communications link to other workstations and to other IT systems.

The development of IT will lead to the introduction of new services that will have to be delivered to the desk. In the past, service and equipment suppliers have used their influence to encourage users of their services and equipment to install their own cables. This is now changing for three reasons:

— The major IT suppliers are moving away from proprietary cabling schemes, and several have developed schemes that can support a wide variety of devices and local area networks (LANs).

— Minor IT suppliers are increasingly building equipment that can operate over the emerging 'universal' cabling schemes.

— The suppliers of certain financial information services are increasingly offering their services over standard cabling systems and local networks. Although tariffed at a premium, it is inevitable that the margin will disappear in time.

It is now possible to install structured cabling schemes that will meet the large majority of communications needs for the next five to ten years. Beyond that time, a growing proportion of users will require optical fibres, so sufficient space should be provided at the outset.

Today's structured cabling schemes vary considerably in their needs for space. The most compact require only 25 mm² of cabling route cross-section per presentation. The least compact require about six times as much. If the nature of the initial structured cabling scheme is known, the space requirement may be calculated. If it is not known, an allowance of 100 mm² per presentation should be made.

Cabling systems are likely to become more compact in future, and it is reasonable to allow 50 mm², or 50 per cent of the initial requirement, whichever is the greater, for a future system. Since it is impractical to fill a duct or tray with cable, a further allowance of 50 per cent should be made. If space for voice and data cables must be reserved before the approach to cabling has been decided, an allocation of 5,600 mm² per 100 m² of NLA should be made, as shown in Figure 6.16.

The secondary distribution of services is the means used to carry services from the building risers to the places where they are needed. The cables may take a variety of routes including under the floor, over a false ceiling, through perimeter trunking, and through furniture. In practice, a mixture of these routes is often best.

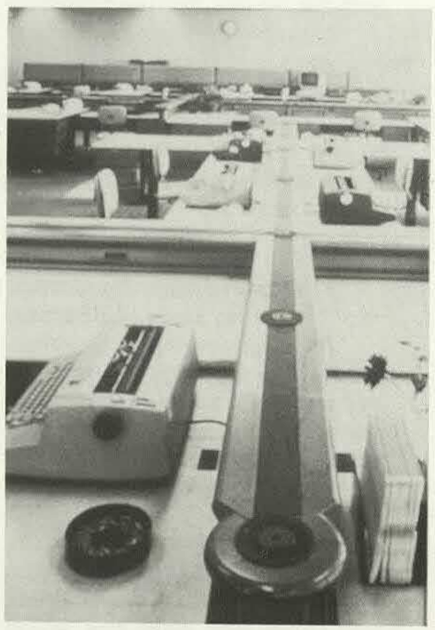


Figure 6.17
Office using Sunar Race furniture system with partition screens between desks removed for clarity
The Sunar Race furniture system provides beams for power, voice, and data cables.

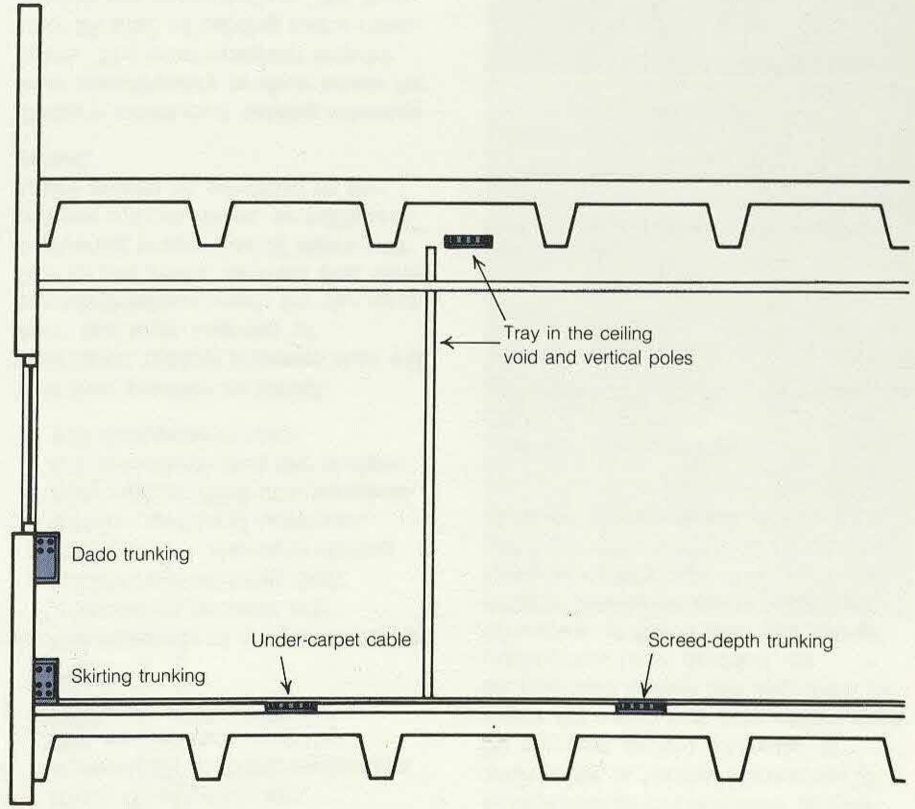


Figure 6.18
Horizontal distribution alternatives
Where access floors are not available, alternative methods may be used.

The routeing of cables is rarely a problem in cellular offices, since the walls provide a variety of horizontal and vertical routes, and ceilings can also be used. Open-plan offices with shallow space are also often straightforward: cables can be distributed along the outside walls and carried into the rest of the space through systems furniture.

Deeper open-plan areas are more difficult, especially if the occupants require complete flexibility in the positioning of desks. Many modern office buildings provide access floors to contain the cabling for these areas. The use of access floors is, however, expensive — typically £30-60/m² — and is not a panacea. Access to the floor void is often difficult, owing to the presence of people, furniture, and equipment on the floor, and the fact that several carpet tiles need to be lifted for each floor panel.

Cables must, of course, pass through the false floor, and this is generally arranged by terminating the secondary cables in a service access box in a floor tile. These boxes can give problems. They tend to trap (and cut) cables, they are often too small to accommodate plugs with projecting cables, and even when the floor has been designed to allow the boxes to be moved, the process can be quite slow. Nor do access floors and service boxes solve the problems of tertiary cabling — the cables connecting the parts of a user's workstation to each other and to the service access box.

Raised access floors give the greatest flexibility but have disadvantages. As discussed on page 6.03, approaches based on fixed desk positions can be achieved without the use of access floors. Such approaches are generally preferable, provided that management is prepared to accept the loss of flexibility.

Power cables may induce electrical noise in communications cables. For this reason, as well as for reasons of electrical safety, they should be routed separately.

Analogue telephony cables carry ringing currents and signalling pulses that may cause interference with data communications systems.

Reference

Code of practice for electrical systems in office furniture and office screens. BS 6396. London: British Standards Institution, 1983.

GUIDELINES

Access floors should be used where a high degree of flexibility is required in a deep open-plan area.

Access floors should have a void depth of at least 120 mm. In cases where a telecommunications closet serves a floor area of more than 500 m², an increased void depth of 150 mm or 200 mm may be required.

Communications cables should not share undivided ducts or trays with power cables.

Data communications cables should be separated from analogue telephone cables by either an electrical screen or a distance of 50 mm.

Many types of cable are used in horizontal distribution. The introduction of structured cabling schemes has reduced the variety by allowing one cable to support several kinds of network, as shown in Figure 6.19. The structured cabling systems available from different supplies each have their own set of installation rules and cannot easily be interconnected on any one site. There is no definite guide to, and only limited agreement on, the fire-safety aspects of communications cabling.

Some progress has been made on the standardisation of copper cables by the (North American) Electronic Industries Association (EIA). As shown in Figure 6.20, the EIA has specified an approach to building cabling that defines topology and maximum cable lengths, while still allowing three choices of copper cables. In effect, the standard endorses the three kinds of cable that are most widely used in North America.

Figure 6.19 Structured cabling concept
Structured cabling systems are based on the use of a single type of horizontal cable that can be patched to support a wide range of intelligent workstations and single-function terminals.

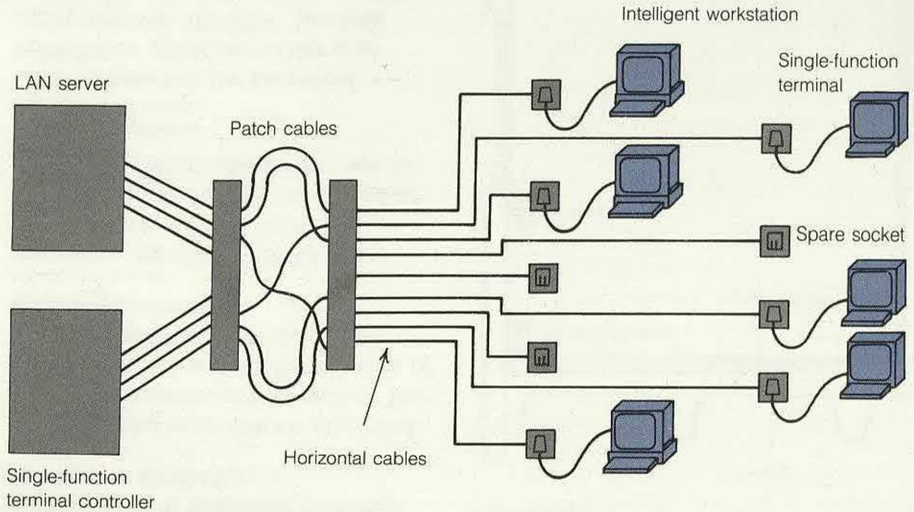


Figure 6.20 Emerging North American standard for horizontal cabling (under development by the EIA)

The cabling should have a star topology, centred on the local patching frame in a telecommunications closet.

No cable run (from local patching frame to presentation) should exceed 90 m in length.

One or more of the following cables should be used:

— 4 pair 100 ohm unshielded twisted-pair cables[1].
— 2 pair 150 ohm shielded twisted-pair cables[2].
— 50 ohm coaxial cables (ISO 8802.3 10 BASE2)[3].
— 62.5 micron multimode fibre.

Notes
[1]The specification of this cable is based on that of AT&T's PDS unshielded twisted-pair cable.
[2]The specification of this cable is based on that of the IBM Cabling System type 1 cable.
[3]That is, 'Thin Wire Ethernet'.

Figure 6.21 Characteristics of BT blown-fibre technology

Preinstallation of flexible plastic tubes:

— 7 mm outside diameter.
— 3.5 mm inside diameter.
— 175 mm minimum bending radius.

Installation of up to 14 fibre cores per tube.

Future requirements
Copper cables have been the standard means of delivering services in the office in the past, and they will continue to meet most users' needs for the next five to ten years. Copper cables are, however, beginning to be challenged by optical fibres, which will be required for some workstations from 1995, and for significant numbers from the year 2000, and by radio and infra-red systems.

Optical fibres
Optical fibres have many advantages over their copper counterparts, including small size, low weight, immunity to electromagnetic interference, resistance to tapping, and enormous bandwidth. Fibre cables are especially attractive in refurbishments, where cable space is limited. Although the fibre cables are inexpensive, their installation and termination requires more time and more highly skilled staff. They also require more complex electronics at each end. Fibre-based systems are therefore usually more expensive than systems based on copper cables, although for high-speed communications, this will cease to be true in time.

Although fibre standards are still immature (work is proceeding in the EIA, the European Computer Manufacturers' Association (ECMA), and the International Standards Organisation (ISO)), the installation of multi-mode glass fibre of either 50- or 62.5-micron core diameter is likely to meet the overwhelming majority of actual requirements.

From about 1995 (sooner in some organisations), there will be a progressively increasing requirement for optical-fibre cables to the desk. One way of preparing for this need is to install 'empty tubes' to the desks through which fibres can be blown when needed. This approach means that a large part of the installation cost can be deferred. (Figure 6.21 shows the characteristics of BT's blown-fibre technology.) In addition, this approach leaves open the number of fibres that should be provided to each desk.

Although attractive financially, blown fibre has three disadvantages:

- The technology is new and not yet proven in long-term use.
- It is currently available only from a single supplier.
- The space occupied by the tubes is unavailable for other uses.

Radio communications
Radio systems have been used for many years for paging and 'walkie-talkies'. Cordless telephones are widely used in homes but their restriction to just six frequencies makes them unsuitable for office use. The second-generation cordless technology (CT2) is likely to be used as the basis of new 'cordless PABXs'. All radio systems suffer from a shortage of bandwidth, possible interference between transmitters, and screening by metal building components. They are currently more expensive than wired systems.

Fire resistance
The United Kingdom has no generally accepted tests for the fire resistance of communications cables. Cables in air plenums present a particular risk, unless they are installed in their own conduits, since any smoke from burning cables will be distributed very quickly. Low-smoke cables should be used to avoid this. (Ordinary PVC cables can be used in computer-room-floor voids, providing that the air circulation is shut down as soon as smoke is detected.)

References

Premises distribution guide. Reference 555-400-021. Middletown, NJ: AT&T Information Systems, 1987.

Open Systems Cabling Architecture: building planning and design guide. Reference: TUP 900. London: British Telecom, 1988.

Commercial building wiring standard. EIA PN 1907 (Draft) (especially Chapter 4). Washington DC: Electronic Industries Association.

DECconnect planning guide. Reference EK-DECSY-CG. 3rd edition. Maynard, MA: Digital Equipment Corporation, 1986.

IBM cabling system: planning and installation guide. Reference GA27-3361. 7th edition. New York: IBM, 1986.

GUIDELINES

To meet today's needs and those foreseen for at least the next five years, structured wiring schemes with copper cables will be adequate.

The distance from the telecommunications closet to the presentation should not exceed 90 m.

The district surveyor and insurers should be consulted about fire protection of the cables that are to be installed.

Fire barriers and effective smoke detectors under the floor should be considered where PVC cables or tubes for blown fibre are to be installed.

If cables are to be installed in air plenums (other than in their own conduits), low-smoke cables should be used.

The use of visual display units in offices has changed significantly the requirements for office lighting. A lower overall level of illumination is needed for staff to see their screens clearly and without discomfort. This reduction makes staff more susceptible to glare from windows and lights. In addition, VDU screens reflect sources of light and brightly illuminated surfaces, which is both irritating and obstructive. Although the need to avoid glare and reflections from screens has been well understood for the last decade, there are still many offices in which computer users are affected by them.

