Telecommunications Project Management

BICSI Resource Material for RTPM Study

First Edition

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Telecommunications Project Management

1st Edition

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The information contained in this technical compilation includes, but is not limited to, national and international codes, de jure and de facto standards, and industry-accepted best practices.

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Chapter 1 Telecommunications Administration

Chapter 1 describes various identification systems used for administration of telecommunications systems.

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Introduction

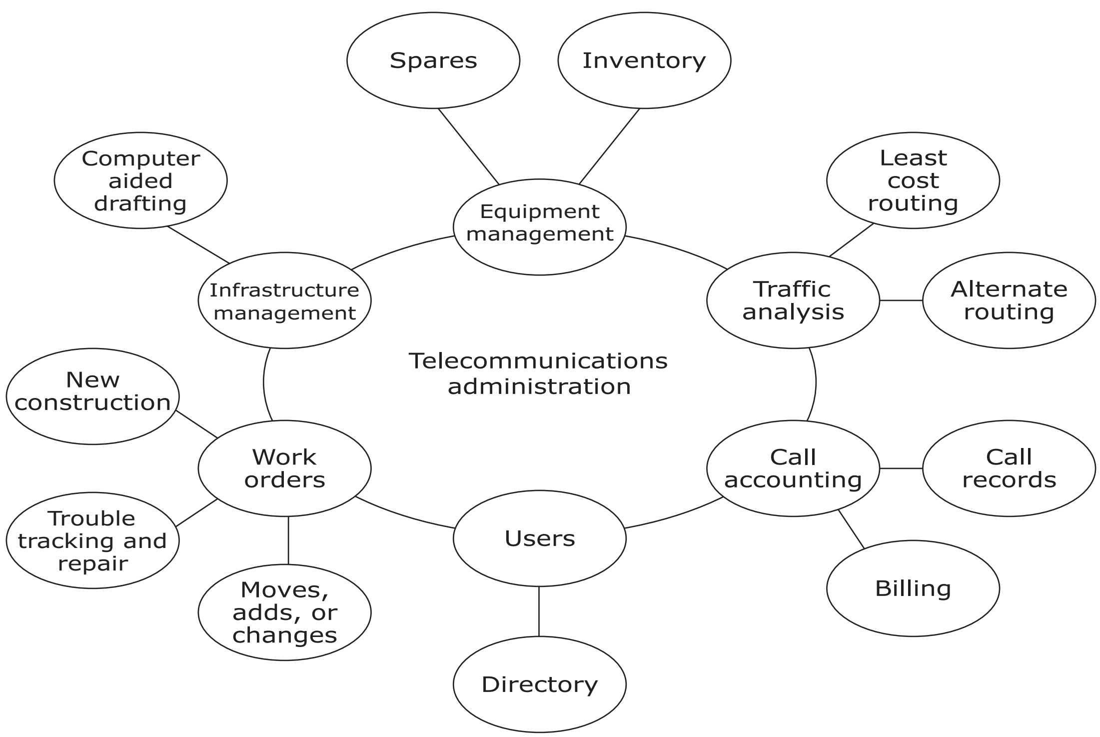
This chapter describes some telecommunications administration methods and numbering schemes. It does not describe complex administration systems in detail.

Telecommunications Administration System

An effective telecommunications administration system is crucial for an efficient operation and maintenance of the infrastructure and equipment in buildings and campus environments.

Telecommunications administration systems vary greatly in scope—from simple paper records to complex computer-based systems. These complex systems can integrate infrastructure and equipment records, inventory, traffic analysis, call accounting and billing, directory information, and work orders, as illustrated in Figure 1.1.

Figure 1.1
Telecommunications administration systems



Benefits of the Telecommunications Administration System

A telecommunications administration system provides both operational and maintenance benefits:

- Operationally, an effective telecommunications administration system simplifies moves, adds, or changes (MACs) by allowing the work details to be determined in advance and then carried out with little guesswork.

  For example, labeling conduits and keeping updated records of conduit use greatly simplifies determining whether unused conduit capacity is available and, therefore, the best route for the new cables.
- Maintenance is simplified because the location of components involved in the failed telecommunications channel can be easily and quickly identified during troubleshooting and repair activities.

Classes of Telecommunications Administration System

The following sections explain the four classes of telecommunications administration system.

General

Four classes of telecommunications administration system are recommended to accommodate diverse degrees of complexity present in telecommunications infrastructure:

- Class 1—Premises served by a single equipment room (ER).
- Class 2—Single building or a tenant served by one or more telecommunications spaces.
- Class 3—Campus.
- Class 4—Multisite system.

