Telecommunications Cabling

Guidance on Standards and Best Practice for Construction Projects

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Preface

Structured cabling projects are complex in nature. Multiple drivers exist with regards to budget, performance, lifetimes and warranties together with interfaces to building structure, architecture and services. Standards are developed with the intent of providing owners, designers and installers with a level of assurance on achieving intended objectives. But standards alone are not enough assurance to guarantee success.

This book is dedicated to promoting a better understanding of the drivers and the risks and project management issues affecting all parties involved in delivering holistic building solutions, including:

- those directly involved in the structured cabling industry;
- project sponsors who drive the requirements;
- construction industry professionals.

Often design and installation of structured cabling is incorrectly viewed as a very simple and straightforward activity – ignoring the latent risks that the IT and other telecommunications service infrastructures, which rely on well designed and co-ordinated cabling, could underperform or unknowingly burden the resulting operating expenses for the premises.

Such risks arise from a lack of early project definition, inadequate 'due diligence' in relation to the more holistic demands of service infrastructures and ineffective governance during the project lifecycle. This often can be traced to a failure to allocate appropriate resources, skill sets and budgets to support the telecommunications objectives of the project sponsor.

This is the first book to attempt to map out the issues, highlight the risk areas and offer guidance to those in the industry from professionals who have first-hand experience of delivering telecommunications infrastructure projects over many years.

Acknowledgements

Mani Manivannan would like to take this opportunity to thank Mike Gilmore for patiently transcribing a wealth of practical experience in the design, project management and delivery of successful projects in telecommunications cabling. The many discussions and frank exchange of viewpoints between the authors that helped to create and shape each chapter is in itself a testament to the intricacies of technical complexity, of the politics of project delivery and the demands of a wider ecosystem of designers, consultants and contractors. Whilst the editorial work was taken on a voluntary basis, Mani expresses his thanks for the support received from the Arup, for the time that it took to arrive at a quality, easy to read manuscript, aimed at promoting excellence within the industry. Further appreciation and thanks are offered to his family, friends and colleagues for the understanding, support and encouragement over the years without which a professional career in telecommunications with an excellent track record and many iconic achievements would not have been possible.

Mike Gilmore would like to thank Mani Manivannan for his patience in explaining the construction project-related concepts outlined in the book which allowed Mike to map those aspects to the existing standardisation landscape that surrounds the design, planning and implementation of telecommunications spaces, pathways and cabling Although the editorial work was undertaken on a voluntary basis over a period of more than twelve months, the Fibreoptic Industry Association provided all the financial support for travel and subsistence during the development of the book. Mike would therefore like to thank the Council and members of the Fibreoptic Industry Association for their support without which this book would not have been published. It is hoped that projects which take account of the ideas expressed will maintain and extend the installation risk reduction concepts promoted by the Fibreoptic Industry Association.

Introduction

In the 1980s, structured cabling evolved to provide a solution for the delivery 'to the desk' of a wide variety of different information technology (IT) 'applications' and telephony over a common cabling infrastructure. Fortunately, this initial implementation of integrated office networks to support IT and telephony services involved personnel that had some knowledge of each other's expertise and were involved at a specific point in the construction or refurbishment of buildings.

Within commercial premises, be they offices, industrial, retail, etc., the range of services that can be delivered over structured cabling has grown as the impact of Internet Protocol (IP) technology has blossomed. The advent of wireless networking has not diminished the role of structured cabling, as the cabled subsystems for the wireless distribution networks use applications that are specifically designed to be supported over structured cabling.

When matched to the recent standardization of power over Ethernet (PoE) and PoE-plus, which is capable of providing approximately 25 W to each connected point, this growth has been fed by a significant uptake in information communications technologies (ICT)-application based solutions for building management and access control systems.

This more recent integration of services over IP networks is generally termed 'convergence', and it has a great many impacts on the preparation, design, pre-construction and construction phases of building projects.

'Convergence' provides the same economic opportunities enjoyed by the IT community 'to the desk' via the use of common applications based on a common cabling infrastructure. However, it presents the construction industry with some serious challenges – and those challenges are presented to personnel who are unlikely to be familiar with the ICT world.

Network convergence forces the consideration of structured cabling into all the phases of a building project, due not only to the type of services the cabling will provide, but also to the enhanced requirements for space, electrical power and environmental control systems that may result.

The provision of power via a network connection presents a significant opportunity for the network attachment of new types of devices, including wireless access points, building management equipment (environmental control, access control) and surveillance equipment (i.e. IP cameras). Moreover, whereas the original use of structured cabling allowed multiple networks and applications to be provided over a common infrastructure in the IT domain, the use of structured cabling to support different services, such as building management and access control, generates the provision of multiple infrastructures using a common set of components. The installation of these infrastructures will need to be completed, and the networks may be required to be operational at different times during the construction or refurbishment of buildings. In addition, the operational responsibility of those infrastructures will lie with different parts of the organization, and this introduces an additional level of complexity in the organization and delivery of cabling projects.

To summarize, the impact of convergence affects a wider community of specifiers and trades, who have not been used to working together and are not aware of the impact and timing of each other's critical decision-making 'pinch points' during the design and construction processes.

This promotes the need for a new approach in the following areas:

- the safeguarding of spatial infrastructure in architectural design;
- the assignment of appropriate responsibilities, liabilities and warranties;
- streamlining of procurement to plan ahead for 'just-in-time' and 'well-before-time' contracts;
- construction sequencing with respect to early beneficial use of the telecommunications infrastructure;
- correct management of an orderly commissioning process;
- requirements for operational support with appropriate documentation.

Guidelines and statements of best practice are beneficial to those organizing the cabling infrastructure projects and the infrastructures that interact with those cabling systems. This book provides information to those trades, such as architects, quantity surveyors and main contractors, that will have to work alongside ICT or, more accurately, telecommunications professionals, and who need to grasp the impact of telecommunications cabling infrastructures that have now become commonplace, if not mandatory, in every type of premises, ranging from offices to apartment blocks, shopping centres to airports.

NOTE: This edition of the document does not address homes (which are covered in a separate publication (PAS 2016), available free of charge) but does cover multi-tenant premises of all types, including commercial, residential and mixed-use premises.

Telecommunications technology trends are truly international, and this book has been created for an international audience, while respecting the nature of national or local regulations. In order to address this global readership, the considerations of the book are given in the following order: the UK, other countries within the European Economic Area served by the EuroNorm system and, last but not least, emerging markets such as those in the Middle East and Asia-Pacific.

The early chapters provide a basic introduction to structured cabling and the development of convergent technologies, and provide a foundation for all readers, as follows:

- Chapter 1: The need for structured cabling.
- Chapter 2: The use of cabling standards within building design.
- Chapter 3: The impact of convergence in IP networks in the built environment.

The later chapters provide more targeted information related to specific aspects of construction projects, as follows:

- Chapter 4: Organizing cabling projects.
- Chapter 5: Mapping business requirements to design objectives.
- Chapter 6: Design strategies and methods.
- Chapter 7: Identifying and managing technical risks.
- Chapter 8: Identifying and managing administrative risks.
- Chapter 9: Operational and management issues.
- Chapter 10: Project close-out.

NOTE: Appendix A contains a bibliography of all the standards mentioned in this book.

The following matrix provides a mapping which indicates the relevance of each of these chapters to those involved in the building design and construction processes.

	4	5	6	7	8	9	10
Project Sponsors	•	•	≈	•	≈	•	•
Project Managers	•	•	≈	•	•	◊	•
Architects	•	≈	≈	≈	•	◊	≈
Building Services Engineers	•	≈	•	•	≈	◊	≈
Telecommuni-cations Consultants	•	•	•	•	•	•	•
Other specialists	◊	≈	≈	≈	◊	◊	◊
Quantity Surveyors	◊	◊	◊	◊	•	◊	◊
Cabling Installers	◊	◊	◊	•	◊	•	◊

Key
• Essential
≈ Recommended
◊ Optional

A large number of standards have been published to assist the industry professional involved in the specification and deployment of structured cabling, independent of its subsequent use, but the relationships between such standards and local and national regulations are not always clear, even for telecommunications professionals. These standards are introduced as required within the chapters but more detailed information on their use is provided in Appendix A: Standards review and bibliography.

Appendix B: Telecommunications Overview provides details of the various implementation solutions applicable for each service. The types of service and solutions are subject to continual evolution, and new options may become available that are not considered in the appendix.

Key terms

Telecommunications and IT - the terms ‘telecommunications’ and ‘information technology’ or ‘IT’ are used somewhat liberally and, to some degree, interchangeably. In the early days of structured cabling, ‘IT’ tended to refer to computer-to-computer communication, and ‘telecommunications’ generally suggested telephony (i.e. person-to-person communications). However, the move towards digital communications has blurred the boundaries of ‘IT’ (e.g. a voice-over-data (VoIP) service is the province of ‘IT’). Moreover, the term ‘telecommunications’ has grown to encompass all forms of communication including voice, video, data, etc. This book focuses on the impact of this increasing coverage of ‘telecommunications’ over structured cabling.

Telecommunications networks are combinations of equipment, cabling and the associated transmission protocols used to deliver particular services to a user.

A given network, such as Gigabit Ethernet, may involve the use of a number of different Gigabit Ethernet applications to distribute the service it carries from one place in the premises to another. For example, 1000BASE-SR (optical fibre) may be required between floors in buildings, whereas 1000BASE-T (balanced cabling) would be used to the work areas in those buildings.

Services - the type of service that a network provides generally falls into the following categories:

- ICT (information communications technologies) – including telephony and recognized data networks;
- BCT (broadcast communications technologies) – focusing on TV;
- CCCB (communication, command and control in buildings) or BAS (building automation systems) – used to control building environment, access control, etc;
- PMCA (process monitoring, control and automation) used to control industrial production and similar equipment.

Applications are the transmission protocols used to deliver a particular service.

1 The need for structured cabling

This chapter provides an overview of the history of structured cabling from its inception to the latest impact of PoE. It provides readers that are new to the topic with basic information, and introduces some of the concepts that influence the demand for structured cabling in commercial, and residential, premises.

It makes reference to the following standards:

- *European: [BS] EN 50173-2, [BS] EN 50173-6 (in preparation).*
- *International: ISO/IEC 11801.*
- *North American: ANSI/TIA-568-C-1, IEEE 802.3 series.*

Appendix A contains a detailed bibliography.

Copper or, more correctly, balanced structured cabling within office premises designed in accordance with the minimum requirements of the recognized standards (BS EN 50173-2, ISO/IEC 11801 or ANSI/TIA-568-C-1), provides a cabling infrastructure capable of supporting a wide range of applications up to and including Gigabit Ethernet (1000BASE-T). The use of higher performance balanced cabling components, beyond the minimum requirements of the standards, provides support for 10 Gigabit Ethernet (10GBASE-x applications). The incorporation of optical fibre within the infrastructure extends that support to 40 and 100 Gigabit Ethernet (40/100GBASE-x applications).

This wide range of application support provides such structured solutions with the alternative title of 'generic cabling systems'.

Two additional factors now extend the opportunities offered by generic cabling – firstly, the integration of wireless networks as extensions to the cabling; and, secondly, the recent standardization of PoE, sometimes referred to as PoE-*plus*, specified to provide up to approximately 25 W to each connected device.

1.1 A history lesson

It is difficult to imagine what the world of work would be like without the advent of easily re-configurable office networks. Before the advent of structured cabling, it was normal to find that office premises would contain multiple IT and telephony cabling solutions, each of which would normally serve only one type of network. Many corporate organizations were often required to support in excess of ten different networks, each one operating with different service level agreements and from different suppliers.

It would have been too expensive to provide flood wiring of all the necessary cabling solutions. As a result, making moves and changes to the working, personnel and networking environment would have required multiple phases of re-cabling before any such move could have been made – one company would have been summoned to provide cabling for new telephone extensions, another to provide new outlets for the cabling of the 10BASE-2 coaxial cabling Ethernet network (and maybe another would be needed for that part of the work group served by the corporate 4 Mb/s Token Ring network).

This ad hoc cabling approach was very expensive and dramatically restricted the operational flexibility of business managers in terms of the opportunities for deployment of personnel, effective space utilization and ease of network evolution.

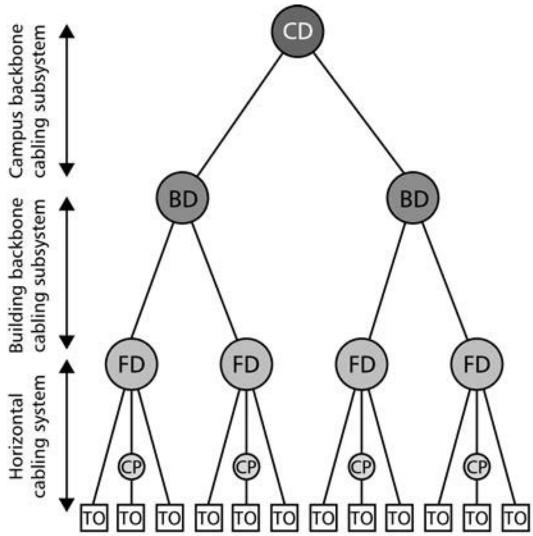
Equally importantly, the networking industry began to be highly competitive, and it was rapidly realized that the development of networking applications that operated over a common cabling solution would accelerate the uptake of new networks, while a customer's ability to undertake moves and changes would encourage growth of the networking market as a whole.

The solution was provided by structured cabling as shown in schematic form in Figure 1 and Figure 2; a series of interconnected subsystems containing passive components (i.e. cables and connectors), allowing rapid re-configuration at the junctions of those subsystems (distributors), coupled with guaranteed transmission performance between the connection points using a mixture of balanced and optical fibre cabling.

1.2 Infrastructure lifetime

The subdivision of premises cabling into subsystems interconnected either by patching or by networking equipment provided an opportunity to redefine the comparative lifetimes of the telecommunications infrastructure.

Cabling that feeds the end-user (i.e. the horizontal cabling in Figure 1 and Figure 2) is generally the most costly to re-install – primarily due to the quantity of cabling required and the accessibility of the pathways that contain the cabling. As suggested in 1.1, the use of ad hoc cabling effectively coupled the lifetime of the network to that of the cabling.

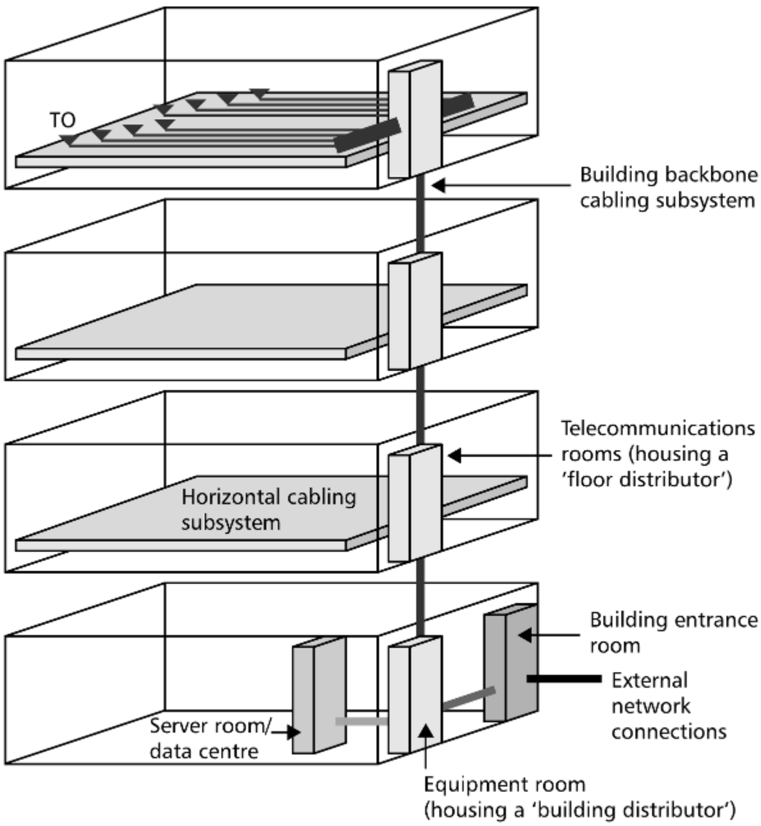


Key
BD building distributor **CD** campus distributor
FD floor distributor **TO** telecommunications outlet
CP consolidation point

Figure 1 – Structured cabling topology for offices

The advent of structured cabling has divorced the lifetime of the network from that of the cabling – although the extent to which this is true depends on the cabling subsystem being considered.

A typical lifetime profile of a horizontal cabling subsystem, feeding an end-user, is shown in Figure 3. The devices connected to the networks have an expected lifetime of 3 years, whereas the networks interconnecting those devices may be reviewed on a 5-year basis. The ability of structured cabling to support evolving networks provides it with an expected lifetime of at least 10 years (according to the relevant standards). Underpinning all of the above, are the expected lifetimes of the spaces and pathways within the buildings, which can have lifetimes extending beyond 20–30 years.



Key
TO telecommunications outlet

Figure 2 – A schematic of generic cabling within a single-tenant office building

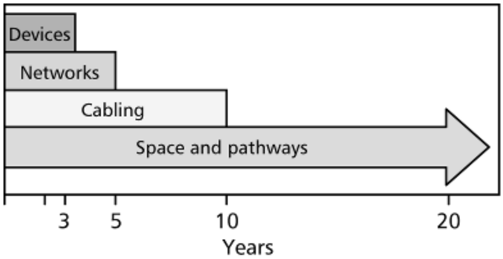


Figure 3 – Lifetimes of horizontal infrastructure

The situation differs within backbone subsystems, where the pathways within and between buildings also have lifetimes in the range 20–30 years but the comparative costs of re-installation of backbone cabling are significantly lower than those of the subsystems that feed the end-user.

Moreover, the technological developments in backbone networks tend to demand more 'leading-edge' cabling solutions, and occur at a more rapid pace than those to the end-user and tend to require more regular review of the cabling infrastructures installed.

1.3 Market development by standardization

The supply of networking equipment is naturally a global business, and international standards are necessary to ensure interoperability. Those groups, such as IEEE, responsible for the development of network standards (and the various applications that deliver those networks) look to cabling standards to ensure that marketing and technical developments are in line with each other's objectives.

Within office premises, the current relevant cabling standards are [BS] EN 50173-2 (in Europe), ISO/IEC 11801 (at international level) and ANSI/TIA-568-C-1 (developed in North America). The cabling structures and performance requirements defined by these standards are, while not being identical, very much aligned.

Networks targeted at the delivery to the end-user (e.g. within the horizontal cabling subsystem in accordance with [BS] EN 50173-2, ISO/IEC 11801 and ANSI/TIA-568-C-1) tend to be implemented using cabling technology options that have been standardized for an extended period and for which there is a substantial installed base. This approach maximizes the opportunity for multiple network evolutions within the lifetime of the cabling.

By comparison, the networks intended for use within backbone cabling subsystems or special areas, such as data centres, are less constrained by concerns over the installed base. These networks tend to establish the 'leading-edge' cabling solutions in support of the fastest networks. However, these cabling solutions tend to be installed in the end-user subsystems, providing them with a potential lifetime even further decoupled from today's networks.

This twin-track approach has allowed the networking standards to evolve in a controlled manner, safe in the knowledge that there is an installed base of cabling with which to interconnect the various networking components.

Key terms

Space - a room or some specified volume that contains elements of the telecommunications infrastructure. Spaces are connected by pathways.

Pathway - within this book, the term ‘pathway’ is used to describe the route that cabling takes between ‘spaces’. ‘Pathway’ is a comparatively vague term that provides an indication of that route (e.g. ‘overhead pathway’ or ‘underfloor pathway’).

Pathway system - defines the route of the cabling within a pathway. It may be a defined ‘cable management system’, or a route (perhaps marked by painted or physical boundaries).

Cable management system - is a pathway system of a specific type which is installed specifically to support cables within a pathway. Examples include conduit (circular ducts), duct, trunking and tray.

1.4 Corporate reorganization

The structured cabling 'revolution' that came about in standardized networks operating over standardized cabling caused the roles of the various in-house networking support teams to be reviewed. Gradually, the concept of the 'data' team and 'voice' team, each of which was responsible for their infrastructure, was replaced by a central telecommunications utility which managed a common infrastructure.

1.5 The growth of structured cabling

Although structured cabling began in commercial business premises (i.e. offices), standards now exist in all three international regions for the specification of structured cabling in data centres, industrial premises, and even homes (see Chapter 2).

The services supported in the office and data centre standards are those of the traditional ICT domain delivered by ICT applications. The industrial premises standards added a new type of service provision, sometimes called PCMA (process control, monitoring and automation).

Homes added two more layers of service provision that had to be supported by structured cabling – building management systems and CCCB.

The need to support PCMA, BCT and CCCB services provided the opportunity for structured cabling to support certain PCMA, BCT and CCCB applications.

NOTE: Information on the difference between services and applications, and an explanation of the meaning of ICT, BCT, PCMA and CCCB, is provided in the Introduction.

Over the last 10 years an increasing number of services from outside the boundaries of traditional ICT services have been delivered using ICT applications. The best and most immediately recognizable example of this concept is the use of broadband deployment to the home and Ethernet networks in the home to provide BCT services to computers rather than televisions (although an increasing number of televisions are now being sold with ICT application interfaces such as 1000BASE-T).

However, this example, albeit valid, tends to focus on the high bandwidth aspects of ICT service delivery.

Key term

Power over Ethernet (PoE or IEEE 802.3at) - allows the delivery of power over two or four pairs of balanced (twisted) cables of Category 5 (and above), while simultaneously delivering an Ethernet IP network of 10, 100 or 1,000 Mbit/s. There are two variants of IEEE 802.3: type 1, which is capable of providing 12.95 W to each connected device (using 350 mA per cable pair); and type 2, which delivers up to 25.5 W to each connected device (using 600 mA per cable pair and is termed PoE-*plus*).

Sometimes different power levels are mentioned: for example, the power supply feeding each connected device is required to provide 15.4 W and 34.2 W for types 1 and 2, respectively.

It should be noted that products are available that provide substantially more power, with appropriate increases in current levels, and their compliance to IEEE 802.3at is a matter of some discussion.

Equally important is the extension of those ICT applications from the office floor to less bandwidth-hungry systems that require remote powering. The introduction of POE-*plus*, as specified in IEEE 802.3at, provides a platform for a rapid increase in the type of services delivered over structured cabling, and extends the range of equipment supported by the IP networks with which POE-*plus* is integrated (i.e. 10BASE-T, 100BASE-T and 1000BASE-T).

The ability to provide remote power to devices as diverse as cameras, sensors and actuators as well as to more traditional networking equipment extends the role of structured cabling to support building management systems (BMS) for access and environmental control. It is this advance more than any other that provides the challenge which this book addresses.

A future European (and therefore British) standard, [BS] EN 50173-6, is being developed specifically to support the extension of structured IT cabling components to service distributed building services, typically those enabled by PoE and POE-*plus*.

2 The use of cabling standards within building design

This chapter provides an overview of the standardization that has been undertaken to ensure the proper function of structured cabling and the services that it delivers.

These standards go far beyond the simple choice of components – they influence key constructional issues, such as space allocation and electrical power demands, while providing support mechanisms during the contractual stages of specification and construction.

By explaining both the existence of, and the opportunities offered by, the standards, this chapter underlines the need for architects to employ telecommunications specialists with an understanding of these standards at the earliest stages of projects – just as specialists are engaged for other aspects of building design.

Appendix A contains a detailed bibliography.

There is always a risk of a significant divide between the experts who produce standards, who are generally clear on their intent, and the users of the standards, who are frequently less than clear on how the standards should be applied.

Commercial pressures can lead to multiple responsibilities being placed on persons delivering, owning or managing infrastructures. Such pressures can present difficulties in the application of standards with regard to their:

- technical requirements;
- recommendations;
- inter-relationships with mandatory regulations.

This situation is certainly prevalent in the field of structured cabling, and will only be exacerbated as network convergence presents structured cabling to a wider range of specifiers and trades – as the types of service the cabling has to support widen in line with trends for 'convergence'.

This chapter addresses the application of cabling standards throughout building design and construction. As discussed in Chapters 5 to 8, it is vital that a telecommunications specialist with an understanding of these standards is employed at the earliest stages of a project, in order to minimize critical technical and administrative risks by applying cabling standards to best effect such that the end-product fulfils the project sponsor's stated objectives.

NOTE: The telecommunications specialist has much wider responsibilities than simply structured cabling.

It is also critical to understand the limitations of cabling design and installation standards. The cabling design and installation standards certainly act as planning guides to the telecommunications specialist, and they do fulfil a role as a quality assurance mechanism at the point where the cabling installer may be contracted to install an infrastructure – to verify that appropriate spaces and pathways exist at that time.

The standards cannot, and are not intended to, specify or control the management of the overall design process, where a number of specialists coordinate to optimize competing demands for space and infrastructure.

The use of cabling standards, in their own right, cannot safeguard against changes being made to volumes designated as telecommunications spaces or pathways within buildings under construction. This latter aspect is the role of standards in the more general area of construction, and is addressed specifically in later chapters.

2.1 Understanding standards

2.1.1 The role of standards

Standards are generally written to define a minimum set of requirements to which a product, system or service can claim conformance. Conformance to certain standards relating to safety is mandatory, when invoked in legislation. However, telecommunications cabling design and installation standards do not fall within this group of standards (see 2.1.5), but have been developed to address specific aspects of the design, installation and operation process, as shown in Figure 4. This shows the areas covered by European and international cabling standardization, and standards generated in the North American region may have a slightly modified approach, which is covered in more detail in Appendix A.

2.1.2 The national application of regional standards in Europe

European standards are almost always endorsed by countries that are involved in their development (under European regulation). They are

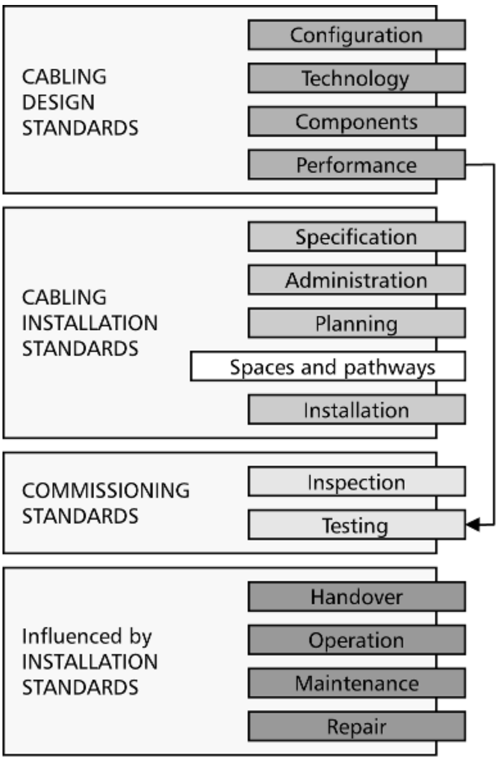


Figure 4 – The role of cabling standards

designated as 'XYZ' EN XXXX, where 'XYZ' is the nomenclature of the national standards body. In the UK the relevant body is BSI and standards are therefore prefixed by 'BS'.

NOTE: It should be noted that an EN itself is not a document that can be purchased – only the various national implementations are offered for sale in English, German and French, or as translated in the language of the national body.

International standards which are endorsed by national bodies (this is not an automatic process) are also designated with a prefix as 'XYZ' IEC XXXXX, 'XYZ' IEC XXXXX or 'XYZ' ISO/IEC XXXXX.

International standards are documents that can be purchased even if they are also published as national standards

All standards referenced within this book which are endorsed by BSI and available as a British Standard are shown with the prefix 'BS'.

Certain international and European standardization documents are published which do not qualify for the status of 'standard'. In many cases these documents contain only recommendations, or are necessarily provisional in nature. They are usually published as Technical Reports or Technical Specifications, and may also be adopted by national bodies. In the UK they are usually identified by the prefix 'BS PD'.

2.1.3 Requirements

All the recognized structured cabling design and installation standards specify requirements by the word 'shall'. Over the years, any misleading words such as 'it is vital to …' or 'it is essential to …' have been removed.

It is necessary to meet all the 'shalls' in a standard, apart from the occasions where a conformance clause renders the application of certain groups of requirements as options.

2.1.4 Recommendations

All the recognized structured cabling design and installation standards specify recommendations by the word 'should', or by stating that 'it is recommended to …'.

They act as guidance or even 'best practice' but, as explained in 2.1.1, these go beyond the concept of minimum requirements and, as a result, recommendations are never a means of conformance to a standard.

NOTE: There are occasions when a recommendation contains a requirement. A simple example could be that 'an object should be painted red. If so, the colour shall be RAL 3014'. This means that it is not required to paint the object red (it could be any colour) – however, painting it red introduces a previously hidden requirement.

2.1.5 Mandatory application of standards

As explained in 2.1.1, cabling design and installation standards are not mandatory from a legal perspective unless conformance to them is included within a commercial contract.

Background information

Standardization silos

There are three standards organizations which produce standards for telecommunications cabling infrastructure. The North American region produces ANSI/TIA standards. The international arena is catered for by ISO/IEC, and the European Economic Area is provided for by CEN/CENELEC. Each group acts as a standardization 'silo' – rarely referencing the standards in another silo.