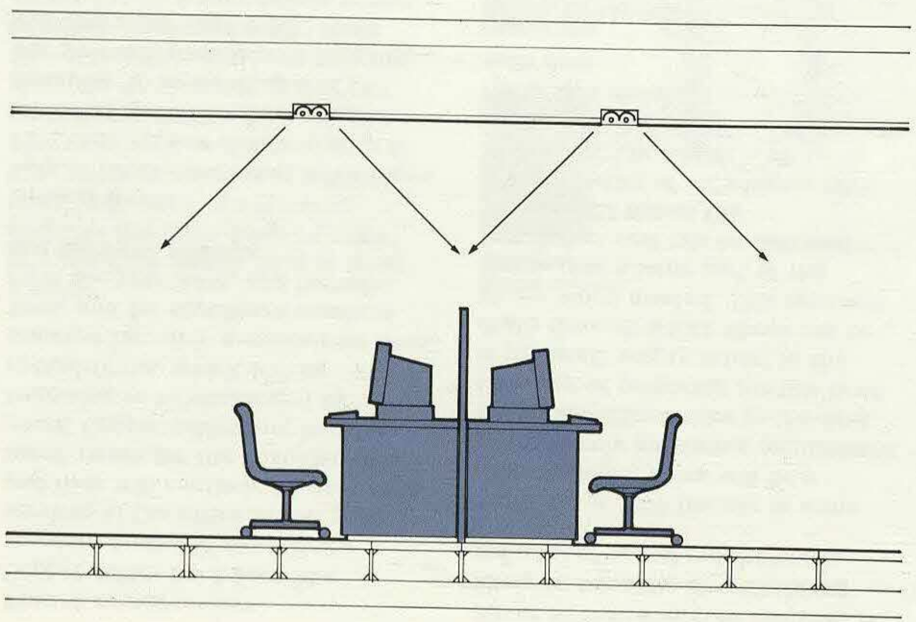


Figure 6.22
Overhead lighting of work surfaces
It can be difficult to prevent an image of the luminaire being reflected into the user's eyes by the VDU screen.

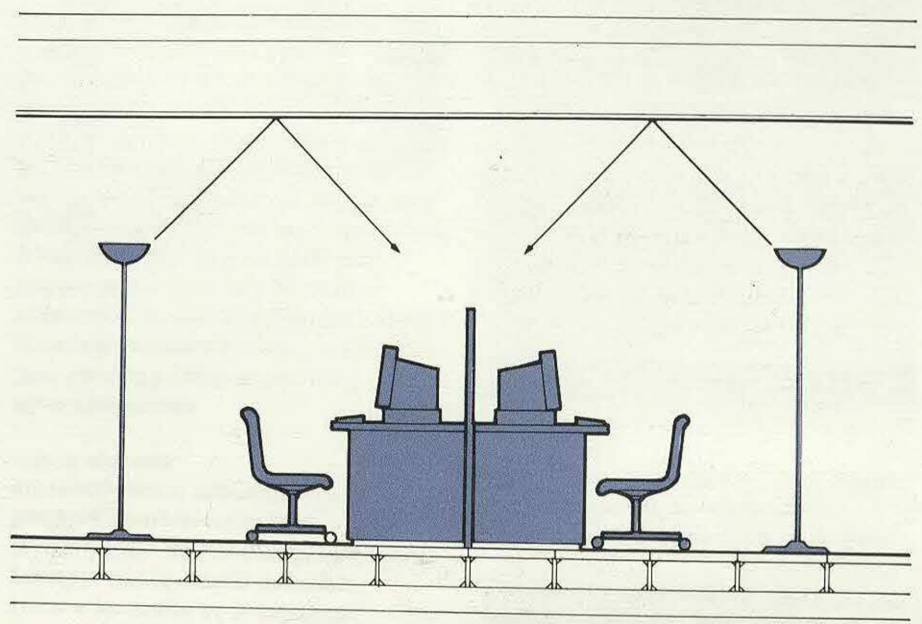


Figure 6.23
Up-lighting of work surfaces
Up-lighters can overcome the reflection problem.

Glare from windows can be avoided by constructing offices in deep space, but most staff would regard this as an unacceptable price to pay. External shading and interior blinds may, however, be used in ways that are effective and acceptable. Glare from lights can be avoided by use of prismatic diffusers. The control of screen reflections depends on furniture, decoration, and IT equipment, as well as on lighting. Satisfactory results are most likely to be obtained if the office lighting and scenery are developed together, and with regard for the IT equipment to be used. The use of visual display units with vertical, rather than sloped, screens is also helpful.

The increased use of black-on-white displays will ameliorate the problem to some degree, since a black screen reflects more than a white one. However, black screens will remain in use for some years.

Individual task lights may be needed for those who work with paper in offices, with the lower overall level of illumination dictated by the use of VDUs.

References

Code for interior lighting. London: Chartered Institution of Building Services Engineers, 1984.

Lighting for visual display units: technical memorandum 6. London: Chartered Institution of Building Services Engineers, 1981.

Framework for colour coordination for building purposes. BS 5252. London: British Standards Institution, 1976.

GUIDELINES

The lighting, space, furniture, and partitions should be planned together to provide an even distribution of light, reduce glare, and eliminate the reflections of lights on visual-display-unit screens.

The lighting should comply with the CIBS Code for Interior Lighting, and Technical Memorandum 6.

The major spaces allocated to IT equipment that have to be fitted out within the building are the frame room, computer suite, communications risers, and telecommunications closets. Each space has specific needs for security, lighting, electrical power provision, cooling, and fire protection.

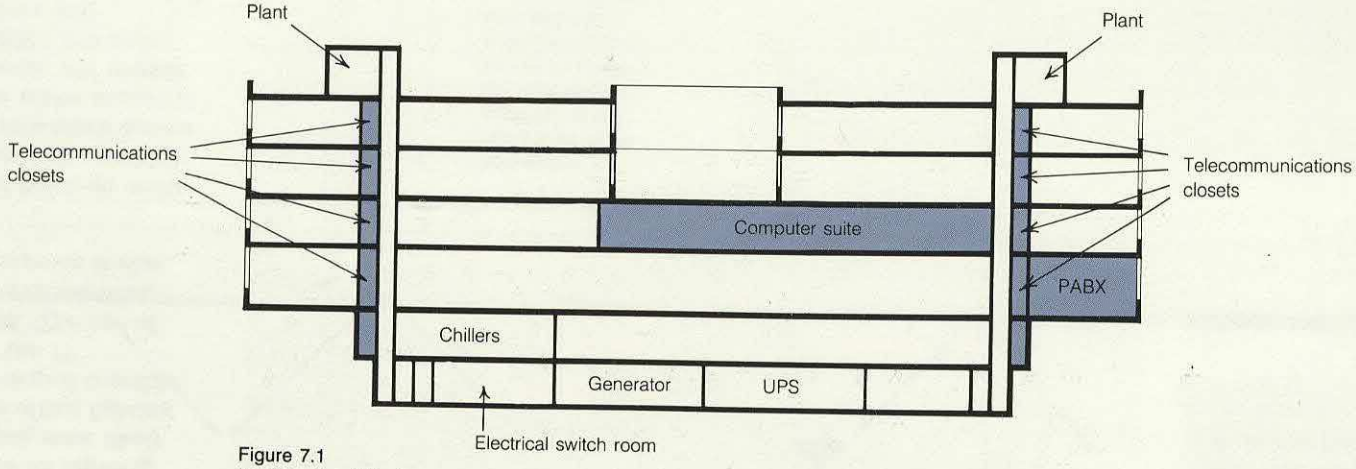


Figure 7.1
Section of a typical office building showing IT service spaces
IT requirements influence the space required for generators, UPS, and HVAC plant as well as determining the space for computer and telecommunications equipment.

Contents

The frame room

The frame room is the room containing the main distribution frame for the building. The frame room should be seen as part of the building cabling rather than as part of the systems attached to it. Frame rooms were described on pages 4.06 and 4.07.

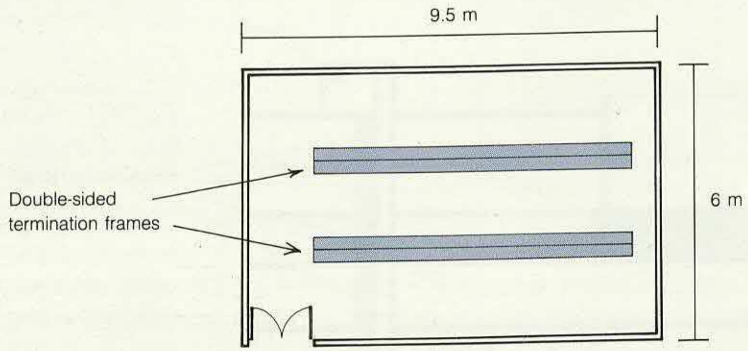


Figure 7.2
A typical frame-room layout
Frame rooms usually house passive equipment for terminating and interconnecting building voice and data cables.

There is a general trend towards the use of high bit-rate digital channels for the provision of services to buildings (such as British Telecom (BT) MegaStream services), and within buildings (mainly local area networks). Today's MegaStream service is delivered over a dedicated four-pair cable of special design, while the lower-speed KiloStream service uses pairs in standard telephony cables. Optical fibres are being introduced for these services in London, and will be used more widely in the future.

These developments have led some suppliers to propose the installation of electronic equipment, such as multiplexors, within frame rooms. However, it is easier to diagnose and correct problems when all the network-terminating equipment and the user's voice and data equipment is located together. The terminating systems for external telecommunications services should therefore be located adjacent to the communications and computer equipment that uses those services most directly, usually private automatic branch exchanges (PABXs) and communications processors. As a separate room containing little or no active electronics, the frame room has no special servicing requirements.

GUIDELINES

Frame rooms should be protected by full-height fire walls of at least 2-hour rating.

Ceilings should be waterproofed.

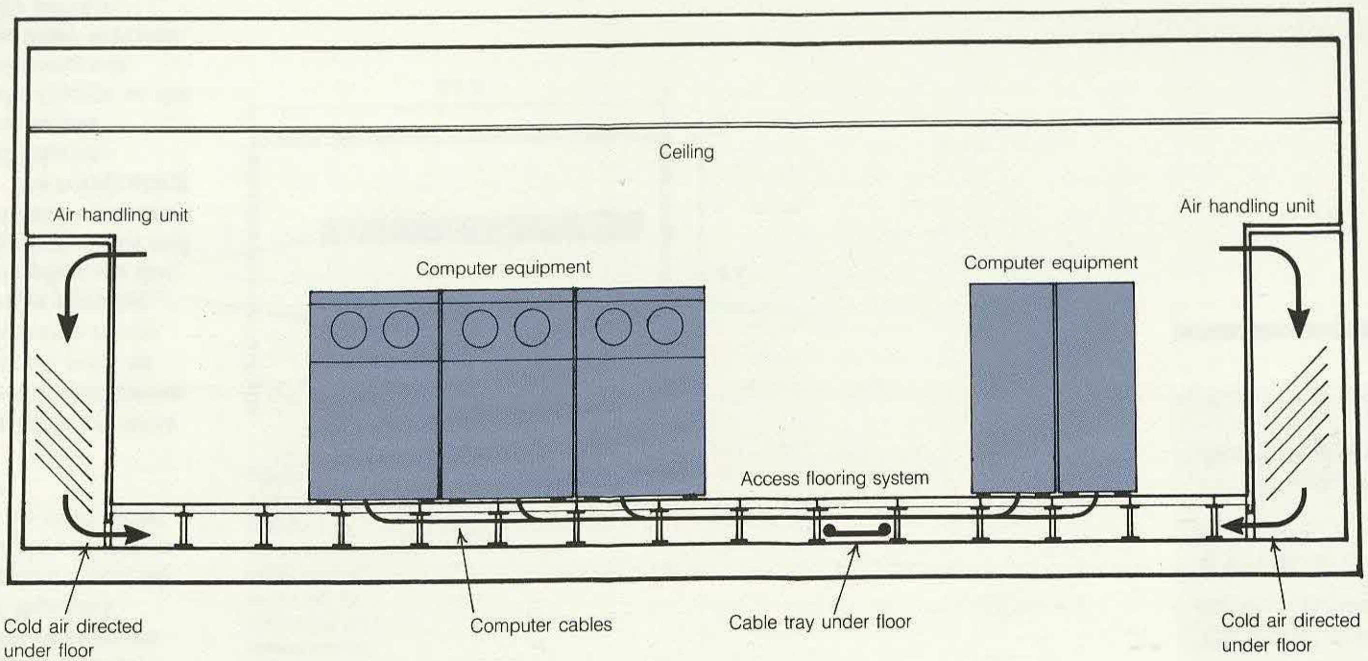
There should be no windows.

The frame room should be safe, secure, and dust-free.

It should be lit to 300 lux at floor level.

Two 13-amp power sockets should be provided.

Figure 7.3
Section through a typical computer room
Careful planning of underfloor services and cable routes is necessary to ensure that the flow of cold air is not restricted.



Current situation

Early computer suites generally accommodated all the computer equipment in a single air-conditioned room. This room therefore included tape drives, processors, printers, and the staff to look after them. The move from batch to online working has greatly reduced the need for operations staff, while increasing the need for continuity of service to the users. Accordingly, the principles of computer-suite design have changed:

- Printers and other paper-handling equipment, with their inherent fire risks, are often excluded from the main computer room.
- Operators are increasingly located outside the computer room where they can enjoy a normal office environment.
- The smallest reasonably practicable computer room is that needed to accommodate two mainframe computers with their associated equipment.

Today's computer suite is therefore a collection of spaces having quite distinct functions and environmental requirements:

- Main computer room.
- Paper-handling area.
- Tape-drive room.
- Media library (with secure store).
- Control bridge.

Figure 4.17 on page 4.08 shows a typical layout for a computer suite based on these principles.

Future developments

The further development of IT will reinforce the trends that are apparent today. Higher reliability will reduce the need for access to the computer room. More comprehensive systems-management facilities will make remote operation easier. The increased use of electronic mail and electronic data interchange will reduce the need for central printing.

The separation of the various areas has benefits in terms of access control, reduction of fire risk, and environmental control. The critical area remains the computer room itself. Although the risks should be minimal, the consequences of a disaster in this region may be so grave that it is worth considering a further line of defence — that of dividing the main computer room into two or more separate rooms, so that the system can be completely replaced without loss of service to users.

If the rooms are divided effectively, a disaster in one (short of the destruction of the whole building) is very unlikely to affect the other, and processing will be able to continue, albeit on a reduced scale. To ensure this, there should be no route between the rooms to allow the movement of fire, smoke, water, gases, or blast. The rooms will also need independent power and water supplies, fire protection, security, and good access routes.

Reference

Halper, Robert F. *Computer data centre design: a guide for planning, designing, constructing and operating computer data centres.* New York: John Wiley, 1985.