The administration systems for each class include requirements for:

- Identifiers.
- Records.
- Labeling.

A telecommunications administration system should provide a method to find the record associated with any specific identifier.

A telecommunications administration system may be managed using a:

- Paper-based system.
- General-purpose spreadsheet software.
- Special-purpose cable management software.

Classes of Telecommunications Administration System, continued

In a general-purpose spreadsheet implementation, each required identifier with its associated record makes up a row and each column contains a particular item of information from the record.

Administration for complex cabling systems may require special-purpose software. Special-purpose cable management software should provide reports comprising information from groups of records.

Drawings should be available showing all identified elements of infrastructure.

Determination of Class

The most relevant factors in determining the minimum class of administration is the size and complexity of the infrastructure. The number of telecommunications spaces (e.g., ER, common ER, telecommunications room [TR], common TR, entrance facility [EF]) is one indicator of complexity.

Classes are scalable and allow expansion without requiring changes to existing identifiers or labels. For mission critical systems, buildings over 7000 square meters (m^2 [75,000 square feet (ft^2)]), or multi-tenant buildings, administration of pathways and spaces, and outside plant (OSP) elements are strongly recommended.

Description of the Four Classes

The following describes the four classes:

- Class 1—Addresses the administration needs of premises served by a single ER. This ER is the only telecommunications space administered, which means that TRs, backbone cabling, and OSP cabling systems are not administered. Presence of simple cable pathways is assumed and they do not have to be administered.

  To administer cable pathways or firestopping locations, a class 2 or higher administration system should be used.

  Class 1 is typically managed using a paper-based system or general-purpose spreadsheet software.

- Class 2—Administration provides for the telecommunications infrastructure administration needs of a single building or of a tenant served by a single or multiple telecommunications spaces (e.g., an ER with one or more TRs) within a single building.

  Class 2 administration includes all of the class 1 administration elements. In addition, identifiers for backbone cabling, multiple-element bonding and grounding (earthing) systems, and firestopping are included. Presence of cable pathways may be assumed, so administration of these elements is optional.

  Class 2 may be managed using a paper-based system, general-purpose spreadsheet software, or special-purpose cable management software.

Classes of Telecommunications Administration System, continued

- Class 3—Administration addresses the needs of a campus, including its buildings and OSP elements.

  Class 3 administration includes all of the class 2 administration elements. In addition, identifiers for buildings and campus cabling are included. Administration of building pathways and spaces and OSP elements is recommended.

  Class 3 may be managed with a paper-based system, general-purpose spreadsheet software, or special-purpose cable management software.

- Class 4—Administration addresses the needs of a multisite system.

  Class 4 administration includes all of the class 3 administration elements. In addition, an identifier for each site and optional identifiers for inter-campus elements (e.g., wide area network [WAN] connections) are included. For mission critical systems, large buildings, or multi-tenant buildings, administration of pathways and spaces and OSP elements is strongly recommended.

  Class 4 may be managed with general-purpose spreadsheet software or special-purpose cable management software.

Classes and Associated Identifiers

An identifier is associated with each administered element of a telecommunications infrastructure. A unique identifier or a combination of identifiers constructed to refer uniquely to a particular element serves to locate the element record.

Classes of Telecommunications Administration System, continued

Table 1.1 indicates the required identifiers for telecommunications infrastructure elements by class.

Table 1.1
Required identifiers by class

	Class of Administration			
Description of Identifier	**1**	**2**	**3**	**4**
Telecommunications space	X	X	X	X
Horizontal link	X	X	X	X
Telecommunications main grounding busbar	X	X	X	X
Telecommunications grounding busbar	X	X	X	X
Building (intrabuilding) backbone cable		X	X	X
Building backbone pair or strand		X	X	X
Firestop location		X	X	X
Campus (interbuilding) backbone cable			X	X
Campus backbone pair or strand			X	X
Building			X	X
Campus or site				X

Numbering Schemes

The numbering schemes used to identify telecommunications components are not standardized. The schemes described in this chapter are suggestions and may be changed to suit specific buildings or systems. This chapter also provides numbering guidance for telecommunications equipment.

Administration System Elements

In the context of this chapter, an administration system consists of three basic elements:

- Labeling or other means of identifying the infrastructure components and equipment.
- Computer- or paper-based recordkeeping system, which tracks the location, use, and status of the infrastructure components and equipment.
- An alphanumeric scheme used both in labeling and in the record system, which defines the relationship (called linkages) and allows cross-referencing of the equipment and components.