The ANSI/TIA cabling design standards demand the use of ANSI/TIA planning and installation standards. Similarly, countries under the CEN/CENELEC umbrella are required to adopt the CEN/CENELEC texts as national standards – therefore European cabling design standards demand the use of European cabling installation standards. This leaves the international arena as being a good place to attempt to sort out difficult technical standardization issues, in the full knowledge that their solutions may not always be reflected in the other regional standardization silos – therefore to a large extent, ISO/IEC acts as another regional body.

In most cases, installation standards for structured cabling within a region reference the relevant electrical installation standards for that region. As the electrical installation standards are non-transferable outside that region, it is strongly recommended that the choice of standardization silo should be based on the applicable electrical installation regimen in the country that the installation of structured cabling will take place.

Although this restricts the use of installation standards outside their sphere of influence, it does not prevent the application of design standards from another region – but the remit of those design standards must be carefully tailored to prevent unintended consequences. In particular, great danger exists in applying design standards that contain:

- hidden requirements beyond the ability or responsibility of those to which they are applied;
- hidden requirements that are not able to be applied outside the standard's original or intended sphere of influence.

2.2 Cabling standardization

2.2.1 Scope

Design standards appear, on the surface, to offer a simple means of specifying a solution to a procurement problem. It is certainly true that when one purchases a mains power supply plug that conforms to BS 1363, one has every right to expect a single product that is compatible with all relevant sockets and that is safe to use. In contrast, when something as complex as a telecommunications cabling infrastructure is being designed, there are a number of options built into the standards which can render one person's design substantially different to an equally conformant design produced by another person.

Within a given type of building (offices, industrial unit, etc.) a design standard will provide a range of different cabling technologies, from which the specifier has to select the most appropriate. Once this has been done, the minimum requirements for the components and the installed performance are specified – as are the methods of inspection and test, contained in the relevant commissioning standards.

Installation standards dictate the production of the detailed specification and planning of the installation, including the quality assurance aspects, in addition to the installation practices that are to be employed. In this respect, installation standards define responsibilities both for the specifier and the installer.

Installation standards are even more complex than design standards, because all conformant installation practices rely on conformant installation specification planning. This division of responsibility between specifiers, planners and installers has been addressed in installation standards published by CEN/CENELEC, and to an even greater extent in the UK. Figure 4 also shows that installation standards may also include operational aspects of the telecommunications cabling, including maintenance and repair. The reason for this is that there are critical decisions within the specification and planning process that directly affect the operability of the resulting infrastructure.

2.2.2 Cabling standardization roles

There are three groups of standards-making bodies, as shown in the standardization matrix given in Figure 5. Details of all these standards are provided in the bibliography in Appendix A. The design standards produced by the European, international and North American standards bodies generally cover the same types of premises, including offices, industrial units, data centres and homes.

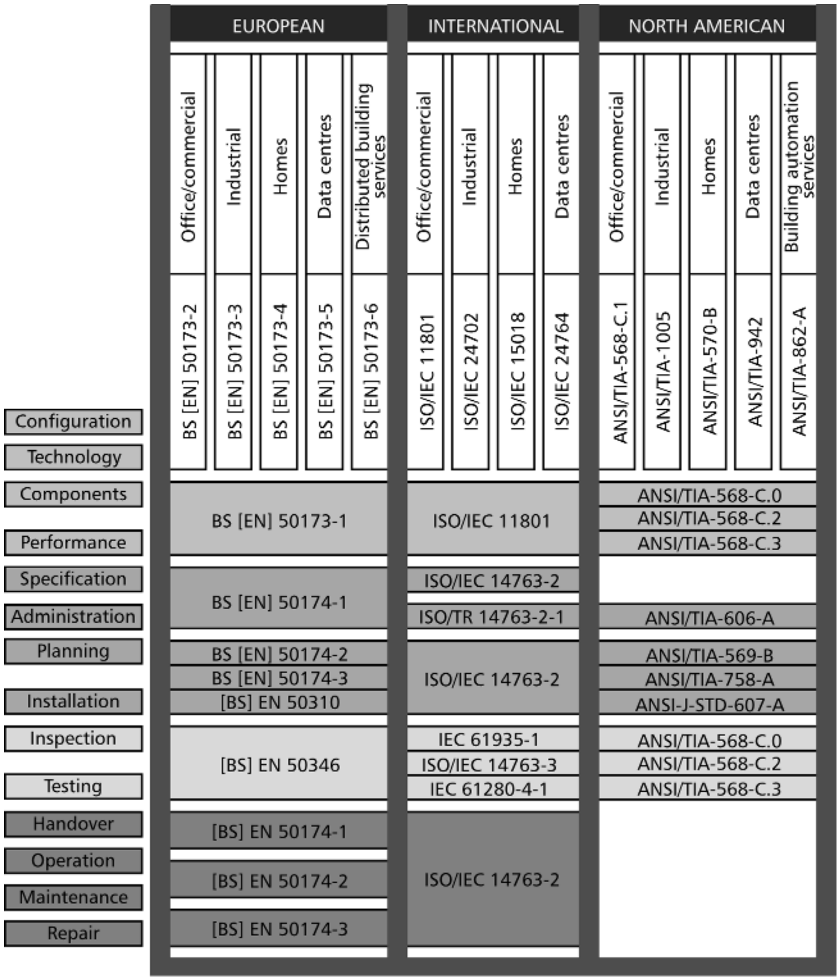


Figure 5 – The telecommunications cabling standards matrix showing regional silos

Given that there are so many seemingly equivalent standards at the design, commissioning, installation and operational levels, it is sometimes difficult to determine a way forward. However, there are two golden rules that provide a considerable degree of simplification – but the application of these rules requires a telecommunications specialist to identify the electrical (power) wiring standards rules, regulations or codes that are to be applied to the project.

NOTE: In some countries the electrical (power) wiring standards applied may vary from project to project, and this provides a further justification for applying the rules below.

- **Rule 1: the electrical (power) wiring standards rules, regulations or codes define the telecommunications cabling installation standards that should be applied**; i.e. if the electrical wiring standards are based on the European HD 60364 series (as they are in the UK), the applicable cabling installation standards are the [BS] EN 50174 series and [BS] EN 50310 – independent of the design standard used. Whereas, if the electrical wiring rules in a location are based on the various North American electrical codes, then it is advisable to apply the installation standards for that region listed in Figure 5.
- **Rule 2: the basic requirements of cabling design and commissioning standards can be applied anywhere**; i.e. the fundamental requirements for cabling structure, component and cabling transmission performance can be taken from any design standard and used in any country. However, to be contractually watertight it is best to apply the design and commissioning standards that match the regional or national nature of the installation standards to be applied.

Failure to follow these rules risks the installation becoming contractually difficult to manage due to conflicts in design and specification.

Within the area covered by CEN/CENELEC standards, and to an even greater extent in the UK, the standards developers have made significant efforts to clarify the role of the cabling design and installation standards and to link them by internal 'normative references' – meaning that the conformance demands of one standard automatically include the conformance demands of others.

This has been undertaken to simplify the application of the standards – but still requires the user to have a detailed knowledge of their requirements.

2.2.3 UK standards

The UK automatically implements EuroNorm (EN) standards as national standards by the addition of the BS prefix, as shown in Figure 5. In addition, the UK has retained and developed its own national standards to support the installation of telecommunications cabling, which mandate the application of the BS EN standards. For example, BS 6701 applies additional requirements in the form of the [BS] EN 50174 series of installation standards and configures the use of those standards for the UK environment – making reference to the UK electrical wiring regulations, BS 7671.

The UK is a world-leader in efforts to simplify the referencing of standards by laymen and experts alike. This is much appreciated and supported in the European standards bodies that have been working hard for the last 7 years to ensure that they produce the simplest possible interrelationships between their standards. The UK always has the opportunity to introduce a National Foreword to Euronorms before their publication as British Standards. In the case of the premises-specific cabling design standards in the [BS] EN 50173 series, the national foreword additionally applies BS 6701 for the installation of such infrastructure designs. This has resulted in the interlocking set of standards shown in Figure 7.

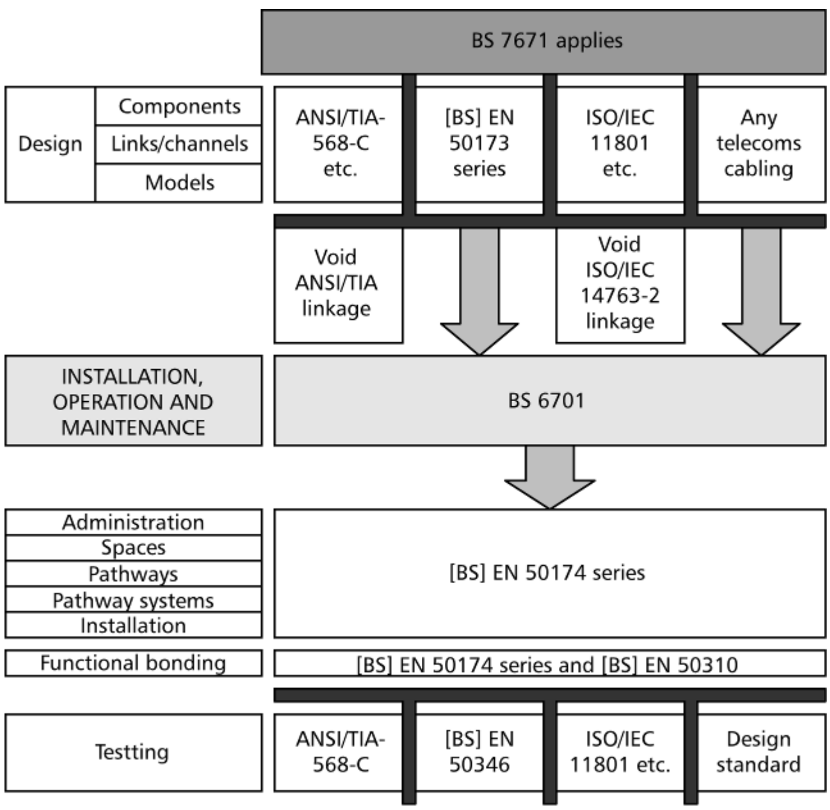


Figure 6 – The UK telecommunications cabling standards system

As explained earlier, cabling design and installation standards are not mandatory from a legal perspective, unless conformance to them is included within a commercial contract. There is considerable confusion with regard to certain standards relating to safety. For example, in the UK, BS 7671 (*Wiring Regulations*, 17th edition) is assumed by many to be mandatory because the word 'regulations' is mentioned in the title. However, there is no legislation that demands conformance to BS 7671 – but any defence against litigation may require the defendant to prove that the practices undertaken were equivalent to those of BS 7671.

It will be noted that Figure 6 includes a reference to standards for functional bonding. [BS] EN 50310 contains requirements for equipotential bonding to minimize the interference that the switched-mode power supplies (which are common within transmission equipment) introduce on to earthing networks – which can affect the transmission performance of the telecommunications infrastructure. [BS] EN 50174 standards mandate the application of [BS] EN 50310, and telecommunications and electrical system designers need to work closely to ensure that its requirements are applied.

2.3 Separation of responsibilities

A key aspect of the planning and installation standards shown in Figure 7 is the clear separation of responsibilities between the specifier/planner and the installer.

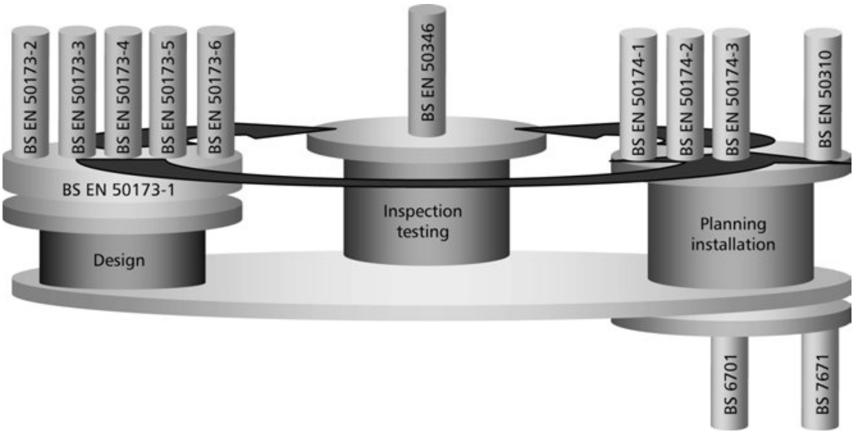


Figure 7 – The interlocking nature of UK telecommunications cabling standards

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BS 6701 and the [BS] EN 50174 series of standards go to great lengths to identify who is responsible for which aspect of the process. Ultimately, the standards define two separate responsibilities – those of the premises owner (who can delegate them as required to architects, consultants, tenants, etc.) and those of the installer.

The specification and planning of an installation are clearly defined as being the responsibility of the premises owner (or the delegated authority). This allocation of responsibility reflects the complexity and importance of defining the correct technology solutions for infrastructures and ensuring adequate accommodation for them within buildings. No installer can implement standards-conformant installations without the architect having provided the adequate volumes for spaces and pathways in the buildings. In extreme cases, the lack of appropriate accommodation will not only affect the conformance of the installation to the relevant standards, it may also affect the maintainability, reparability and operability of the entire telecommunications infrastructure.

2.4 The boundaries of standardization

2.4.1 Legislation

All cabling standards are subject to national and local legislation – an example of local legislation is that applied by local authorities for certain types of premises, such as those for which the local authority provides an 'operating licence' (e.g. places of public entertainment). Standards do not take precedence over 'law', and the conformance requirements of all recognized cabling standards clearly state that any such legislation shall be applied.

Of particular importance is where standards are thought to merge, to some extent, with legislation. One example of potential confusion is the issue of electromagnetic compatibility and the various national implementations of the European Union legislation, known as the 'Electromagnetic Compatibility (EMC) Directive'. To be clear:

- telecommunications equipment carrying the relevant CE mark is required to meet the electromagnetic emission and immunity performance defined in specific product standards;
- the type of cabling over which that performance has been achieved has to be specified by the equipment supplier;
- for each type of cabling, the planning and installation standards such as [BS] EN 50174 series and ISO/IEC 14763-2 contain requirements and recommendations (covering installation practices including

segregation/separation as explained in 7.1.3) intended to maintain its emission and immunity performance to support the relevant telecommunications equipment.

This situation is summarized in the structured cabling design standard [BS] EN 50173-1, where it states that:

> *... generic cabling is a passive system and cannot be tested for EMC compliance individually. Application-specific equipment, designed for one or more cabling media, is required to meet relevant EMC standards on those media. Care should be taken that the installation of any of those media in a cabling system does not degrade the characteristics of the system. The installation methods of EN 50174 series should be used to minimize the effect of electromagnetic disturbances.*

The telecommunications specialist is therefore required to select cabling types and performance levels that support the equipment to be installed. Where, typically, the actual equipment is not known at the time when the cabling selection has to be made, then it is recommended that the selection is based on the widest range of probable equipment solutions. Following installation of the cabling, the national legislation implementing the EMC Directive demands that the attachment of the appropriate equipment to the cabling maintains the emission and immunity performance of the fixed installation (which combines the equipment and cabling).

Another example of this is the selection of components with particular fire performance characteristics. It is expected that, by July 2013, telecommunications and power cables traded across borders within or into the EU will be required to be assessed for conformance to a fire performance class in accordance with the EU Construction Products Regulations. However, in general, any direction as to where the various cables may be used within a building will be a matter for national legislation.

2.4.2 Specific practices in building trades

As structured cabling solutions are being applied to an increasing number of building services, there is a point where the legacy practices associated with those trades, either by law or custom and practice, either prevent the full implementation of a standard or serve to amend those requirements. Examples of such practices are the prevention of sharing of pathway systems or the colours of cables.

2.4.3 Industry-specific practices

Very few standards can claim to be truly universal (i.e. fully applicable in all circumstances). For example, standards such as EN 50173-1 provide environmental classifications (termed MICE, explained in detail in Chapter 6), which cover a wide range of premises yet explicitly exclude such extreme environments as might be encountered in areas within hazardous installations such as nuclear plants, etc.

2.4.4 Customization within industry sectors

Certain industry sectors (e.g. petrochemical and railways) apply local regulations or codes of practice. In addition, insurers may apply specific requirements, which also act as premises-specific codes of practice. Designers should to ensure that these regulations/codes of practice meet the minimum requirements of the standards, in order to avoid technical risks or future litigation. More details are provided in Chapter 6.

3 The impact of convergence in IP networks in the built environment

This chapter provides more details on the 'convergence' concept and its impact on the spaces and pathways required to support its implementation.

The chapter provides clear warnings that 'convergence' does not automatically mean 'consolidation', and that 'common infrastructure' does not mean 'shared services'.

References are provided to real-world examples of convergence, common infrastructure and shared services that non-telecommunications professionals can relate to.

This chapter makes reference to the following standards:

- *British: BS 8492.*
- *European: [BS] EN 50173-1, [BS] EN 50173-2, [BS] EN 50174-2.*
- *International: ISO/IEC 11801, ISO/IEC 14763-2.*
- *North American: ANSI/TIA-568-C-2, IEEE 802.3at.*

Appendix A contains a detailed bibliography.

'Convergence' is the term used to describe the trend towards an ever-increasing use of IP as a means of communicating between devices – and the ever-increasing range of devices that will use IP to communicate.

As the most common methods of delivering the information between IP-enabled devices are based on the Ethernet applications used for office networking, the immediate and obvious impact on the cabling infrastructures within buildings is the use of a standards-compliant set of cables and connectors – and the potential to adopt common, although possibly separate and overlaid, cabling infrastructures.

Just as structured cabling has provided a platform for multiple networking solutions in the ICT sector, convergence is able to take advantage of structured cabling to provide BCT, CCCB and PMCA services such as those shown in Figure 8. The recent standardized support for applications such as 10/100/1,000 Mb/s Ethernet (10/100/1000BASE-T) to deliver up to 25 W of power to connected devices has led to a rapid increase in the number and type of devices, and the functions that they provide have also rapidly increased. This does not bode well for those building automation, access and environmental control systems that continue to use proprietary cabling systems.

Service type	Service
ICT	ICT (including telephony)
	Audio-visual (presentation aids/meeting)
	Multimedia/digital content (video on demand)
	Electronic point of sale (EPOS)/vending
	Public switched telephone network circuits
	Public address
	Master clock
BCT	Digital signage
BCT	Television
BCT/CCCB	Security – closed circuit television
CCCB	Security – access control system
	Building management systems (BMS)
	Building automation systems (BAS)
PCMA	Supervisory control and data acquisition/ metering
	Life safety alarms

Figure 8 – BCT, CCCB and PMCA telecommunications services

The use of common components brings with it the obvious economies of scale in terms of procurement costs. However, the concept of common cabling structures produces a number of collateral impacts that require consideration as part of the building design – the 'devil is in the detail'. In particular, the separate ambitions of system integrators that wish to use those components and take part in the design process of the common infrastructure do not always act in the best interest of the architect – it is critical that a specialist with a good understanding of the impact of convergence is employed at the earliest stages of a project in order to take control and manage the competing demands.

3.1 Introducing convergence

Convergence forces structured cabling, in some form, into all parts of a building. For example, external walls or perimeter fences may feature IP-enabled cameras for surveillance and access control, ceiling spaces will contain connection points for wireless access points, and environmental sensors and control systems will require connection to management systems. In addition, a variety of alarm systems may also need to be considered and implemented.

While it is true that the quantity of cables and connection points required to support all these new 'converged' services may be lower than that necessary for the provision of IT services to the workplace (the 'original' structured cabling), they have the potential to significantly influence the building design and construction process.

In order to understand the full impact of convergence, it is important to be clear about the terms we use. For the purpose of this book, the objective of convergence in relation to structured cabling should best be described as being 'the use of a set of standards-compliant cabling subsystems'.

This is not the same thing as having a common set of components – although there will be some commonality. Figure 9 shows the types of balanced cabling components and installed cabling specifications specified in the recognized cabling design standards as being required to support the hierarchy of Ethernet applications.

Application	Components		Installed cabling	
	ANSI/TIA	BS EN ISO/IEC	ANSI/TIA	BS EN ISO/IEC
10BASE-T 100BASE-T 1000BASE-T	Category 5e	Category 5:2000	Category 5e	Class D:2000
10GBASE-T	Category 6_A	Category 6_A	Category 6_A	Class E_A

Figure 9 – Typical telecommunications services

Figure 10 shows an example of a building served by three separate structured cabling systems – although in practice there may be more than three. For example, service 1 could be conventional IT service, service 2 could be the environmental control system, and service 3 could be the access control system for the building. The structure of each system is identical to that discussed in Chapter 1 – with the services being fed from a building distributor to a set of floor distributors to a multitude of service connection points on each floor. However, the performance of the cabling for the different services may not need to be the same.

It is certainly true that in the cabling subsystem between the floor distributors and the various service connection points, the installation of Class D cabling (according to European and international standards) or

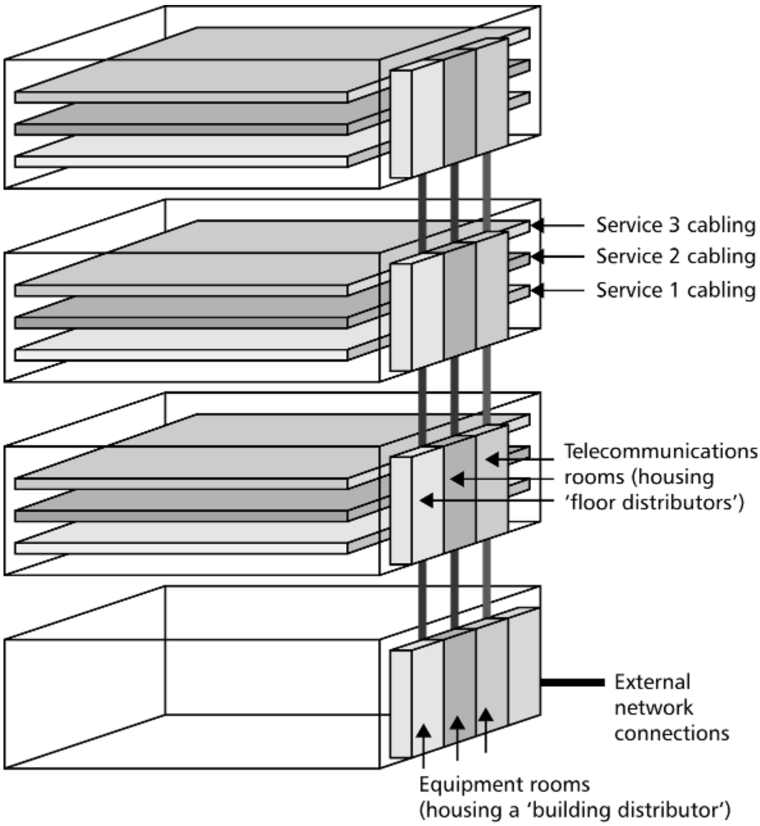


Figure 10 – Multi-service structured cabling

Category 5e cabling (according to ANSI/TIA) using Category 5:2000 or Category 5e components, respectively, will provide a suitable base for applications up to Gigabit Ethernet (1000BASE-T) and supporting PoE in accordance with IEEE 802.3at. This would be perfectly adequate for environmental and access control systems.

However, the IT cabling may be targeted to support 10GBASE-T (10 Gigabit Ethernet), which demands higher performance cabling components. While this application may be a desirable objective for the IT cabling to the workplace, it is unlikely to be necessary for the control of the other building services, and to install the higher performance cabling everywhere may be unnecessarily expensive.

Similarly, this does not automatically mean sharing of physical spaces or pathways, and certainly does not imply the mandatory sharing of cabinets between different services. Such decisions are operation – rather than technology – related and are discussed in more detail in 3.3.

3.2 Competition in convergence

It is a mistake for architects to assume that convergence of telecommunications services over a common infrastructure means that responsibility for designing and planning that infrastructure can be automatically passed to a system integrator that is an expert in the provision of any one of those services.

For example, an organization with expertise in the implementation of IT infrastructures may have a good understanding of pathways and pathway systems to support the distribution of IT services to the desk, but may have little knowledge of the equipment accommodation demands of BMS. Similarly, access control system designers will be experienced in the management of their systems, including the positioning of sensors and actuators, but will tend to be unaware of the planning of pathways systems or which components to select to deliver leading-edge IT solutions.

Simply using a common infrastructure based on standards-compliant components within defined subsystems does not make each system integrator an expert in the other's field. However, while the claims made by the competing integrators may be very persuasive, the architect must retain control of the project – by means of an appropriate qualified telecommunications expert – particularly in relation to the building volumes allocated to spaces and pathways as described in 3.3.

3.3 Building accommodation to support convergence

3.3.1 Rooms and cable routes

The most important issues for building design and construction relate to the use, by multiple structured cabling systems, of common spaces and, in part, common pathways. As shown in Figure 10, the distribution of the cabling for the different services on the floors may involve the use of parallel pathways. For example, the cabling distributed to users for desk-based connectivity may be served from a network of under-floor pathway systems, whereas BMS may be routed above ceilings. However, there will be points of aggregation where cabling for the different systems comes together (such as entry points into the rooms housing shared cabinets etc.) or in routes between distributors (risers, etc.). In these areas of aggregation it would tempting to consider the total predicted quantity of cabling and to apportion the required space to the chosen type of pathway system necessary to support that quantity.

Key questions that need to be addressed are, for example:

- Are the building distributors co-located, i.e. accommodated in and sharing the same room or space?
- Are the floor distributors on each floor co-located?
- If spaces are shared, is it desirable for the different cabling systems to be presented in the same cabinets, rack or frames?
- Are the cables running into and between the spaces that accommodate the distributors contained in the same pathways – or even within the same pathway systems or cable management systems?

The European cabling installation standard [BS] EN 50174-2 and the international standard ISO/IEC 14763-2 contain requirements and recommendations for the planning of spaces used to house the cabinets, frames or racks for all forms of telecommunications cabling.

The minimum size of any room housing cabling and equipment is recommended to be 3.2 m × 3.0 m and the space allocation increases with the number of cable terminations contained within that space. Therefore, the sharing of rooms and, going even further, the sharing of cabinets across the multiple services, as shown in the example in Figure 10, can have a substantial impact on the space allocated to the total cabling infrastructure. Specific examples of the improvement in space utilization in buildings which results from convergence are detailed in 3.3.3.

Both [BS] EN 50174-2 and ISO/IEC 14763-2 also contain requirements and recommendations for the minimum dimensions of pathway systems required to support a given quantity of cables, and include appropriate allowances for growth (which is generally inevitable between initial specification and final implementation). Using single pathway systems that are sized according to the total quantity of cabling across the multiple services provided by converged networks may increase the risk of damage to cabling if the build schedule results in multiple installation phases of cabling installation. Specific examples are detailed in 3.3.3.

3.3.2 Room sizes

Figure 11 illustrates the impact of sharing of spaces by the distributors for three separate systems, as exemplified in Figure 10, dimensioned in accordance with the recommendations of [BS] EN 50174-2 and the ISO/IEC 14763-2 to house the following:

- a service 1 cabling distributor serving 300 terminations and associated equipment;
- a service 2 cabling distributor serving 125 terminations and associated equipment;
- a service 3 cabling distributor serving 75 terminations and associated equipment.

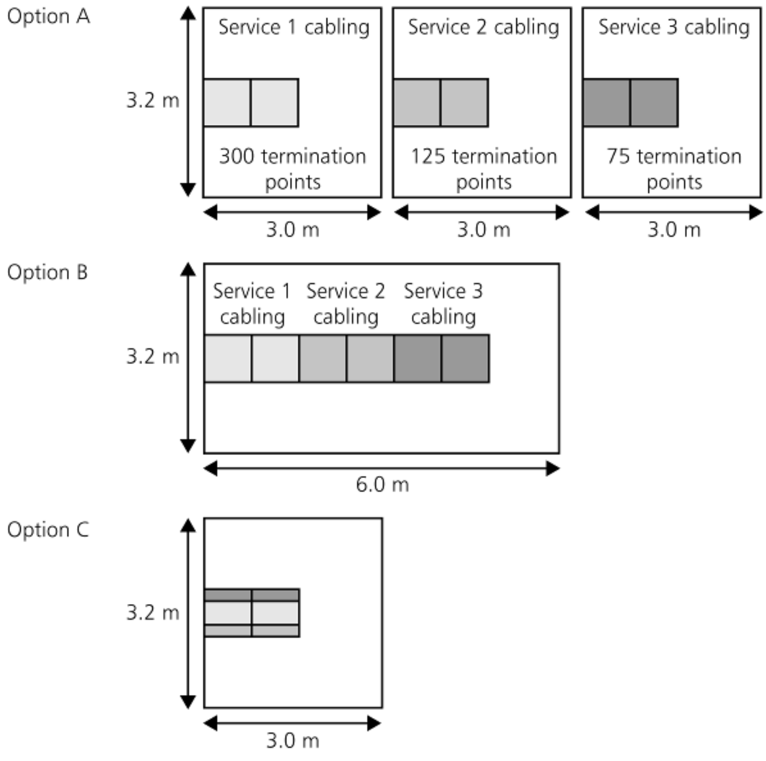


Figure 11 – Options for space sharing

If the three services were provided in separate rooms or spaces, the floor space used would be approximately 29 m² (3.2 m × 9 m) as shown in Option A. If the three services were housed in the same room, as shown in option B, the standards recommend that the room be 3.2 m × 6.0 m (approximately 20 m^2). This represents a 30 per cent space saving and would still provide each service with its own dedicated cabinets (with access controls as required). Going one stage further, as shown in Option C, would require sharing of the cabinets themselves in a room measuring approximately 10 m^2 (3.2 m x 3.0 m), which would deliver a 66 per cent space saving.