GUIDELINES

The computer room, media library, control bridge, and paper-handling areas should be separate rooms.

For suites of more than 1,000 m^2, the division of the main computer room into two independent rooms, or the construction of two computer rooms in separate parts of the building, should be considered.

Computer suites need their own fire-detection and firefighting systems. This is not because they present particularly great fire risks in themselves, but because of the value of the equipment they contain and the very considerable damage to the business that may be caused by the loss of processing capacity and, especially, stored data.

C E Wooding

Figure 7.4
A computer suite after a major fire
Computer equipment is not usually the source of ignition, but it must be protected from fires that start outside the computer room.

Fires rarely start in computer suites and, when they do, the most likely causes are paper and underfloor cables. Computer suites are, however, sometimes damaged by fires that start elsewhere and spread to the computer suite, or that create smoke and fumes that affect the suite. Computers can be seriously damaged by smoke and corrosive gases (such as the hydrogen chloride given off by burning PVC cables). They can also be damaged by the materials used to extinguish fires, including water and carbon dioxide. In many cases, the damage due to fire-fighting facilities has exceeded that due to the fire itself.

The appropriate principles for fire protection are therefore:

- Reduce the likelihood that a fire will start.
- Reduce the likelihood that a fire will spread.
- Minimise the damage that a fire can cause.

The risk of a fire starting will be minimised if the computer suite is located away from plant rooms and stores of flammable materials. If this is not possible, the computer suite should be separated from any such stores by fireproof and waterproof walls of sufficient rating to enable a major fire in the risk area to be extinguished without damage to the computer suite. In the parts of the building outside the computer suite, and especially in the adjacent parts, good fire precautions should be taken. Within the suite, the risks will be minimised by keeping all paper-handling equipment away from other equipment. All underfloor power cables should have Low Smoke and Fume spread (LSF) sheaths.

The risk of fire spreading and consequent damage can be minimised by the use of suitable fire-fighting systems, discussed overleaf.

GUIDELINES

The computer suite should be located away from fire risks.

Good fire precautions should be taken throughout the whole building and especially in the areas adjacent to the computer suite.

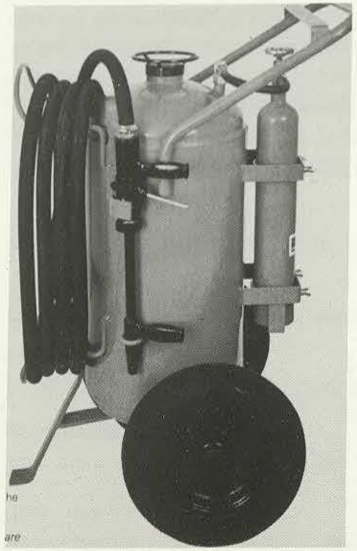
Computer rooms should be no larger than 2,500 m^2.

All construction materials used in the computer room should be non-combustible.

An area should be designated to serve as a reserve bridge in the event of an emergency. It should be provided with appropriate cabling, and so on.

Secure storage for important data should be provided, preferably off-site.

Figure 7.5
A typical trolley-mounted fire extinguisher



	Paper-handling area	Bridge	Tape-handling area	Computer room
Fire risk	High	Moderate	Low	Very low
Cost of assets	Moderate	Low	Moderate	High
Cost of disruption	Moderate	High	Moderate	Very high
Human occupancy	Frequent	Constant	Variable	Low

Figure 7.6
Fire risks in the computer suite

Although the risk of fire is low, computer suites need systems for firefighting in case fires do occur. Moreover, the insurer will insist on them. There is no ideal firefighting system for computer rooms. However, dry-pipe water-sprinkler systems are acceptable and may be combined with portable extinguishers to give better localised control. (In some cases, insurers may insist on sprinklers for structural protection.)

The correct approach is to consider the various parts of the computer suite — the bridge, the paper-handling area, the tape-handling area, and the computer room — as separate spaces. The paper-handling areas pose the biggest risk and should be given the most careful attention. The bridge should be treated in the same way as other office space although more emergency training will be justified. (Water sprinklers, hoses, and hand-operated extinguishers are the common means of firefighting in ordinary offices.)

The greatest difficulty arises with the main computer room. Because carbon dioxide is a suffocating gas, and because the thermal shock from carbon dioxide systems damages computers, many organisations have installed Halon systems. However, Halon systems also have disadvantages:

- Halon is expensive.
- Halon has been implicated in the depletion of the ozone layer in the upper atmosphere, and international restrictions on production are being introduced.
- To be effective, Halon must be discharged in the early stages of a fire.
- Halon is widely distrusted by computer operators who tend to leave the system turned off.

Halon systems are less effective in practice than they are in theory, and they are likely to become less acceptable over time. More acceptable substitute gases are being developed, but their effectiveness in firefighting systems is not yet established.

Portable carbon dioxide extinguishers and water sprinklers may both be used. Water sprinklers should be of the kind in which a valve is activated by the simultaneous triggering of two fire detectors rather than those triggered by the softening of a heat-sensitive plug.

Detectors need careful attention. Conventional smoke and heat detectors do not always work well in air-conditioned computer rooms with high air velocity, especially when low-smoke cables are installed. Sampling detectors in the return air supply may be the most effective. However, conventional detectors should be installed as well, in case the fire starts when the HVAC system is shut down.

Reference

Code of practice for fire protection for electronic data processing installations. BS 6266. London: British Standards Institution, 1982.

GUIDELINES

Portable carbon dioxide fire extinguishers should be available.

Dry-pipe water-sprinkler systems that are activated by two detectors are a good choice for computer rooms.

HVAC systems for computer rooms should be designed to minimise the ingress of smoke from fires elsewhere in the building.

If sprinklers are used, power and air circulation systems in the affected areas should be shut down when the sprinklers are activated.

The primary distribution spaces accommodate the backbone communications network. The backbone communications network carries communications services from their points of origin, or entry to the building, to the spaces to be served. In most buildings, the primary distribution spaces consist of risers, ducts linking the risers, frame rooms, and any computer rooms, as shown in Figure 7.7.

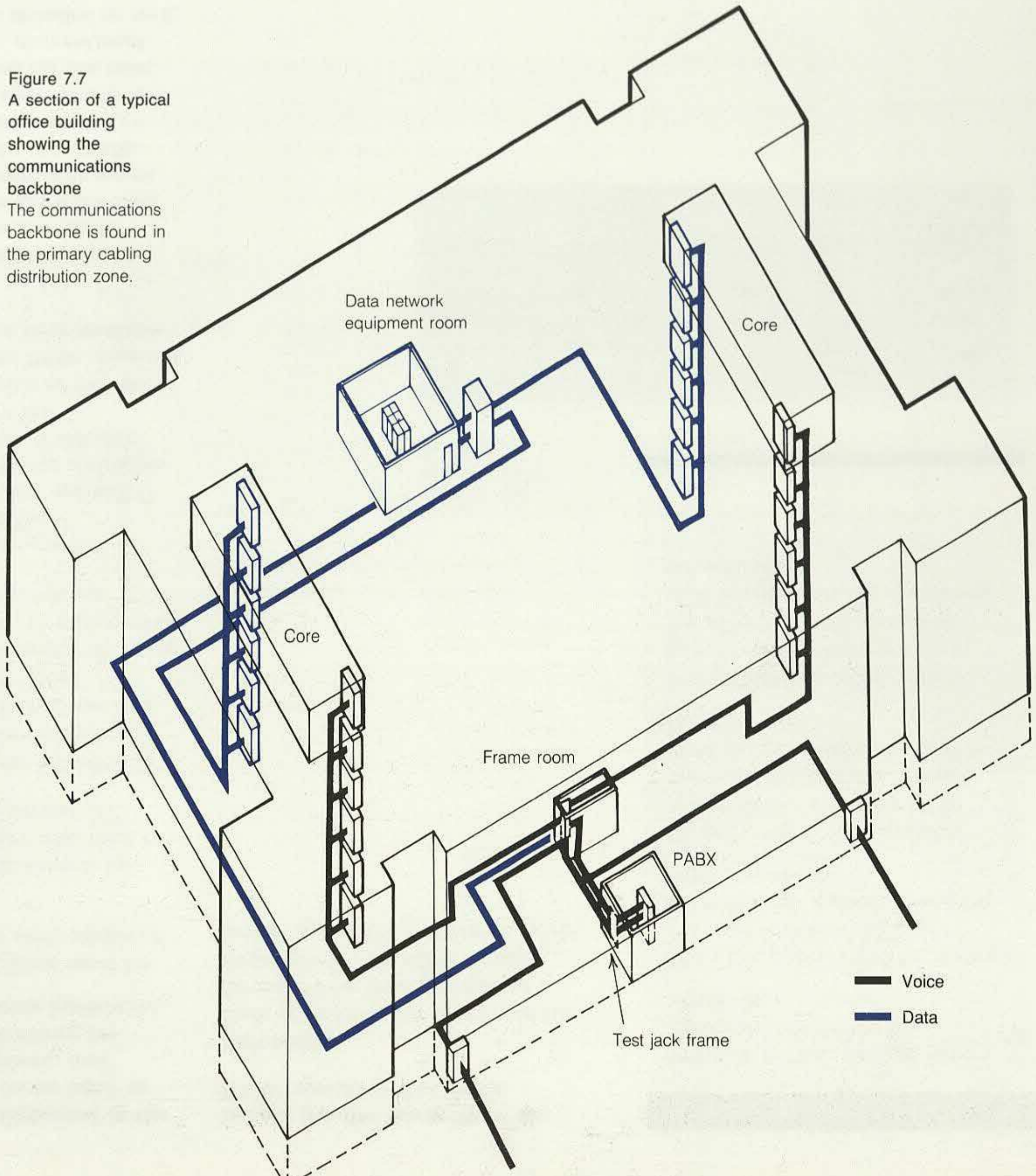


Figure 7.7
A section of a typical office building showing the communications backbone
The communications backbone is found in the primary cabling distribution zone.

Figure 7.8
Evolution of building wiring
In the future, wiring for separate services will be more integrated, but complete integration is unlikely.

Today's wiring	Future wiring
Security Environmental control Public address	Integrated building services wiring
PABX cables Network service cables	Integrated telecommunications wiring to ISDN standards)
Data terminal cables LAN cables	Structured data communications wiring

Current situation
Most buildings have several independent backbone subsystems (some have many: our research located one building with 57 different kinds of cabling in its backbone). For instance:

- PABX wiring: High-count multi-pair cables connect the frame room to telephony termination frames on each floor.
- BT and/or Mercury Communications Ltd (MCL) network wiring.
- Terminal support: Either:
  - Data cables connecting terminal controllers in the computer room with individual terminals.

    or
  - High-quality data cables or optical fibres connecting the computer room with multiplexors or controllers in satellite equipment rooms.
- Local area networks (LANs): High-specification data cables linking multiplexors or bridges in satellite equipment rooms with the computer suite and gateways for off-site networks.
- Paging: A leaky feeder running between floors and radiating its signal along its length.

At present, rules made by the Office of Telecommunications (OFTEL) forbid the integration of the wires to PABX extensions with those that convey a BT or MCL network service. This policy has created considerable difficulties for users, and is currently under review.

OFTEL rules also make it undesirable to integrate voice and non-voice cabling, since this would bring non-voice systems within the scope of the OFTEL rules on connection to the public networks and might require them to be maintained by the PABX maintainer.

The need to install separate backbones for several kinds of building network increases and complicates the work of cable design and installation. It also complicates the management and enhancement of communications systems because each needs to be managed separately.

Structured cabling systems
The introduction of structured cabling systems such as AT&T's Premises Distribution System (PDS), BT's Open Systems Cabling Architecture (OSCA), DECconnect, and the IBM Cabling System (ICS), has eased the non-voice cabling position considerably, since a single kind of cable is able to meet a variety of data communications needs. However, all schemes have restrictions on their application, which makes the design of any scheme for a particular building a skilled task.

Future trends
In both voice and non-voice communications, there are trends towards the use of a few high bit-rate channels rather than a large number of low bit-rate or analogue channels. These fast channels will comply increasingly with standards drawn either from the integrated services digital networks (ISDNs) or LANs, and these standards are increasingly likely to be based on optical fibre cables rather than copper cables. The problems posed by multiple backbones are therefore likely to disappear in the medium to long term, as is shown in Figure 7.8.

References
Telecommunications wiring in business premises and homes. OFTEL 5/87. London: Office of Telecommunications, 1987.

G U I D E L I N E S

The person responsible for a fit-out should seek the assistance of a telecommunications expert to design the backbone cabling system.

Data cabling should not be integrated with telephony or network services cabling.

A coordinated cabling scheme should be installed for all telephony and public network service access.

Figure 7.9
The relative sizes of fibre and copper cables

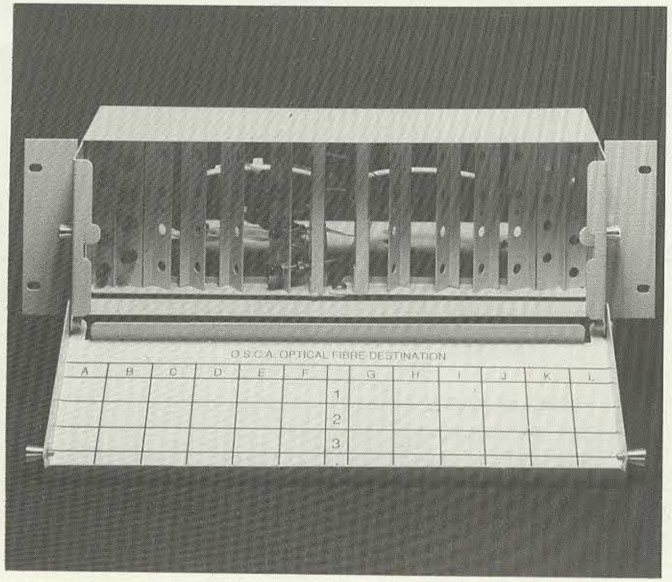


Figure 7.10
A typical optical-fibre cable junction box
Fibre cables require purpose-designed termination facilities.

Figure 7.11 Emerging North American EIA standard for optical-fibre backbone cabling

The cabling should have a star topology with no more than two levels of cross-connection — for instance:

- Main distribution frame:
  - Main distribution cables.
- Intermediate distribution frame:
  - Intermediate distribution cables: no cable section should exceed 500 mm in length.
- Local patching frame (treated as part of the horizontal cabling).

No cable route (from main distribution frame to local patching frame) should exceed 2,000 m in length.