Table 1.2 shows how the basic elements are interlinked and gives the minimum required information and optional information for a record.

Administration System Elements, continued

Table 1.2
Minimum and optional administration system elements

Category	Component	Required and Optional Information	Required and Optional Linkages/ Cross-Reference
Spaces and Pathways	Spaces	Space identifier Space type	Pathway record Cable record Grounding record
	Pathways	Pathway identifier Pathway type Pathway fill Pathway loading	Cable record Space record Pathway record Grounding record
	Firestopping	Firestop location	Firestop record
Cabling	Cable	Cable identifier Cable type Pairs available Pairs usable Test date and results* Date installed	Termination position record Splice record Pathway record Grounding record Equipment record*
	Termination hardware	Termination hardware identifier Termination hardware type Available positions Unavailable positions	Termination position record Space record Field record User record
	Termination field*	Termination field identifier* Field type*	Termination hardware record*
	Termination position	Termination position identifier Termination position type User code Cable pair number	Cable record Termination hardware record Space record Other termination position record
	Splice	Splice identifier Splice type	Cable record Space record

* Indicates optional information.

Administration System Elements, continued

Table 1.2, continued
Minimum and optional administration system elements

Category	Component	Required and Optional Information	Required and Optional Linkages/ Cross-Reference
Bonding and grounding	TMGB	TMGB identifier Busbar type GEC identifier Resistance to remote earth Date of measurement	TBB record Space record
	TGB	TGB identifier Busbar type	TBB conductor record Space record EBC record*
	TBB	TBB identifier Conductor size and type Busbar identifier	TMGB record TGB record Pathway record
Equipment	By system level (e.g., PBX, voice mail system, LAN)	System identifier Rack/cabinet identifier Shelf identifier Slot identifier Circuit or port identifier Workstation identifier Date installed*	Space record EBC record Cable record Pathway record User record Inventory record

* Indicates optional information.

EBC = Equipment bonding conductor
GEC = Grounding electrode conductor
PBX = Private branch exchange
TBB = Telecommunications bonding backbone
TGB = Telecommunications grounding busbar
TMGB = Telecommunications main grounding busbar

Identification Systems

Introduction

As the need and practice of administration schemes for telecommunications have matured, the need for a wider variety of tags and labels has driven the development of many products and methods to exhibit the administrative system identifiers.

In addition to developing new and better materials for labels and tags, technology is being integrated into telecommunications administration.

Methods

A variety of methods can be used to display the identifiers for the buildings, pathways, spaces, cabinets, racks, cabling, connectors, and other components of structured cabling systems. The choice of material and fastening method depends on environmental, performance, and security issues.

Commonly accepted methods of displaying administrative numbering schemes, bar codes, and graphics include:

- Labels.
- Tags.
- Electronic identifiers.

Labels

Labels typically consist of material known as face stock, upon which an alphanumeric or graphical image can be written, affixed, or printed, and are defined as being pressure sensitive and consisting of two parts:

- Label face
- Adhesive material applied to the front, back, or both sides of the label face

Adhesive labels have the most common method for identifying cabling pathways, spaces, equipment, and components. The various label surfaces, applications, and environments have led to the development of a large array of label types.

The label face material may be:

- Paper.
- Cloth.
- Plastic.
- Metal.
- Hybrid of one or more materials.

Methods, continued

The label environment and the expected label lifecycle largely determine material selection. For example, a label used in a humid environment should be made from the material that can resist moisture-induced decay and degradation. A label that is used outdoors may have to be ultraviolet (UV) light protected and heat and cold resistant.

In many cases, the label suitability depends not only on the material used in the label face but also on the type of character, bar code, and image imprint.

Types of label imprint include:

- Handwritten.
- Computer printed.
  - Dot matrix.
  - Inkjet.
  - Laser.
- Thermal.
  - Direct.
  - Thermographic.

Performance Characteristics

The telecommunications distribution designer must identify the label performance characteristics based on the environment, location, and substrate and determine the appropriate label material, adhesive, and printing method.

The following list includes some of the metrics considered in selecting the appropriate labels for an administrative system:

- Application
  - Printing area
  - Food-contact rating
  - Freezer-rated adhesives
  - Opacity, translucence, and transparence
  - Removable
  - Moisture content
  - Bleed-through
  - Conformability

Methods, continued

  - Memory
  - Porosity
  - Phosphorescence
  - Fluorescence
  - Infrared (IR) capability
- Durability
  - Smudge resistance
  - Cohesion
  - Adhesion
  - Permanency
  - Thickness
  - Aging resistance
  - Abrasion resistance
  - Chemical resistance
  - Adhesive type
  - Edge lift
  - Coating
- Environmental
  - UV rating
  - Temperature rating
  - Moisture resistance
  - Service exposure
- Security
  - Tensile strength
  - Tamper evidence
  - Tamper resistance

Methods, continued

Testing Requirements

There are standards that benchmark the performance of labels and printed tags. The most widely referenced of these is Underwriters Laboratories® (UL®) standard 969, *Marking and Labeling Systems*, which provides methods for quantifying the label performance. The performance metrics include:

- Visual inspection.
- Rub test.
- Scrape test.
- Adhesion test.