Clearly, the sharing of spaces across cabling systems maximizes the usability, in economic terms, of the remainder of the space in the building. The release of economically productive space is a significant factor in any discussion of convergence, but a number of other issues have to be considered, including:

- **Space assumptions:** while Figure 11 shows a typical configuration for a floor distributor or small building distributor in terms of termination points for IT, environmental control (service 1) and access control (service 2), the physical volume of the equipment associated with each service can vary dramatically. For example, the transmission equipment (switches and, where appropriate, PoE equipment) typically uses a similar amount of cabinet space to that used by termination points. However, the equipment associated with other services may use significantly more cabinet space per termination point, and this limits the total possible reduction in allocated floor space. Services such as environmental control and access control have, in the past, used power supplies installed local to their sensors and actuators to maintain function. One impact of convergence and PoE moves the provision of uninterruptible power supplies (UPS) into the distributors, and the space taken up by this equipment must not be overlooked.
- **Fire safety:** BS 8492 recognizes the potential for telecommunications cabling to spread fire unless appropriate actions are taken – which may be summarized as either creating effective fire compartments throughout the building or selecting cabling materials with appropriate fire performance (these may be applied in combination). The fire performance approaches for different telecommunications services, in terms of fire compartmentation and cabling product selection, may differ, and the sharing of spaces between different services may impose modified requirements on some of the cabling infrastructures accommodated within those spaces. It should be noted that BS 8492 recommends the use of fire compartmentation as the preferred solution, as opposed to product selection, and this requires the effective maintenance of fire barriers and control of fire-stops that are used to reinstate such barriers following their penetration by pathways and pathway systems (see 3.3.3).
- **Building construction:** the sharing of spaces across different building services may lead to complexities of installation planning and

contract management where the scheduling of the works is required to provide the cabling for the different services.

- **Operational issues:** the question of sharing spaces, or even cabinets, is a fundamental matter of which functions the cabling systems serve and how the building is going to be operated by the project sponsor. For example, the sharing of cabinets, frames or racks across different services may be unacceptable to the project sponsor due to data security concerns.

3.3.3 Pathway and pathway system cross-sections

There are a number of different types of pathway system, some of which utilize pre-manufactured cable management systems, such as tray, basket, ladder, duct and conduit. [BS] EN 50174-2 recommends that, during initial planning, the initial quantity of cables should not use more than 40 per cent of the usable cross-sectional area within the chosen pathway system – subject to the following definition for usable cross-sectional area:

- for uncovered pathway systems and cable management systems (e.g. tray, basket), cables are not installed above the sidewalls;
- bends in the pathway systems may restrict the usable space, depending on the specified bend radii of the cable to be installed;
- for non-enclosed pathway systems to which cables are to be attached or supported (e.g. by catenary wires or designated routes), the cross-sectional area shall be considered to be the minimum available area surrounding the pathway system.

Using the example of the distribution cabling in options B and C in Figure 11, a total of 500 cables need to be accommodated at the entry point to the room. Assuming a typical effective cross-section of 36 mm^2 for each cable, this cable entry requires a total cross-sectional area of 18,000 mm^2, which, with a 40 per cent uplift added in accordance with the planning recommendations of [BS] EN 50174-2, requires a pathway system of cross-sectional area of 30,000 mm^2.

If each cabling system was treated separately, the total cross-sectional area required would be the same, but it would be partitioned in three separate pathway systems of 18,000 mm^2 for the 300 service 1 cables, 7,500 mm^2 for the 125 service 2 cables and 4,500 mm^2 for the 75 service 3 cables.

[BS] EN 50174-2 requires that, where cable is to be installed in shared pathways, precautions shall be taken to avoid damage to existing cables or structures within those routes. So, while the standard does not promote any space-saving benefit resulting from treating the cables as a single group, it does require that care shall be taken if the cables are to be installed in multiple phases.

However, the problem of multiple installation phases within a pathway system is not restricted to the risk of cable damage. [BS] EN 50174-2 requires that fire barriers and gas seals shall be opened only when necessary and resealed on completion of works – because it is recognized that telecommunications cabling penetrates many fire compartments, as it is distributed across a building, and the transfer of fire across those boundaries can result in catastrophic reduction in the overall fire protection of the building.

While it is recognized that the formal establishment and assessment of fire-stops to retain fire barrier performance is commonly a post-completion task, the repeated removal of fire-stops and subsequent reinstatement of barriers during multi-phase cabling installations requires particular control, and may demand the implementation of additional contractual responsibilities, possibly with third parties.

Changes in fire regulations also have to be taken into consideration. The recent introduction in the UK of self-certification by premises owners (or a delegated authority) places an increased burden on architects, and has raised the profile of fire performance as a design and construction issue. This is reflected in an increased number of standards and similar documents. In the UK, BS 8492 discusses the design options available to telecommunications infrastructure designers, and has particular importance for those planning fire compartments within buildings.

3.4 Space, convergence and service level agreements

While 3.3.2 discusses potential savings offered by total convergence, it has to be recognized that, while the services may be converged, it is probable that the contractual responsibility for the management of service delivery may be subject to a number of different service level agreements – and via different service providers.

While 3.3.3 highlights the concerns in relation to risks during the installation of cabling in shared pathway systems, the operational (i.e. chronic) aspects of multiple service level agreements may have a longer term impact. As a result, the risks associated with disputes over access to the shared infrastructure should not be underestimated.

4 Organizing cabling projects

This chapter addresses the two primary drivers of building planning and design – form and function. By prioritizing 'form' ahead of 'function', architects and associated entities risk delaying the involvement of telecommunications specialists to a point where revision of building designs to support the required telecommunications function is either extremely costly or impractical. In contrast, this chapter explains how the early involvement of telecommunications specialists can simplify the planning, design and construction process while producing a building that provides the required added value and meets its business objectives.

While recognizing that this represents a challenge to conventional approaches for building planning, design and construction, one clear objective of this chapter is to allow telecommunications professionals and building professionals to see the organization of cabling projects with building construction from each other's perspective – to the ultimate benefit of all.

This chapter makes reference to the following standards:

- *British: BS 6701, BS 8492, BS 7671.*
- *European: [BS] EN 50173-5, [BS] EN 50174 series, [BS] EN 60825-2.*

Essential reading for: Project Sponsors, Project Managers, Architects, Building Services Engineers, Telecommunications Consultants

Optional reading for: Other specialists, Quantity Surveyors, Cabling Installers

Appendix A contains a detailed bibliography.

Given the importance of telecommunications to the business function following completion of a building project, it is virtually impossible to consider the organization of telecommunications cabling projects as being separate from the overall organization of building projects.

There are many recognized, *de facto* standard, approaches to the organization of the building preparation, design and construction phases. This document recognizes the Royal Institute of British Architects (RIBA) Work Stage approach as shown in Figure 12. However, independent of which approach is selected for a particular project and the degree of service convergence to be applied it is critical that the organizational approach introduces the appropriate telecommunications specialists early in the project. This will minimize the risk of irreversible decisions being taken – particularly those relating to space allocation and electrical power provision which enable the overall telecommunications investment (typically orders of magnitude greater than that of the structured cabling) to deliver the desired business objective.

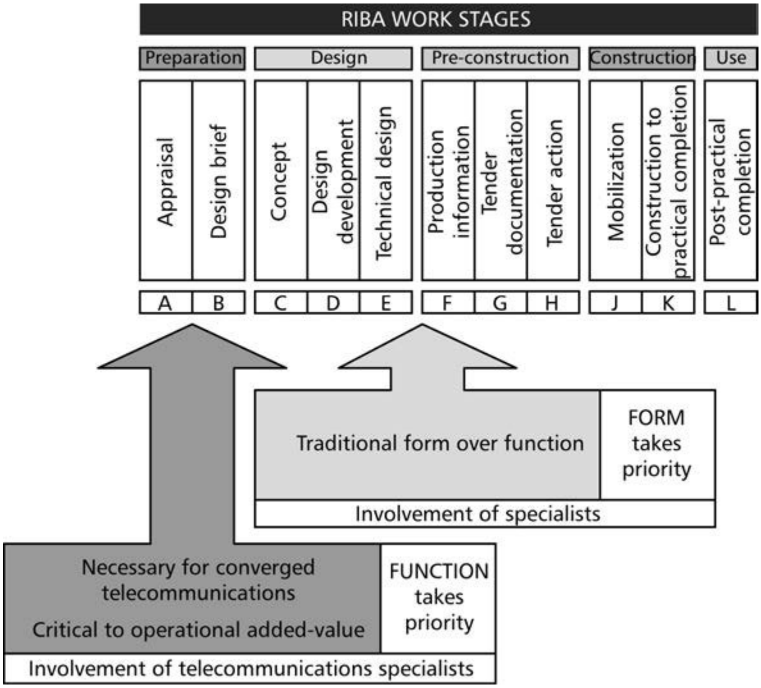


Figure 12 – RIBA Work Stages and the implications of function over form

This justifies a detailed review of the relative priority of form and function, but where function takes priority, as it should in most commercial premises (almost irrelevant of their possible iconic status), such early involvement of telecommunications specialists is critical to the degree of added value attained during the operation of the building.

4.1 Project definition

For the purposes of this book, projects are classified as new build, refurbishment or network upgrade.

New build or refurbishment may be undertaken as either a 'speculative build' project or as a 'designed to requirement' project in response to a defined requirement formulated by, or on behalf of, the project sponsor – see Chapter 5 for further details.

4.2 Function over form

Specialist, telecommunications-based buildings such as data centres obviously focus on 'function' and involve telecommunications specialists at the RIBA 'preparation' phase, as shown in Figure 12. Such involvement is critical to ensuring that the planning submissions are correctly prepared, calculated and justified in relation to the physical impact of the building on its environment (and vice versa through risk of flooding, etc.) together with its electrical power demands and environmental control solutions.

At the other extreme, an iconic building such as a museum may focus on 'form' to the detriment of function – only considering the demands of telecommunications infrastructure later, and in some cases too late, in the project.

Data centres

Data centres exist within most buildings

Most architects now consider data centres to be purpose-built facilities accommodating data storage, processing and transmission equipment with high-performance connections to the outside world. Such buildings are demanding in terms of power and environmental control systems.

However, cabling standards such as [BS] EN 50173-5 and cabling professionals consider any spaces, within any type of building, that contain data storage, processing and transmission equipment that provide data which is subsequently carried over the distribution cabling within the building (or via cabling external to that building) to be a data centre.

> This definition extends the architects' definition, and according to it most buildings accommodate one or more data centres – at the very least containing servers or private automatic branch exchanges (PABXs). How much power these spaces use, and if they require environmental control, depends upon their size and intended function. This definition is in accordance with that applied by the EU Code of Conduct for Data Centre Energy Efficiency.
>
> Data centres are recognized as, in many cases, substantial users of energy, not only to power the equipment they contain but to provide the cooling systems required to operate that equipment in a reliable manner. The objective of making data centres as energy efficient as possible impacts the design of the power distribution systems, the layouts of the spaces and the environmental control systems used.

However, virtually all premises do have a space that contains the functional aspects of a data centre – which acts as the engine room of building control, business activity (for commercial premises) or service delivery (in the case of museums). The integration of infrastructures for the data centre and data distribution, which are further impacted by the intended degree of service convergence, suggests that a failure to consider 'function' as a prime driver at the 'preparation' phase will result in a building that fails to deliver the required added value for its occupants. Remedial design works to recover the situation tends to be more expensive than investment at the 'preparation' phase. For example, data centres that are incorrectly sized or are located in an inappropriate part of a building will incur substantial costs to re-design or re-locate.

In order to maximize the added value provided by a correctly planned, specified and constructed telecommunications infrastructure, it is critical for a project sponsor to understand the value of 'function over form'. Architects and those in related professions should understand the need to deliver that added value during the operational life of the building.

Without such an understanding, the traditional approach to 'preparation', 'design', 'pre-construction', etc., as shown in Figure 12, follows an automatic sequence of professional actions that may not fully deliver the required objective. For example, according to the RIBA Work Stage schedule, specialists are first involved at Stage C, as shown in Figure 12, but even this is somewhat misleading.

If the form of the building is the main priority, the specialists are more likely to be architects rather than technologists. It would be more common for the telecommunications specialists to be consulted at Stage E or even F – much too late to influence the ‘preparation’ phase.

If, in contrast, the project sponsor focuses on the function of the building, then a modified approach is critical. An obvious example of function taking precedence over form is in retail, warehousing or manufacturing. In such cases, conformance to standards is a factor in the eventual usability of the building.

Whether the building is speculative or is ‘designed to requirement’, telecommunications specialists need to be involved in the very early stages (e.g. RIBA Work Stages A/B), as shown in Figure 12, to ensure that the correct apportionment of space and facilities or conformance to standards.

4.3 Project leadership and coordination

4.3.1 Roles and responsibilities

For new-build and refurbishment projects, the ownership/leadership role will generally rest with the ‘estates’ function due to the capital nature of the projects. The ‘estates’ or ‘facilities’ function traditionally manages building spaces, building services and the capital projects associated with them – this automatically gives them operational responsibility for building management systems (BMS).

An integrated telecommunication strategy requires the involvement of two other critical operational responsibility areas: information systems (IS) specialists – also termed ‘business solution specialists’ – who focus on the both the IT and wider telecommunications service delivery for the business, and ‘telecommunications specialists’, who focus on the implementation of telecommunications, networking and computing resources in the building. Projects managers and architects need to be aware of the distinction between these two responsibility areas and the differences in competency areas between structured cabling and the wider telecommunications remit.

In summary, the operational objectives of the IS function, delivered by the telecommunications function, cannot be met without the direct involvement of the ‘estates’ function – and vice versa – and co-operation between all parties is critical to success.

The demands of telecommunications on the building ‘preparation’ and ‘design’ phases are much greater than just the provision of adequate spaces and pathways, and places major demands on the provision of electrical power and environmental control.

Speculative, 'installation-ready' buildings require the greatest allocation of provision of pathways, space, electrical power supply and environmental control in order to cater for the widest range of user demand. By comparison, a 'designed to requirement' building will allow a more considered allocation of these expensive resources as required by the applicable network strategies, as discussed in 4.3.3.

However, in both cases, the provision of adequate electrical power is critical to the effective operation of telecommunication equipment, and environmental control (which requires additional power) is also required in certain areas. In this respect, at least, it is somewhat inaccurate to consider telecommunications as a 'fourth utility', isolated from the other services in the building.

Key terms

Primary cabling costs

Within this book the term 'direct cabling cost' relates to the total cost of telecommunications cabling components and the infrastructure installed to support them (tray, trunking, panels, cabinets, etc.). It does not include the cost of the networking and other equipment to which that cabling will be attached.

Secondary cabling costs

The primary cabling cost does not include the facilities and infrastructures required to provide electrical power and environmental controls to the equipment that will be connected to the cabling. The inadequate provision of these facilities and infrastructures represents a risk to the subsequent functionality of the system.

Is telecommunications a 'utility'?

Telecommunications is often referred to as the 'fourth utility', following the recognized primary utilities of electricity, gas and water supply. Although it is true that most business premises could not function without the external and internal telecommunications systems, it has to be recognized that telecommunications cannot function without the support of one or more of the three primary utilities.

'Installation-ready' buildings

During the building design phase, both cabling design and installation standards have a critical role to play, and enable building designers/owners to claim conformance to those standards – but there is a significant planning responsibility, particularly in the area of spaces and pathways, that requires a significant architectural impact early in the building design process.

If that architectural impact is correctly applied, it is possible, with the appropriate 'use of property' caveats, to issue certificates of conformance both for the building and any subsequent cabling installations. It is unfortunate that conformant installation specifications and planning practices are uncommon, and, as a result, the installation standards tend to serve as a 'non-compliance checklist'.

The standards that would support such certificates of conformance depend upon the appropriate standardization silo (see Chapter 2):

- within the UK standardization silo, certificates of conformance could be issued against the installation specification and planning requirements of BS 6701 which contains a normative reference to [BS] EN 50174 series standards;
- within the European Economic Area standardization silo, certificates of conformance could be issued against the installation specification and planning requirements of the EN 50174 series standards (together with any national standards that may be applicable);
- within the North American standardization silo, certificates of conformance could be issued against the installation planning requirements of the ANSI/TIA-569-B standard.

Outside these silos, it is possible to issue certificates of conformance against the installation specification and planning requirements of ISO/IEC 14763-2 (together with any national standards that may be applicable).

Clearly, the initial estimated demand for power and environmental control can only be assessed with the assistance of telecommunications specialists. However, telecommunications cabling standards such as BS 6701 or the [BS] EN 50174 series do not specify the scaling or the design of power distribution to and within the cabinets, frames and racks that will contain telecommunications equipment. Instead, they demand the application of national or local regulation – in the case of the UK, BS 7671. As the contents of cabinets, frames and racks tend to be subject to substantial change over their lifetime, the electrical provision should err on the side of caution – even if that incurs additional upfront cost – since retrofitting is difficult or impossible without disruption to operation (leading to greater cost). This applies to all spaces within the building that will accommodate telecommunications equipment, but is particularly applicable in areas of buildings that will be designated as data centres.

Telecommunications also has implications for building design in relation to safety. In addition, the recognized safety standards such as BS 7671 for electrical wiring and [BS] EN 60825-2 for optical fibre safety provide requirements and recommendations for both installation and operation.

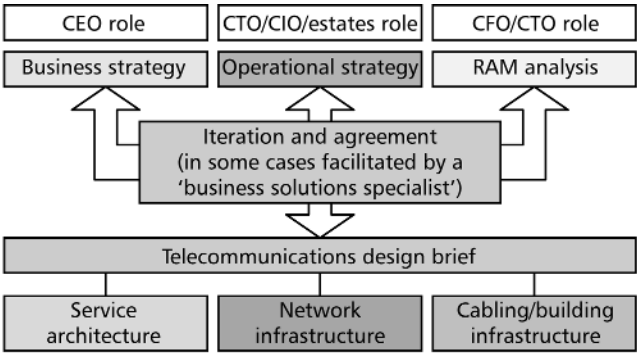
While the intent of such standards is to identify and mitigate areas of risk, compliance to standards should not be confused with meeting the objectives of regulations and other legislation covering safety. As an example of this, and as mentioned in Chapter 3, BS 8492 recognizes the potential for telecommunications cabling to spread fire unless appropriate actions are taken. However, the latest UK national regulations have increased the responsibility for architects relating to fire certification, and it is wise to take account of both the potentially substantial burning load associated with telecommunications cabling and the need to provide effective fire compartmentation (and detection and suppression systems within those compartments).

Other examples of relevant regulations and legislation for the UK include the Construction Design Management (CDM) Regulations, Control of Substances Hazardous to Health (COSHH) Regulations together with implementations of European Union Directives such as those relating to Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS), Electromagnetic Compatibility (EMC) and Construction Products.

4.3.2 The need to consider ‘operation’ within ‘construction’

The correct provisioning of telecommunications spaces, pathways and, equally importantly, the secondary facilities and infrastructures, providing power and environmental control necessary to ensure the correct function of the services they provide, is a complex issue as indicated in Figure 16.

Service convergence combining the provision of telecommunications services such as those shown in Figure 8 has a direct impact in relation to shared spaces and pathways – see 3.3. Those responsible for the



Key
CEO chief executive officer; **CFO** chief financial officer;
CIO chief information officer; **CTO** chief technology officer;
RAM, reliability, availability and maintainability

Figure 13– The ideal template for the development of a telecommunications design brief

operation of these services require representation at the time at which the major and, in practice, irreversible decisions are taken in relation to building construction.

Where function takes priority, the involvement of telecommunications specialists during the preparation phase (RIBA Work Stages A/B, as shown in Figure 12) brings great advantages to the estates function, ensuring that adequate justifications are provided for space and pathway provision – which in turn provides great benefit to the telecommunications specialists during the design phases. In most cases, the early involvement of telecommunications specialists with the combination of skills necessary to prepare the telecommunication design brief shown in Figure 13 can also assist the architectural design process to mitigate the risk of downstream re-work of certain aspects during the design and construction phases. This is addressed in much greater detail in Chapter 5.

4.3.3 The impact of network strategies

Network strategies have to address the demands for availability and security of the telecommunications services within the building, and may require the consideration of the resilience of the spaces, the facilities and infrastructures that serve those spaces and the pathways that connect them. This adds to the complexity of the basic provision of spaces and pathways for the telecommunications infrastructure.

The impact of network strategies on power demand

The integration of mobile (wireless) communications within the overall telecommunications package has hidden planning and implementation costs: it is rarely realized that the wireless implementations for acceptable levels of service of simple voice systems, data systems and VoIP can differ dramatically in terms of density of access points, antennae and network management. High-quality surveys taking into account the building construction and service demands are critical. These surveys, in turn, may indicate that building works are required. European standards are now being initiated to address the methodology and outcomes of such surveys. In addition, it must not be forgotten that the access points and antennae consume power that will either have to be supported by local power supplies or by PoE (it should be noted that the latest IEEE 802.11n devices may require multiple PoE feeds). The planning and installation issues surrounding wireless access provision are now being addressed in design standards (a future [BS] EN 50173-6), and the wider issues of the provision of power over telecommunications cabling will feature in a forthcoming amendment of [BS] EN 50174-2 expected in 2012.

However, in both cases, the provision of adequate electrical power is critical to the effective operation of telecommunication equipment, and environmental control (which requires additional power) is also required in certain areas. In this respect, at least, it is somewhat inaccurate to consider telecommunications as a ‘fourth utility’, isolated from the other services in the building.

Client architectures (requiring much less processing and electrical power at the desktop, but more at centralized locations) may also directly affect the demands on, and distribution of, electrical power. They may also have dramatic and positive effects in terms of the environmental control systems within the building since substantially lower levels of cooling may be required (as compared to the 25 W/m^2 to 20 W/m^2 typically catered for in office premises). Thin-server approaches (using servers located off-site rather than in premises-based data centres) have further knock-on effects.

> The ultimate extension of client solutions coupled with wireless service delivery has the potential to radically redefine the utility base for the building. The above examples point to the need to engage those involved in telecommunications strategy at an early stage to ensure that money is not wasted in over- or under-provision of those utilities.

Other aspects that may impact provision include the recent growth in mobile (wireless) solutions and the increased consideration of thin-project sponsor and client server concepts. As can be seen in the boxed text 'The impact on network strategies on power demand', the network strategies not only affect the spaces and pathways but may impact, to a significant degree, the secondary infrastructures providing power and environmental control.

Cabling design standards define the minimum requirements of component performance together with the types and configurations of components to be used to deliver that performance. In specific areas they define minimum implementations in terms of provision of connectivity at specific points in the building. The standards cannot replace the essential process of defining a network strategy, which ensures that the final infrastructure, including the provision of power and environmental control, addresses fundamental business issues such as repairability, availability and maintainability (see Chapter 5), including business continuity planning and, ultimately, disaster recovery.

The early availability of a network strategy does not necessarily imply the production of a network design during the 'preparation' phase. This underlines the separate responsibilities and contributions of the business solutions specialist and the telecommunications specialist highlighted in 4.3.1.

The absence of a business-specific network strategy, as in a speculative, 'installation-ready', building will generally lead to an overprovision of spaces, pathways and services for telecommunications. However, even in the case of a speculative building, there is a role for an outline networking strategy that addresses these business objectives – no future tenant or building owner will wish to commit to premises that are subject to a high cost of ownership due to poor infrastructure decisions having been taken.

By comparison, the existence of a network strategy, based on identified business needs, can have a dramatic impact on the final infrastructure forcing the development and recognition of such a strategy to precede the telecommunications design brief at RIBA Stage B as shown in Figure 15.

In both cases the resulting demand for telecommunications spaces, pathways and services needs to be addressed before RIBA Stage C as shown in Figure 15.

4.3.4 Co-operation and co-ordination

While the 'estates' function clearly understands the role and demands of traditional BMS, they are less likely to understand the impact of convergence of BMS with the wider telecommunications infrastructure, and are even less likely to have a strong understanding of the needs for the resulting spaces and pathways. If the true needs of the telecommunications infrastructure for space and building services have not been made clear to the 'estates' function sufficiently early in the building programme, it may be impossible to retro-fit those requirements – and even if it is possible, it will cause considerable inconvenience, delay and cost for the overall project. It is therefore in the long-term interest of the 'estates' function to encourage early input from telecommunications specialists.

A real example of this lack of early consultation was the decision to ignore an IT department's requirement for cabinets in a 'comms room' to be mounted on plinths – to allow cables to be installed from beneath the cabinets. As a result, cable trays were presented above the cabinets and cables fed down into the cabinets, preventing the installation of the necessary fans to cool the equipment that would be subsequently be installed, and in any case disrupting the intended airflow. This resulted in the cabinets only being able to house half the intended quantity of equipment which, in the long term, required additional space to be allocated elsewhere in the building.

This failure to plan appropriately at the early stages of a project represents an absence of rigour that jeopardizes the subsequent functionality of the building – i.e. the day-to-day business operability of the resulting building – putting at risk any planned added value. Unfortunately, IS/IT personnel may only be employed by the enterprise that occupies the building or, alternatively, third-party 'technology partners' may be employed by the building owner or their consultants, after the delivery of the building, to provide the IS and IT services to the building occupants. In either case, the appointment of the IS/IT 'function' may not occur until the building is in use (beyond RIBA Work Stage L), and in such cases it is vital that competent consulting organizations are approached in their stead (see 4.4.3).

In contrast, network upgrades are often considered to be the province of the IT function (even if the upgrades are at the behest of the IS function). However, network upgrades are increasingly subject to associated demands on space and building services. This is exemplified by the impact of a network upgrade for the widespread introduction of PoE.

The necessary modifications to the spaces housing the remote powering equipment have implications for electrical power supply, e.g. UPS, to those areas – and, in some cases, have an allied demand for environmental controls that require even greater availability of electrical power and environmental control systems.

The operational responsibilities identified above have to be mapped onto the responsibilities for project sponsorship and leadership during the building preparation, design and constructional phases.

4.3.5 Keeping the options open

In general, it can be expected that the larger the project, the greater the timescale between concept and completion. It is not uncommon for this timescale to be between 5 and 7 years. The lifetime of the building following completion, and therefore that of the critical spaces and pathways, may be as long as 20 years before major remodelling or demolition takes place.

Following the development of a design brief, there is obviously a point during the 'design' phase at which final decisions are made in relation to the allocation of telecommunications spaces and pathways and also for the facilities and infrastructures necessary to support those telecommunications spaces.

The co-operation and co-ordination discussed in 4.3.4 is obviously critical prior to and at the 'pinch point' (illustrated in Figure 14), but it is also essential that the decisions taken prior to that point provide adequate flexibility of final cabling implementation – taking into account the probable technical advances in the market together with changing customer requirements for resilience, redundancy, security and 'smartness'. In addition, both the building earthing systems and segregation between the telecommunications cabling and power supply cabling (provided by separation and/or barriers) may also be impacted by telecommunication cabling design solutions, and vice versa (where supplier warranties may be voided by incompatibilities).

This balance between cost and flexibility (which has to 'factor in' the entire life of the building) and the decision as to the scale and location of safeguarded spaces and pathways can have a major impact on both capital cost and revenue-earning aspects of the building. The latter is also true to some degree in relation to spaces allocated during refurbishment.

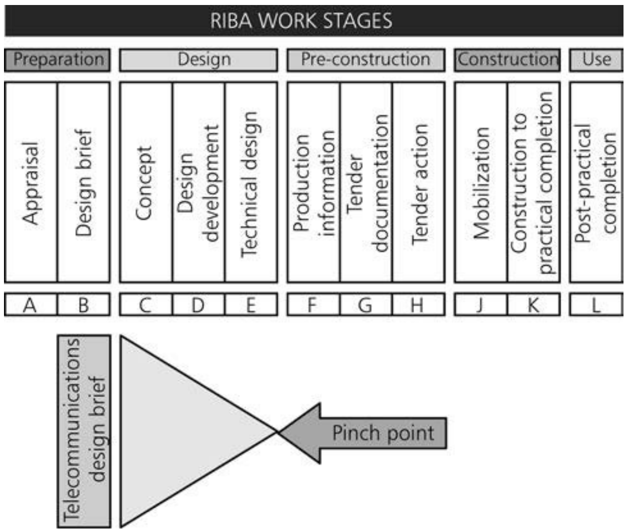


Figure 14 – The telecommunications infrastructure 'pinch point'

4.4 The impact of project size

4.4.1 Project grading

Table 1 provides a grading scheme for new build, refurbishment and network upgrade projects based upon the highest assessed grade across four separate building and project parameters. The boundaries between small, medium and large grades are somewhat arbitrary but are used to highlight the differences in the following aspects of the project management:

- budget (Table 2);
- timeline (Table 3);
- resource (Table 4).

The expectations of the project sponsor may be lower for smaller projects, and the risk to added value may be similarly reduced. Whereas for larger projects, although the total cost of telecommunications infrastructures as a percentage of the overall project may be lower than for a small project, the risk and ongoing cost of inadequate provision is greatest.