Optical-fibre cables should be graded-index, dual-window, multimode fibre with a core diameter of 62.5 microns. Bandwidth and attenuation limits will also be specified.

It is impractical to recommend general standards for either the backbone network or the backbone cabling because of the many different kinds of office equipment. The variety of equipment demands a multiplicity of data link protocols, and especially LANs. LANs themselves demand a variety of cable types and installation topologies. Moreover, the increased use of high bit-rate channels in PABXs and data systems (discussed in Chapter 2) requires a medium that can support those rates. Technical considerations and the evolution of standards both point to optical fibre as the best long-term choice for backbone cabling. In the short term, fibre will be selected for more and more new applications and network products.

Some organisations will have only limited requirements for optical fibre within the next five years, even in their building backbones. These organisations may prefer to defer any large-scale installation of fibre until their needs are better established, the standards clearer, and the products less expensive. Others, especially those refurbishing buildings with undersized risers, may need to install substantial fibre systems now, and should choose systems that comply with the emerging standards.

Standards

The standards for optical-fibre cabling are emerging before either users or suppliers have made major investments in proprietary technology and products. In addition, there is a broad industry consensus in favour of the emerging fibre-distributed data interface (FDDI) specification for high-speed LANs. These developments make it even more attractive to view an optical-fibre backbone cabling system as a building utility, able to support a variety of voice, data, and other communications.

At present, the (North American) Electronic Industries Association (EIA) is taking the leading role in standards for optical-fibre building cabling. The main points of the EIA standards for optical-fibre backbone cabling are shown in Figure 7.11. The EIA standard does not currently specify a connector for fibre cables.

Further standards work is taking place in the European Computer Manufacturers' Association (ECMA) and the International Standards Organisation (ISO). Because 50-micron fibre is already used in Europe and Japan, it is likely that the international standard will admit both 50- and 62.5-micron fibres. Cabling installed to these standards will be usable as a utility, supporting systems from a variety of suppliers.

Fire resistance

British Standards and codes of practice do not provide clear guidance on the measures needed to avoid the spread of fire via cables. US practice, which is based on the National Electrical Code (NEC) and well defined tests of fire resistance, is better. Adequate fire resistance may be achieved by the use of either fire-retardant cable or fire stops in risers.

The former increases the cost and reduces the choice of cable in ways that may be inconvenient. The latter requires appropriate disciplines when new cables are installed or old cables removed. In a refurbishment, the choice may be influenced by the nature of any cables already installed in the risers.

References

Premises distribution guide. Reference: 555-400-021. Middletown, NJ: AT&T Information Systems, 1987.

Code of practice for the installation of private branch exchanges for connection to the British telecommunications public switched telephone network. BS 6506. London: British Standards Institution, 1984.

Code of practice for installation of apparatus intended for connection to certain telecommunications systems: general recommendations. BS 6701: Part 1. London: British Standards Institution, 1986.

Open Systems Cabling Architecture: building planning and design guide. Reference: TPU 900. London: British Telecom, 1988.

DECconnect planning guide. Reference EK-DECSY-CG. 3rd edition. Maynard, MA: Digital Equipment Corporation, 1986.

Commercial building wiring standard. EIA PN 1907 (Draft) (especially Chapter 5). Washington DC: Electronic Industries Association.

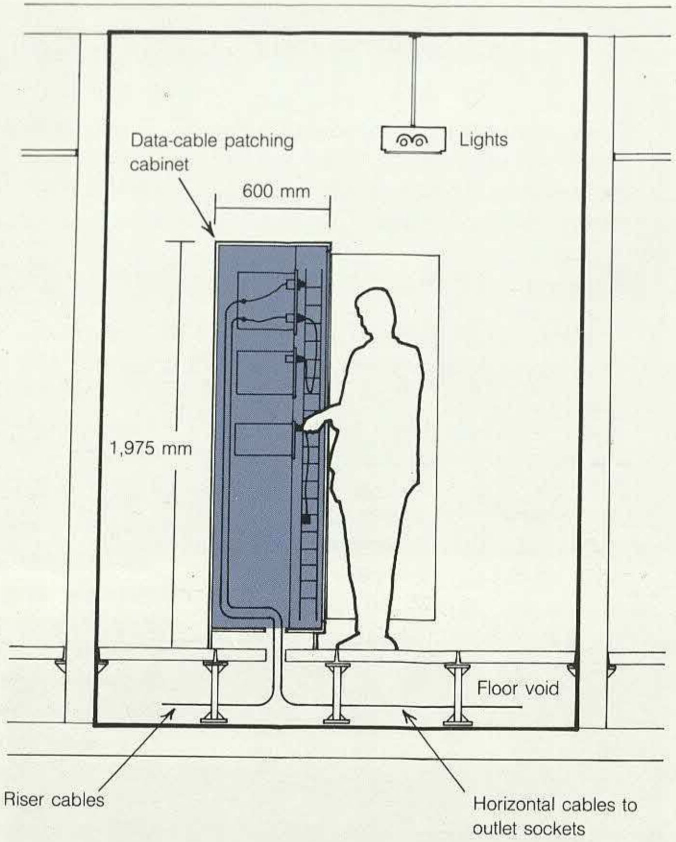
Generic specification for optical waveguide fibres. EIA/TIA-492000-AA. Washington DC: Electronic Industries Association, 1987.

IBM cabling system planning and installation guide. Reference GA27-3361. 7th edition. New York: IBM, 1986.

GUIDELINES

Any large-scale fibre installation should comply with the emerging standards.

Figure 7.12
A technician working in a telecommunications closet
Space must be allowed for access to voice and data patch panels.



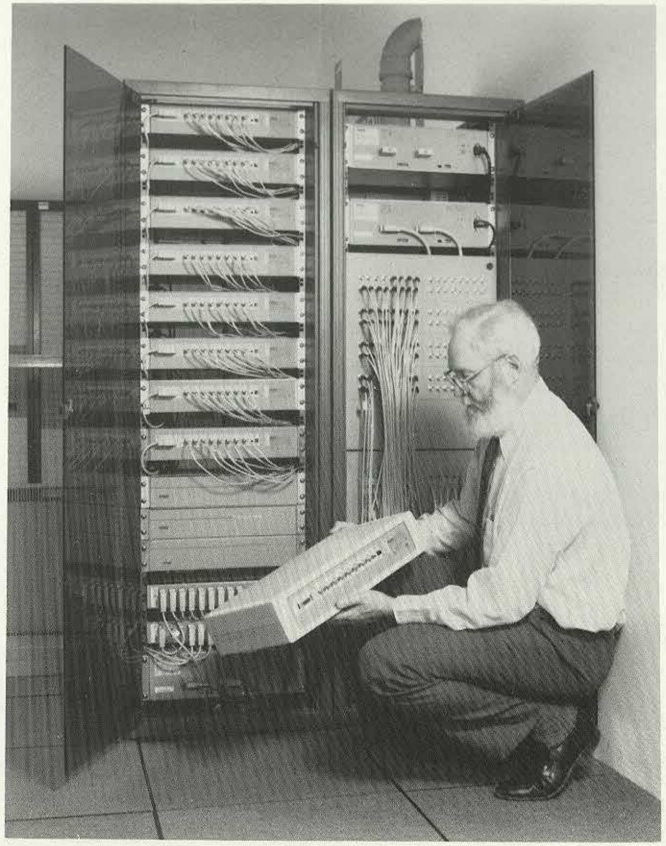


Figure 7.13
A DEC frame

The most important parts of the fit-out of a telecommunications closet are those that hold cables and equipment. Cables usually enter from the riser at a low level and exit at a high level. Cables for horizontal distribution may leave at any level, depending on the location of the horizontal distribution spaces (overhead, peripheral trunking, or underfloor). A common layout is shown in Figure 7.12. Cables are generally tied to metal trays, while patching and other equipment may be secured to the wall or left to stand on the floor. The minimum radius of a cabling route should be sufficient for the least bendable cable in general use.

Because the telecommunications closet is unoccupied most of the time, it is generally located in deep space. It lacks windows, and aesthetic considerations do not figure highly in its fit-out. When left unoccupied, the most important issue is security. This can be achieved either by a locked door of suitable fire rating, or by firestopping the horizontal or vertical cable entries, or both.

As discussed on page 4.13, a telecommunications closet may take the form of a passive riser cupboard, a wiring closet, or a cable patching room. These have different requirements for services.

In order to make it convenient and efficient to work in the closet, it should be properly lit and provided with necessary services (including a telephone with which the technician can consult his supervisor or the facilities manager when necessary). The provision of suitable power supplies and earths was discussed on pages 5.06, 5.07, and 5.08 above. Power should be provided from the relatively clean desk supply.

GUIDELINES

Services
Access to the two special earths should be provided:

- One for data cable screens.
- One for PABX earth recall.

A telephone should be installed.

There should be a power socket for a portable lamp next to any connection box.

Cable routes should have a minimum bending radius of at least 175 mm.

Additional services for wiring closets and cable patching rooms
The closet should be lit to 300 lux at floor level by lights 2.5 m above finished floor level.

There should be a clean power supply of at least 3 kVA.

There should be sufficient cooling capacity to remove 1 kW of heat.

Fitting out
The door should be fitted with a lock.

Doors should not open inwards or outwards into escape routes in such a way as to cause obstruction. (Folding doors may facilitate access without disrupting other work.)

Proprietary metal channel sections, such as Unistrut, are best for holding equipment.

Open riser shafts should have steel grid floors to prevent personnel and tools falling down the shaft.

Because IT-related building spaces represent a valuable asset, the responsibility for their management should be vested in a designated individual. Cable management, which includes controlling the installation of new cables and maintaining records for them, should also be the responsibility of a named manager.

Figure 8.1
A typical stacking plan
Stacking plans show which floor each department occupies and how much space is used.

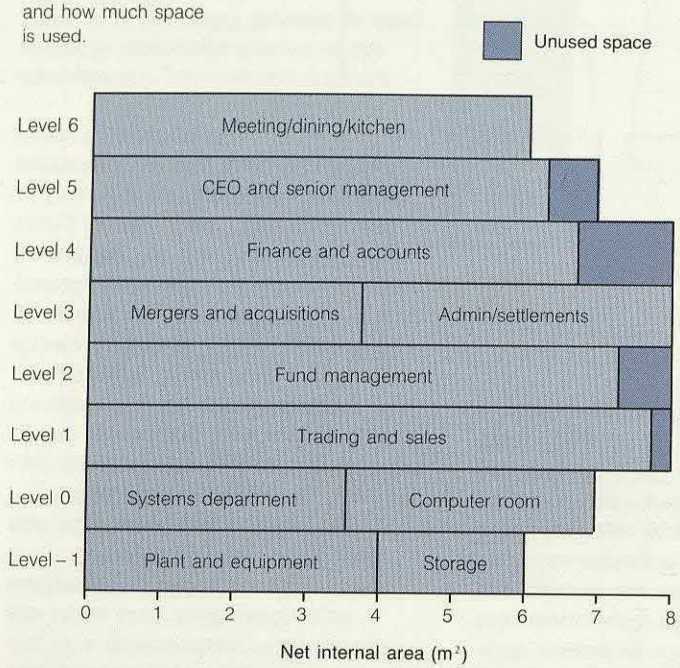
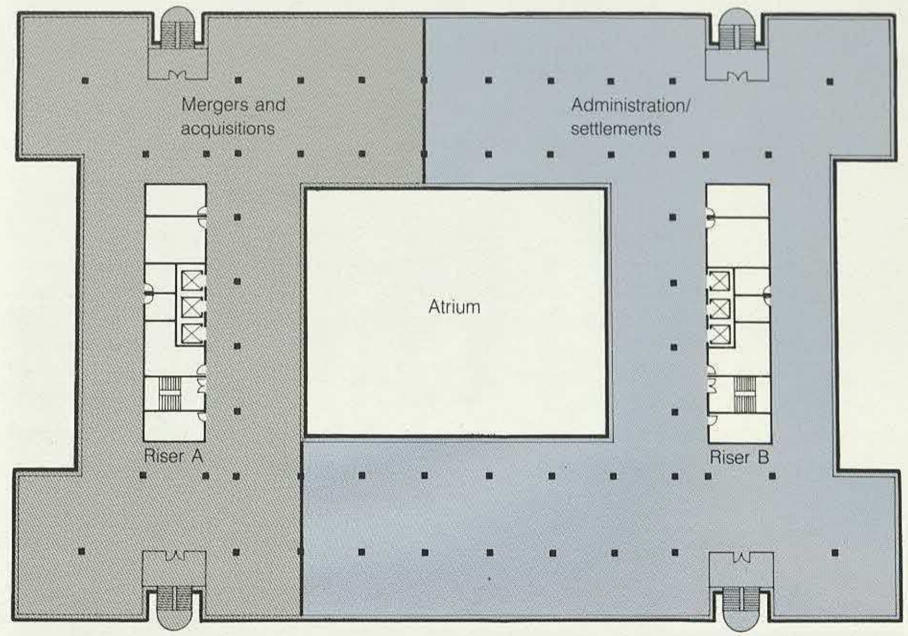


Figure 8.2
A typical blocking plan
Blocking plans show the allocation of space on an individual floor.



Contents

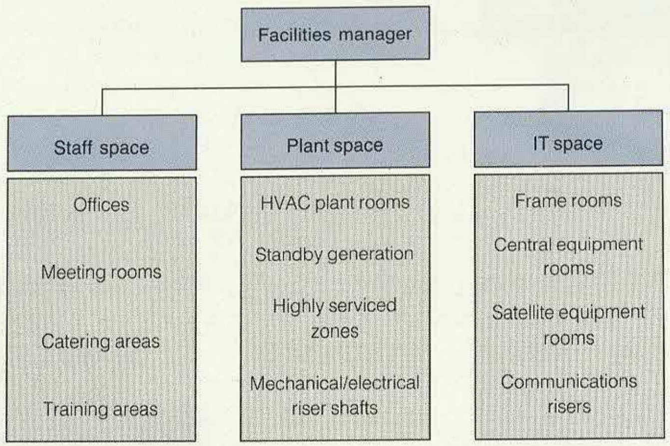


Figure 8.3
Responsibilities of a facilities manager in controlling the use of space

IT-related building spaces are of many different kinds, including frame rooms, risers, heavily serviced zones, and expansion spaces for wiring closets. The corresponding space requirements can be calculated according to the assumptions set out in Chapters 2 and 3. These calculations, however, will be correct only if the spaces are managed effectively.

Consider a common case. If a wide variety of communications cables is allowed to proliferate within the risers and distribution spaces, the available space will soon be used up. Similar considerations apply to the spaces reserved for the expansion of plant rooms, computer rooms, and frame rooms. These spaces are valuable, and their value may not be immediately apparent. It is therefore important that someone should be charged with maintaining the flexibility represented by these spaces. This is especially significant in refurbished buildings, where limited service spaces can be made adequate only by exercising a close discipline over their use.

