Telecommunications Cabling

Guidance on standards and best practice for construction projects
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Mike Gilmore and Mani Manivannan
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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.
Introduction

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.
Introduction

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.

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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:

- International: ISO/IEC 11801.

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.

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.
1 The need for structured cabling

Key
TO telecommunications outlet

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

Figure 3 – Lifetimes of horizontal infrastructure

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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.
1 The need for structured cabling

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.