Table 1 – Project grading

Project grade	**Business metrics**		**Project metrics**	
	No. of occupants	**No. of outlets**	**Timescale**	**Budget**
Small	<200	<400	6 months	£100,000
Medium	200–500	400–10,000	6 months to 4 years	£100,000 to £2 million
Large	>500	>10,000	>4 years	>£2 million

[1] The budget includes the primary and secondary cabling costs as described in 4.3.1

Table 2 – Project grading and budget

Small	The following guidance obviously applies to medium and large projects, but they tend to be scrutinized in greater detail anyway because their budgets are higher. The impact of unwanted budgetary surprises is higher for small projects, and greater attention to detail in the planning stage is therefore more than justified. • Present the whole case. • Ring fence the cost. • Make sure the budget includes all relevant primary and secondary costs as in 4.3.2. • Include all possible contingencies to avoid under-pricing the tasks. • Take into account the impact of the applicable industry standards. • Take into account the additional impact that corporate standards may have on the project, e.g. component selection and containment issues. • Avoid the temptation to bring capital expenditure into operating expenditure (not only is this bad practice but it tends to isolate the IT department for the necessary co-ordination with other groups). An example of this would be a cabling upgrade, which then allowed IP telephony, which then demanded significant extension of the UPS systems, which had a knock-on effect on the power distribution system in the building (the latter items not being accounted for in the original budget). • Avoid the temptation to cut out aspects that

	seem unacceptably costly (as they may make the difference between operational success and long-term failure – with potential increases in associated costs). • Include the cost of the procurement process (see 4.4.2). • Consider the impact of scheduling failures (see Table 3).
Medium	The following guidance is additional to that for small projects: • As the project gets larger, the costs of quality assurance and project supervision/management need to be considered.
Large	The following guidance is additional to that for medium projects: • As the project gets larger, the costs of other professional services need to be included. • The opportunity for volume discounts, needs to be reflected in budgetary planning. • The opportunity for more effective procurement resulting from the impact of convergence (different parts of the overall project using common components) needs to be considered. • Exchange rate fluctuations and financial offsets (insurance • , buying currency) need to be considered.

Table 3 – Project grading and timelines

Small	• Errors in scheduling are more critical for small projects (the opportunity for project buffering is lower due to the restricted overall timescales). • Budget over-runs are more probable. • There is a risk for quality assurance due to short cuts required to make up time.
Medium	• The impact of the issues highlighted for small projects is reduced at the early stages of medium projects – due to the ability of longer project timescales to adjust and cope with any early delays. However, the impact of scheduling errors increases if they occur towards the end of the project.
Large	• The impact of the issues highlighted for small projects is reduced at the early stages of large

	projects – due to the ability of longer project timescales to adjust and cope with any early delays. However, the impact of scheduling errors increases if they occur towards the end of the project. • The impact of product obsolescence needs to be addressed – particularly in multi-phase projects. Generic cabling provides an infrastructure that can support a wide range of telecommunications applications, network evolution and service developments. Nevertheless, the selection of cabling technology should take into account the steady introduction of higher transmission performance options defined in the published cabling design standards. This may imply the use of higher-category balanced cabling components or the introduction of single-mode optical fibre alongside the use of multimode implementations.

Table 4 – Project grading and resource assessment

Small	• Self-assessment of in-house resources, in terms of availability, competency and adequacy (number) is critical. • Determine if external assistance is required based on primary/secondary infrastructure aspects.
Medium	The following guidance is additional to that for small projects: • A breakpoint is reached where in-house resource requires additional support (to allow the in-house resource to meet normal business needs). External contracted help is required to address: interdisciplinary co-ordination; contractual compliance (including standards).
Large	The following guidance is additional to that for medium projects: • A breakpoint is reached when it is obvious that the scale of the task requires external project management, which requires a separate procurement stage to obtain the most competent support.

4.4.2 Procurement

Independent of the project grade, a number of procurement options exist, including:

- construction management;
- design and build;
- build, own and operate;
- business process outsourcing;
- build, own and transfer;
- drawing production;
- third-party (independent) witnessing;
- quality management;
- construction 'snagging'.

The approach selected has a dramatic impact on the standards that are applied, who is employed (e.g. an electrical contractor with specialist subcontractors, a specialist IT contractor or main contractors) and who has the responsibility for applying those standards. Further details are provided in 8.2.

4.4.3 Allocating the planning resource

Determining the appropriate level of planning resources to allocate to the telecommunications infrastructure is a complex mix of project scale and the project sponsor's expectations.

Providing inadequate levels of resource and failure to apply the appropriate form of consultation during the building 'preparation' and 'design' phases represents a significant risk to the value added (including availability and security of the telecommunications services) achieved by the building, and may, in some cases, result in an ineffective building from the telecommunications perspective. This risk needs to be fully understood by, and be made visible to, the estates function, the architects, planners and finance managers alike.

The concepts of primary and secondary cabling costs were introduced in 4.3.1. The allocation of telecommunications planning resources and the funds allocated to expert assistance should not be based upon the primary cabling cost. The secondary cabling costs, combining the provision of power, possible environmental control, space allocation and any structural engineering and decoration required within those spaces may be many times that of the primary cabling cost. It is the combination of the primary and secondary costs that should be the basis of planning and justifying the resource allocation provided for business solutions and telecommunications specialists.

The medium- to large-grade projects (see 4.4.1) will sometimes require more than one equipment room (albeit with one being described as a main equipment room) and a significant number of telecommunications (or satellite equipment) rooms housing building and floor distributors, as described in Chapter 1. The secondary cabling cost associated with these spaces can easily be an order of magnitude greater than the primary cabling cost – and this factor may be even greater for small projects since the primary cabling costs are comparatively low.

5 Mapping business requirements to design objectives

This chapter discusses the techniques that should be applied to the analysis of business requirements to prepare effective telecommunications objectives and solutions, featuring a integrated production and review of business and operational strategies combined with a Reliability, Availability and Maintainability (RAM) analysis leading to the final development of a design brief for the telecommunications infrastructure.

The approach taken covers 'speculative' and 'designed to requirement' building projects – serving both single and multiple tenants.

This chapter makes reference to the following standards:

- *British: BS 6701.*
- *European: [BS] EN 50173-2, [BS] EN 50174 series.*
- *International: ISO/IEC 11801, ISO/IEC 14763-2.*
- *North American: ANSI/TIA-568-C-1, ANSI/TIA-569-B, IEEE 802.3at.*

Essential reading for: Project Sponsors, Project Managers, Architects, Building Services Engineers, Telecommunications Consultants

Optional reading for: Other specialists, Quantity Surveyors, Cabling Installers

Appendix A contains a detailed bibliography.

For the purposes of this chapter, construction projects for single owner/tenant premises are divided into two groups – 'speculative build', where the telecommunications requirements of the owner/tenant are unknown at the time that the design brief is prepared, and 'designed to requirement', where the design brief is closely linked to the strategic and operational telecommunications objectives of a known tenant.

Construction projects resulting in multi-tenant premises may be entirely 'speculative', entirely 'designed to requirement' or a combination of the two.

In the case of speculative build projects, it is certainly possible to adopt a structured cabling design standard that will deliver clearly defined levels of telecommunications provision to the owner/tenants. The adoption of such an approach supports the application of cabling planning standards that define the size and location of the necessary spaces together with the associated electrical and environmental control infrastructures. This could enable the construction of an 'installation-ready' building, introduced in Chapter 5, allowing the subsequent installation of products from the cabling design standards to produce an effective telecommunications infrastructure. However, such solutions have, almost by definition, to include some level of overprovision in certain areas, and have some attendant financial disadvantages in terms of potential waste of space, or over-specification of the electrical supply or environmental control systems. As a result, an appropriate provision of telecommunications infrastructure in speculative build projects is rarely implemented. Often, there is a tendency to avoid any investment in telecommunications infrastructure, leaving many speculative projects at a commercial disadvantage – since the cost and delays involved in retrofitting the required infrastructure may discourage potential tenants.

In contrast, a 'designed to requirement' project allows early preparation and planning stages to focus on the requirements for physical, electrical and environmental control infrastructures that are more accurately defined to match the strategic telecommunications objectives of the project sponsor. The relevance of particular cabling design standards has to be assessed against these objectives and the operational solutions being considered in these early design phases. However, irrelevant of any cabling design standards, the cabling planning standards are able to be applied to determine the 'envelopes' of spaces and pathways provisioned to be applied during the building design process.

This chapter describes both the demands of realistic telecommunications support in speculative build projects and a methodology for mapping the requirements in the case of 'designed to requirement' projects – leading to the definition of an effective telecommunications design brief.

5.1 Speculative build projects

A building designed and constructed as 'speculative', without knowledge of the final tenant, owner or user, has to balance some fundamental aspects. There is obviously a desire to maximize floor space within a given footprint while, at the same time, maintaining the basic functionality of the premises. The incorporation of IT and the wider aspects of telecommunications (via the convergence concepts introduced in Chapter 3) within that basic functionality has a significant influence on that balance.

The question is often asked 'Can a speculative building provide adequate resources for telecommunications in terms of spaces, pathways, power supply and environmental control?'

It is certainly possible for a building designer to claim that a building is 'installation-ready' as described in Chapter 4, against a pre-defined cabling design standard and in accordance with a cabling planning and installation standard even before cabling has been installed – provided that adequate consideration has been applied to the spaces and pathways and, where appropriate, the supply of electrical power and environmental control.

Similarly, in a building that is 'installation-ready', it is possible for an installer to claim conformance to those design, planning and installation standards after the cabling installation has been completed. However, in order for a building to be 'installation-ready' the purpose of that building has to be taken into account – specifically the number of personnel to be accommodated within the building and the quantity of end-user connections they will require. Once this is defined, the planning and installation standards allow the calculation of the minimum sizes for the relevant spaces and pathways associated with the cabling and associated transmission equipment that will eventually be required. Clearly, this has to be done at a very early stage and the architect will need to consult a telecommunications/IT specialist in addition to the other skill-sets such as mechanical, electrical, fire, acoustics, etc.

Table 5 indicates the contents of the various design, planning and installation standards which may be used to support the implementation of infrastructures within speculative building projects.

Table 5 – Cabling standards support for speculative build projects

	British, European and international standards		**North American standards**	
Design standards	[BS] EN 50173-2/ISO/ IEC 11801		ANSI/TIA-568-C-1	
	Require- ment	Recom- mendation	Require- ment	Recom- menda- tion
Minimum number of outlets per work area	✔	●	✔	●
Size of work area	●	●	●	●
How many people per work area	●	●	●	●
Maximum cabling lengths between connections at work areas and telecommuni- cations rooms	✔	●	✔	●
Minimum performance of cabling performance to the work area (both balanced and optical fibre cabling)	✔	●	✔	●
Floor area covered by telecommuni- cations rooms providing connections to work areas	●	✔	●	✔

	British, European and international standards		**North American standards**	
Number of telecommunications rooms (per floor) providing connections to works areas	●	✓	●	✓
Minimum number of equipment rooms per building providing connections to telecommunications spaces/rooms	✓	●	✓	●
Planning/ installation standards	[BS] EN 50174-2 ISO/ IEC 14763-2	ANSI/TIA-569-C	[BS] EN 50174-2 ISO/ IEC 14763-2	ANSI/TIA-569-B
	Requirements	Recommendation	Requirement	Recommendation
Dimensions of telecommunications spaces/rooms providing connections to work areas	●	✓	●	✓
Dimensions of equipment spaces/rooms per building providing connections to telecommunications spaces/rooms	●	●	✓	✓
Dimensions of pathways				

	British, European and international standards	North American standards
Power supply capacity		
Environmental control system capacity		
Key ✔ = addressed ● = not addressed		

For example, in order to house the floor distributors in single-tenant commercial premises, the UK, European and international structured cabling design standards recommend the provision of a dedicated telecommunications room on each office floor of area up to 1,000 m^2 – with further rooms for each additional 1,000 m^2. As was discussed in 3.3, these standards recommend minimum dimensions for these rooms based on the number of connection points on those floors (the North American standard ANSI/TIA-569-C contains similar demands for space, but based on the floor area served).

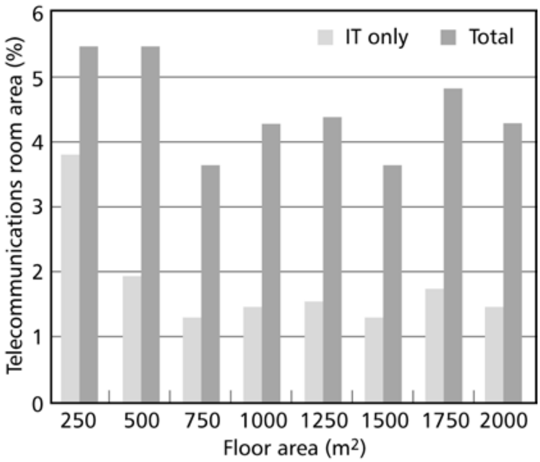
The impact of these recommendations is shown in Figure 15. The floor area required for these rooms to solely accommodate IT cabling and equipment is approximately 1.5 per cent. However, the impact of convergence and the additional space (whether shared or not) required for power supply and environmental control in those rooms can substantially increase the percentage of allocated space (also shown on the graph) to approximately 4 per cent.

NOTE the area required assumes the rooms have a minimum height of 3 metres. If the available height fails to meet this requirement, the area of the rooms has to be increased accordingly.

Associated calculations, based upon these planning and installation standards, can be applied to the space allocations for the equipment rooms housing the building distributors and the pathways used to house the cables between these rooms and the various connection points.

It should be pointed out that the standards-based approach to space allocation does not extend to the sizing/capacity of either the power supply systems or the environmental control systems for those spaces.

Clearly, the minimum, standards-based, provision of approximately 4 per cent of floor space on each floor to provide space for telecommunications distribution has a direct impact on the rentable space and the associated business models of buildings. So, while



This figure shows the minimum space allocation for accommodation of telecommunications rooms per floor based upon work areas of 3 m^2, each containing two connection points.

Any additional requirements based on resilience demands are not taken into account.

The 'IT only' values relate to the minimum recommendations of the standards to provide accommodation for the structured cabling for the user areas across the floor and the networking equipment to support those connections.

The 'total' values reflect additional space subsequently required to support the additional convergent infrastructures together with all the power supply and environmental control equipment to those rooms.

Figure 15 – Standards-based floor space allocation

standards can be used to design the telecommunications infrastructure of speculative buildings, the implications of this approach represent a substantial financial obstacle.

It is this conflict between revenue-earning space and adequate provision for future telecommunications demand that frequently results in inadequate telecommunications provision, in terms of space allocation, power and environmental control, in single-owner speculative build projects. The project sponsor will prefer to restrict the spaces and power provision to the minimum required to support any building management services together with those building entrance facilities necessary to support incoming service provision. The latter tends to militate against considerations of convergence of those services with the IT infrastructure.

However, the importance of telecommunications provision in the business strategy of the eventual owners, tenants or users of the buildings should be a major design criterion – as an inadequate apportionment or positioning of spaces and facilities could lead to substantial add-on costs that would lead to the premises being viewed as less attractive in a competitive market.

This justifies the involvement of telecommunications specialists (using the services of either in-house teams or external professionals) to interpret the options and advise as to solutions that balance the commercial value of the premises with the provision of adequate space and pathway allocation to support operational requirements of the telecommunications infrastructure.

5.2 Designed to requirement build

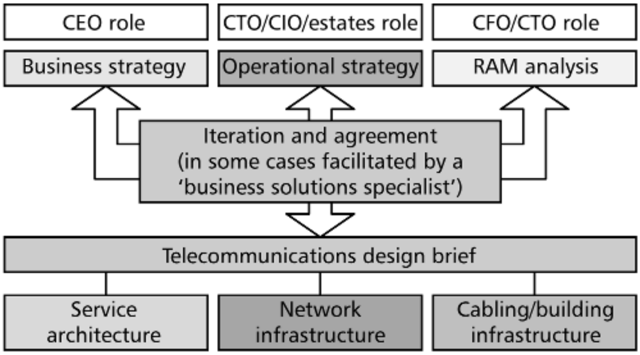
5.2.1 The process of requirement mapping to produce the telecommunications design brief

In comparison to speculative build projects, the ability to respond to a specific project sponsor requirement offered by a 'design to requirement' approach provides an opportunity to meet accurately defined requirements for the space, pathway, power supply and environmental control systems to support the strategic telecommunications objectives. However, the nature of those objectives has to be fully defined.

Figure 16 indicates that a three-pronged approach is necessary in order to develop a viable telecommunication design brief that properly encompasses service architecture, network infrastructure and the vital building and cabling infrastructures necessary to support the overall objective. The three-pronged approach comprises the business strategy, the operational strategy and the RAM analysis.

5.2.2 The business strategy and its impact on telecommunications

It is critical to obtain a clear vision of the objectives in relation to each of the telecommunications services solutions to be applied by the business. These objectives may be influenced by a wide range of drivers, including the obvious – energy efficiency, flexibility of space and staff – together with possible less tangible aspects such as maximizing staff motivation.



Key
CEO chief executive officer; **CFO** chief financial officer;
CIO chief information officer; **CTO** chief technology officer;
RAM, reliability, availability and maintainability

Figure 16 – The 'ideal' template for the development of a telecommunications design brief (RIBA Work Stage B)

The overall telecommunications package has to address the complete range of services (see Figure 17 for typical examples) considered relevant to the business, which will certainly include IT and building services but may extend to other areas such as the broadcast services distribution or process control, monitoring and automation systems in industrial plant.

The business strategy addresses the desired solutions at an individual service level. Examples of this approach would include the intended solutions for the distribution of voice services (conventional fixed telephony, converged VoIP solutions or even totally outsourced mobile telephony solutions). The storage and delivery of business information has a significant role to play in determining the infrastructure options. For example, whether it is desirable to have conventional enterprise data centres (either on-site or remote) or to obtain hosting services or consider full 'cloud computing' concepts. These decisions not only have significant financial (capital versus operational expenditure costs) and management impact but may also influence the methods of data distribution, i.e. fixed cabling versus wireless solutions.

5.2.3 Operational strategy

Faced with a well-defined business strategy coupled to a financial allocation (addressing both capital and operational expenditure), it is necessary to produce an operational strategy that balances the two.

Corporate fixed local area network (LAN)	
Corporate wireless LAN	
Server access/data centre LAN	
Telephony/unified communications	
Audio-visual (presentation aids/meeting)	
Multimedia/digital content (video on demand)	
Electronic point of sale (EPOS)/vending	
Public switched telephone network circuits	
Public address	
Master clock	
Digital signage	
Television	Off-air
	Cable
	Community antenna (CATV)
	Satellite master antenna (SMATV)
Security – closed circuit television (CCTV)	
Security – access control system (ACS)	
Building management systems (BMS)	
Building automation systems (BAS)	
Supervisory control and data acquisition/ metering	
Life safety alarms	

Figure 17 – Typical business telecommunications services

The personnel responsible for delivering the overall telecommunications infrastructures (which will at least include the telecommunications and the estate areas) will need to develop technical solutions in response to the business strategy and to determine the relevant implementation and operational costs. It is not uncommon for the project sponsor or project manager to employ a business solutions specialist (also termed 'information systems (IS), management information (MIS) or 'enterprise architect' specialists) to assist in the conversion of the business strategy to the operational strategy. In some cases, the business solutions specialist may fulfil the role of the CTO in developing the alternative implementation options (see Figure 10).

Clearly, if business strategy cannot be achieved with the available funds, some type of iteration has to be undertaken in relation to redefining the business strategy or obtaining increased financial allowances.

However, assuming that the business strategy and the financial allocation are aligned, the operational strategy defines the approaches to be employed – once again on a service-by-service basis. This definition has to take into account how, and by whom, the various telecommunications services are to be delivered. The 'how' has to address the extent of convergence to be applied and the technology approach to be adopted for each service, as discussed in 4.3.3. The 'by whom' aspect has to consider the solution to be employed for the provision of each of the telecommunications services, e.g. IT and building control.

Both of these decisions have a major impact on the space and pathways. While the convergence and technology approaches to be employed for each service will define the size and minimum number of spaces allocated to telecommunications rooms, equipment rooms and data centres in the building, the strategy for operational network support has a direct bearing on the location, configuration and actual quantity of those spaces. This is addressed more fully in Chapter 6.

5.2.4 Reliability, availability and maintainability (RAM) analysis

5.2.4.1 RAM

The telecommunications solutions resulting from a financially viable implementation of the business strategy should be subjected to an analysis of demands for reliability, availability and maintainability (RAM) as outlined in Figure 18. This analysis is critical to ensuring that a 'designed to requirement' build achieves an optimal implementation.

The project sponsor needs to have a quantitative understanding of the costs to the business of failure of the telecommunication systems employed within the building. The impact of convergence indicates that this analysis covers much more than the IT services to the employees in their work areas – it may also address one or more of the telecommunications services listed in Figure 17. However, although these functions are important, a failure of these control systems can be mitigated in many different ways. In comparison, a failure of the IT provision may produce an instant disruption of internal communication and/or external service connections.

The cost of such failures depends upon the type of business conducted by the project sponsor, but it is critical to understand the impact of failures in these areas in order that appropriate design solutions (see Chapter 6) may be applied and that the additional costs (both capital and operational) are factored into iteration of the business and operational strategies. Examples of alternative solutions arise from single point of failure analysis undertaken on a reference design. It should be noted that the minimum requirements of the structured cabling design standards take no account of resilient configurations, although examples are provided.

		Service-by-service analysis	
	Working definition	Business	User (localized operational impact)
R Reliability	The ability of a system to consistently perform its intended or required function or mission, on demand and without degradation or failure	Mean time between failures (MTRF)	Resilient service solutions
A Availability	The ability of a system to be committable, operable usable upon demand to perform its designated or required function	Mean time to recovery (MTTR)	Resilient infrastructure solutions
M Maintainability	The probability that a failed system can be restored to its normal operable state within a given timeframe, using the prescribed practices and procedures	Ease of access System reconfiguration to maintain service System design to support rapid repair	Configuration management to manage complex resilience

Figure 18 – Key aspects of RAM analysis

The analysis should be undertaken from two separate perspectives – firstly, that of the overall business, and then from the viewpoint of the individual end-user.

5.2.4.2 RAM analysis – the business perspective

From the business perspective, the service provision needs to be broken down into two parts – external network connections and internal service distribution. The internal service distribution needs then to be considered on a service-by-service basis (e.g. treating voice and data separately). The reason for this separate analysis is that, despite the obvious advantages offered by convergence, the dependence of a business and therefore the associated cost of downtime may vary dramatically across the services it uses.

The reliability of each telecommunications service should be judged on the mean time between failures (MTBF) that is deemed acceptable to the operation of the business (workflow) and the function of the building. The causes of failure range from external factors such as excavation damaging an incoming cable to the failure of the power supplies to critical parts of the building. Despite considering each service separately, any mutually dependent services need to be taken into account (i.e. does a failure of the data network cause a parallel disruption to the voice service?).

The availability of each service is assessed in terms of the mean time to recovery (MTTR) following service disruption. For example, the degree of accessibility for authorized personnel to vertical pathways (e.g. risers) and horizontal pathways and equipment spaces has a direct effect on the MTTR where cable replacement is required. Similarly, the appropriate allocation of space surrounding cabinets within those spaces may be critical to effecting repair and replacement of equipment within them. The cost of downtime has to be applied to the combination of the MTBF and the MTTR for each service – and this cost has to be set against the potential cost for any design solutions that increase the MTBF and/or reduce the MTTR.

The maintainability of each service has a direct influence on its MTTR – the time taken to recover from failure is a complex function of ease of access to critical areas in the building coupled with the ease with which the failed systems can be reconfigured (this is subtly different to serviceability, which relates to repair of the failed system). The use of roll-out shelves for large items of equipment or the adoption of modular solutions are examples of implementations that may improve maintainability and thereby reduce the MTTR. In addition, the ease with which faults can be analysed and corrected/repaired also affects the MTTR.

5.2.4.3 RAM analysis – the outsourcing option

The issues of maintainability also focus attention on plans for the operation of the various infrastructures. It is tempting to consider 'outsourcing' of service provision as a simple way of reallocating or short-circuiting the design responsibility for the telecommunication infrastructure(s). However, it is rarely that simple – and a number of fundamental questions have to be asked – and answered – in order to ensure that the desired objectives are realized.

One such question could be: 'Can a single outsourcing contract be possible for all the services delivered over the telecommunications infrastructure?'

If the answer to this question is 'no', then each service will need a separate provider – each with a defined service level agreement. In such a circumstance, further questions are raised such as 'How viable would shared spaces be?' and 'How would unauthorized access be managed in relation to physical infrastructure, documentation, electronic data and even to other, sensitive, parts of the building?'

The availability demands for each service also have to be taken into account. It is unrealistic to apply high-availability requirements to a service level agreement if the building infrastructure has not considered the allocation of spaces to support the necessary resilience. Failure to consider the long-term demands for service provision at the building design stage can have serious financial implications for the cost of service provision over many years.

In summary, plans for outsourcing future telecommunications service operation does not allow abdication of effective design and construction of appropriate spaces and pathways. Early investment in planning of the spaces and pathways is necessary to ensure the basic viability of outsourcing, keeping the service options open and enabling the cost-effective provision of the desired service level.

5.2.4.4 RAM analysis – the end-user perspective

From the perspective of individual users, the key issue is the provision of service to a desk or work area. However, by assessing reliability on a service-by-service basis, design approaches can be implemented to minimize the impact of specific types of failure to both external service connection and internal service distribution.

Availability can be increased not only by implementing resilient service solutions but by applying resilient cabling configurations to work areas that can be initiated either by manual reconfiguration at patch panels or by automatic rerouting of the services.

It should be considered that overall service reliability and availability for an individual end-user may be achieved at the expense of total service provision by focusing provision on key parts of the business.

Maintainability has to reflect the time taken to implement re-provision of service to an end-user, and will depend on the complexity and content of the reconfiguration process. The more complex, at a physical level, the reconfiguration process, then the more technology will be required to minimize errors in the process – suggesting Simple Network Management Protocol (SNMP) management for equipment-based solutions and intelligent patching for infrastructure-based solutions.

5.2.5 Completing the process

An agreement of the user requirement for telecommunications, following the successful co-ordination and alignment of business strategy, operational strategy and RAM analysis, represents the best opportunity to create a telecommunications design brief.

Unfortunately, the majority of construction projects do not apply this approach, with neither a business solutions specialist nor a telecommunications specialist employed by the client or project manager. In such cases, the resulting design briefs may be non-existent, partial or, even worse, incorrectly formed by parties without the telecommunications skills – this represents a major administrative risk to the project (see Chapter 8). The authors' experience indicates that this results from a misplaced perception that a cabling project is an insignificant portion of the total contract value or building budget (as outlined in 4.3).

Of course, the correct application of the three-pronged approach detailed in this chapter may not result in the definition of a single solution during the earliest stages of a project – as indicated in Figure 19. All solutions need to be evaluated in terms of detailed requirements for the spaces and pathways and the associated requirements for electrical power and environmental control. Chapter 6 provides further information on the design strategies and methods that may be applied to determine the specific requirements of the possible options.

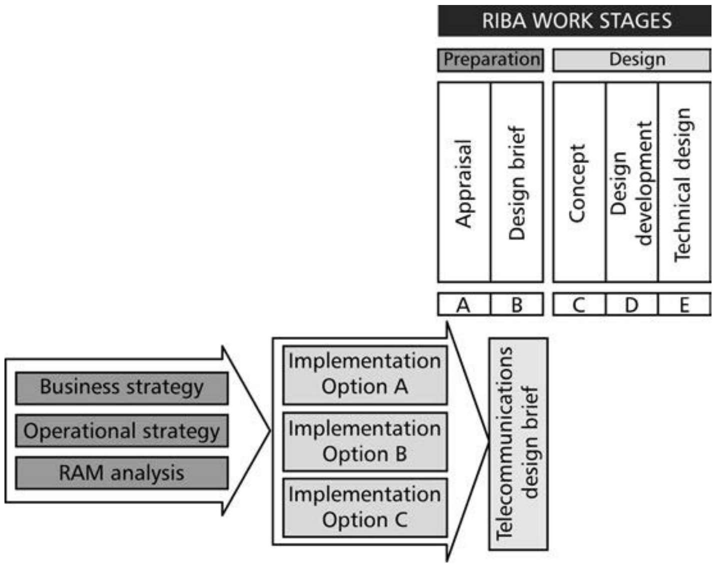


Figure 19 – Multiple implementation options at RIBA Stage C

As the construction process advances beyond RIBA Work Stage C, the final implementation will be agreed, but it is critical that no construction-related decisions are taken before that time that would prevent the agreed solution being implemented correctly. Later chapters discuss the technical risks (see Chapter 7) and administrative risks (Chapter 8) during these early phases of the construction project, and the controls necessary to mitigate those risks.

5.3 Multi-tenant premises

Multi-tenant premises present an additional level of complexity that has to be addressed by an effective telecommunications infrastructure design. This reflected by their separate treatment in Amendment 2 of [BS] EN 50174-2 which deals with the common spaces and pathways and in such premises – in parallel with those spaces and pathways of purpose-specific premises such as office, industrial, residential and data centres.

However, it is not always possible to differentiate the common spaces and pathways from those within the tenant areas; some of the more sophisticated overall building management networks such as access monitoring and control systems and other BAS operated by the landlord that extend into tenant areas. Moreover, it is not always physical infrastructure that defines such boundaries – if the landlord's network is implemented using wireless technologies, these may restrict or conflict with subsequent wireless spectrum allocation used by future tenants.

As suggested in the introduction to this chapter, multi-tenant premises construction projects may be entirely 'speculative', entirely 'designed to requirement' or a combination of the two.