The requirement is particularly critical if the building is to be let to several tenants, or if part is to be sub-let by a tenant. Probably all tenants and subtenants will need space for bringing telecommunications services to their offices and for distributing them between office areas. It is commonplace for these services to run through risers and telecommunications closets to which other occupants also need access. This raises concerns about interference and interception, either deliberate or accidental. The required levels of privacy and security can be met by installing conduits within risers, and allocating the whole of one or more conduits to each occupant. However, the effectiveness of such a scheme requires careful management of the conduits.

In many buildings, service space is a scarce resource. To avoid using it up unnecessarily, it should be treated as an asset, the responsibility for which should be vested in a named individual (the facilities manager). This individual should probably be in the facilities management department, not in communications or systems. He or she will need an appreciation of IT — for example, a familiarity with multiplexing options. Figure 8.3 shows the relationship of the facilities manager to the service spaces.

The best way of managing this space will often be through the explicit use of a price mechanism. In this case, the facilities manager charges other departments a rent for the use of service space. The level of the rent should be set so as to encourage the degree of space efficiency required by the building.

GUIDELINES

Control of the service spaces and of the reserves for the expansion of service spaces should be vested in a facilities manager.

No-one should be allowed to install equipment in these areas or to occupy them without the consent of the facilities manager.

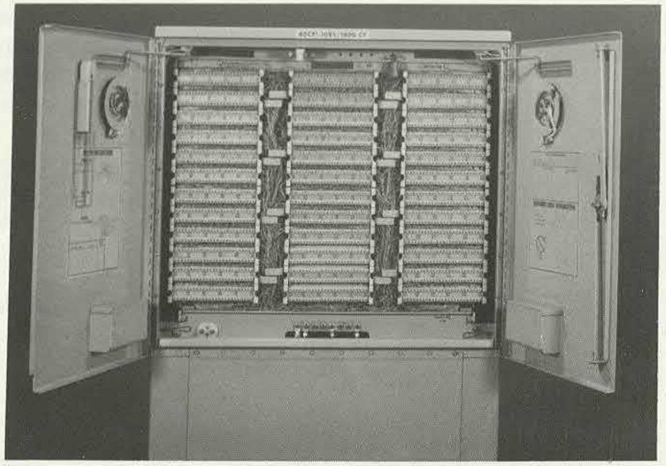


Figure 8.4
A typical data-cable termination and interconnection frame

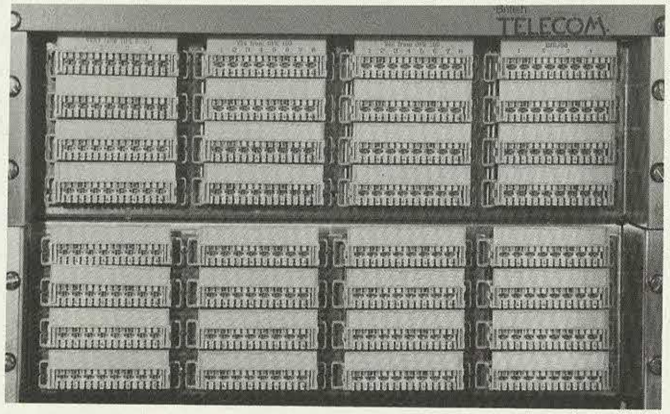
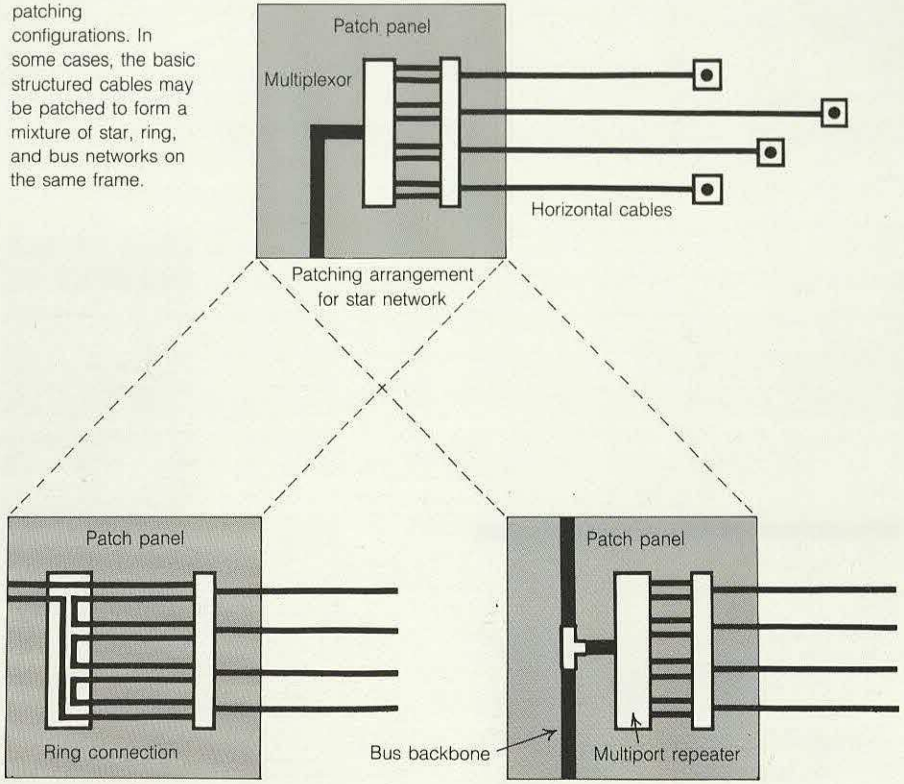


Figure 8.5
A typical telecommunications-cable termination and interconnection frame

Figure 8.6
Using structured cabling
Cable-management systems should enable occupiers to keep track of cable patching configurations. In some cases, the basic structured cables may be patched to form a mixture of star, ring, and bus networks on the same frame.



Cable management spans three areas of responsibility — controlling the reconfiguring of the cabling system, via patch panels, identifying the occasional need for new cables to be installed, and controlling the installation of new cables, where necessary.

As recently as five years ago, data cables were mainly dedicated to particular signalling systems, protocols, and desk locations. If any of these changed, it was usually necessary to install a new cable, often of a different kind, as a replacement. A few sophisticated computer users sought to avoid this by installing structured cabling schemes to their own designs. They were usually based on twisted-pair cables. A few others solved the problem by adopting Ethernet or broadband local area networks (LANs) for their local communications, and cabling their offices to support these networks.

Only a minority of users, however, took either of these routes. In most organisations, cables were, and still are, installed on an ad hoc basis to meet developing needs. Where this is the case, cable management is simply one part of telecommunications management. It does not exist as a distinct activity. Moreover, in most organisations, telephony wiring in the past has come under the British Telecom (BT) monopoly, attracting little attention from telecommunications managers, and less from anyone else.

The introduction of the first structured data cabling scheme in the United Kingdom, the IBM Cabling System (ICS), drew attention to this area. Structured cabling systems can support a wide variety of local communications networks. Figure 8.6 shows how, by precabling in a star topology, a variety of networks can be realised through the use of suitable baluns and other electronics. The most widely used structured cabling schemes are based on twisted-pair cables with at least two pairs to each presentation. They can support:

- 'Standard' terminal signalling schemes such as RS232 and 423.
- Proprietary terminal protocols such as IBM 3270 and 5250.
- LANs, including ISO 8802.3 and 8802.5 (but excluding ISO 8802.4).

Where a structured cabling system has been installed with a sufficient number of presentations (as discussed in Chapter 5), cable installation is separate from the provision of a communications connection in a particular case. Cables are installed during building fit-out or refurbishment. Connections are provided by supplying the user with an appropriate balun, making appropriate connections on the patch frames, and sometimes installing additional electronic equipment.

If the guidelines given in Chapter 5 have been followed, the building will have been comprehensively pre-wired for both voice and data during the fit-out stage. If this has been done well, the need for installing further cables will be limited, but such installations are the responsibility of cable management when the need does arise.

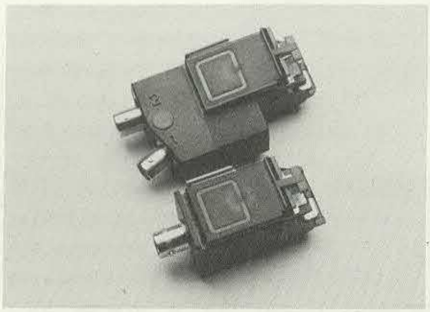


Figure 8.7
Typical baluns for use with structured data cabling

PABX port identity	Riser pair identity	Jumper in place	Frame pair identity	Horizontal cable identity	Outlet socket identity	Remarks
1601	201	Y	**'001**	**V2001**	**U2001**	Desk No 201
1605	202	Y	**'006**	**V2002**	**U2002**	Desk No 202
			'011	**V2003**	**U2003**	
1609	203	Y	**'016**	**V2004**	**U2004**	Desk No 203
1613	204	Y	**'021**	**V2005**	**U2005**	Desk No 204
			'026	**V2006**	**U2006**	
1701	205	Y	**'031**	**V2007**	**U2007**	Desk No 205
			'036	**V2008**	**U2008**	

Figure 8.8
Example of a paper record of cables and patching
Bold type indicates permanent horizontal cables; standard type indicates patching and variable data.

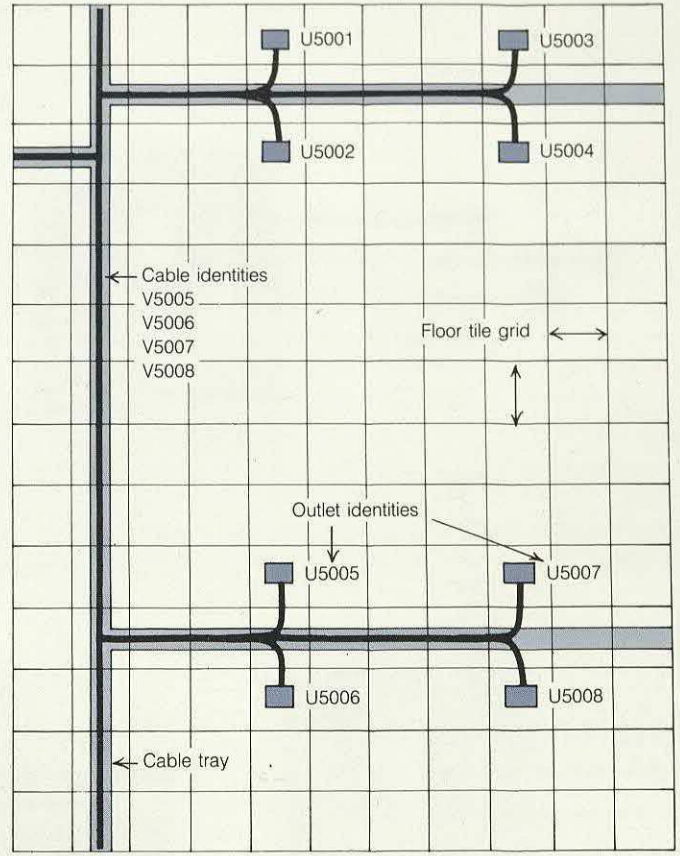


Figure 8.9
A typical cable layout/routeing drawing
Cable routeing drawings should show cable routes and cable numbers.

It is important to distinguish the needs of the installer of the initial cabling scheme from the needs of the occupant. In the past, these needs overlapped greatly because the initial cable installation was incomplete and many cables were installed later. With a structured cabling scheme, most cables are installed during fit-out. Very few more are likely to be installed during the first five years or so, although special requirements are increasingly likely to arise thereafter.

During the early years, the occupant will need to change the patching frequently to track changes, but will rarely need to install new cables. (The installation of new baluns, shown in Figure 8.7, and specialised communications equipment, will be commonplace, however.) Later on, the need for special cables will increase. Many users will need to install a new structured cabling scheme (probably based on fibre) within 10 years.

Good record-keeping and maintenance of the cabling system are essential. Indeed, the keeping of good records of private automatic branch exchange (PABX) wiring is a requirement of the Branch Systems General Licence (BSGL). (The BSGL provides the legal basis under which approved equipment is connected to the public networks in the United Kingdom.) Preprinted cable documentation for this purpose is available for most cabling schemes (Figure 8.8 shows a suitable paper record). In addition, computers can be used to assist with the administrative work in all but the smallest offices. Computer systems that generate lists of changes to achieve a desired result are valuable, particularly for large and complex installations.

Cable-management systems for large installations should be interfaced to the network-management system, but we do not generally see a need for integration. The interface functions should include the use of common numbering schemes for ports and presentations, functions to inform network management of the physical location, and circuit details of the equipment connected to a network port.

GUIDELINES

The cable manager should control what is done, not merely record it.

In small offices (say, less than 1,000 m^2), records may conveniently be kept on paper. (However, if the records for a number of such offices are centralised, they should be held on a computer.)

In medium-sized offices (say, between 1,000 m^2 and 10,000 m^2), cable and patching records should be kept on a simple, probably personal-computer-based, system. (An organisation with many medium-sized offices might, however, be wise to invest in a more sophisticated cable-management system.)

There is no need to integrate these records with drawings: numbering systematically the presentations and routes (routes, not cables, should be shown on the drawings) should be sufficient.

In large office buildings (over 10,000 m^2), records should be held on a more powerful computer. The system should be able to generate the complete list of changes needed to achieve a specified result — for example, moving the marketing department's equipment to the third floor, west wing. The integration of drawings and cable lists on the computer may be valuable.