The label or label stock could also be preconditioned depending on the intended application. The intent of the testing is to simulate and accelerate any effect the end-use environment may have on the performance of the label based on the tests and determine which exposures are allowed based on the intended application.

The following are the test details by environment type:

- Indoor use only
  - 72 hours at room temperature
  - 10-day exposure to elevated temperature at applicable temperature rating
  - 48-hour immersion in deionized water at room temperature
- Incremental for outdoor use
  - 7-hour exposure to the lowest temperature intended for label use
  - 30 days in carbon arc weatherometer per American Society for Testing and Materials (ASTM) standard G153, *Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*
- Incremental tests for both indoor and outdoor use
  - Visual examination of labels
  - Loss of adhesion
  - Print legibility
  - Bubbling
  - Wrinkling
  - Shrinkage
  - Legibility after printing is rubbed 10 times back and forth
  - Defacement test
  - Scraped 10 times across printed areas and edges with 2 mm (0.08 in) steel blade
- Must resist defacement and removal pass test
  - Quantitative adhesion test for adhesion value of not less than 0.5 pound (lb) per inch width when pulled at 90-degree angle (for metric values, 1 lb = 4.45 newton (N) and 1 in = 25 mm).

Methods, continued

Tags

A tag is different from a label in that it is most often only partially attached to the mounting surface.

It can be fastened by:

- Adhesive.
- Cable ties.
- Strings.
- Other methods.

The same materials and adhesives are generally used in the manufacturing of tags and labels.

Electronic Identifiers

The need for privacy, security, and storage of more information that can be printed in an alphanumeric or bar code scheme has led to the use of technology as a labeling tool in some applications.

Wireless technology provides the ability to store more detail per component and prevent potential intruders from identifying the locations of key infrastructure components. The most common method of electronically tagging components is radio frequency identification (RFID).

RFID is a generic term for technologies that use radio waves to automatically identify people or objects. Of the several methods of identification, the most common is to store a serial number and other information that identifies a person or object on a microchip attached to an antenna.

The chip and the antenna together make up an RFID transponder or tag. A reader converts the radio waves reflected back from the RFID tag into digital information that can provide text readout on a handheld computer or personal digital assistant (PDA).

Thus, an RFID system consists of a tag comprising a microchip with an antenna and an interrogator or reader with an antenna. The reader sends out electromagnetic waves. The tag antenna is tuned to receive these waves.

A passive RFID tag draws power from the field created by the reader and uses it to power the microchip's circuits. This technology is easily used to identify passive components in a cabling system where no distributed power system exists. The chip in a passive RFID system modulates the waves that the tag sends back to the reader and the reader converts the new waves into digital data.

Conversely, an active RFID tag performs similarly but utilizes a battery to increase the read range and is not a recommended method for administrative purposes.

Labeling

Components

All telecommunications infrastructure and equipment components should be labeled. The labeling made for each component should be:

- Unique, to prevent confusion with similar components.
- Legible and permanent enough to last the lifecycle of the component. In some systems, the components can last 20 to 30 years or longer. Pathways in a building normally have the same lifecycle as the building, which can approach or exceed 50 years.

The following infrastructure and equipment components should be labeled:

- Telecommunications spaces
- Telecommunications pathways
- Telecommunications cables
- Zone boxes (CP, horizontal connection point [HCP] and wireless)
- Connecting hardware
- Grounding (earthing) system
- Telecommunications equipment

Telecommunications Spaces

Telecommunications spaces include:

- Equipment rooms (ERs).
- Telecommunications rooms (TRs).
- Telecommunications enclosures (TEs).
- Work areas.

Spaces should be labeled at their entrances, as follows:

- In small, single-story buildings, a simple sign on the door (e.g., telecommunications room) is sufficient.
- In larger buildings, the labeling should provide a unique identifier, since there may be a number of telecommunications spaces.

The original architectural plans for a building always identify the spaces, but these are valid only upon construction. A remodeled building or space may require a different numbering scheme.