It should be pointed out that multi-tenant premises may be single buildings comprising multiple tenanted areas or campus premises containing many buildings – each of which may have one or more tenanted areas.

Where one or more of the tenants are known at the outset and their telecommunications requirements are defined, the infrastructures within those tenanted areas and the spaces and pathways serving those tenanted areas can be considered to be 'designed to requirement' projects. However, unless all the tenanted areas and their telecommunications requirements are known and fixed at the outset, there is a substantial element of speculative build.

The areas of speculative build lie both in the common spaces and pathways and the tenanted areas themselves. Clearly, if initial tenancy uptake is phased, it is important to avoid the risk of 'first come, best served – last come, least served', and to ensure that the spaces and pathways associated with each tenancy are safeguarded. Of course, the number of tenanted areas may increase or decrease during the construction project or the lifetime of the premises.

Moreover, the nature of those spaces and pathways depends on the approach taken to external service provision in the premises. Specifically, the telecommunications service provision to each tenanted area may simply be an extension of the external service provision to the premises (providing each tenant with a direct connection to the access network), as shown in Figure 20 (a).

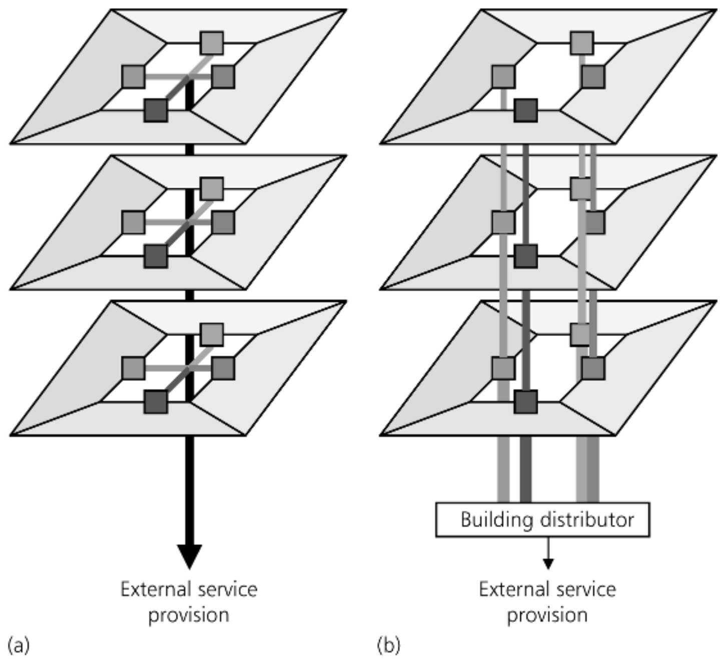


Figure 20 – Multi-tenant building configurations

Alternatively, the external service provision to each tenanted area may be via a private infrastructure owned and operated by, or on behalf of, the building owner, as shown in Figure 19 and Figure 20 (b). The latter approach produces a backbone infrastructure similar to that of a single-tenant building with distributed spaces on each floor – therefore requiring the allocation of substantially more space than the direct-access connection model. However, the direct-access connection model leads to uncertainty as to the size and location of pathways that may be necessary to provide each tenant with their own choice and capacity of access connection as tenant migration and evolution takes place.

The difficulty in providing adequate spaces and pathways for all future tenants is compounded when it is considered that those tenants may decide to expand into additional tenanted areas on the same floor or different floors (or buildings if a campus premises is considered). The implementation of ‘internal’ networks for such project sponsors requires effective security of all common spaces and pathways. This favours the universal solution in line with the building distributor approach (even if all connections at that point are passive), but effective methods of restricting unauthorized access to the spaces and pathways must be implemented to give tenants confidence that their data are not corrupted or ‘stolen’.

Clearly, such flexibility of infrastructure requires a greater provision of common spaces and pathways (particularly if coupled with a pathway structure to service direct external connections). Such space allocation may be viewed as excessive by tenants, and may not be recoverable in rental charges.

As mentioned in 5.1, the involvement of telecommunications specialists (using the services of either in-house teams or external professionals) is critical when interpreting the various options and advising as to solutions that balance the commercial value of the premises with the provision of adequate space and pathway allocation to support the operational requirements of the telecommunications infrastructure.

5.4 ‘Limited life’ and ‘limited demand’ infrastructures

There are two further types of telecommunications infrastructures that may be applied to both speculative and ‘designed to requirement’ projects and which are subject to modified user requirements as follows:

- **limited life** – that is, initially designated as being temporary, and independent of the intended life of the premises;
- **limited demand** – that is, designed to reflect a specific demand for given periods during the intended life of the premises.

The common theme of such premises is that the requirement for network support is defined either by virtue of the lifetime of the infrastructure or by the period over which those networks are required to operate to their full capability.

Limited life infrastructures may be subject to a desire for cost controls that may affect overall cabling design implementation (in terms of the number and location of telecommunications spaces) or the choice of pathway systems. For example, in order to reduce the number of telecommunications spaces for structured cabling 'distributors' (see Chapter 3), it may be desirable to extend the cabling lengths beyond those that are defined in the generic cabling design standards (e.g. [BS] EN 50173-2 or ANSI/TIA-568-C-1). This may result in the longer paths being unable to support the demanding telecommunications applications – but being perfectly usable for others. This is a wholly reasonable design decision with a commercial rationale. However, the risk of such strategies is that infrastructures of limited life often become more permanent, and any such application support restrictions need to be fully understood by all future users of the infrastructure.

Similarly, it may be tempting to select pathways and cable management systems that reflect the intended temporary nature of the cabling that they are to support. Once again, the risk of extending the required life of the infrastructure will undoubtedly place unplanned physical demands on those pathways and pathways system that may degrade the performance of the telecommunications cabling.

Limited demand infrastructures should not be confused with low demand. In fact, the demand may be very high but of short duration. An example of this would be the telecommunications solutions to provide coverage and management of sports events, which would have to provide high levels of availability during the period they are operational. Premises containing limited demand infrastructures are more likely to be 'designed to requirement' since it is the demand on the telecommunications infrastructure that is designated temporary, and during that period the systems shall be fully effective against a defined objective.

Both limited life and limited demand infrastructures need to be designed, planned and installed with the same degree of competence as a permanent, continuously operated, infrastructure.

6 Design strategies and methods

This chapter reviews the design options that support the major network strategy options introduced in Chapter 5. The impact of the different approaches on project planning, procurement and construction is outlined.

The chapter also explains the separate functions of the cabling design and installation planning standards and how they are used, either on their own or in conjunction with corporate standards, to develop the telecommunications design brief for the cabling and associated infrastructures.

This chapter makes reference to the following standards:

- *British: BS 6701, BS 8492.*
- *European: [BS] EN 50173-2, [BS] EN 50173-3, [BS] EN 50173-4, [BS] EN 50173-5, [BS] EN 50173-6, [BS] EN 50174-1, PD ISO/IEC TR 29106.*
- *International: ISO/IEC 14763-2*

Essential reading for: Building Services Engineers, Telecommunications Consultants

Recommended reading for: Project Sponsors, Project Managers, Architects

Optional reading for: Other specialists, Quantity Surveyors, Cabling Installers

Appendix A contains a detailed bibliography.

As stated in the introduction to Chapter 3, 'Convergence' is the term used to describe the trend towards an ever-increasing use of IP as a means of communicating between devices – and the ever-increasing range of devices that will use IP to communicate' and '…as the most common methods of delivering the information between IP-enabled devices are based on the Ethernet applications used for office networking, the immediate and obvious impact on the cabling infrastructures within buildings is the use of a standards-compliant component set of cables and connectors – and the potential to adopt common, although possibly separate and overlaid, cabling infrastructures.'

Faced with the need to define operational strategies in relation to the various telecommunications services in order to meet a strategic business objective, a great many options may be considered. The influence of convergence cannot be underestimated, and it has to be addressed at two different levels. The first decision relates to the viability (or desirability) of convergence to deliver a specific telecommunications service at the technology level. If it is decided that converged solutions are indeed required, it is necessary to understand the impact that such a decision will have on the physical infrastructure adopted for that telecommunications service.

At the earliest stages of project planning, it is critical to determine a technology roadmap that addresses each of the services to be provided by the telecommunications infrastructure. For large projects, the roadmap has to reflect the predicted changes in networking approaches and the impacts that these changes would have on the selection of options within the infrastructure.

Examples of such changes in the past that have had substantial impacts are wireless networking, VoIP, PoE and thin-client implementations. Future changes could include storage virtualization and ‘cloud’ computing.

Monitoring the progress of technologies against the roadmap and assessing the compatibility of the infrastructure allows the overall infrastructure design to remain flexible up until the ‘pinch-point’ concept introduced in 4.3.5 and shown in more detail in Figure 21. While it may be that maintaining this flexibility as long as possible does attract costs, it may serve to reduce the risk of unexpected increases in project costs that would result from substantial changes to fixed plans.

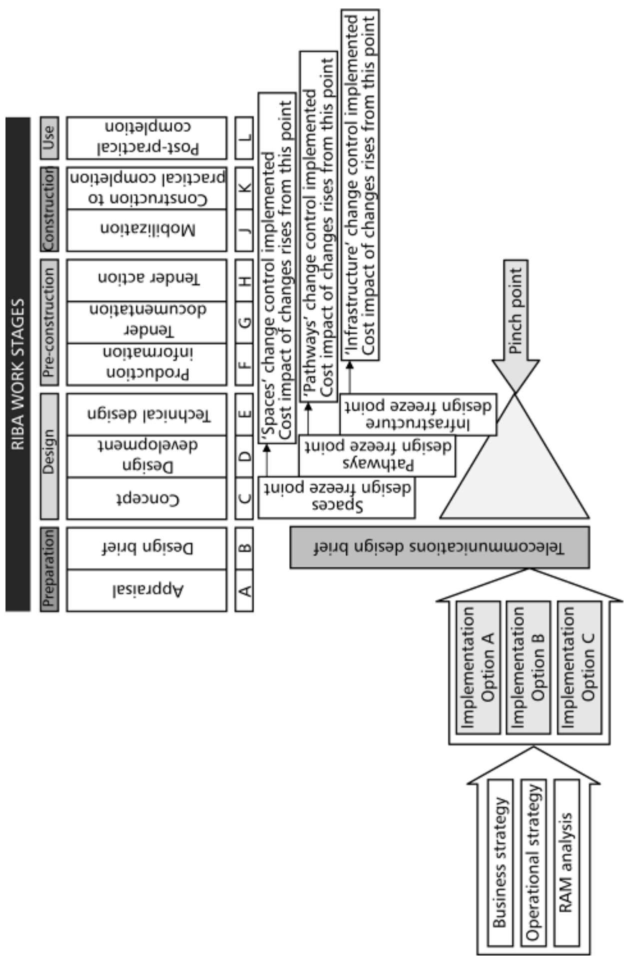


Figure 21 – Phased decision-making leading to the pinch point

It has to be reiterated that neither cabling design nor cable planning nor cable installation standards explain how to undertake such analysis – but once the decisions have been taken, they support the design, installation and commissioning process in accordance with the stated performance objectives.

This chapter provides further detail regarding the design strategies and implementation methods in support of the various telecommunications services described in Chapter 5. Proof of concept is critical before any decisions are taken as to the viability of a particular solution.

6.1 Telecommunication service provision

6.1.1 Telecommunications services

For the purposes of this chapter, the telecommunications services refer to those listed in Figure 17. The following sections discuss the typical services and provide relevant guidance that may be found useful during the process that results in the production of the telecommunications design brief shown in Figure 21 via the process outlined in Figure 16. Appendix B provides further information for some of the services not reviewed in this chapter.

6.1.2 Corporate local area networks (LANs)

6.1.2.1 Fixed infrastructures

The ‘corporate fixed LAN’ refers to the cable-based (copper and optical fibre) network that is deployed in most commercial buildings to support the business IT or certain building systems.

There is a growing trend for some businesses to consider a partial replacement of the corporate fixed LAN with a wireless implementation.

In some cases, there is a desire for a complete replacement. In both cases, this may be a viable alternative when the RAM analysis of 5.2.4 suggests that such a solution matches the demands of the business. However, concerns over data security may prevent or restrict the use of wireless, and the corporate fixed LAN may remain the only viable option – and it should be remembered that even an all-wireless implementation will still have a skeleton fixed LAN to enable wireless access points to offer access to the network backbone.

Corporate fixed LANs are typically owned and operated by the occupier – where it is considered to be a critical business asset. However, this is not always the right approach, and the advent of managed service solutions –

particularly in mixed-use environments or multi-tenanted properties – offers the possibility that a third-party service provider could operate, or even own and operate, the corporate fixed LAN on behalf of the occupier(s).

The business may have justified reasons to consider the outsourcing of the investment in LAN infrastructure and the associated management of the service it delivers. Key issues to be addressed before a formal management decision can, and should, be made include work flow, data security, compliance procedures, financial metrics, agility and the flexibility for adds, moves and changes.

It should be pointed out that not all equipment that is considered part of a corporate LAN may be designed to connect directly to structured cabling. Although the percentage of such equipment is steadily reducing, legacy systems may exist that require adaption by means of proprietary interfaces that allow its use within the transmission performance envelope provided by structured cabling. This is also true of a wide range of other services (see 6.1.4).

6.1.2.2 Wireless infrastructures

Corporate wireless LAN refers to the wireless-based network that needs to be deployed for the purpose of providing mobility to users with portable IT devices such as smartphones, together with wireless-equipped laptops, netbooks or tablet devices. It should be remembered that even where data security considerations preclude a corporate wireless LAN, it is usually necessary to provide wireless LAN guest access to allow visitors, contractors and staff access to the public internet.

Design options include the deployment of an occupier owned-and-operated wireless LAN infrastructure or of a public Wi-Fi hotspot/hotzone within the building or on campus.

A business will need to assess the need for a corporate wireless LAN during the development of the telecommunications design brief, and, if required, decisions will have to be taken with regard to the intended coverage, i.e. universal or limited to specific zones. Where the business does not have access to a CTO or CIO with appropriate competence authority to make decisions on behalf of the project sponsor, then specialist advisory services should be considered to assist and manage the decision-making process.

Early decisions are vital, as building designers may need to select construction materials, spatial geometry and interior designs in order to provide a ‘wireless-friendly’ environment. A telecommunications specialist may also be employed to model the wireless performance of a building to determine the strategic locations for wireless access points (i.e. the devices, usually ceiling mounted, that wirelessly transmit and receive data to end user devices).

6.1.3 Server access or data centre LANs

6.1.3.1 General

Most enterprises have server rooms (also called computer rooms) that contain the equipment that stores and processes business-related applications and associated data. The size and complexity of such spaces vary according to the business needs.

As indicated in Chapter 4, all such spaces are considered to be data centres from the cabling perspective, and are subject to specific cabling design and installation standards that address topologies, configuration and installation planning and practices. To be specific:

- structured cabling design aspects for all types of data centre are addressed in [BS] EN 50173-5 (equivalent to ISO/IEC 24764) and ANSI/TIA-942-A, although the latter addresses many other facets specifically applicable to larger data centres;
- general cabling installation planning and practices within all types of data centre are addressed in specific clauses of [BS] EN 50174-2 and ISO/IEC 14763-2.

However, in larger data centre constructions there are substantial added complexities arising from the need to co-ordinate with the mechanical and electrical aspects catering for high-performance computing.

These facilities are not always located in the premises they serve, and they may be owned and operated by the enterprise or hosted by third parties.

6.1.3.2 Fixed infrastructures

While the corporate LAN provides connectivity to end users, a business with an on-site data centre facility will need to deploy a fixed cabling infrastructure to enable access to the servers within that facility. This may also apply to the fixed cabling infrastructures within ‘owned and operated’ facilities that are located off-site.

If the data centre is to be located off-site, under any form of in-house or external contractual agreement, the design of the cabling infrastructure providing access to that external service provision becomes a critical aspect of the RAM analysis outlined in 5.2.4.

6.1.3.3 'Cloud computing'

A total reliance on the public cloud for applications services such as office automation and email, finance and human resources systems makes the design of the cabling infrastructure providing access to that external service provision a critical aspect of the RAM analysis outlined in 5.2.4.

However, at the time of writing, public cloud implementations are in the early adopter stage, and reliance on in-sourced or outsourced data centre infrastructure is fairly widespread.

6.1.3.4 Telephony/unified communications

Telephony requirements together with unified communications applications can greatly influence the telecommunications cabling design in buildings.

Analogue telephony historically used components and cabling structures (e.g. 'block wiring') that are incompatible with the delivery of other IT and wider telecommunication services. The advent of structured cabling, in accordance with [BS] EN 50173 series standards and their international and North American equivalents, continued to support the use of multi-pair analogue telephony cables as part of the backbone cabling technology mix, but required distribution to the user via higher-performance-category cables and connections that provided generic application support.

The trend towards VoIP and IP telephony in most new buildings has resulted in the replacement of the analogue telephony cables in the backbone. However, national legislation or local regulations may demand the presence of at least some traditional private branch exchange (PBX) or direct exchange lines which may necessitate an independent backbone cable distribution.

The telephony infrastructure may be owned and operated by the business or outsourced to an external service provider but while the hardware and accompanying firmware may be outsourced, the cabling infrastructure may not. This produces an additional layer of management complexity in administration since additional management overheads arise when a telephony service is outsourced and the corporate LAN infrastructure is not.

As a result, a common outsourcing approach will usually combine the corporate LAN and telephony services, implying a third-party managed cable infrastructure as well.

6.1.4 Other services

Many buildings need to support other 'extra-low-voltage' applications, some which are listed in Figure 17. The requirements for such systems are usually business-driven. For example, audio-visual multimedia services can be deployed using structured cabling over the corporate LAN while electronic security systems such as CCTV or door access control may use the corporate LAN or be supported over a standalone building management LAN) via a parallel structured cabling infrastructure.

Convergence, reflecting the increasing pervasiveness of IP and Ethernet as the communications medium, together with the implications of such decisions on the allocation of spaces and pathways, are fundamental to the effectiveness of the building.

These implications are reflected in new implementations of structured cabling. [BS] EN 50173-6 (under development at the time of publication of this book) defines topologies to support a wide variety of distributed building services.

As shown in Figure 22, the structured cabling may be used to connect to a single converged technology device such as an IP camera or a wireless access point. Alternatively, the structured cabling may feed a service control point (SCP) where local interface equipment can be installed to support a wide range of devices such as sensors and actuators in an unrestricted topology (and provide power to them as required).

A new series of standards, EN 50600 (in preparation at the time of publication of this book), provides requirements and recommendations for a variety of facilities and infrastructures in data centres. Many of these infrastructures (e.g. power distribution, environmental control and security) require the provision of sensors to measure operational parameters. [BS] EN 50173-6 will provide the structured cabling approaches to support such demands. For example, an SCP can be located:

- adjacent to power distribution units, to connect a number of power consumption monitors;
- within a cabinet to connect or a number of environmental monitoring devices (temperature, humidity, air flow, etc.).

6.1.5 Integration

As is specifically mentioned in 6.1.2 and 6.1.4, the structured cabling may be used to support any or all of the following:

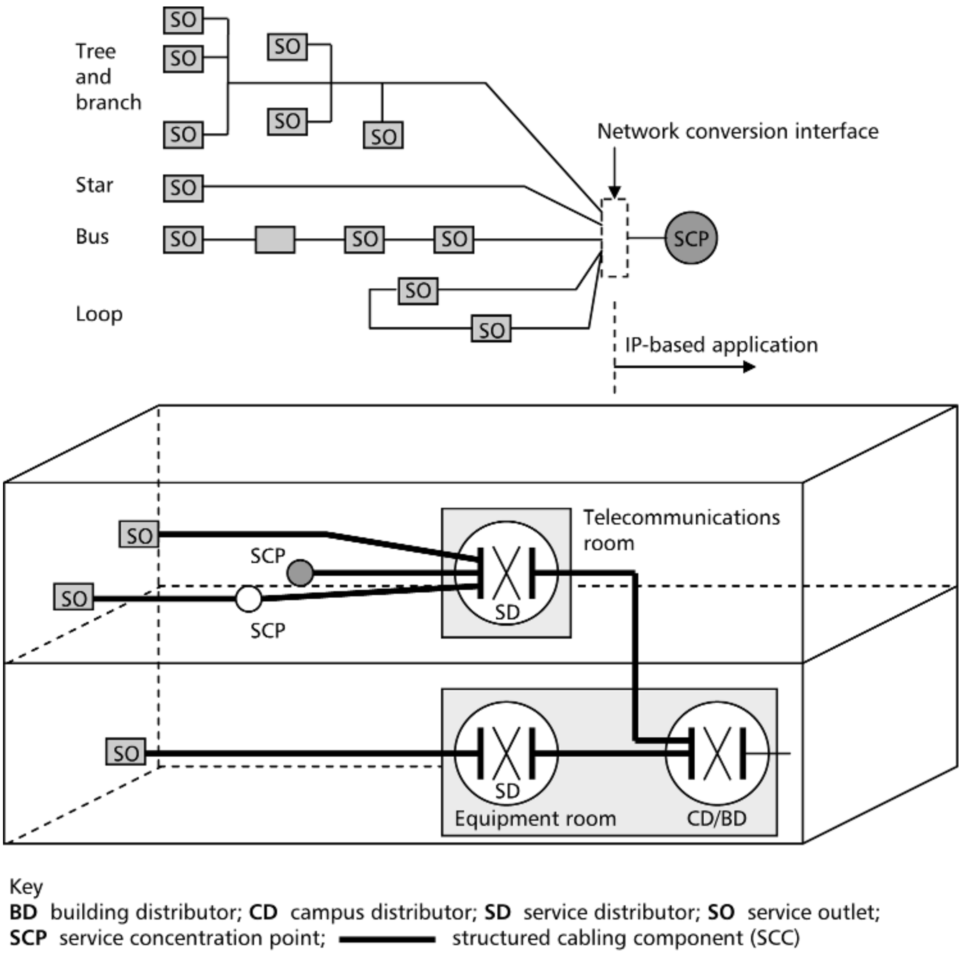


Figure 22 – 'Distributed building services' cabling in EN 50173-6

- IT and other distributed building services that communicate using, directly, the standardized IP-based applications designed to operate over the relevant transmission performance envelopes;
- IT and telecommunications services that can be configured by the use of adaptors or other media convertors to operate over the relevant transmission performance envelopes;
- distributed building services that adopt very localized non-structured cabling distribution networks fed via local concentration points that communicate with 'head-end' end equipment over structured cabling by either of the two previously mentioned transmission methods.

The decisions regarding the degree of service convergence to be applied and the resulting methods of implementation require the involvement of a telecommunications specialist to mitigate any risks of incompatible interfaces or cable types.

6.2 Diversity

Independent of the type of telecommunication service provided by an infrastructure, one of the most significant impacts on both capital and operational costs is the provision of diversity, i.e. the additional infrastructure and equipment required to provide that service in the event of the failure of the primary provision.

The RAM analysis of 5.2.4 suggests that a full-scale review of diversity should consider:

- external service provision;
- external access provision (including multiple entrance facilities to the premises);
- additional infrastructures between distribution spaces;
- multiply-routed infrastructures from distribution spaces to end users (or the equivalent).

The implications of diversity go far beyond the basic costs associated with the installation of redundant spaces and pathways. For example, the spaces require power and environmental control, and the equipment within them has to be specified to make effective use of the diverse routing offered by the infrastructures. The degree of automation involved in any diversity-based actions also places increased responsibilities on the operational management of the services provided.

Clearly, the total costs of diversity have to be weighed against the demands for the maintenance of provision of each particular service. It is equally clear that the 'operational analysis' of 5.2.3 has to include a diversity analysis in terms of both cost and building design, since it may become impossible to provide the desired level of diversity if adequate spaces, pathways and associated infrastructures are not available.

The application of 'structured' cabling design standards

There are four 'premises-specific' generic or 'structured' cabling design standards that apply in Europe – these are [BS] EN 50173-2 (office premises), [BS] EN 50173-3 (industrial premises), [BS] EN 50173-4 (homes) and [BS] EN 50173-5 (data centres). There are equivalent, though not always identical, standards at the international level and in North America. These standards specify the different structures, dimensions and minimum performance of the cabling subsystems that serve to produce generic cabling in the relevant premises types.

However, it is a serious mistake to assume that the application of any of these standards is limited only to the particular premises type mentioned in the title of a standard. For example, hospitals are best served by the solutions provided by 'office' standards – because they have the most appropriate cabling structure. Airports are similarly best served by the 'industrial' standard because of their dimensions.

A future [BS] EN 50173-6 will define structures, dimensions and cabling performance for distributed building services – for example, serving wireless access points or systems for access control, surveillance or building automation. This standard is intended to be applied in any type of building, and represents an overlay for the main IT infrastructures detailed above.

As mentioned in Chapter 4, virtually every commercial building contains a data centre of some type, and in this respect [BS] EN 50173-5 also represents an overlay. However, because data centres may be housed in dedicated buildings, the standard is sometimes seen as 'premises-specific', but the cabling described is only that of the data transport, processing and storage functions within the data centre itself. The other telecommunications services, e.g. basic IT services such as telephony or LAN connectivity, are served by [BS] EN 50173-2.

6.3 The application of cabling design and planning standards

Many clients operate their own corporate standards for the various aspects of telecommunications infrastructure design, planning, installation, commissioning and operation. Sometimes those corporate standards reference standards without really understanding the implications of that reference. In other cases, the corporate standard may largely ignore standards because they are felt to be inapplicable to the particular circumstances of the client.

These two scenarios reflect a general lack of understanding of how the telecommunications standards have developed to support telecommunications specialists. It is wiser for clients to refer to, and require conformance to, the established regional standards that address each aspect before adding specific nuances that tailor those standards to their particular approaches. Adopting this approach makes a corporate standard much easier to create (in the knowledge that all the key elements are covered) and makes it substantially easier for all involved to have confidence in those corporate standards.

Whether or not corporate standards are applied in a given circumstance, it is undeniable that effective implementation of telecommunications infrastructures depends upon the application of quality assurance standards to the design, planning, installation, commissioning and operating processes. The requirements of the appropriate quality assurance schemes are defined in two important multinational standards – for Europe, [BS] EN 50174-1 provides the correct references while, internationally, ISO/IEC 14763-2 defines similar approaches. Unfortunately, there is no direct equivalent in the North American standards structure.

The standards therefore define minimum levels of conformance that can be used as a basis for corporate standards to be built – embracing the recognized regional and/or national standards but adding to them as appropriate.

[BS] EN 50174-1 is essentially universal – written to support all types of telecommunications cabling in all types of premises – and defines the minimum requirements (and best practice recommendations) to cover the installation specification and quality assurance processes. Obviously, such standards are written for practitioners. It is the role of specialists to map user requirements using the applicable standards.

Both [BS] EN 50174-1 and ISO/IEC 14763-2 focus on two fundamental procedures – the development by, or on behalf of, a client of an installation specification and the agreement between the installer and the client (or their representatives) of a quality plan that sets out how that installation specification is going to be complied with. The two standards detail the key aspects to be addressed in each of the procedures. These aspects are able to be applied to any design solution involving the installation of telecommunications cabling, and are so valuable in contractual terms that their application is extended beyond cabling by other standards such as BS 6701 (incorporating telecommunications equipment).

This chapter focuses on the requirements of [BS] EN 50174-1 because it is more general than ISO/IEC 14763-2 – since [BS] EN 50174-1 supports the implementation of any telecommunications cabling design – whether 'structured' or ad hoc.

The first aspect to be addressed within the installation specification is the selection of an applicable telecommunications cabling design standard. The difficulty sometimes encountered in selecting an appropriate standard often leads users to reject or ignore the benefits of their use.

Design standards for structured cabling provide three key platforms upon which to build, as follows:

- **Structure**. Unfortunately, the titles of the design standards indicate their applicability to a particular type of premises, e.g. offices. It is not immediately obvious that the 'office' standard is applicable to hospitals or schools. However, the structure of the interconnected cabling subsystems used in offices is wholly applicable to the future operation and maintenance of infrastructure in hospitals, schools and many other types of premises.
- **Dimensions**. The industrial premises standards were not only created to reflect the structures applicable to those situations – they were also physically extended to take account of the scale of large industrial plants. Airports are of similar scale, and the industrial standards form a good basis on which to address airports, retail parks and other similarly sized constructions.
- **Minimum levels of transmission performance to be delivered in the different parts of the cabling structure**. Whereas the structures and dimensions are largely non-negotiable, the actual transmission performance required by a client may be significantly above that which meets the minimum requirements of the standard – and a range of performance options are given. It is important to reiterate that generic cabling design standards such as those of the [BS] EN 50173 series are not simply 'one-stop shops', and a reference to a design standard is no substitute for a comprehensive installation specification that defines the options (e.g. media type or cable category) that have been selected.

The planning process, which is critical to the development of the installation specification, converts the application of the relevant design standard into a 'real' infrastructure.

One of the most critical issues is that of environmental performance. [BS] EN 50174-1 requires that the installation specification takes the predicted installation and operational environments into account when selecting cabling components, installation techniques and/or methods and also detail any mitigation products or techniques necessary to allow the components selected to be installed and operate as specified when subjected to those environmental conditions.

NOTE: Cabling components include any product associated with the cabling installation, including cables, connecting hardware, closures, cabinets, frames, racks and pathway systems together with components used to provide earth connections.