Figure 8.10
The occupier requires drawings and documents indicating how the building should be used and maintained

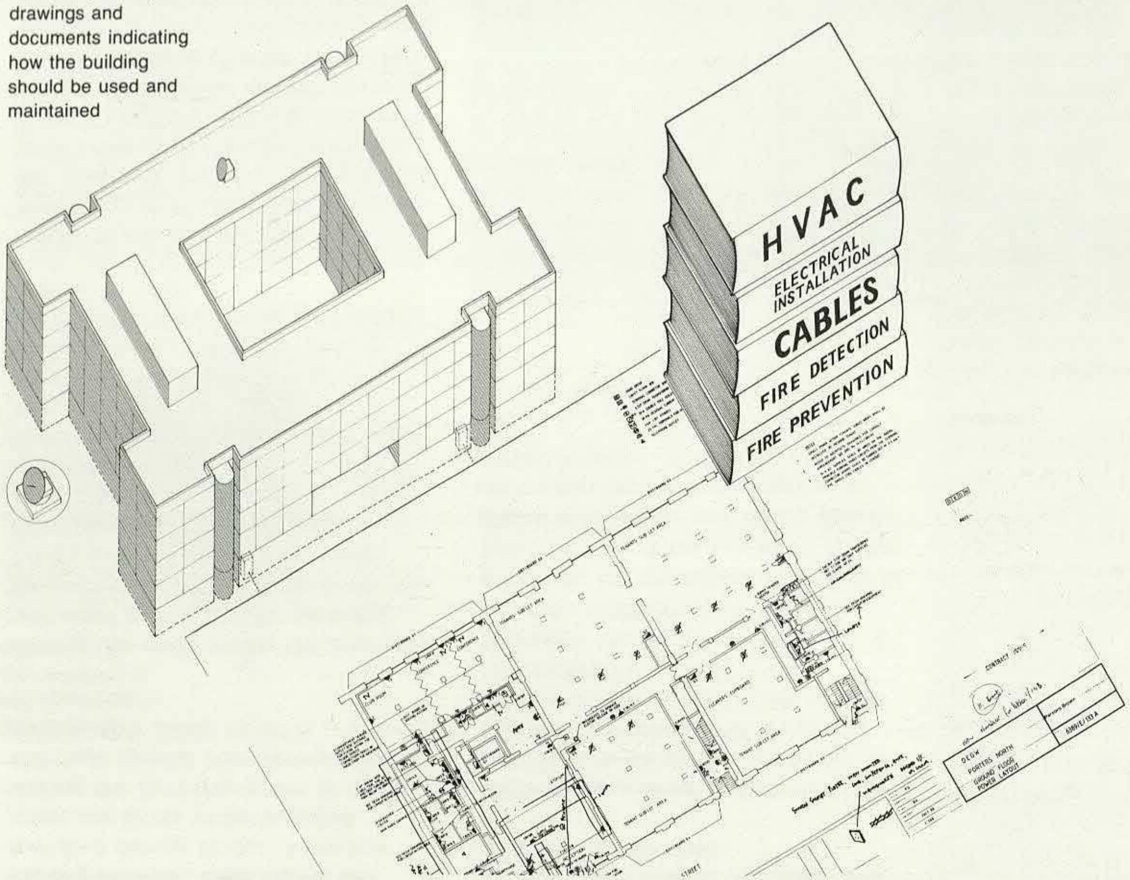


Figure 8.11 IT-related management rules

Staffing density	The average occupation density should not exceed one person per 8 m^2 of NLA. The density should be regulated so that the loads on the power supplies and cooling systems do not exceed their capacities.
Use of space	Areas designated for open-plan use should not be converted to cellular offices, and vice versa.
Fire precautions for computer suites	The computer room should be paper-free, and combustible materials should be excluded. Inflammable materials should never be stored next to computer rooms and frame rooms.
Power	The main-office power supply should be kept clean by excluding noise-creating equipment. If additional needs for non-stop operation develop in offices, management should consider either moving those concerned to an area with no-break power supplies, or converting the floors or parts of the floors concerned to no-break power supplies.
Satellite antennae	The southerly arc between south-east and south-west of the planned antennae locations should be kept free of obstructions.
Communications risers	Holes should be firestopped when not being worked on.
Lighting	Lights should be cleaned and maintained regularly.
Furniture	Foot-rests and document holders should be available.
Security	Wiring closets should be kept locked when not in use. Access should be restricted to persons genuinely needing access.

The design of a building is an exercise in professional skill aimed at satisfying specified requirements within financial constraints. Occupants who attempt to make the building do more than it has been designed to do risk difficulties ranging from inconvenience to themselves, to damage to the structure.

Equally, the design team makes certain assumptions about the management of the building after occupation. If these expectations are not fulfilled, the efficiency and effectiveness of the buildings and its users are likely to suffer. This is especially important for refurbished buildings, since the limitations of the basic design may make it necessary for the landlord to accept certain compromises in requirements or design.

In Chapter 2, we stressed the need for both requirements and design information to be passed from the developer to the contractors, and also to the final landlord and occupants. It is the responsibility of facilities-management staff to be aware both of the limitations of the design and of the designer's expectations. They should then manage the building in such a way as to maintain the integrity of the design.

Figure 8.11 lists some of the IT-related management rules that should be observed by facilities management. Most of these rules relate to more than one trade or profession — for instance, space planning and electrical engineering or computer operations, fire safety, and building maintenance. It is essential that the various trades and professions concerned with the construction, maintenance, and use of buildings should make contact and take account of one another's concerns and contributions. It is the task of the facilities manager to ensure that they do so.

Information technology (IT) is a generic term for computing, telecommunications, and office systems in business.

The rapid advances that characterise the progress of IT are being driven by developments in four fundamental technologies on which the subject is based. Developments that occur at this level are incorporated rapidly into commercial computing, telecommunications, and office systems products. In turn, these products and services become the basic enablers upon which business applications are built.

In this appendix, we first describe four fundamental technologies influencing IT developments and the evolution of IT products in the form of computers and communications facilities. Next, we describe the application of IT to business under five main headings.

Of all the advances in IT, the one having the most impact on offices, and hence on office buildings, is that of the personal workstation. The way in which the workstation will evolve over the next 10 years is already reasonably clear. This appendix is completed with a glimpse into the future of the personal workstation, and with a summary of the main areas of uncertainty about IT in the context of offices and buildings.

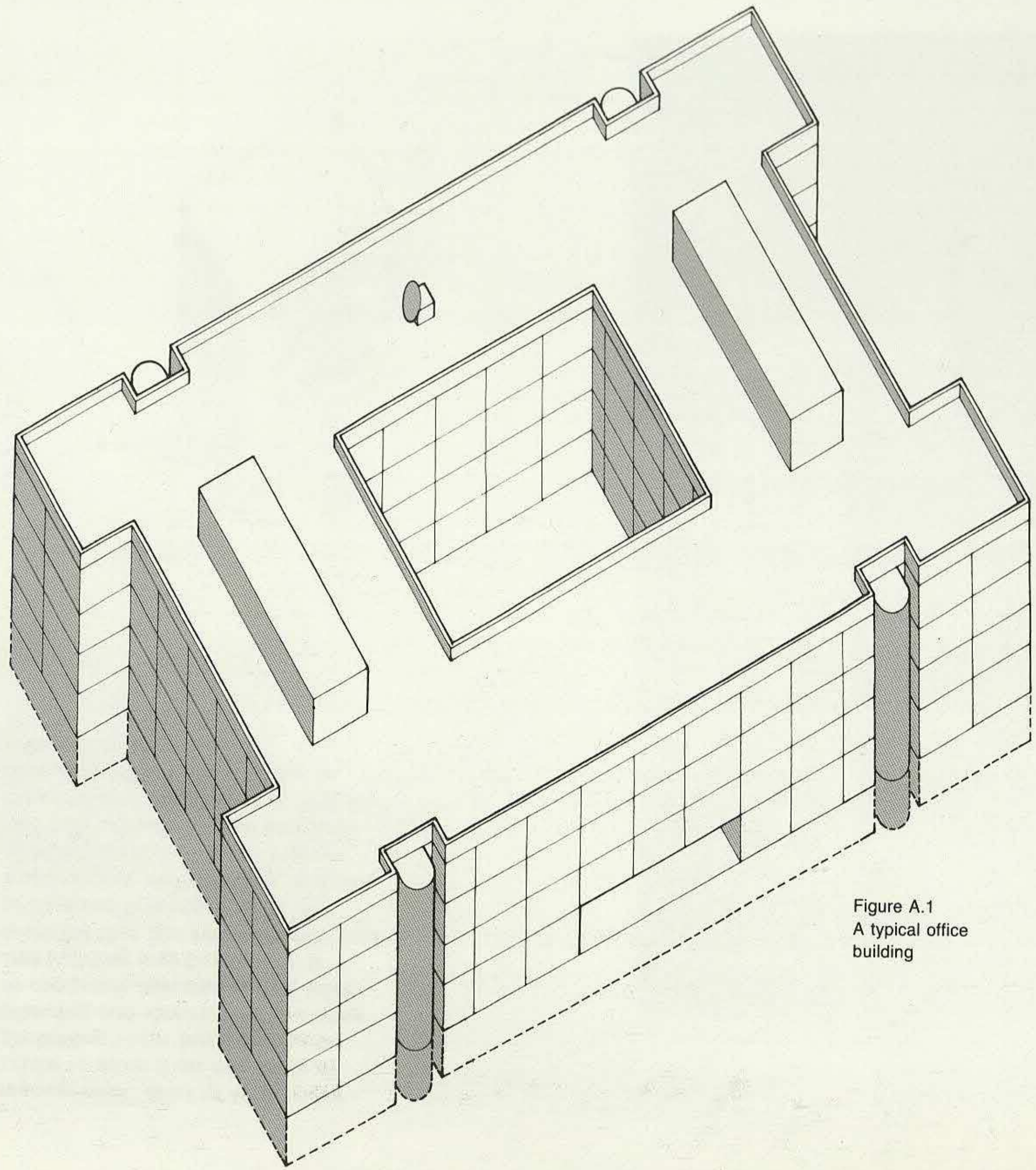


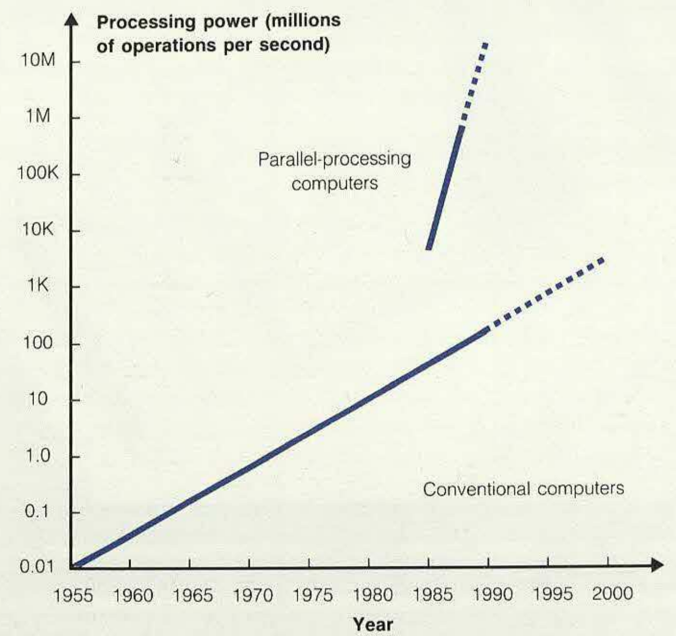
Figure A.1
A typical office building

Contents

BUTLER COX

The most fundamental information technologies are semiconductor engineering, computer architecture, opto-electronics, and programming. All four are likely to continue developing over the next 10 years (and probably much longer) at rates similar to those of the past, although there will have to be some major innovations. Few fields change as fast as IT, yet the main developments can be confidently predicted because they will follow from decisions and investments that have already been made.

Figure A.2
Computer-processing power has improved over the last 30 years
The new parallel-processing computer desgins promise dramatic increases in power over conventional single processing designs.



Semiconductor engineering
Semiconductor engineering has been the main driving force behind the advance of IT to date. Almost every year since the late 1950s, engineers have delivered a 30 per cent increase in the processing speed of the fastest chip and, more importantly, a 30 per cent improvement in price/performance.

Engineering developments, together with the use of new materials such as gallium arsenide, provide scope for further advances. There are, however, both theoretical and practical limits to these developments. They are already restricting growth, and the restrictions will begin to become acute for large computer systems even within the next five years.

Computer architecture
For most of the past 30 years, computer architecture has remained wedded to the single-processor, dumb-memory principle, first formulated by John Von Neuman in the 1940s. Design teams have, in the meantime, introduced many new features and exercised great ingenuity, but the principle has remained intact. Only fairly recently have designers begun to depart from this approach. On the one hand, they have sought, in reduced-instruction-set computers, to make processors simpler and faster by providing fewer features. On the other hand, they have begun to connect large numbers, sometimes thousands, of simple processors into complex parallel arrays to obtain higher speeds. Parallel computers are now the world's fastest computers, as is shown in Figure A.2, while smaller parallel machines make the power of a supercomputer available for the price of a minicomputer.

Opto-electronics
As technology nears the limits of electronics, engineers have begun to develop opto-electronics, computing with light. This is furthest developed in the application of optical fibres for long-distance communication, but is already assured of a very important place in local communication. Moreover, opto-electronics will become a significant factor in computing within the next 10 years.

Programming
It may seem odd to classify programming as a technology. Programming is, however, central to the advance of IT. Not only is it part of the definition of the (stored program) computer, but also the reason for the vast applicability of IT. For the first time in history, the function of a machine can be changed without rebuilding it — simply by loading a new program. Yet programming technology has advanced only slowly, and many of the problems that bedevilled the pioneers continue to plague today's programmers.

Advances in programming have been of two kinds, which we call 'general' and 'inspirational'. General advances, such as the development of higher-level languages and structured methods, are applicable to all sorts of programming. General advances have been due as much to better management as to better technology, and although they will continue, there is little sign of any breakthrough.

Inspirational advances in programming are specific innovations such as the spreadsheet package, the word processor, and the graphical interface. They make some aspects of computer use much easier and more productive, often by allowing the user to avoid the need to 'program' in the conventional sense. The flow of such innovations will continue, but it is hard to forecast their nature and the rate of their development.

Computers may be divided, somewhat arbitrarily, into three broad categories: mainframes, minicomputers and workstations. It is commonplace for computers in all three categories to be linked together through both local and wide-area communications.

Figure A.3
Trends in computer performance
In 10 years' time, personal workstations will have a performance equal to today's large mainframes

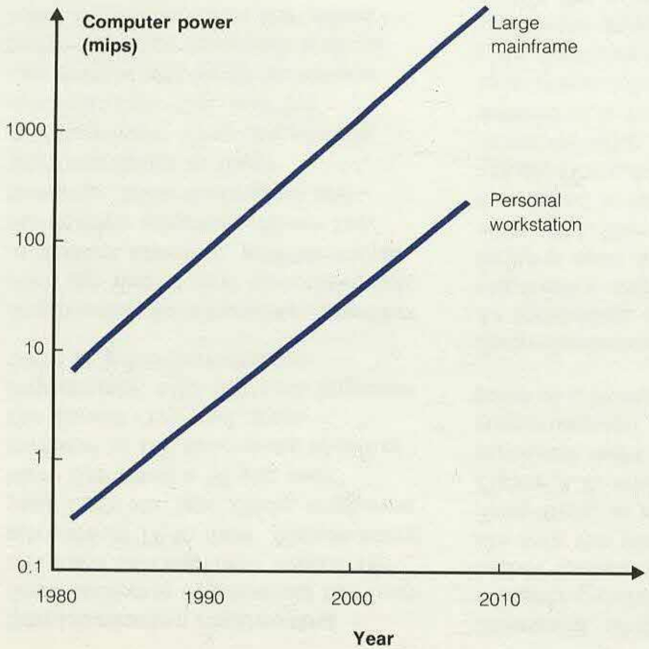


Figure A.4
Electrical power demand of personal computers used as office workstations
It is difficult to predict the electrical power demand of future office workstations.

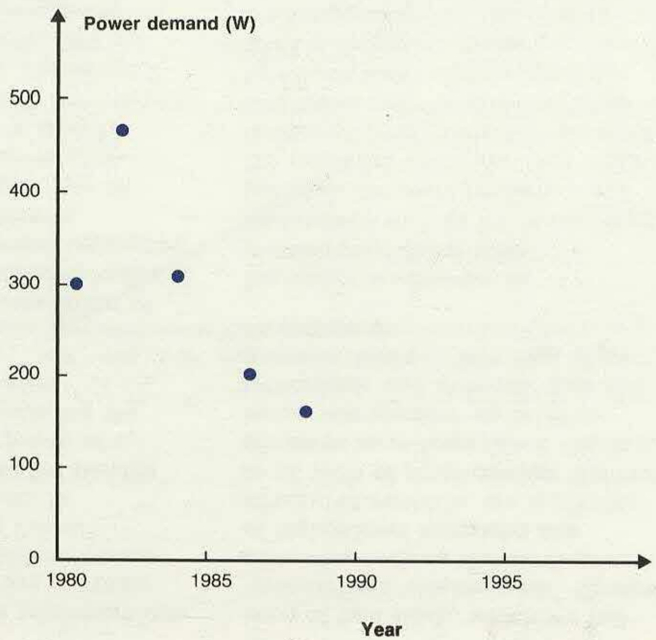
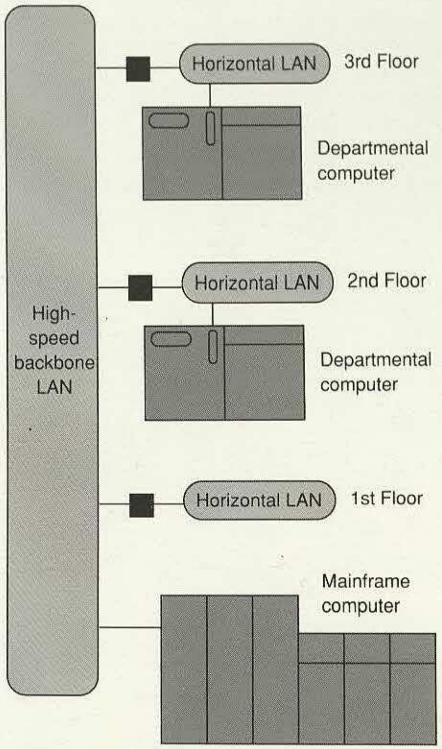


Figure A.5
A typical LAN configuration for an office building
A configuration with a local area network (LAN) on each floor and a high-speed backbone LAN is expected to become a comon arrangement for office building data networks.



Mainframes
A mainframe is a general-purpose computer able to manage a very large volume of data for many users. Requiring a dedicated computer room, a mainframe can process a mixture of batch work, online transactions, and time-sharing work. Existing ranges will continue to develop, and new designs, based on parallel architectures, will be introduced over time.

Minicomputers
Compared with the mainframe, minicomputers deliver more limited services to a smaller number of users, and are more tolerant of their environment. Their evolution is more difficult to foresee. The performance of the largest minicomputer is already comparable with that of mid-range mainframes and they are used in similar ways, although often by smaller organisations. The main trend in minicomputers is likely to be that of specialisation. The deployment of local area networks (LANs) will create a market for minicomputers especially designed to perform such tasks as database management, printing, and communications.

Workstations
Workstations sit on desks, and each supports a single user.

By the year 2000, personal workstations, each having 20 megabytes of memory and a power of 30 mips (roughly the power of a large mainframe today) will be available for much the same price as a personal computer (PC) of today. By 2010, the performance of a personal workstation will equal that of today's small supercomputer.

Displays will improve more slowly. However, a resolution of 300 dots per inch should be common by the year 2000. This is comparable with that achieved by today's desktop laser printers, and will allow screens to replace paper in many applications.

The electric power demand (and heat output) of a PC is greater than that of a dumb terminal. Since the first appearance of the PC, its power demand has first increased and then declined, as shown in Figure A.4. Because LANs enable printers and discs to be shared by many users, the power demand of the average PC will continue to decline somewhat, although the growing power demand of the shared equipment will offset this trend.

The development of workstation software will be marked by three main trends — increasingly powerful applications packages, the emergence of a small number of standards, and the ability of a single workstation to provide access to a wide variety of systems and services, both local and remote.

Local communications
Local communications will see a continuing move from analogue to digital, increases in bandwidth, and the wider adoption of standards.

Most business telephony is already switched digitally. Within buildings, however, it is transmitted in the form of analogue signals. The introduction of private automatic branch exchanges (PABXs) compatible with the integrated services digital network (ISDN) will extend the digitisation of signals down to the individual telephone. Integrated services PABXs (ISPBXs) will, in addition, offer digital connections for non-voice equipment.

Over the next 10 years, most terminal support communications will be replaced by LANs that comply with International Standards Organisation (ISO) standards. In the office, the dominant standards will be ISO 8802/3 (Starlan and Ethernet) and 8802/5 (Token Ring). In a large building, these local LANs will be linked by a high-speed backbone LAN of the sort shown in Figure A.5, to one another, to departmental computers, and perhaps, to a central mainframe. Often the high-speed backbone LAN will be based on optical fibre and will comply with standards that are now emerging for fibre-distributed data interface (FDDI).

Wide-area communications
Wide area communications will, like local communications, see a trend to digital rather than analogue operation, increases in bandwidth, and the wider adoption of standards.

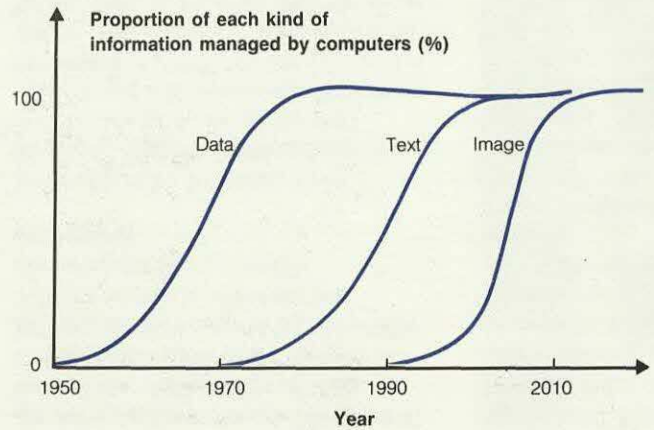
Users will benefit increasingly from the investments that British Telecom (BT) and Mercury Communications Ltd (MCL) are making in optical-fibre transmission systems and their ISDNs. These networks will support high-speed digital transmission services such as BT's KiloStream and MegaStream. Users will benefit from higher operating speeds between sites, and lower costs, especially for data communications.

Taken together with standards for electronic mail and electronic data interchange, these developments will enable telecommunications to replace letter post, telephony, and to a lesser extent, meetings, for a large proportion of business communications. ISDN's most important role will be to improve the telephone system. ISDN will also act as a focus for the development of non-voice, interbusiness services, such as high-speed facsimile and electronic mail.

Figure A.6
Emerging IT support for office staff

Type of staff	IT support
Senior executives	Specialised information retrieval systems ('executive information systems') giving access to personnel, financial, and operating information.
Graphic design teams	Workstations with full-colour displays, access to a wide range of stored artwork and pictures, and both computer-aided design (CAD) and freehand drawing programs.
Financial traders	Multiple screens giving access to a variety of information services, some provided in-house and some by outside service providers.
Systems analysts	PC-based workstations with software that supports, or even automates, the collection and analysis of facts, specification, and design.

Figure A.7
The progressive computerisation of business information
A high proportion of business data, and a fair proportion of text, is already held on computers. Over the next decade, these proportions will rise towards 100 per cent and an increasing proportion of images will be computer-managed as well.



The range of applications of IT will increase considerably during the next 20 years. Existing applications will evolve, and new kinds of application will appear. Office applications will grow considerably in importance.

Office applications may be divided into four groups: transaction processing, such as accounts, stock control, and airline-seat reservations; decision support, including spreadsheet modelling and information retrieval; office automation, including word processing, electronic mail, and the creation of business graphics; and engineering design systems, including computer-aided design (CAD).

Within each group, the overall impact of IT will be to reduce the need for people to perform routine business processes, such as distribution and manufacture, leaving them free to concentrate on exceptions, policy, and interpersonal issues.

Transaction processing
In the future, businesses will be linked together electronically, enabling them to react more quickly to the demands of their customers. Electronic interbusiness links will enable transaction-processing systems in different organisations to exchange information directly with one another, rather than through intermediate data-entry staff.

The addition to transaction processing, first of expert systems, and later other forms of artificial intelligence (AI), will further reduce the need for direct human intervention in many business processes. The introduction of image-management systems will broaden transaction-processing systems to include diagrams, photographs, and signatures.

Decision support
Decision-support systems will be enriched in two ways — by the wider availability of high-resolution colour displays, and the use of techniques derived from AI to draw attention to particularly significant data, to suggest possible explanations, and to propose courses of action.

Higher capacity data stores (especially optical discs) and new methods of text analysis (running on parallel computers) will extend the analytical power of decision-support systems to include text as well as structured data.

Office automation
Better displays, higher-capacity stores, more powerful computers, and faster LANs will all be required to integrate data, text, and image in tomorrow's office systems. By the year 2000, office systems will generally be able to capture, create, store, and retrieve compound documents without the user needing to consider the nature of the matter to be manipulated.

Engineering design software
The introduction of AI-derived techniques to engineering design and analysis will lead to the publication of design manuals in the form of programs. Instead of looking up a handbook, engineers will simply ask for the guidelines to be applied directly to their work, thereby producing a critique, or even a revised design. This approach will be applicable to almost all forms of professional work, including computer-systems design and many sorts of graphic design.

Integrated office systems
The greatest benefit of office systems will result from integrating all the technologies and systems needed by staff to do their jobs. Figure A.6 shows how multiple systems and services may be brought together to support particular kinds of office worker.

This integration will become increasingly common during the next decade. For many office workers, the personal workstation will become the obvious tool for communication, calculation, and even ordering of thoughts for a meeting or presentation.

Much of the deployment of IT over the next 20 years can be foreseen in broad outline. In particular, it is clear that powerful intelligent personal workstations will become the almost universal basis for most office work by the year 2000. This development is coming from two directions; from advances that are occurring in workstation technology, and from other technologies, such as document scanning and the electronic interchange of commercial data with trading partners, that deliver information across the corporate networks to workstations.

Figure A.8
A British Telecom telephone

Figure A.9
An IBM PS/2 personal computer
Personal computers with local area network connections are expected to become the standard office workstations of the 1990s.

Figure A.10
A DEC workstation
For certain applications, including design and publishing, more powerful workstations are often used.

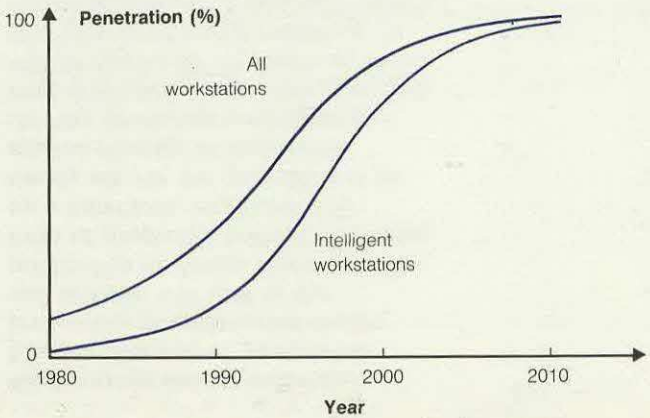


Figure A.11
The increasing penetration of workstations
The penetration of computer terminals and networked personal computers is growing rapidly. In the future, dumb terminals will tend to be displaced by intelligent workstations.

Proliferation of workstations
At present, the ratio of workstations to staff ranges from as low as 1:10 in some small organisations to as much as 1.5:1 in a few very exceptional cases. In most office buildings, the ratio now stands somewhere between 1:5 and 1:1 and the penetration of workstations is increasing every year. Within five years, the ratio will have reached 1:1 for office staff in many buildings, including those that have not been well served in the past.

Workstation penetration exceeds 100 per cent in some offices (most notably in offices housing software development groups and financial traders) because the staff there need to access more than one computer system or information service.

It is obviously inconvenient to have several workstations on one desk. They take up space, and transferring information between them (to include results prepared on one system in a report prepared on another, for instance) is seldom easy.

The technical problems are being overcome by the development of standards and gateways that allow interworking between dissimilar systems. As these developments advance, the financial balance is likely to swing in favour of integrated workstations. As a result, the penetration of workstations among office staff is unlikely to exceed 100 per cent over the next five to ten years (as shown in Figure A.11).

The move to intelligent workstations
Today, most workstations are dumb terminals (that is, they rely on a separate, central, or departmental computer for processing power and data storage). Adding intelligence costs relatively little, and the unit cost of intelligence is set to fall still further. When the full costs of mainframe access, resilience, and spares are included, a group of intelligent workstations may already be less expensive than a similar number of dumb terminals with their communications equipment.

Intelligent workstations are essential for many of today's most innovative applications. These include expert systems, document image processing, desktop publishing, and mathematical modelling with graphical output.

Intelligent workstations are likely to replace dumb terminals on most desks within five to ten years. The intelligent workstation will combine the functions of the dumb terminal and the PC. It will provide both local processing and access to information and systems residing on other computing equipment. In order to ease the integration of intelligent workstations into the corporate IT infrastructure, businesses will have to establish standards for communications, workstation processing, and user interfaces.

The sharing of resources
The communications requirements of intelligent workstations will differ from those of dumb terminals. They will be best met by high-speed LANs, allowing personal workstations to share printers, files, and communications lines, yielding economies, resilience, and a base for sophisticated future applications. Workstations will also share information held on minicomputers and mainframes.

Although much of the future of IT can be foreseen, some important uncertainties still persist. The roots of these uncertainties lie in local communications, departmental computing, and the growth of data storage. In particular, departmental computer rooms and wiring closets may grow as a result, or they may disappear almost entirely. Buildings should therefore be designed to enable changes to be made economically.