Environmental aspects are addressed in two stages. The [BS] EN 50173 series addresses the most common environmental conditions that directly affect cabling by applying the MICE classification approach.
[BS] EN 50174-1 requires the planner to assess the local environment into which the cabling is to be installed against the boundary conditions of the MICE system outlined in Figure 23.

M	echanical	Shock/bump, vibration, tensile force, crush, impact, bending flexion, torsion
I	ngress	Particulate ingress, immersion
C	limatic hemical	Ambient and rate of change of temperature, humidity, solar radiation, liquid and gaseous pollution
E	lectromagnetic	Electrostatic discharge, radiated and conducted radio-frequency, EFT/B, magnetic fields

Three levels are specified for each parameter, leading to the classification of an environment as, for example,

$$M_1I_2C_3E_1$$

The derivation of the boundary conditions is explained in [PD] ISO/IEC TR 29106

Figure 23 – The MICE classification system

Different points along the cable route may be subject to different MICE classifications. As an example of this, consider the cabling between a telecommunications room and an end user. The cabling within the telecommunications room may experience a relatively benign environment ($M^1I_1C_1E_1$) since transmission equipment such as network switches needs to be accommodated and operated within such spaces. However, once the cable emerges from the telecommunications room, it may experience elevated temperatures (perhaps due to the proximity of the pathway to heating pipes) that would modify the environment to $M_1I_1C_2E_1$. Along its route it may pass sources of electromagnetic noise that would push the E classification to E_2. Finally, the end user location may be in a laboratory where it is necessary to intermittently ‘pressure wash’ the areas containing the connection points, rendering that location an $M_1I_3C_1E_1$ environment.

Of course, no standard can be expected to cover every situation, and the MICE classification specifically points out that certain situations (e.g. nuclear facilities) are not adequately addressed. However, the vast majority of issues are highlighted and are required to be the basis of any product selection and installation planning solutions employed and defined in an installation specification.

Additionally, the [BS] EN 50174-1 standard requires that the following more global parameters are considered:

- atmospheric pressure;
- biological attack (e.g. mould or fungal growth);
- physical damage (accidental or malicious), including damage caused by animals;
- presence, or the potential presence, of hazards (e.g. contaminating, toxic or explosive materials);
- movement of air (e.g. caused by fans, heating and ventilation systems);
- wind effects;
- direct lightning strike/lightning-induced overvoltage.

In addition, the environmental conditions resulting from abnormal environmental conditions shall be considered. These include flooding, immersion in fluids following the operation of sprinkler systems and earthquake. The component selection or mitigation employed is required to take into account the nature and duration of such conditions, which leads to a decision regarding component performance or mitigation.

Environmental impact and mitigation options

As stated, [BS] EN 50174-1 demands that either (a) the components used are specified to operate under the predicted conditions or (b) mitigation measures are applied to modify that local environment to allow the use of less robust components. The most obvious examples that apply this approach relate to the assessment and treatment of cabling components in relation to temperature and electromagnetic interference issues.

High temperatures increase the signal attenuation within balanced cables, which reduces the operable distance (undermining the dimension 'rules' of the standards). If a reduction in that distance is unacceptable, then the planner has two alternatives – either the selection of a cable with a lower initial attenuation (e.g. Category 6 rather than Category 5) or to place the cable in some form of cooled pathway system. Low temperatures present planners with other problems that have to be resolved accordingly.

Ingress protection (from both liquid and particulate contamination) is important for both metallic and optical fibre cabling. In some countries, balanced cabling connection points designed for end user access are provided with shutters, but these generally only provide a basic protection against particulate ingress. This is also true for optical fibre connections that are almost always provided with caps of some type. However, these provide little more that I1 performance. One of the best examples of the success of the MICE concept is that it is now possible to specify interfaces with I3 performance, capable of being used in the most demanding circumstances.

The immunity of balanced cables depends upon their construction (heavily screened cables are more immune than unscreened cables). In a given situation, either type of cable can be used, provided that additional external screening is applied to the less immune cables. As the E classification of the MICE system rises from 1 to 3, it becomes increasingly necessary to apply mitigation techniques if balanced cabling is to be used, before perhaps moving to an optical fibre solution that might increase the cost of transmission equipment but removes the need for mitigation.

These examples are used to indicate that environmental assessment is a universal requirement. Elevated temperatures can be found in any type of premises, as can sources of electromagnetic noise. Similarly, it may be necessary to provide cabling components (e.g. connectors) with protection against immersion not just in industrial premises but also in laboratories that could be considered to be 'office space'. Hydrocarbon pollution is often found on industrial plants but will also be discovered in airports.

One more aspect that can influence the selection of cabling components or mitigation methods is that of fire performance. BS 8492 suggests that the preferred approach to the management of fire performance of telecommunication cabling and associated infrastructures is to apply compartmentation within the premises and only to employ product (i.e. material) selection where such mitigation is not practical.

The 'operational analysis' of 5.2.3 has to at least incorporate the impact of these environmental assessments since the decisions regarding selection of cabling components and the application of mitigation methodologies can radically affect the cost of a specific design solution.

6.4 Financial planning

A telecommunications infrastructure and its supporting facilities combine a wide range of components, fixtures and fittings – some of which could be considered to be relatively temporary such as the cables, connectors and other components that are considerably more permanent, e.g. power supplies and environmental control systems.

The determination of the return on investment and the time after which the business benefits in a financial sense from the investment made in the infrastructure depends on how the various elements of the telecommunications infrastructure are judged.

Historically, infrastructures relating directly to the premises themselves (e.g. access control and building management) have been considered 'building' assets whereas infrastructures for business operation (e.g. IT) may have been more related to 'fixtures and fittings'. Clearly, the taxation rules relating to the different types of assets and associated levels of depreciation have an influence on the return on investment. However, the impact of convergence begins to blur the boundaries.

Another important factor is that of refurbishment. With regard to the structured cabling design process, the standards contain non-negotiable minimum requirements for cabling structure and cabling distribution provision together with minimum performance specifications, supplemented by a range of higher-performance options. As outlined in 3.1, the objective of convergence is to use a set of standards-compliant cabling subsystems, rather than dictating a single set of components. In some ways the design standards can be dangerous in that they restrict the view of users, being based on the desires of the supply chain. Standards are written to support users but can be guilty of driving those users to demand more performance (at higher cost) than they really need: for example, installing Category 7A components when Category 5 would have been perfectly adequate.

The European, North American and international cabling design standards define component sets (cables and connectors) with a range of transmission performance specifications ranging from 'entry level' to 'state-of-the-art'. While 'entry level' performance is predicted to have an extended lifetime in support of building management systems, there is an assumption that, for IT applications, the cabling systems with higher performance will have greater longevity and support evolving applications – but at greater initial expense. This suggests that the cabling components of the IT infrastructure may be replaced, or at least added to, during the life of the wider telecommunications infrastructure. The perceived permanence of the IT component solution may have some influence on the classification of the nature of the asset.

In whichever way the telecommunications infrastructure is classified, there is a point of 'payback' at which the appropriate return on the investment is deemed to have been achieved.

While there are many ways of defining exactly when this point has been reached, it is clear that it is definitely influenced by the cost of procurement.

Accurate financial planning is key to ensuring that the return on investment calculations obtain the best possible start, and it is important to ensure that all relevant contingencies are applied. This obviously is more important for large projects than small ones – primarily because of the sums involved, but also due to the extended timescales involved.

Another factor that is often overlooked is the impact of variations in exchange rates and commodity prices. The impact of exchange rate variations is well understood, but the relatively unstable nature of copper and plastic prices can influence installed cabling costs quite dramatically. The risk of a substantial impact on the overall project costs may be offset by financial mechanisms such as insurance policies that guard against fluctuations.

Contingencies should be considered, and may be applied against the obvious technical and administrative risks (see Chapters 7 and 8, respectively).

7 Identifying and managing technical risks

This chapter highlights the technical risks during the early phases of the construction project and the controls necessary to mitigate those risks.

This chapter makes reference to the following standards:

- *British: BS 6701, BS 7671.*
- *European: [BS] EN 50173 series, [BS] EN 50174-2, [BS] EN 50174-3, [BS] EN 60825-2.*
- *International: ISO/IEC 14763-2.*

Essential reading for: Project Sponsors, Project Managers, Building Services Engineers, Telecommunications Consultants, Cabling Installers

Recommended reading for: Architects, Other specialists

Optional reading for: Quantity Surveyors

Appendix A contains a detailed bibliography.

Chapter 5 discusses the application of an iterative approach used to develop a design brief for the telecommunications specialist relying on the successful co-ordination and alignment of business strategy, operational strategy and RAM analysis. It was pointed out that the application of this three-pronged approach may not result in the definition of a single solution during the earliest stages of a project.

As shown in Figure 24, the final decisions for spaces are reached before those for pathways, and they in turn are made before those necessary to define the final technical specification of the cabling or equivalent infrastructures. The final decision represents 'design freeze' points, after which 'change control' procedures are put in place, which, in turn, mean that the cost of changes has to be borne by the project and that the scale of these costs tends to increase with time and also as each subsequent design decision point is passed.

This chapter highlights the risks and outline the approaches that may be employed to mitigate those risks.

7.1 Spaces and pathways

7.1.1 General

If implementation options exist within the telecommunications design brief, it is critical that the spaces and pathway decisions taken at RIBA Work Stages C and D are supportive of all the options under consideration at that stage.

Any changes made to the space and pathway envelopes without high-level consideration may impact the implementation of the finally approved technical solution. The danger is that the full implications of such changes may only be understood by the telecommunications specialists and missed by other specialists – resulting in uncontrolled changes that may cause serious shortfalls in telecommunications capacity within the building that ultimately affect the business strategy employed.

7.1.2 Spaces

The principal technical risk is that the allocation of spaces defined at the early stages of the building design process to support all the possible telecommunications infrastructure implementation options are modified during the construction phase – by persons or organizations who do not realize the impact of those modifications – before the final technical solutions are agreed at the pathways and infrastructure pinch points (typically at RIBA Work Stages D and F, respectively) indicated in Figure 21. The cabling planning and installation standards cannot be relied upon to prevent such changes being made – they only act as a quality assurance mechanism during the lowest-level supply contract.

It is critical that contractual statements are applied to the entire construction contract process, to require that any changes to the three-dimensional allocation of building volumes to telecommunications spaces (for whatever reason) are flagged at the highest level.

Typical issues that need to be guarded against include:

- reduction of the overall dimensions of the spaces;
- routing of other infrastructures (such as water pipes) through the spaces;
- changes that would affect any proposed segregation within the spaces with respect to joint use;
- changes that would enable, or remove restrictions for, unauthorized access to connection points dedicated to telecommunications services for other business areas as discussed in Chapter 5;
- safeguarding (protection) of the spaces during building construction.

Incorrect provision of power supplies to, and environmental control within, the spaces are directly related, and represent a technical risk during both the design and ongoing operation of the spaces. The provision of adequate electrical power is critical to the effective operation of telecommunication equipment. Similarly, the capacity of the environmental control needs to match the demands of that telecommunications equipment.

Clearly, the initial estimated demand for power supplies and environmental control can also only be achieved with the assistance of telecommunications specialists. As the contents of cabinets, frames and racks tend to be subject to substantial change over their lifetime, the electrical provision should err on the side of caution – even if that incurs additional upfront cost – since retrofitting is difficult or impossible without disruption to operation (leading to greater cost). This applies to all spaces within the building that will accommodate telecommunications equipment, but is particularly applicable in areas of buildings that will be designated as data centres.

Because of the potential changes to both the power consumption and the associated cooling requirements during the life of the spaces, it is sensible to apply a modular approach for both the power supply and environmental control systems that can support the maximum predicted load. This approach not only allows a phased introduction of demand (which may result in lower initial costs) but may provide greater operational effectiveness by operating each module in its highest efficiency modes (e.g. UPS solutions).

If a number of implementation options exist within the telecommunications design brief, the costs of supporting all the options may differ dramatically. Before any building facilities requirements brief is created to support that telecommunications design brief, it is critical to determine these costs (both direct and indirect) with the input of relevant mechanical and electrical expertise. If the cost of supporting all the options is viewed as 'material' within the overall project cost, it may be necessary to discuss the viability of the most expensive option(s) with the project sponsor. This allows the most expensive option(s) to be discounted via a formal mutually agreed decision.

This underlines the need to co-ordinate the input of telecommunications specialists with the direct experience of implementation practice prior to RIBA Work Stage C alongside the appropriate mechanical and electrical expertise, as shown in Figure 24; failure to do so leaves the responsibility of any resulting expenditure with those responsible for the mechanical and electrical design.

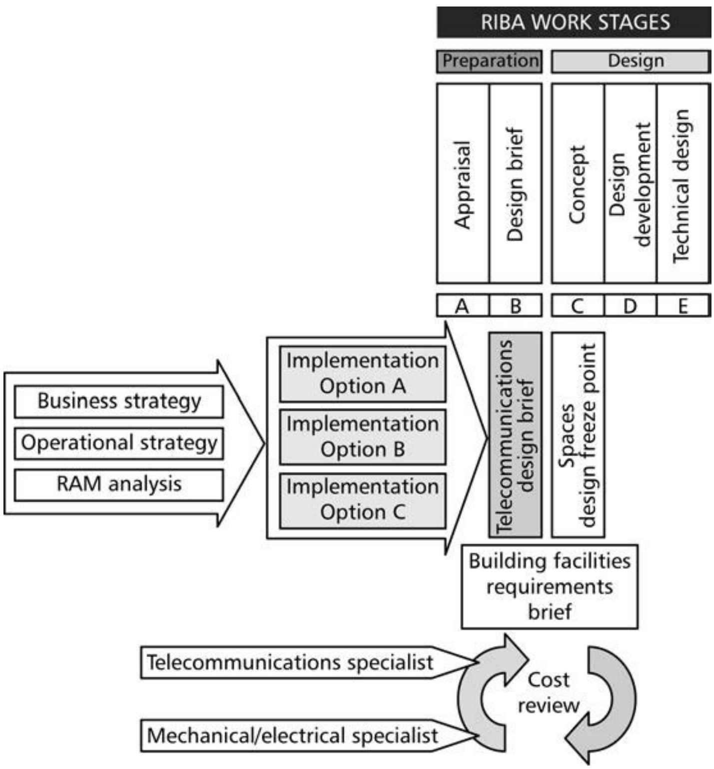


Figure 24 – Cost review of space provision options

7.1.3 Pathways and pathway systems

The principal technical risk is that the allocation of pathways developed at the early stages of the building design process to support all the possible telecommunications infrastructure implementation options are modified during the construction phase – by persons or organizations who do not realize the impact of those modifications – before the final technical solutions are agreed before the infrastructure pinch point (typically at RIBA Work Stage F) shown in Figure 21. The cabling planning and installation standards cannot be relied upon to prevent such changes being made – they only act as a quality assurance mechanism during the lowest-level supply contract.

It is critical that contractual statements are applied to the entire construction contract process to require that any changes to the three-dimensional allocation of building volumes to pathways (for whatever reason) are flagged at the highest level.

Typical issues that need to be guarded against include:

- reduction of the overall dimensions of the pathways;
- restrictions of access to insertion and extraction points both during and after installation (e.g. building of fixed constructions adjacent to the pathway systems or cable management systems);
- changes that would affect any proposed segregation within the pathways and pathway systems with respect to joint use;
- changes that would affect any necessary segregation within or between pathways and pathway systems with respect to protection and electromagnetic interference;
- changes that would enable, or remove restrictions to, unauthorized access to pathway systems dedicated to telecommunications services for other business areas as discussed in Chapter 5;
- safeguarding (protection) of the pathways and pathway systems during building construction.

Pathway system selection

Pathway system selection and the resulting segregation rules within, or around, those pathway systems in relation to power supply cabling result from two separate perspectives – and this tends to mean that the relevant requirements and recommendations exist in two types of standards.

Safety and protection of telecommunications equipment connected to telecommunications cabling are generally treated in national standards. In the UK, the relevant standards are BS 6701 and BS 7671. As these relate to safety, the requirements of these documents form the minimum requirements for any installation.

However, from the telecommunications-planning viewpoint, it is critical that the selection of pathways and the resulting segregation rules take account of the risk of interference posed by power supply cabling. The most comprehensive set of requirements in this area are provided in the European standards [BS] EN 50174-2 (inside buildings) and [BS] EN 50174-3 (outside buildings) – although similar requirements are included in ISO/IEC 14763-2. In all cases, the required separation distances between telecommunications and power supply cabling can be mitigated by the selection of the materials of the pathways systems. For example, plastic conduit or trunking systems will provide excellent safety protection but will do nothing against electromagnetic interference, while metallic pathway systems may provide improved levels of immunity but require specific installation practices to maximize that benefit. Of course, the choice of telecommunications cabling design also has an impact – with screened or optical fibre cabling presenting other mitigation opportunities. In relation to electromagnetic interference, standards such as [BS] EN 50174-2 present the information from the perspective of the telecommunications cabling planner. However, the power supply cabling planners viewpoint is catered for by a European standard, HD 60364-4-444. This document is not an EN standard but forms the basis for the production of national electrical wiring standards. The requirements of HD 60364-4-444 in the UK are included in Amendment 1 of BS 7671, published in July 2011.

An understanding of the combined requirements of safety and electromagnetic interference that are published in multiple standards is sometimes best served by some form of trade association documentation. In the UK, the Telecommunications Infrastructure Advisory Board (TIA-B: www.tiab-online.co.uk) provides a standards interpretation document on this subject. This document is available free-of-charge to members of two of the TIA-B host associations, the Fibreoptic Industry Association and the Electrical Contractors Association.

Additional considerations that need to be addressed in relation to the selection of pathways and pathway systems or cable management systems and which can be considered to represent a technical risk include:

- the suitability of the selected pathway systems or cable management systems in relation to the MICE classification;

- the effectiveness of any mitigation of the MICE environmental classification provided by the pathway systems or cable management systems to the cables contained therein;
- the functional earthing of pathway systems or cable management systems that are intended to provide some form electromagnetic screening to the cables contained therein;
- the physical robustness of the pathway systems or cable management systems with respect to the protection of the cables (with specific reference to earthquake zones or other areas of vibration);
- the compatibility of the pathway systems or cable management systems with the types of cables to be contained, e.g. bend radius (as either single or bundled cables), loading or lengths of unsupported cables;
- the support for the desired fire performance of the building in terms of fire barriers, fire-stopping techniques that are able to be applied to the pathway systems or cable management systems (and their materials).

These issues can only be addressed by a telecommunications specialist with current knowledge of the telecommunication cabling standards. In these technical areas, the standards are sufficiently mature to be considered in a similar manner to those addressing electrical cabling (e.g. BS 7671) where amendments tend to be minor and address specific issues.

If a number of implementation options exist within the telecommunications design brief, the costs of supporting all the options may differ dramatically. Before any building facilities requirements brief is created to support that telecommunications design brief, it is critical to determine these costs (both direct and indirect) with the input of relevant mechanical and electrical expertise. If the cost of supporting all the options is viewed as 'material' within the overall project cost, it may be necessary to discuss the viability of the most expensive option(s) with the project sponsor. This could allow the most expensive option(s) to be discounted via a formal mutually agreed decision.

This underlines the need to co-ordinate the input of telecommunications specialists with the direct experience of implementation practice prior to RIBA Work Stage C alongside the appropriate mechanical and electrical expertise as shown in Figure 25; failure to do so leaves the responsibility of any resulting expenditure with those responsible for the mechanical and electrical design.

7.1.4 Diversity

As highlighted in 6.2, the provision of diversity represents a calculation of risk versus cost – both in direct financial terms and in the use of additional spaces, power supply, environmental control and interconnecting pathways.

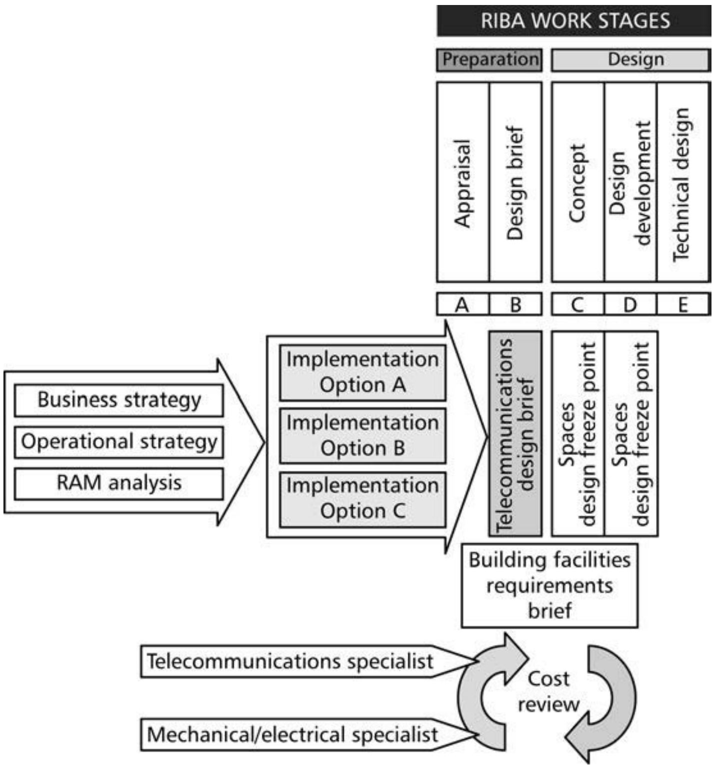


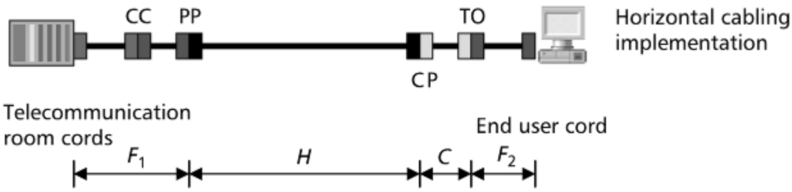
Figure 25 – Cost review of pathway provision options

Failure to implement the necessary spaces and pathways required to provide the desired levels of diversity represents a fundamental technical risk that cannot be easily rectified at a later stage.

7.2 Cabling performance

As mentioned in 6.4, the cabling design standards contain non-negotiable minimum requirements for cabling structure and cabling distribution provision, together with minimum performance specifications – supplemented by a range of higher-performance options.

A technical risk exists where the cabling specification (and therefore the specification of the cables and connectors) does not reflect the likely evolution of the applications delivering the various telecommunications services.



Components	H (m)	Channel
Category 5: 2002	$\leq 105 - (F_1 + F_2)X - CY$	Class D: 2002
Category 6, 6_A, 7 and 7_A	$\leq 102 - (F_1 + F_2)X - CY$	Class E, E_A, F and F_A
X, Y = 1, 2 for unscreened cords and 1, 5 for screened cords		

Temperature	Unscreened cabling: Cord length (m) ($F_1 + F_2$) 5	10	15	20	Screened cabling: Cord length (m) ($F_1 + F_2$) 5	10	15	20
20°C	100	100	99.0	98.0	99.5	97.0	94.5	92.0
30°C	99.1	98.2	97.4	96.5	97.6	95.3	92.9	90.6
40°C	97.3	96.5	95.8	95.0	95.9	93.7	91.4	89.2
50°C	93.9	93.3	92.8	92.2	94.2	92.1	90.0	87.9
60°C	90.7	90.4	90.0	89.6	92.5	90.6	88.6	86.7
	Channel length (m, max.)				Channel length (m, max.)			

Key
CC cross-connect panel; **CP** consolidation point; **PP** patch panel; **TO** telecommunications outlet

Figure 26 – Standards-based implementation rules

Historically, the most demanding networks that have driven the choices for cabling performance have been those supporting the ICT services of the corporate, server access or data centre LANs. The minimum standards-based implementation of corporate LANs to the end user requires the installation of cabling to support 1000BASE-T – a solution that also matches the demands of building 'control' systems such as BAS/BMS and access control systems (ACS). By comparison, the minimum standards-based implementation of server access or data centre LANs requires the cabling to support 10GBASE-T.

However, the demands of high-definition multimedia applications are beginning to require the installation of higher-performance cabling implementations and the almost automatic use of screened cabling components associated with such technologies.

7.3 Cabling topology/architecture

Misunderstanding the needs of the various telecommunication services represents a clear and obvious technical risk. The term 'misunderstanding' covers a wide range of issues but the most serious is a failure to obtain a full picture of the degree of convergence that is required, including:

- basic convergence as defined by this document allows the use of a set of standards-compliant components within a common topology and structure as defined by the structured, or generic, cabling standards such as the [BS] EN 50173 series. However, the use of a common set of structural distribution models does not automatically mean the sharing of the same spaces or pathways;
- overestimating the required degree of convergence, for example by enforcing the use of shared spaces or pathways may result in fundamental problems once the premises become operational;
- underestimating the required degree of convergence may result in the incorrect allocation and location of spaces and pathways (potentially wasting commercially viable space in the premises) which prevents any subsequent amendment of the convergence strategy;
- Spaces and pathways are difficult or impossible to reconfigure since implemented and poor decisions made at RIBA Stages C and D are rarely able to be corrected at Stage J;
- Mitigating this risk requires that telecommunications specialists be involved to undertake an iterative approach combining top-down and bottom-up analyses of the desired degree of convergence and the implications that has for the network topologies and resulting architectures within the premises;
- Having determined the correct apportionment and segregation of spaces and pathways required to meet the desired level of convergence, the next technical risk involves the correct application of the selected cabling design standards to ensure the most comprehensive application support.

The principal dimension to be considered is the last '100 metres' often quoted (and sometimes misquoted) in relation to the cabling length between the user equipment 'at the desk' and that in the local telecommunications room. Figure 26 shows that the 100 metres is a special case rather than a general requirement and indeed the true maximum may be less than that supposed limit.

Certain applications (particularly those of low demand, delivering lower data rates) will operate over greater distances but the 'killer apps' tend to be restricted to the standard-based lengths of Figure 26. Equally importantly, new network applications undergoing development tend to assume that users have implemented these rules. Therefore, while it may be tempting to flex this maximum length (where the alternative is the installation of additional telecommunications rooms), there is a defined risk of not achieving the widest application support over lengths in excess of those specified by the standards. Mitigation of such a risk is not possible and, if implemented, the longer lengths would have to be described as suboptimal in terms of potential application support.

There are no dimensional restrictions on the remainder of the premises infrastructure (either inside or outside the buildings). In these areas the design philosophy is to install the correct combination of transmission media (cable types) to ensure that the desired application support is possible over the distances present. Figure 27 provides useful guidance for a mix of applications and cabling specifications.

Cabling transmission performance	Channel length (m, max.)					Typical application
	Component category					
	5	6	6_A	7	7_A	
Class A	2000	2000	2000	2000	2000	Analogue voice
Class B	245	255	255	255	255	ISDN
Class C	165	180	184	185	187	10BASE E-T
Class D	100	106	109	110	112	1000BASE E-T
Class E		97	100	101	103	
Class E_A			97	99	102	10GBASE E-T
Class F				97	102	
Class F_A					97	

This figure shows the maximum channel lengths (assuming a total cord length of 10 m) capable of being constructed to service a variety of transmission performance classes using particular component categories.

The right-hand side of the figure shows typical applications delivered using the transmission performance classes of [BS] EN 50173-1.

It should be pointed out that these implementation rules only apply at 20°C and that higher operating temperatures result in shorter link and therefore channel lengths.

Figure 27 – Backbone application support using balanced cabling

External cabling on a multi-building campus deserves careful attention if an opportunity is identified to modify the use of the campus over time. An example of this is a [BS] EN 50173-2 implementation where a defined building acts as a central point of distribution that may be altered to a series of independent buildings, each served by a network access provider. Figure 28 shows the topology planning that may be considered in such cases.

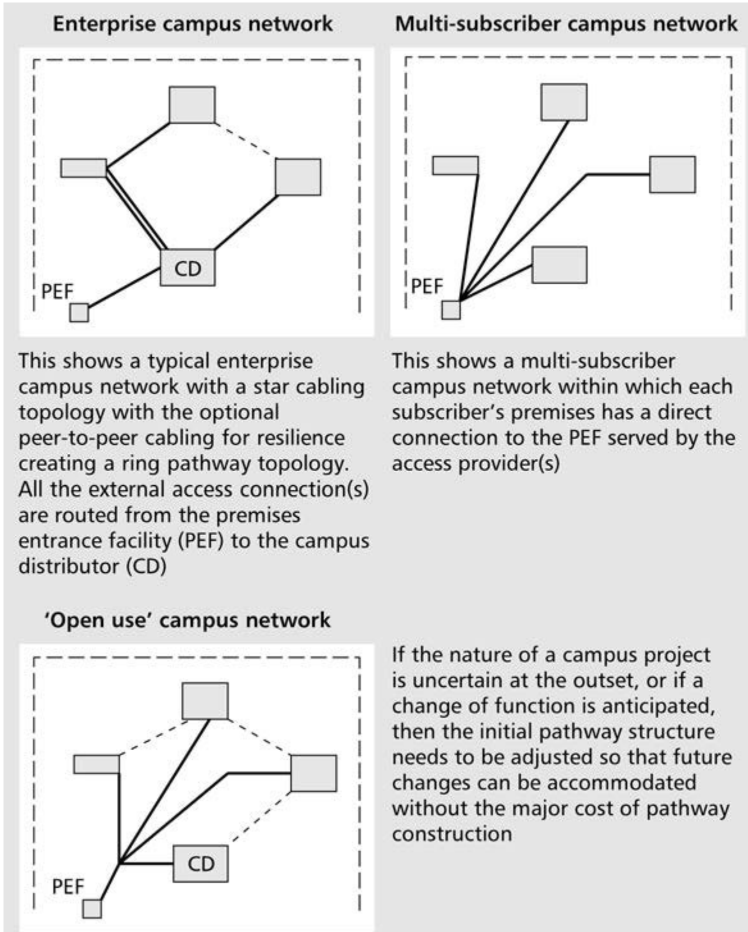


Figure 28 – Campus topology to support change of use

7.4 Cabling distribution density

The greatest risk in any implementation of premises cabling is 'underprovision' of corporate fixed LAN connection points. A failure to provide the necessary quantity obviously affects basic operation of the premises, and may be irrecoverable – since the requirements for spaces and pathways and the associated infrastructures that serve them may also be underestimated.