Figure A.14
Growth in online data storage requirements
Organisations' total online data storage may continue to grow exponentially or slow down owing to a lack of things worth computerising

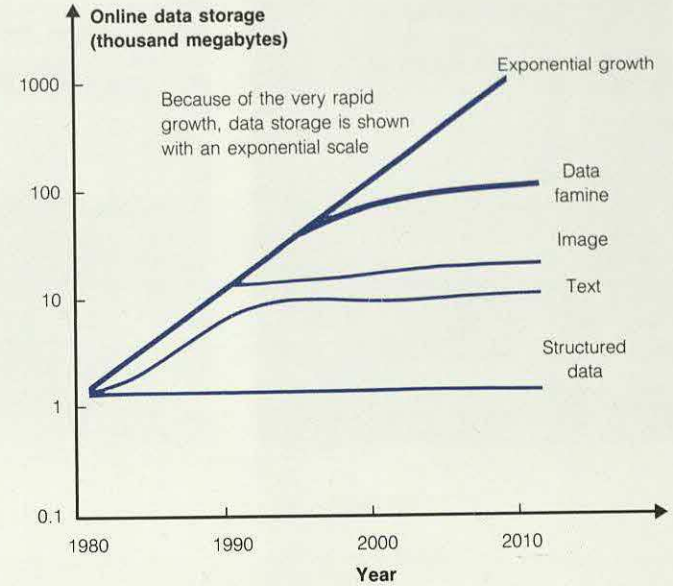


Figure A.12
A three-level system
A three-level system is one in which end users are connected to a local or departmental system, which in turn provides access to the central computer.

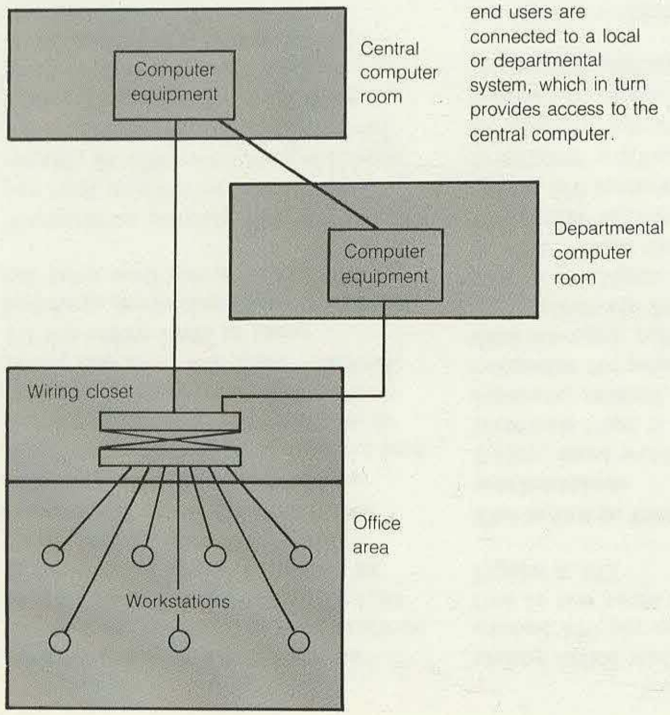
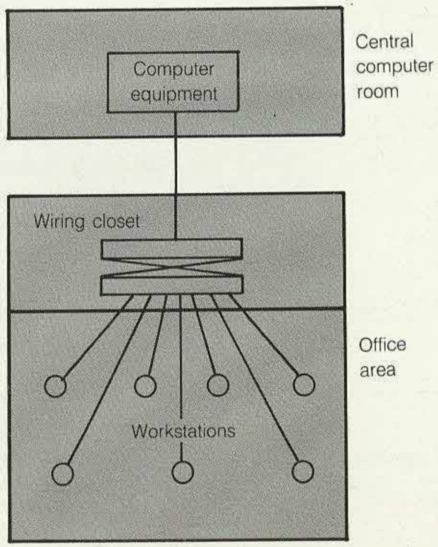


Figure A.13
A two-level system
A two-level system is one in which end users are directly connected to the central computer.



Local communications
During the past 10 years, data-transfer rates in local networks have increased significantly. Speeds of several hundred thousand bit/s have been needed for resource sharing between PCs, and one million bit/s or more between engineering workstations. Speed requirements will continue to grow, especially as document image processing finds a place in the office. The integration of voice into workstation systems will add a further impetus.

These high speeds can best be met by LANs, and particularly by optical-fibre LANs. However, the move to optical fibre, and especially the standardisation of both fibres and LANs, creates the possibility of eliminating cable patching, and possibly the associated telecommunications closets as well.

Departmental computing
Computer power for departmental computing can be provided, as shown in Figure A.12, through a mixture of personal workstations, workgroup systems (which might be based on either minicomputers or LANs), and centralised mainframes in specialised computer rooms.

At present, the low cost of workstation computer power makes intelligent workstations look attractive, while their high speed makes them ideal for such processing-intensive applications as document manipulation, expert systems, and image processing. Workstations connected to LANs (and to shared servers, based on workstation hardware) have the potential to displace conventional minicomputers as the primary vehicles for departmental systems.

It is not yet clear, however, that this potential will be realised. That is because a second set of trends favours a more centralised approach, as is shown in Figure A.13. One is that managerial and professional workstations are increasingly used to access data held in central databases. Another is the growing realisation that the most effective office systems require the integration of graphics, text, and mainframe databases. Yet another is that line departments, having introduced minicomputers for particular applications, are seeking to transfer the operation and control of these systems to their information systems departments.

The future may well see an oscillation between decentralisation and centralisation in departmental computing. At first, a growth in the number of personal workstations may lead to the installation of LANs and shared resources within the office area. Later, this might be followed by the introduction of minicomputers to replace the shared resources and, later still, a migration of these systems into computer rooms.

The growth of data storage
In most organisations, the amount of data held online (usually on magnetic discs) has shown a relentless exponential growth for as long as online computer systems have been in use. Information systems staff often assume that this trend will continue indefinitely.

In many organisations, however, the large majority of business transactions are already processed by computer and held online during the time they are needed for business operations. Online storage volumes often receive a further large boost when the information about each transaction is extended, and when online times are extended to allow the retrospective analysis of trends. There is, however, a limit to the degree to which this is useful.

In future, online storage volumes will increase greatly as organisations begin to deploy document image systems. However, once all the significant paper documents have been captured, online volumes will cease to grow as rapidly as in the past, as is shown in Figure A.14.

In short, once the main data, text, and image systems have been implemented, there may be little data left to computerise. In some large organisations, this point is less than 10 years away.

Glossary

AI
Artificial intelligence.

Architecture, Computer
A computer architecture is a set of principles specifying the general functions of, and interfaces between, the various hardware and software components of a computer system.

Backbone communications network
Sometimes known as primary distribution — that part of the on-site communications network that carries communications services from their points of origin or entry to the building to the spaces to be served. In most buildings, the backbone runs through risers and between the risers, frame rooms, and any computer rooms.

Balun
A device that converts the balanced signalling used on a structured wiring scheme to and from the unbalanced signalling required by many kinds of IT equipment — hence, *bal*anced to *un*balanced convertor.

BMS
Building-management system.

BRE
Building Research Establishment — publishes authoritative works on buildings.

CAD
Computer-aided design.

CCTV
Closed-circuit television.

Centrex
A service, offered in the United Kingdom by BT and MCL, in which business telephony services are provided by exchanges controlled by the service provider rather than by the user's own PABX.

CIBS
Chartered Institute of Building Services.

Closet/wiring closet
A room in which the primary, backbone network is connected to the secondary, horizontal distribution.

Computer suite
A set of rooms accommodating one or more computers, with their ancillary equipment and supervisory staff.

Control bridge
A room in the computer suite from which the operation of computer, and sometimes, communications systems, is monitored and controlled.

CT2
Second-generation cordless telephone system using digital telephony.

Distribution frame
A metal frame holding termination blocks by which voice and data cables are interconnected.

Document image processing
A technology which acquires, stores, and presents images, usually of business documents, in the office.

dpi
Dots per inch, a measure of resolution in printing and visual displays.

Dumb terminal
A computer terminal with neither processing power nor data storage of its own.

ECMA
European Computer Manufacturers' Association.

EDI
Electronic data interchange.

Expert system
A computer program that embodies the judgement of one or more human experts.

Fit-out
The process of installing services, floors, ceilings, wall coverings, and furniture within an otherwise complete building shell.

Frame room
Room in which connections are made between telecommunications cables, including cables connected to external services.

Gross external area
Area of building measured outside perimeter walls and used for planning applications.

Gross internal area
Area of building measured inside perimeter walls, and including all common parts, such as service cores, toilets, and plant rooms.

HVAC
Heating, ventilation, and air conditioning.

ICS
IBM Cabling System.

IEE
Institution of Electrical Engineers.

ISDN
Integrated services digital network.

ISO
International Standards Organisation.

ISPBX
Integrated services private branch exchange.

Intelligent workstation
IT system intended for use by one person at a time and having its own processing power and memory. It may be placed on the desktop or beside the desk and may have its own discs, printer, and other peripherals.

LSF
Low-smoke and fume spread.

Glossary (continued)

LAN
Local area network.

M&E
Mechanical and electrical engineer(ing).

MCL
Mercury Communications Ltd.

NIA/NLA
Net internal area/net lettable area — floor area, measured inside the building, available to the tenant. It excludes common parts, such as service cores, toilets, and plant rooms.

OFTEL
The Office of Telecommunications.

PABX
Private automatic branch exchange.

Patch frame
Distribution frame on which cables can easily be connected ('patched') to one another.

Presentation
The place at which cable-based services (voice, data, and power) can be accessed for the connection of equipment. Usually a group of sockets, sometimes located in an outlet box.

PSTN
Public switched telephone network.

Riser
Vertical shaft, connecting floors, in which services can be installed.

Shell and core
Basic structure of walls, roof, and floor slabs, and sometimes taken to include central services such as lifts, toilets, power supply, HVAC plant, and so on.

UPS
Uninterruptible power supply.

Usable space
Space in which it is possible for the occupant to install his staff, machines, and furniture, usually 80 to 85 per cent of the net internal area, the balance being primary circulation space.

VDU
Visual display unit.

Bibliography

Books

Eley, Peter and Worthington, John. *Industrial rehabilitation: the use of redundant buildings for small enterprises.* London: The Architectural Press, 1984.

Goldblum, Edward. *Computer disasters and contingency planning.* London: Amdahl and Butler Cox, 1982.

Halper, Robert F. *Computer data center design: a guide for planning, designing, constructing and operating computer data centers.* New York: John Wiley, 1985.

Judkins, Philip, West, David, & Drew, John. *Networking in organisations: the Rank Xerox experiment.* Aldershot: Gower, 1985.

Long-term Perspectives Group. *IT futures ... IT can work.* London: National Economic Development Office, 1987.

Office needs: the occupier's view. London: Debenham, Tewson and Chinnocks Holdings plc, 1988.

Toffler, Alvin. *The third wave.* London: Collins, 1980.

Worthington, John, & Konya, Allan. *Fitting out the workplace.* London: The Architectural Press, 1988.

Standards and specifications

Building standards for telecommunications media and systems. EIA PN 2072 (CSA T530). Washington DC: Electronic Industries Association.

CIBSE guide: design data: internal heat gains. Volume A, Section A7. London: Chartered Institution of Building Services Engineers, 1986.

Code for interior lighting. London: Chartered Institution of Building Services Engineers, 1984.

Code of practice for design of buildings: ventilation principles and designing for natural ventilation. BS 5925. London: British Standards Institution, 1980.

Code of practice for electrical systems in office furniture and office screens. BS 6396. London: British Standards Institution, 1983.

Code of practice for fire protection for electronic data processing installations. BS 6266. London: British Standards Institution, 1982.

Code of practice for installation of apparatus intended for connection to certain telecommunications systems: general recommendations. BS 6701: Part 1. London: British Standards Institution, 1986.

Code of practice for internal non-loadbearing partitioning. BS 5234. London: British Standards Institution, 1975.

Code of practice for protection of structures against lightning. BS 6651. London: British Standards Institution, 1985.

Code of practice for the installation of private branch exchanges for connection to the British telecommunications public switched telephone network. BS 6506. London: British Standards Institution, 1984.

Commercial building wiring standard. EIA PN 1907 (Draft) (especially Chapter 4). Washington DC: Electronic Industries Association.

DECconnect planning guide. Reference EK-DECSY-CG. 3rd edition. Maynard, MA: Digital Equipment Corporation, 1986.

Draft British Standard recommendations for ergonomics requirements for design and use of visual display terminals (VDTs) in offices: VDT workstation design. Part 5. Document number 87/40678. London: British Standards Institution, 1987.

Draft British Standard recommendations for ergonomics requirements for design and use of visual display terminals (VDTs) in offices: work environment. Part 6. Document number 87/40679. London: British Standards Institution, 1987.

Framework for colour coordination for building purposes. BS 5252. London: British Standards Institution, 1976.

Generic specification for optical waveguide fibres. EIA/TIA-492000-AA. Washington DC: Electronic Industries Association, 1987.

IBM cabling system: planning and installation guide. Reference GA27-3361. 7th edition. New York: IBM, 1986.

Lighting for visual display units: technical memorandum 6. London: Chartered Institution of Building Services Engineers, 1981.

Office furniture: specification for design and dimensions of office workstation, desks, tables and chairs. BS 5940: Part 1. London: British Standards Institution, 1980.

Open Systems Cabling Architecture: building planning and design guide. Reference: TUP 900. London: British Telecom, 1988.

Premises distribution guide. Reference 555-400-021. Middletown, NJ: AT&T Information Systems, 1987.

Bibliography (continued)

Recommendations for the accommodation and operating environment of computer equipment. IST 22. (Draft) London: British Standards Institution, 1989.

Regulations for electrical installations. 15th edition. Institution of Electrical Engineers, 1987.

Specification for performance requirements and tests for office furniture: desks and tables. BS 5459: Part 1. London: British Standards Institution, 1977.

Telecommunications wiring in business premises and homes. OFTEL 5/87. London: Office of Telecommunications, 1987.

Traffic noise and overheating in offices. BRE 162. Watford: Building Research Establishment, 1979.

Ventilation requirements. BRE 206. Watford: Building Research Establishment, 1981.

Index

Index (continued)

Index (continued)

Index (continued)

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

Butler Cox plc
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, The Netherlands
☎ (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, West Germany
☎ (089) 5 23 40 01, Fax (089) 5 23 35 15