By comparison, overprovision provides greater business flexibility but is also very expensive, both for cabling and in terms of the wasted resources allocated to those same spaces and pathways.

Correct provision necessitates some level of overprovision above the initial base load. However, it is critical to understand the business strategy in order to have the best opportunities to assess that base load.

Figure 29 illustrates two basic types of provision solution within buildings. Figure 29 (a) provides a single density across all the premises based on a number of connection points per unit area. Figure 29 (b) provides a variety of such densities based on the type of activity to be undertaken in a given area of the building (basic office, call centres, trading floor, etc.). To avoid the inevitable technical risk associated with under-provision, it is critical for a telecommunications specialist to have direct access to the client to establish the desired level of business flexibility required.

Providing the flexibility to move business groups using the former approach may simply require the provision of an overlay of additional connection points on a larger grid to act as concentration points to support flexibility creation and recreation of demanding business units. However, providing the correct overprovision to allow high-density areas to grow to meet business demand is difficult to support unless the highest-density areas are increased beyond their initial planned area.

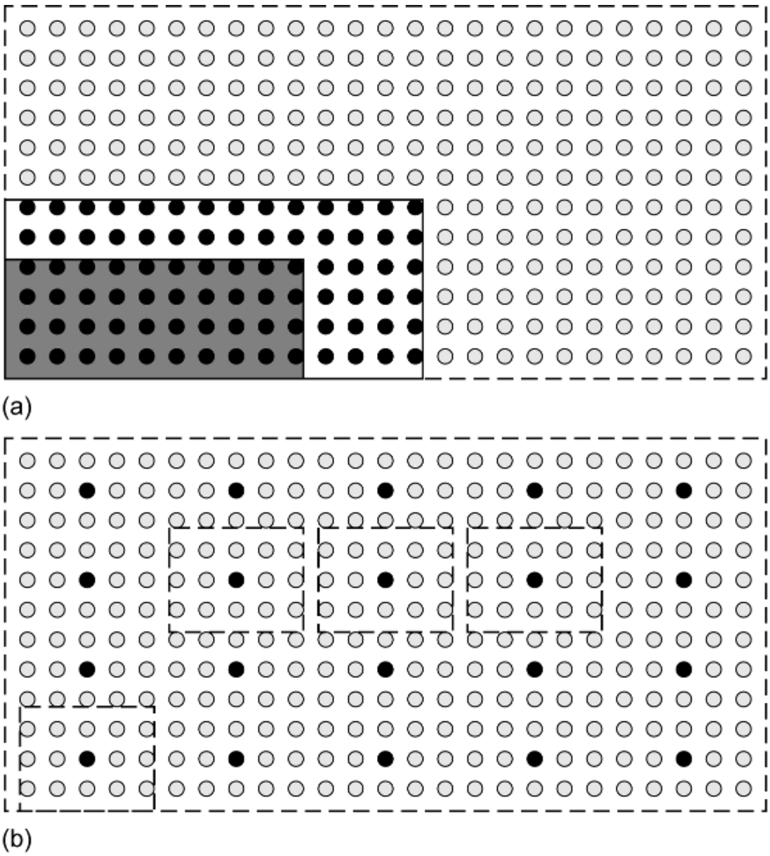
To avoid the inevitable technical risk associated with under-provision, it is critical for a telecommunications specialist to have direct access to the client to establish the desired level of business flexibility required.

7.5 Other issues

7.5.1 Unintended consequences of convergence

One of the technical risks associated with convergence is that integration of different management systems can have unintended consequences. It is important that 'what if' analysis of integrated systems is undertaken to assess the impact of alarms in the different systems managed. For example, a fire alarm in one area may result in the automatic disruption of power supply to another, otherwise unaffected, area, which would have unintended consequences for the corporate LAN operated in that area – or even more significantly, the server access or data centre LAN.

Unless the diversity provided to the various telecommunications services is adequate, it may be advisable to de-couple the integration under alarm conditions.



The grey dots indicate areas provided with a normal density of end-user connections. The black dots show areas served by a much higher density of end-user connections.

The upper diagram (a) illustrates the concept of extending areas of high concentration beyond that initially required. The lower diagram (b) illustrates the concept of providing a grid-based system supporting 'business group' flexibility.

These examples show the clear differences in approaches that may be taken to suit different business needs.

Figure 29 – Density options

7.5.2 Regulations and legislation

While the intent of the British and European cabling installation standards is to identify and mitigate areas of risk, compliance to standards should not be confused with meeting the objectives of regulations and other legislation covering areas such as basic safety and electromagnetic compatibility. However, there are examples of recognized safety standards such as BS 7671 for electrical wiring and [BS] EN 60825-2 for optical fibre safety that provide rules for installation and operation.

7.5.3 Maintenance of suppliers' warranties and guarantees

The major risk in this area relates to incompatibility between the selected pathway systems and the cables chosen to be installed within them, resulting in the revocation of any guarantees provided by the cable supplier. The [BS] EN 50174 standards address this issue as follows.

The planning tasks of [BS] EN 50174-1 require that 'the pathway systems selected shall be in accordance with the instructions supplied by the manufacturers or suppliers of the cabling components'. This allows a designer to consult the general marketplace to determine the most appropriate pathway system for a particular type of performance of cable.

This is reinforced by the requirements of the standards specific to internal and external installation (i.e. [BS] EN 50174-2 and [BS] EN 50174-3), which state that 'the selection of cable management system shall be made by considering … the cabling products to be contained'. Once the installers begin their task, these standards require that 'installation of cables shall be in accordance with the instructions supplied by their manufacturers/suppliers'. This is a double-check system to ensure that the technical risk of incompatibility leading to problems regarding system warranties/guarantees are minimized.

There are many such instances of these check and double-check processes within the [BS] EN 50174 standards, which are dedicated to minimizing risk for both the planner and the installer alike.

8 Identifying and managing administrative risks

This chapter highlights the administrative risks during the early phases of the construction project and the controls necessary to mitigate those risks.

This chapter makes reference to the following standards:

- *British: BS 6701, BS 7671.*
- *European: [BS] EN 50173 series, [BS] EN 50174-2, [BS] EN 50174-3, [BS] EN 50346, [BS] EN 60825-2.*
- *International: ISO/IEC 14763-2.*

Essential reading for: Project Managers, Architects, Telecommunications Consultants, Quantity Surveyors

Recommended reading for: Project Sponsors, Building Services Engineers

Optional reading for: Other specialists, Cabling Installers

Appendix A contains a detailed bibliography.

The conversion of a telecommunications design brief to a completed telecommunication infrastructure within the boundaries of a construction project generally requires the involvement of many different technical disciplines and contractual interfaces.

The administrative risks encountered during such a project usually focus on a lack of clear specification within the telecommunications design brief or an absence of continuity of telecommunications specialism throughout the procurement process.

This chapter highlights the risks and outlines the approaches that may be employed to mitigate those risks.

8.1 Assessing the rigour of the telecommunications design brief

The appointment of an architect by the client or project manager represents the initial step of a construction project. As indicated in earlier chapters, the overall design brief created as an output from the 'preparation' phase should contain an element that could be termed the telecommunications design brief. The greatest administrative risk to a project exists when the telecommunications design brief and/or the associated budget is unrealistic.

Therefore, as is common for the rest of the design brief, the architect needs to assess the rigour employed in the preparation of the telecommunications design brief before accepting it – and formulating subsequent RIBA Work Stages based upon it.

Ideally, the telecommunications design brief has been processed in accordance with the methodology of converting the project sponsors requirements into a telecommunications design brief, as outlined in Chapters 5 and 6. This ensures that the design brief matches the project sponsors business strategy, and that that strategy has been assessed in terms of the available budget.

Unfortunately, as mentioned in 5.2.5, the majority of construction projects do not conform to this approach and do not employ either a business solutions specialist or a telecommunications specialist during the development of the design brief. In such cases, the telecommunications aspects of the design brief provided to the architect have to be treated as having a substantial content of what could be termed 'unknown unknowns' in relation to the required telecommunications infrastructure.

In order to minimize the administrative risk to the project, it is vital to convert any 'unknown unknowns' into 'known unknowns' in order to determine the gaps that have to be addressed. This will, as a minimum, require the involvement of a telecommunications specialist with proven competence in the field of spaces, pathways and infrastructure design and specification that is relevant to the combination of telecommunications services demanded by the design brief. It may additionally require the involvement of a business solutions specialist if there are more fundamental flaws in the application of the approach outlined in Chapter 6. This intervention to support the role of the architect is shown schematically in Figure 30.

Converting 'Unknown unknowns' to 'known unknowns'

'Unknown unknowns' are easy to define – being 'those things that we do not know that we need to know' – but by that very definition are hard to spot, which is why early involvement of specialists is important. Only by recognizing an issue can a resolution be developed – converting that 'unknown unknown' into a 'known unknown'.

Examples of 'unknown unknowns' in the telecommunication field could be:

- lifetime planning in terms of both time and available space;
- outsourcing strategies for business support functions.

Paradoxically, for a given project, just reading these examples would convert them from 'unknown unknowns' into 'known unknowns', and the first step has been taken towards obtaining the required information ('known knowns') to allow the development of specific telecommunications solutions.

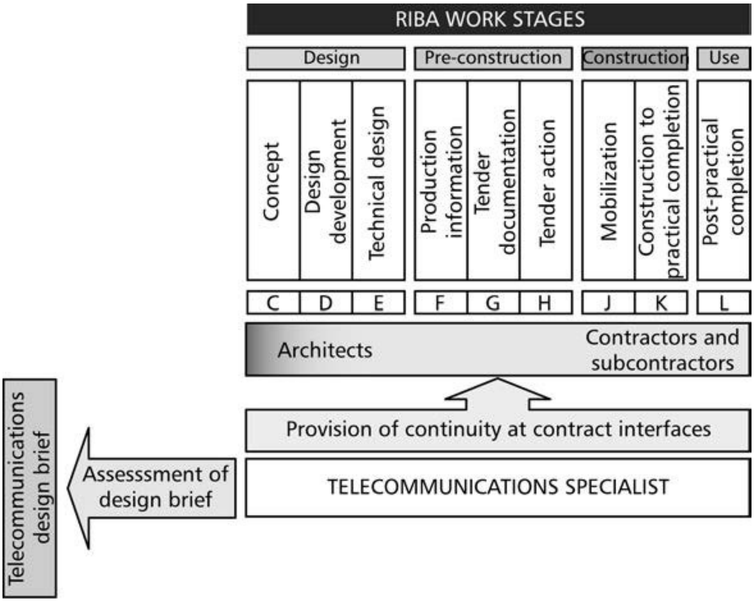


Figure 30 – The role of the telecommunications specialist

There are fundamental assessment criteria that may be applied to determine the degree of rigour that has been applied in the 'preparation' phase:

- the brief identifies the 'problem space' and elaborates the 'optioneering' approach employed (i.e. the reasoned argument behind the selection of the various options contained in the brief);
- the budgetary costs aspects are both included and realistic (with supporting arguments);
- timelines are correctly defined, showing the business relevance (phasing of the telecommunications implementation, e.g. deadlines for availability or relocation).

Even in the case of projects that are supported by rigorous telecommunications design briefs, the telecommunications specialist will be able to convert any 'known unknowns' into 'known knowns', allowing the establishment of an effective procurement process.

The involvement of telecommunications expertise at such an early stage is unusual when the value of the telecommunications package is low. However, the issues highlighted above demonstrate its criticality of such involvement to the operation of the business.

8.2 Procurement choices

8.2.1 Project options

Chapter 5 describes the strategies that may be employed in the design phase of speculative build, designed to requirements and multi-tenant premises. A number of procurement routes are identified within 4.4.2 that can be applied as the 'design' phase moves into the 'construction' phase.

8.2.2 The role of an architect telecommunication specialist

Independent of the type of premises and the procurement options selected for a given project, there is an overriding requirement, according to construction regulations in many countries, to provide all the relevant information necessary to support the procurement process. There are a number of different measures or templates by which the completeness of such a process may be assessed . For example, in the UK such templates and additional services are provided by:

- the Joint Contracts Tribunal (JCT, www.jctcontracts.com);
- BSRIA (www.bsria.co.uk).

Failure to provide all the relevant information may jeopardize the proper implementation of the project at the initial stages – but may be more damaging when the failure to provide the correct input at the beginning affects much later procurement stages in the construction process.

Failure to employ a telecommunications specialist (who may also fulfil the role of assessing the rigour of the design brief) to ensure the correct application of such templates in relation to the telecommunications infrastructure represents a substantial administrative risk.

These templates cannot be arbitrarily applied but must reflect the procurement methodology selected for the project (see 8.2) and be matched to the type of project (new building, refurbishment or upgrade as described in 4.1). The telecommunications specialist needs to be competent to react to specifics of the current design brief and not simply repeat the last successful project that may have been subject to different needs.

In addition, the telecommunications specialist needs to take into account the procurement option to be applied and map both the outputs at the various contractual interfaces and the methods of their delivery.

8.2.3 The role of a telecommunication specialist during procurement

Within the acquisition process it is critical to ensure that the scoping, boundaries and interfaces of the facets of the design and implementation process are managed such that the 'performance envelope' (i.e. the budget, boundaries and scheduling of the telecommunications package) is understood by the primary contractors in the construction process even though that package may not be directly placed on those contractors.

It is unfortunate that in most cases, even if a telecommunications specialist is employed to undertake the task set out in 8.2.2, the role is not maintained during the construction process – i.e. there is no continuity of telecommunication oversight at the various contractual interfaces during the construction process. This represents a substantial administrative risk, and a telecommunications (or other) specialist should be appointed by the architect or main contractor to provide appropriate expertise from the beginning to the end of the project, as shown schematically in Figure 30.

NOTE: The end of the project may extend beyond the normal practical boundaries of the 'practical completion' of the base build into the 'fit-out' phase – and may even incorporate aspects of relocation and migration of existing facilities.

This justifies the role of the telecommunications specialist beyond practical completion, as described in Chapter 10. It has already been pointed out in 7.1 that 'it is critical that contractual statements are applied to the entire construction contract process, to require that any changes to the three-dimensional allocation of building volumes to telecommunications spaces and pathways (for whatever reason) are flagged at the highest level'.

The 'highest level' referenced in the text is embodied by a telecommunications specialist who provides continuity throughout the procurement process.

Table 6 contains a typical example of tasks together with their associated scopes, risks and mitigation actions that require consistency of approach by a telecommunications specialist throughout the construction phase.

Table 6 – Profiling risks

Task	Typical scope	Risk	Mitigation
Site clearance Enabling works	Preparing the site for foundations, piling and basement dig	• Damage to external telecommunications spaces and pathways (maintenance chambers and conduits) • Unplanned pathway diversions	Prior to commencing works: • check and verify as-built or legacy records • due diligence checks with external access providers
Shell and core	Superstructure, building cores, foundations, basement, floor slabs, structural walls	Site works may have modified intended volumes for telecommunications spaces (internal usable dimensions for telecommunications rooms, equipment rooms, data	Construction liaison with the contractor

Task	Typical scope	Risk	Mitigation
		centres spaces, etc.)	
Electrical 1st fix	Major electrical plant/ machinery and switchgear, high-voltage (HV) cable intakes, building earthing	Site works may have modified intended segregation between telecommunications cabling and HV (or high-current) power supply cabling	Construction liaison with the contractor. Supply technical specifications for pathway systems and require compliance with [BS] EN 50174-3 (for external pathways)
Electrical 2nd fix	Major pathway systems for low-voltage (LV)/extra-low-voltage (ELV) power supply cabling and telecommunications cabling	Site works may have modified intended pathways in terms of usability, accessibility or specification of pathways systems, leading to issues in relation to securing: • identifiable pathway systems and capacities for telecommunications cabling • compatible pathway specifications and compliance with telecommunications cable system vendor requirements	Construction liaison with the contractor. Supply technical specifications for pathway systems and require compliance with [BS] EN 50174

Task	Typical scope	Risk	Mitigation
		• segregation/separation from sources of electromagnetic interference	
Electrical 3rd fix	Secondary pathway systems for LV/ELV power supply cabling and telecommunications cabling to wall, floor or ceiling outlet locations Installation of telecommunications cabling	• Compatibility of furniture systems with intended cable and outlet presentation • Warranty requirements for end-to-end connectivity may be compromised	Liaison with the interior designer Liaison with the programme manager and the project manager for sequential timing of installations

An associated administrative risk exists due to the multiple contractual interfaces between the initial procurement specification (within which the telecommunications cabling element produced by the telecommunications specialist will, by definition, be only a small portion) and the cabling installers.

Extended contractual chains

> An example of an extended contractual chain is one in which the optical fibre cabling installer is a subcontractor to the copper cabling installer, who is a subcontractor to the electrical contractor, who is a subcontractor to the general electrical and mechanical services contractor, who is a subcontractor to a main contractor.

In such extended contractual chains there is a risk that aspects of the original specifications (together with the references to the applicable standards) are amended or even deleted as the procurement crosses contractual interfaces. In such circumstances, the probability of the copper or optical fibre cabling installers being able to discuss the detail of the standards specified by the client or their consultants is low – so even when problems are identified by those with real expertise in the specification of design and installation of telecommunications cabling, it is unlikely that they will be resolved in advance of the installation, and may only be discussed once problems are identified.

Of course, the value-for-money of employing a telecommunications specialist is often questioned. As highlighted in 4.4.3, it is the combination of the primary and secondary costs associated with telecommunications cabling that should be the basis of telecommunications resource allocation – and it is the mitigation of this administrative 'continuity' risk that reduces the technical risks of Chapter 7.

8.2.4 The role of cabling standards and the administrative risk of their misuse

Chapter 2 introduced the role of cabling standards in support of the proper implementation of telecommunications infrastructures.

The standards were effectively separated into design standards and installation standards. While the design standards are necessary to define the correct topologies, configurations and performance requirements for the cabling, it is the installation standards that provide the basic requirements for the specification, quality assurance, planning and practices associated with the installations.

It is therefore critical that the telecommunications specialist for the specification and planning of an installation is aware of the relevant requirements of the design and installation standards. Similarly, it is critical that the cabling installer is aware of the relevant requirements for quality assurance and installation standards.

A significant administrative risk involving the abuse of standards during the procurement process tends to be related to one or more of the following aspects:

- specifiers attempting to apply standards outside their original or intended sphere of influence;
- specifiers applying an overly extensive list of standards – and adding to that list new standards as they are published – without consideration of the impact of obsolescence, duplication or conflict in the standards contained within the list;
- both specifiers and installers relying on the other party to be aware of the requirements of the relevant standards.

The ideal situation for the procurement of all infrastructures is that the minimum number of standards should be referenced – but that these standards should be the correct ones and that the responsibilities identified within those standards should be recognized and complied with. Moreover, it will serve to reduce the risk of installers being tempted to accept contracts containing inaccurate and potentially dangerous requirements for compliance to inappropriate standards or combinations of standards.

It is very unlikely that the levels of risk identified above are going to improve in the immediate future, as new groups of people become responsible for the procurement of telecommunications cabling as it expands to support a widening range of telecommunication services.

However, the continuity of telecommunications expertise across contractual interfaces described in 8.2.3 is able to mitigate such risks.

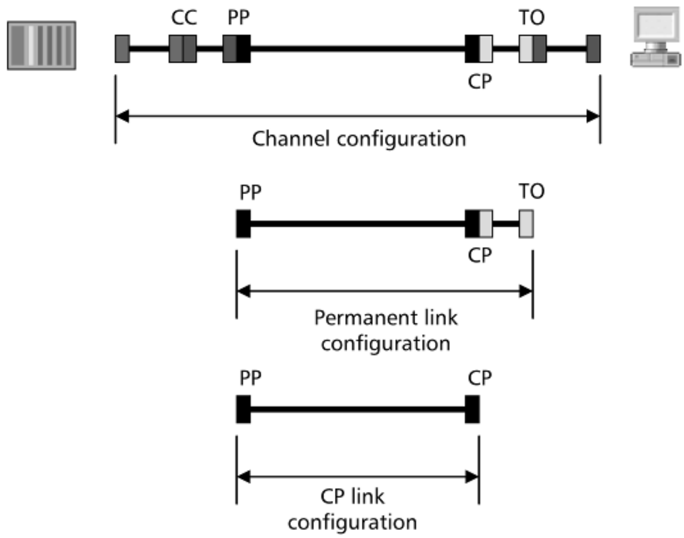
8.2.5 Telecommunication cabling installation and commissioning

Despite the necessary mitigation undertaken at earlier contractual stages, the actual installation of telecommunications cabling can only be undertaken once spaces and pathways are available (i.e. during the 'electrical third fix' task identified in Table 6). The risk of damage to the installed cable due to other trades and activities in this phase is well understood, and it is normal to undertake testing of installed telecommunications cabling links as soon as possible and preferably in parallel with the termination of those links, to determine the initial performance.

This testing may be separate from any contractual testing (which may be subject to witness process, third-party verification or independent audit). The presence of a telecommunications specialist within the procurement process can significantly reduce the administrative risk associated with such actions.

By reference to Figure 31, it is vital to apply the correct testing to the cabling configurations that are available at a given stage in the installation task. The test results can also become a key tool for subsequent repair and maintenance activity, and should be considered as part of the record-keeping within the administration system applied to the telecommunications cabling. The applicable test methods are referenced from the structured cabling design standards by reference to specific test standards (e.g. [BS] EN 50173 series standards reference [BS] EN 50346).

Perhaps one of the most misunderstood areas in relation to testing is the latent administrative risk of 'marginal results'. These are test results that



Key
CC cross-connect panel; **CP** consolidation point; **PP** patch panel;
TO telecommunications outlet

Testing of structured telecommunications cabling is not meant to present the installer with a technical hurdle, since the components specified by the design standards provide the required installed performance, given that they are used in the correct combinations and configurations and are installed correctly in accordance with the installation standards and the supplier instructions.

For cabling in accordance with [BS] EN 50173-2, ISO/IEC 11801 and ANSI/TIA-568-C.2, there are three possible test configurations for the horizontal cabling: channel, permanent link and CP link.

Channel tests are intended to be used once the cords intended for connection to the end equipment are installed.

Permanent link and CP link testing is more appropriate to the basic installation of the fixed cabling. However, the test limits for the CP link are more demanding than those of the permanent link – to allow for the subsequent addition of the cable/cord between the CP and the TO.

Figure 31– Testing configurations for horizontal cabling

lie within the measurement accuracy of the test equipment – making it difficult to decide if a test has passed or failed. For copper cabling, many test equipment suppliers enable their equipment to designate results as 'marginal pass' or marginal fail'. Fortunately, this issue has not spread to optical fibre testing, where, particularly for the short links encountered in data centre and building backbone environments, virtually all results would be classified as marginal.

There is a great temptation for contracts to disallow marginal results because of their assumed indecisive nature. However, this is contraindicated in the quality assurance element of [BS] EN 50174-1 because:

- such a contract forces the installer to achieve 'better than standard' performance but in an undefined manner since it depends upon the accuracy limits of the test equipment;
- the trend towards cabling with higher performance (e.g. Class EA rather than Class D) and the associated higher measurement frequencies generally produces worse measurement accuracy – leading to increasing proportions of marginal test results – and trying to ignore this situation will actually lead to more contractual problems rather than less.

8.3 The impact of convergence on the procurement process

8.3.1 'Just-in-time' (JIT) procurement

The increasing focus on converged solutions creates new challenges to those involved in organizing and managing the procurement processes in construction projects – in both new-build and refurbishment projects.

Often, the telecommunications specialist may not be represented in the planning processes for procurement, and this may lead to the realization of unintended risks in the sequencing of construction and commissioning activity.

Traditionally, IT specialists would recommend the 'last responsible moment' approach to specifying and installing structured cabling and data networks – using a JIT concept to allow the most recent products to be specified for installation when the building site was relatively clean and when other heavy and wet trades had completed their tasks. Such an approach is justified both at a technical level and from a construction risk mitigation perspective.

However, convergence means that a new approach is required, as the structured cabling not only serves the traditional IT systems but also supports other telecommunications services, some of which have to be installed and commissioned much earlier in the construction process.

Maintaining a JIT approach to structured cabling procurement in both converged or non-converged environments is possible when procurement processes allow the decoupling of the 'shell and core' construction phase (see Table 6) from the procurement of the interior design, i.e. small power systems, extra-low-voltage systems, and furniture, fittings and equipment (FF&E) – but this is not always the case.

Regardless of the degree of convergence to be applied, telecommunications specialists are recommended to fine tune the JIT concepts for structured cabling with the wider construction procurement – taking account of the interrelationships with other trades. This will assist in minimizing any programme anomalies from becoming potential administrative risks during the implementation.

When JIT is not viable – because of the level of convergence desired – or because the contract to be placed demands a full complement of mechanical, electrical, telecommunications and other specialist systems, then a 'well-before-time' concept needs to be adopted.

8.3.2 'Well-before-time' (WBT) procurement

'WBT' usually means the design, specification and installation of systems well ahead of the time necessary simply to align with contractual or project implementation requirements.

Such situations are common with very large or complex projects where the uncertainty associated with JIT design, specification or installation is considered to be a risk in its own right.

Often, cost consultants and project managers are not aware of the latent administrative risks in WBT procurement, and the telecommunications specialist is well advised to manage the risk mitigation process. These unintended administrative risks include:

- ambiguous or insufficient technical requirements early in the project;
- technology improvements in the supply industry, introducing design obsolescence before the project is complete;
- detailed designs and interfacing requirements being subject to change orders initiated by other trades;
- costing and budgetary inaccuracies from exchange rate fluctuations, inflation and volatility in commodity prices (e.g. we have in recent times experienced impacts on the cost of buying cabling due to both currency depreciation/appreciation with the US dollar and the price of metals).

When a converged cabling infrastructure is a requirement, there are merits in following a WBT approach. The interdependencies between various impacted trades usually means that design solutions need to be co-ordinated, and a WBT approach will encourage co-ordination within the wider project team. Having overall programme convergence (design and construction) dovetailing with telecommunications design is a major asset that aids the mitigation of administrative risks in establishing clear scope boundaries, budget responsibilities and commissioning targets.

Establishing the concept of WBT or JIT execution during the 'preparation' phase of a project, whether in the 'design' or 'construction' phases, is advantageous in delivering successful outcomes.

8.3.3 Materials consolidation

One of the key benefits of increasing the degree of convergence is that, to a great extent, the cabling components are selected from a common standards-based component set of the structured cabling design standards. This allows a 'consolidated' approach to be applied to materials procurement – obtaining the best pricing based on the overall volume of products required and enabling the maximum flexibility in terms of delivery scheduling.

8.4 Competence

8.4.1 Telecommunications specialists

There is no single qualification that provides confidence in the competence of a telecommunications specialist. However the following provides indications of appropriate skills:

- a qualification in design and implementation in at least one of the telecommunication services listed in Figure 17 that is relevant to the project under consideration;
- a curriculum vitae that contains verifiable experience in the design and implementation of the majority, in combination, of the telecommunication services listed in Figure 17 that are relevant to the project under consideration.

Additional qualifications in project management such as PRINCE2.

NOTE: PRINCE2 ('PRojects IN Controlled Environments') is a process-based method for effective project management, and claims to be a *de facto* standard used extensively by the UK government, and is widely recognized and used in the private sector, both in the UK and internationally.

8.4.2 Cabling component vendors

With respect to procurement, the term 'cabling components' covers all the products used to implement the fixed and operational telecommunications infrastructure, i.e. cables, connecting hardware, cable management systems, panels cabinets, etc.

Assessment of suitable cabling component vendors should consider far more than basic conformance to functional performance requirements, although recognized third-party verification or certification of that performance is useful.

Additional factors to consider include:

- The manufacturer's compliance to [BS] EN ISO 9001.
- The full traceability of products supplied – it has to be recognized that even under the best quality assurance systems, mistakes can occur, and in the case of mass-produced components such as cables and connecting hardware the result of such production faults can affect many batches of product. It is critical that the complete supply chain operates a traceability system in order that delays caused by reinstallation are minimized and focused on those areas affected rather than by global replacement – this can be a major issue for multi-phase projects.
- The availability of appropriate warranties and guarantees (and the clear statement and feasibility of any obligations for the onward procurement of consumables that may apply).
- The methodology of installer accreditation.
- The commitment to supply the specified products over a defined period consistent with the design objectives of the telecommunications infrastructure.

8.4.3 The use of 'approved installer' schemes

The term 'approved installer' covers a wide range of different statuses. Many of the approvals are supplier-based and merely signify that the installer has the 'right' to offer the supplier's warranties/guarantees to a customer. Obviously, such approved installers are important in the procurement process if the customers feel that such warranties or guarantees are necessary.

However, there are more universal approvals, such as those operated by trade associations.

An example of one such scheme is that established by the Fibreoptic Industry Association (FIA, www.fia-online.co.uk), which is based on the principles of risk reduction. The scheme uses the detailed requirements and recommendations of the design and installation standards as a basis for the construction of a risk element matrix. FIA Approved Installers under the scheme are required to assess projects against the relevant aspects of the matrix – reducing the risks with the establishment of a procurement contract under the 'electrical third fix' task, identified in Table 6 to the benefit of all concerned.

9 Operational and management issues

This chapter highlights the need for the close control of the operation of the telecommunications infrastructure by the establishment and ongoing application of an administration system.

This chapter makes reference to the following standards:

- *British: BS 6701, BS 7671.*
- *European: [BS] EN 50174-1, [BS] EN 50173 series, [BS] EN 50174-3, [BS] EN 60825-2.*
- *International: [BS] ISO/IEC 14763-2, [BS] PD ISO/IEC 14763-2-1.*

Essential reading for: Project Sponsors, Telecommunications Consultants, Cabling Installers

Optional reading for: Project Managers, Architects, Building Services Engineers, Other specialists, Quantity Surveyors

Appendix A contains a detailed bibliography.

One of the greatest risks to the successful operation and management of telecommunications infrastructures is inadequate administration. The more obvious purpose of administration is to record the location of points of connection and what is connected at and between those points.

In addition, suppliers' warranties/guarantees may demand procurement policies for consumable items such as cords, which may also managed by the administration system.

It could be argued that effective administration is the most important infrastructure design decision because the degradation of transmission performance due to poor infrastructure management is likely to have a more significant impact on operational performance than any improvement that would be attained by the use of components with enhanced performance.

Equally relevant is that any failure to facilitate the establishment and maintenance of accurate records may result in a significant risk to the desired levels of RAM of the infrastructure.

While the above issues impact either directly or indirectly the transmission performance of the infrastructure, the rules for the operational administration of the cabling can also extend to the procurement of transmission equipment. This can support corporate governance objectives in support of national legislation such as that addressing electromagnetic compatibility and other safety issues such as managing optical power hazards.

9.1 Administration standards

The cabling installation standards such as [BS] EN 50174-1 and [BS] ISO/IEC 14763-2 restrict the definition of administration to those aspects which affect record-keeping – the key components being identifiers, labels and the records themselves. Both standards refer to two types of administration:

- **installation** – which maintains the information relating to the interconnections between the various cabling termination points;
- **operational** – which extends the systems to encompass the cords and even the services provided over the cabling.

However, both standards make the point that the administration systems are a critical element of the installation specification and need to be selected and agreed early in the construction process.

It is important to differentiate between an administration system and the tools (e.g. spreadsheets, databases and even sophisticated management packages) that are used to implement the system.

The foundation upon which all administration systems are based is a common set of identifiers for the cabling components (cables, cords, termination points, panels, faceplates, cabinets, etc.), spaces and pathways to be employed by the administration tools.

The minimum requirements for an identifier scheme are quite simple – providing unique and unambiguous identifiers for each component. However, in the absence of such a scheme, the system defined in [BS] PD ISO/IEC TR 14763-2-1 is mandated as a default by both [BS] EN 50174-1 and [BS] ISO/IEC 14763-2. The North American standard ANSI/TIA-606-A also contains recommendations for an identifier scheme.

The minimum requirements of the standards, defining what is included within the administration system (i.e. what is required to have identifiers, labels and records), depend on the type of premises and the quantity of cabling and transmission equipment.

9.2 Migrating from installation to operational administration

There is a significant risk if installation and operational administration are treated as two separate procedures.

The production of a precise connectivity record that may be 'live' during the installation process – reflecting last minute changes (e.g. to pathways and locations of the connections points) – allows a seamless migration to the operational administration systems via the introduction of connection or patching records.

The need for such an approach is emphasized as a wider range of telecommunications services are supported by structured cabling infrastructures that become operational at different times in the project – some before practical completion and others after that point.

If the transition from installation to operational administration is not seamless, there is a heightened risk that records may become subject to dislocation, resulting in errors.

9.3 The impact of errors in operational administration

It is often tempting to ignore the importance of operational administration, since investment in record-keeping systems and the generation of 'initial-condition data' may be substantial. However, the costs of ineffective administration can be much higher than the cost of effective record-keeping systems.

There are significant costs associated with errors – since they are normally only discovered when some type of service disruption is encountered and the errors in record-keeping result in trouble-shooting/fault-finding costs. The costs escalate if the errors are discovered during large-scale changes to the infrastructure that have to be completed during periods of scheduled downtime.

Once errors in the record-keeping systems are identified, the whole administration system comes under suspicion, and confidence in it is undermined.

The natural reaction is to undertake a connectivity audit to 'reset' the information. However, such an audit uses significant resources and is not instantaneous – meaning that operation continues, with changes being made, while the audit is underway.

9.4 Beyond the standards

The basic administration requirements of the standards do not explicitly extend:

- to cover the ongoing procurement of cabling components to maintain the performance of the installation (and to support suppliers' warranties and guarantees) – the most obvious risk to performance is the procurement of sub-performing cords used to connect elements of the cabling or to connect the cabling to the equipment (however, this extends to the installation of the correct cords in an improper manner);
- to address the selection of transmission and terminal equipment – for example, to ensure that the electromagnetic compatibility of the resulting systems is documented, as discussed in 2.4.1;
- to maintain the designation of locations from the optical fibre safety perspective;
- to include multi-service delivery using converged cabling where additional designation is desirable via labelling and colour coding.

Optical fibre safety

The international standard for the safety of optical fibre communications systems is IEC 60825-2, which is published in Europe as [BS] EN 60825-2. This document provides a foundation for processes and procedures to enable the safe installation and operation of optical fibre cabling and the equipment attached to it.

The standard designates locations within premises as being unrestricted, restricted or controlled – each being able to accommodate increasingly powerful optical equipment (and therefore the hazards associated with it) and each also being impacted by increasingly restrictive operational controls.

The designation of a particular location is the responsibility of the planner – and is nothing to do with the installer – and has to be maintained by the user of the premises. This defines:

- the type of equipment to be used in, or transmitting to, those locations;
- the labelling and other practices that have to be applied to optical interfaces in those locations.

The more sophisticated administration tools allow additional information to be recorded and calculated. For example, the type(s) and total volume(s) of plastics materials can be included, which may be useful at a later date for non-transmission-related assessments, including:

- the determination of recycling costs, which might influence decisions on future refurbishment dates and/or technologies;
- the modelling of fire performance via the calculation of the distribution of the burning load.

Such systems also allow integration with other management databases – such as network and service management systems.

However, the presence of even the most sophisticated administration tool cannot automatically be relied upon to guarantee the specific service to any connection point. All administration systems require individuals to manage the connection of services in telecommunications or equipment rooms to ensure that a specific user outlet is provided with a service.

Intelligent management systems represent the peak of administration technology. Such systems are able to automatically detect disconnection and reconnection of cords and equipment. They may even allow scheduling of the connected service over the installed infrastructure, but they cannot redirect services.

9.5 Wider implications for business

Administration is not just a 'paper' exercise – effective administration may require changes in the operational structure of the business. For example, a business that has historically operated a 'service-based' organizational structure, where one group of people has managed the voice service (installed using voice grade cabling) and another group has been responsible for 'data' systems, is going to be faced with some fundamental changes following the installation of structured, multi-service cabling. This has seen the erosion of the telephony function within many organizations.

This situation is exacerbated with the introduction of the wider converged solutions now possible. Increasingly, businesses are becoming dependent on the IT function if it is to deliver and manage a wider range of building systems, and this can create an uneasy interrelationship with the estates function if it is not correctly managed.

If these issues have not been addressed by senior management, it is quite possible that any administration system will be undermined, and, as mentioned above, once confidence in any record-keeping system is damaged, the system becomes essentially useless.

Further convergence of any degree suggests the creation of a common group responsible for infrastructure management that manages the total administration package, including that defined by the standards, together with procurement and implementation at the cabling level. This allows the service-specific groups to focus on equipment procurement, deployment and connection to the infrastructure and provides with them a single point of co-ordination in relation to cabling-related matters.

This approach mimics that operated in the wide-area network, where there is now a clear differentiation between access providers (i.e. the cabling infrastructure managers/operators) and service providers. For example, the cabling to the subscriber is delivered by one company, with a multitude of service providers being able to compete for the use of that infrastructure.

10 Project close-out

This chapter highlights the issues associated with effective project close-out and the possible benefits of maintaining the role of the telecommunications specialist after that point. Historically, it has been common to consider practical completion as being coincident with the end of the 'electrical third fix' task identified in Table 6.

This chapter makes reference to the following standards:

- *British: BS 6396.*
- *European: [BS] EN 50173 series.*

Essential reading for: Project Sponsors, Project Managers

Recommended reading for: Architects, Building Services Engineers, Telecommunications Consultants

Optional reading for: Other specialists, Quantity Surveyors, Cabling Installers

Appendix A contains a detailed bibliography.

Historically, it has been common to consider Practical Completion as being coincident with the end of the Electrical 3rd fix task identified in Table 6. However, as the importance of the telecommunication infrastructure has grown, it has become necessary to consider alternative contractual states such as 'operational readiness' or 'service activation' that reflect the true demands of the business to be served by the premises.

Convergence blurs the practical completion boundary, and it is important for the telecommunications specialist to maintain continuity beyond practical completion up to and including the project close-out phase.

10.1 The role of a telecommunication specialist beyond 'practical completion'

The convergence of telecommunications services to a common standards-based component set of the structured cabling design standards (e.g. the [BS] EN 50173 series) can result in a complex situation at practical completion. For example:

- Building management and access controls systems will be required to be fully functional at practical completion – the cabling having been installed, commissioned, connected to the various pieces of transmission and terminal equipment and proven to meet the specifications for those systems.
- The fixed corporate LAN will typically have been installed, terminated and tested in the telecommunications rooms, equipment rooms and at consolidation points or telecommunications outlets but transmission and terminal equipment may not have been installed and no cords installed - these aspects will generally be addressed during the 'FF&E' task identified in Table 6.

Errors of procurement management across the practical completion boundary need to be minimized. Three obvious examples of such risks are given below:

- the procurement and installation of cords that undermine cabling system suppliers' warranties/guarantees;
- the installation of furniture that introduces additional connection points that undermine transmission performance;
- the extension of cabling beyond the structure supported by the standards.

The last example above is quite common where a user outlet designated in the design concept as a telecommunications outlet (TO in Figure 31) is relegated to a consolidation point (CP) by the installation of furniture with integrated cabling (e.g. that specified in BS 6396) that produces a new TO 'on the desk'. This not only means that the test results obtained (see 8.2.5) are rendered irrelevant but the installed cabling channel performance will be degraded (possibly affecting short channels more than long ones).

As a result, there is considerable administrative risk in not taking into account the phased nature of the telecommunications implementation during the definition of practical completion.

It may be desirable to extend the role of the telecommunications specialist as shown schematically in Figure 30 to include the FF&E task and even to address other wider issues, including:

- the relocation of existing enterprises;
- the migration of telecommunications services from existing enterprises;
- defect liability periods.

10.2 Measuring success

10.2.1 Cabling

The successful completion of a cabling project can be determined by relatively simple means.

The obvious aspects are that the as-built drawing reflects the reality of the fixed installation – this is critical for ongoing support of the infrastructure, and should be checked on a sample basis (with appropriate increases in sampling levels should errors be discovered) – and that the installed performance meets the required test limits (see 8.2.5).

However, as administration is the key to the successful operation of a structured cabling solution – independent of the degree of service convergence – the final and most important pointer to success is the successful migration from installation administration to operational migration, as defined during the process of patching and initial service connection and configuration.

10.2.2 The rest

The achievement of the design objectives of a telecommunications infrastructure is not measured at project close-out. It requires engagement by senior management to ensure that the operating rules for that infrastructure are strictly applied and that administration systems are maintained without error.

Technology can take the process only so far – the rest is up to humans.

Appendix A: Standards review and bibliography

A.1 Understanding standards

A.1.1 Conformance

There are three recognized bodies producing structured cabling design and installation standards:

- the North American region produces ANSI/TIA standards;
- the international arena is catered for by ISO/IEC;
- the European Economic Area is provided for by CEN/CENELEC.

Fortunately, all three bodies are very clear about what it means to conform to their standards, but, unfortunately, the rules for conformance to ANSI/TIA standards differ from those of the ISO/IEC and CEN/CENELEC documents.

All the structured cabling standards produced by ISO/IEC and CEN/CENELEC, be they design- or installation-related, contain a most important clause entitled 'Conformance'. This clause dictates which of the other clauses in the standard shall be complied with in order that conformance may be claimed.

In contrast, ANSI/TIA standards do not contain a conformance clause – conformance to these standards simply demands that all requirements of a particular standard are met.

Recognizing 'requirements'

> The wording of standards differs from colloquial English in certain very important ways. Properly written standards distinguish requirements by the use of the word 'shall'. Words which have a similar meaning in colloquial English such as 'must' tend to be avoided. The words 'may' and 'can' represent permissions (i.e. possible options) whereas the word 'should' indicates a recommendation to do something – but *not* a requirement.
>
> Badly written standards combine certain words such as 'should always' – which is best interpreted as a requirement as there are no circumstances in which the action is to be avoided.

A.2 Standards review

A.2.1 British Standards

The most developed and all-encompassing telecommunication cabling standards environment exists in Europe – and this situation is even more comprehensive in the UK.

From the cabling perspective, British standards are either 'home grown' or are national implementations of European or international standards.

'Home-grown' standards are designated as BS XXXX.

European standards that are almost always endorsed by BSI (under European regulation) are designated as BS EN XXXXX. International standards that are endorsed by BSI (this is not an automatic process) are designated as BS IEC XXXXX, BS IEC XXXXX or BS ISO/IEC XXXXX.

A.2.1.1 Design

The generic structured cabling standards in the [BS] EN 50173 series (see A.2.2.1) are published as [BS] EN 50173 standards in the UK. Each of the premises-specific documents (i.e. [BS] EN 50173-2, -3, -4, -5, etc.) contain a national foreword that requires the application of BS 6701.

[BS] EN 50346 defines test methods, primarily by reference to other standards [BS] EN 61935-1 for balanced cabling and [BS] ISO/IEC 14763-3 for optical fibre cabling).

None of the ISO/IEC generic cabling design standards are endorsed as British Standards, but a number of tangential ISO/IEC Technical Reports are available as 'Published Documents' from BSI.

A.2.1.2 Planning and installation

All telecommunications cabling can be contractually subjected to a requirement to conform to BS 6701. This standard requires the application of BS 7671 together with the [BS] EN 50174 series of standards. In turn, [BS] EN 50174 standards require the application of [BS] EN 50310, which addresses equipotential bonding inside buildings.

None of the ISO/IEC generic cabling installation standards are endorsed as British standards, but a number of tangential ISO/IEC Technical Reports are available as 'Published Documents' from BSi.

A.2.2 European standards

A.2.2.1 Design

Since 2007, EN 50173-1 has contained requirements that are, or may, be common to generic cabling designs for different types of premises – acting as a reference book for the other parts.

EN 50173-2 then defines the specific choices from EN 50173-1 that apply to offices, and EN 50173-3 provides solutions for industrial premises. EN 50173-4 specifies generic cabling for homes, as does EN 50173-5 for data centres.

EN 50346 defines test methods, primarily by reference to other standards (EN 61935-1 for balanced cabling and ISO/IEC 14763-3 for optical fibre cabling).

A.2.2.2 Planning and installation

EN 50174-1 contains requirements and recommendations for the specification of an installation by or on behalf of a project sponsor and the quality assurance responses from the installer.

Based on the application of EN 50174-1, EN 50174-2 contains the requirements and recommendations for installation planning and practice inside buildings, while EN 50174-3 addresses these issues outside buildings.

EN 50310 contains requirements and recommendations for the improvement of earthing systems inside buildings to provide the desired equipotentiality necessary for the effective operation of telecommunications equipment.

A.2.3 International standards

A.2.3.1 Design

ISO/IEC standards for generic cabling are substantially technically equivalent to the European standards, but they are not structured in the same way.

ISO/IEC 11801 is targeted at the office premises area but also contains the common technical requirements for generic cabling in certain other types of premises – being referenced from ISO/IEC 24702 for industrial premises, ISO/IEC 15018 for homes and ISO/IEC 24764 for data centres. However, each of these other premises-specific standards contains its own technical requirements for components and cabling transmission performance.

This lack of structure is now being addressed, but will take a number of years to resolve completely.

A.2.3.2 Planning and installation

ISO/IEC 14763-2 is similar to a combination of [BS] EN 50174-1, -2 and -3 (see A.2.2.2) but is restricted to the installation of ISO/IEC generic cabling designs. It is supported by an ISO/IEC Technical Report (TR 14763-2-1) covering identifiers within cabling administration systems.

A.2.4 North American standards

A.2.4.1 Design

ANSI/TIA-568 standards have been restructured as TIA-568-C.0, C.1, C.2 and C.3. To some extent this restructuring reflects the restructuring of the European EN 50173 series of standards that was completed in 2007.

It is not uncommon to find ANSI/TIA-568-C, the principal North American standard for the design of structured cabling, to be included in procurement contracts outside its original, intended, sphere of influence. Of the four current parts, C.1 contains the requirements for structured cabling in commercial premises. The other parts contain general requirements, applicable to all premises, and specific requirements for balanced and optical fibre cabling components and the respective installed cabling.

Other structured cabling design standards exist for particular types of premises, including:

- ANSI/TIA-1005 for industrial premises;
- ANSI/TIA-570-B for residential premises;
- ANSI-942-A for data centres.

Another potentially very important design standard is ANSI/TIA-862-A, which addresses BAS – applicable as an overlay in many of the premises covered by the other design standards.

All of these other design standards will be updated over the next few years to reference the requirements listed in ANSI/TIA-568- C.0, C.2 and C.3.

A.2.4.2 Planning and installation

Unfortunately, the North American cabling design standards mandate the application of additional North American standards relating to the planning and installation process. While this would initially appear to be entirely reasonable, the problem lies in the fact that, first, most of the planning requirements for the necessary spaces and pathways lie outside the scope of any installer (being more relevant to architects) and, secondly, some of the requirements of those planning and installation standards are not applicable to outside areas that are subject to North American electrical codes.

It is clear that anyone who specifies or accepts a contractual requirement to provide 'cabling in accordance with ANSI/TIA-568-C.1' is at substantial risk of future litigation if:

- in areas subject to North American electrical codes, inadequate space has been allocated to the infrastructure, together with inadequate lighting and decoration in those spaces;
- in other areas, inadequate space has been allocated to the infrastructure, together with inadequate lighting and decoration in those spaces *and if* the local electrical regulations are in conflict with those of North American codes (including the supplied voltages).

A.3 Cabling standards comparisons

A.3.1 General

Due to the different scopes and structures of the sets of standards produced by the three regional standardization bodies, there can be no direct correlation of requirements across individual standards.

A.3.2 Design

The best comparative description is that the three standards ANSI/TIA-568-C.0, C.2 and C.3 are intended to act as basic references for all types of premises (similar to [BS] EN 50173-1 and ISO/IEC 11801) whereas ANSI/TIA-568-C.1 is similar to EN 50173-2 and ISO/IEC 11801.

TIA-568-C.2, approved in August 2009, contains the requirements for Category 6A components, links and channels.

In February 2010, ISO/IEC 11801 Ed.2 Amendment 2 was approved, which contains requirements for Category 6A and 7A components, together with installed requirements for Class EA and FA links (the channels were specified in ISO/IEC 11801 Ed.2 Amendment 1 in 2008).

In Europe, EN 50173-1:2011 maps the contents of ISO/IEC 11801 Ed.2 Amendment 2. The requirements for Category 6A/Class E^{A} in the international and European standards are more stringent than for the Category 6A components and cabling of TIA-568-C.2 – although the relevance of this for application support is minimal.

Developments in the specification of optical fibre cabling are also included in the 2010 amendments of ISO/IEC 11801 and [BS] EN 50173-1:2011, featuring both the definition of requirements for Category OM4 cabled optical fibre and the inclusion of 40 Gb/100 Gb Ethernet as supported applications. The details of these developments are available as White Papers on the FIA website (www.fia-online.co.uk).

A.4 Cabling standards bibliography

A.4.1 British standards

BS 6396, *Electrical systems in office furniture and education furniture – Specification*.

BS 6701, *Telecommunications, equipment and telecommunications cabling – Specification for installation, operation and maintenance*.

BS 8492, *Telecommunications equipment and telecommunications cabling – Code of practice for fire performance and protection*.

BS 7671, *Requirements for electrical installations – IEE Wiring Regulations – 17th edition*.

BS EN 50173-1, *Information technology – Generic cabling: General requirements*.

BS EN 50173-2, *Information technology – Generic cabling: Office premises*.

BS EN 50173-3, *Information technology – Generic cabling: Industrial premises*.

BS EN 50173-4, *Information technology – Generic cabling: Homes*.

BS EN 50173-5, *Information technology – Generic cabling: Data centres*.

BS EN 50174-1, *Information technology – Cabling installation: Installation specification and quality assurance*.

BS EN 50174-2, *Information technology – Cabling installation: Installation planning and practices inside buildings*.

BS EN 50174-3, *Information technology – Cabling installation: Installation planning and practices outside buildings*.

BS EN 50310, *Information technology – Application of equipotential bonding and earthing in buildings with technology equipment*.

BS EN 50346, *Information technology – Cabling installation – Testing of installed cabling*.

BS EN 61280-4-1, *Fibre optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement*.

BS EN 61280-4-2, *Fibre optic communication subsystem basic test procedures – Part 4-2: Fibre optic cable plant – Single-mode optic cable plant attenuation*.

BS PD ISO/IEC TR 14763-2-1, *Information technology – Implementation and operation of customer premises cabling – Part 2-1: Identifiers*.

A.4.2 European standards

All the other countries in the European Economic Area apply the EN standards listed in A.4.1. In most cases, they are translated into the relevant national language, but where this is not undertaken, the English translation is used.

EN 50173-6, *Information technology – Generic cabling: Distributed building services*.

EN 61280-4-1, *Fibre optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement*.

EN 61280-4-2, *Fibre optic communication subsystem basic test procedures – Part 4-2: Fibre optic cable plant – Single-mode fibre optic cable plant attenuation*.

A.4.3 International standards

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*.

ISO/IEC 15018, *Information technology – Generic cabling for homes*.

ISO/IEC 24702, *Information technology – Generic cabling – Industrial premises*.

ISO/IEC 24764, *Information technology – Generic cabling for data centres*.

ISO/IEC 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*.

ISO/IEC TR 14763-2-1, *Information technology – Implementation and operation of customer premises cabling – Part 2-1: Identifiers*.

ISO/IEC 14763-3, *Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling*.

IEC 61280-4-1, *Fibre optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement*.

IEC 61280-4-2, *Fibre optic communication subsystem basic test procedures – Part 4-2: Fibre optic cable plant – Single-mode fibre optic cable plant attenuation*.

IEC 61935-1, *Testing of balanced communication cabling in accordance with ISO/IEC 11801 – Part 1: Installed cabling*.

A.4.4 North American standards

ANSI/TIA-568-C-0, *Generic telecommunications cabling for customer premises*.

ANSI/TIA-568-C-1, *Commercial building telecommunications cabling standard*.

ANSI/TIA-568-C-2, *Balanced twisted-pair telecommunications cabling and components standard*.

ANSI/TIA-568-C-3, *Optical fiber cabling components standard*.

ANSI/TIA-569-C, *Commercial building standard for telecommunications pathways and spaces*.

ANSI/TIA-570-B, *Residential telecommunications cabling standard*.

ANSI/TIA-606-A, *Administration standard for commercial telecommunications infrastructure*.

ANSI/TIA-758-A, *Customer-owned outside plant telecommunications cabling standard*.

ANSI/TIA-862-A*, Building automation systems cabling standard*.

ANSI J-STD-607-A, *Commercial building grounding and bonding*.

ANSI/TIA-942-A, *Telecommunications infrastructure standard for data centers*.

ANSI/TIA-1005, *Telecommunications infrastructure standard for industrial premises*.

Appendix B: Telecommunications overview

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
Corporate fixed LAN	•	•	•	Alternate design solution: corporate wireless LAN	✓
Corporate wireless LAN (including third-party external providers)	•	•	•	Alternate design solution: corporate fixed LAN Consideration: some distributed building services cabling will be required to support wireless access points – wireless modelling may be used to predict outlet locations and thus cabling outlet locations Consideration: security considerations may prohibit or limit access to guest-only 'hotel	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
				mode' or enforce virtual private network (VPN) access	
On-site server access/data centre LAN	•	•	•	Alternate design solutions: external service, including 'cloud computing' 'hybrid clouds' with a mix of private and public cloud solutions could be common place soon Consideration: a data centre infrastructure strategy should be formed during the preparation stages of a new-build or refurbishment project Consideration: cabling in data centre environments may require higher-performance products, custom connection topologies and physical security considerations; consult new	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
				standards for guidance in this area	
Telephony/unified communications (including third-party external providers)	•	•	•	Alternate design solution: 2 × 2 option matrix – cabled versus wireless, digital PBX versus VoIP Consideration: quality of service (contention) issues lead to discussion relating to options such as DECT on digital PBX or IP Alternate design solution: 3G mobile coverage (non-converged cabling solutions) could be attractive to small and medium-sized enterprises preferring to only rely on public 3G services and corporate GSM service offerings	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
Audio-visual (presentation aids/meeting rooms)	•	•	•	Within meeting rooms Alternate design solutions: prevalence of high-definition media and other bandwidth-intensive multimedia formats is a challenge in corporate environments; traditional structured cabling may not always be the optimum solution Consideration: cabled pathways may present a challenge and wireless infrastructure may be appropriate	
				To meeting rooms Consideration: check strategies for in-room digital media delivery systems as well as a reliance on a central distributor Consideration: structured cabling designers should consult with acousticians and audio-visual systems designers to define interfaces	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
Multimedia/digital content (video on demand)	•	•	•	Consideration: performance and latency issues indicate a preference for a cabled solution – possibly a mixture of dedicated (e.g. HD-SDI or baseband) and IP/Ethernet-based delivery.	✓
Electronic point of sale (EPOS)/vending systems	•	•	•	Consideration: check for compliance with Payment Card Industries (PCI) requirements for cabling and network infrastructure where applicable	✓
Public switched telephone network (PSTN) circuits				Consideration: minimum requirements are defined by local regulations Consideration: 'demarcations' between the owner and the service provider – which may have implications for space and pathway requirements	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
Public address	•			Consideration: structured, i.e. Star (IP or not), interfaces and delivery methods vary	✓
				Alternate design solution: other configurations (e.g. daisy chain); interfaces and delivery methods vary	
Master clock (More common in premises servicing a public function, e.g. hospitals, universities, schools and airports)	•			Several independent clocks	✓
Digital signage	•			Consideration: IP/Ethernet delivery systems are now commonplace	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
Television: off-air/cable/CATV/SMATV	•	•	•	Technique: converged technology (IP TV)	✓
				Alternate design solution: coaxial distribution Consideration: cabling choices are often determined by local laws, operating costs and whether 'pay TV' distribution is required – solutions vary in owner-occupied premises and multi-tenanted premises	
Security CCTV	•	•	•	Consideration: parallel converged infrastructure possible if operating policies dictate Consideration: common spaces 'silo-ed' to prevent access – e.g. IP access ring-fenced to avoid hacking Consideration: electronic storage of evidential data may require	✓

Telecommunica-tions service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastruc-ture and service)	Alternate design solutions, techniques and considerations	Supported by convergence
				dedicated recording and storage; external CCTV coverage in large premises or on a campus is a challenge, and special considerations will be needed for a converged infrastructure	
Security ACS	•	•	•	Consideration: parallel converged infrastructure possible Consideration: IP access ring-fenced to avoid hacking Consideration: IP solutions require local power (unless supported by PoE-plus) – proprietary solutions do not require local power Consideration: spaces and pathways under common design and management	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
Building automation systems (BAS) Building management systems (BMS)	•	•	•	Consideration: common spaces 'silo-ed' at the head end Consideration: separate spaces for zone controllers/end devices Consideration: IP access ring-fenced to avoid hacking Consideration: IP solutions require local power (unless supported by PoE-plus) – proprietary solutions do not require local power	✓
Supervisory control and data acquisition (SCADA)/metering	•			Technique: smart metering solutions are increasingly IP/Ethernet-based (treated as a distributed building service) – IP zone concept or direct connect	✓
Life safety alarms				Consideration: fail safe solution – deterministic solutions may mitigate against the use of IP (alternatives may become more	✓

Telecommunications service	Own and operate	Managed service (infrastructure owned but service outsourced)	Outsourced (both infrastructure and service)	Alternate design solutions, techniques and considerations	Supported by convergence
				prevalent, e.g. real-time Ethernet)	

Key
✔= addressed
● = not addressed

Telecommunications Cabling

Guidance on Standards and Best Practice for Construction Projects

Whether small-, medium- or large-scale construction, new build or upgrade; whether cabling has to last for the short-term or over many years, making the right decisions will affect the way an investment works and how the end users experience service delivery as a network or applications experience.

This is the first book to map out the issues, highlight the risk areas and offer guidance to those in the industry, written by professionals who have first-hand experience of delivering telecommunications infrastructure projects over many years.

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