Telecommunications Pathways

Labeling of pathways helps prevent inadvertent installation of cables from systems that may interfere with each other.

Table 1.3 shows guidelines for identifying telecommunications pathways.

Table 1.3
Identifying pathways

Situation	Identification Guideline
Dedicated telecommunications pathways	Uniquely identify the telecommunications pathways to visually separate them from pathways for other uses (e.g., electrical power and pneumatic systems).
Dedicated pathways for individual system, such as: • Voice/data or office automation. • Heating, ventilating, and air conditioning. • Security. • Energy management systems. • Fire/life/safety systems.	Uniquely identify each system.
• Each compartment in ductbanks innerduct. • Each innerduct (ductliner) placed in conduits or ductbanks.	Uniquely identify each compartment or use colored innerduct.

When labeling pathways, the following guidelines should be met:

- Labeling should be affixed at the ends of each pathway.
- Pathways should be labeled at regular intervals and wherever they are accessible.
- In a basic system, the conduits should be marked from the main ER by painting or using a permanent-colored tape-wrap made for this purpose.
- In systems utilizing zone boxes for consolidation or distribution of low-voltage systems, each box label should include the information about the room of origin and system usage.
- In complex systems or large buildings:
  - A striped tape should wrap pathways with the base color identifying them as telecommunications pathways and tracer color identifying the individual uses.
  - Each pathway should be assigned a unique alphanumeric identifier.
  - All wall or floor penetrations should be labeled.

Telecommunications Cables

When labeling telecommunications cables:

- Cables should be identified at each end with a permanent label or physical/electronic tag. The same alphanumeric identifiers should be used at both ends of the cable.
- Cable should be identified at regular intervals throughout its length with its alphanumeric identifier when cables are rearranged, rerouted, or removed in spite of the added cost.

In systems that are:

- Basic, the labeling scheme can be a simple number sequence.
- Complex, the labeling may indicate the type, function, and terminating position.

Color coding the cables by function (e.g., LAN/voice/fire alarm/environmental control) may be helpful. For this purpose, a high-quality colored vinyl tape may be affixed at each termination and wherever the cables are accessible. Alternatively, different cable jacket colors may be used to distinguish the service type (e.g., voice and data).

Connecting Hardware

Connecting hardware items (e.g., cross-connect fields and telecommunications outlet/connectors) require a unique, alphanumeric identification such as the following three-level scheme:

- First level—Termination field or patch panel. Color-coding or other labeling should be used to uniquely identify each termination field (e.g., voice and data) on a common mechanical assembly.
- Second level—Terminal block within a given field or patch panel, which could be a row of insulation displacement connectors (IDCs), optical fiber connectors, or modular jacks.
- Third level—Defines the individual position within a given terminal block or patch panel.

Grounding (Earthing)

Grounding system components (e.g., ground bars and grounding conductors) require special labeling for safety and noise control purposes and for simplifying and expediting ground system audits.

All equipment grounding conductors should be labeled to indicate the:

- Grounded rack, cabinet, or shelf.
- Ground bar to which the grounding conductors are connected.

Each grounding conductor in a building should be labeled, including those connecting building steel, grounding electrodes, water pipes, radio towers, and telecommunications structural components.

Telecommunications Equipment

Telecommunications equipment labeling normally takes the form of an alphanumeric numbering scheme.

In basic systems, the equipment may consist of a single wall-mounted key telephone system (KTS). In this case, special means of identification, other than the station or telephone number, may not be required.

In complex systems consisting of multiple equipment racks or cabinets, it is necessary to use a system that identifies the:

- Location of the equipment in the space (e.g., equipment lineup or row).
- Number for each equipment bay in the row.
- Number for each shelf within a bay.
- Number for each printed circuit card slot within a shelf.

Card slots on an equipment shelf are normally factory numbered or otherwise identified. Some equipment (e.g., private branch exchange [PBX] station and trunk cards) may have more than one circuit on a card. Workstation equipment (e.g., telephone sets, and personal computers) should be labeled and included as part of the equipment records.

Recordkeeping

A recordkeeping system should be implemented. The system, whether manual or computerized, should reference related infrastructure and equipment components in a logical way.

- For basic systems, the records usually are paper-based; however, simple database programs can be easily developed, which helps to minimize the paper records and simplify updating.
- Complex systems are best administered by computer programs specially designed for the purpose because of their relative economy and greater accuracy in comparison to manual records.

Paper Records

It is often assumed that paper records can be eliminated by a computerized administration system. This is not the case. For example, cross-connections and major rearrangements are always printed for use by telecommunications installers.

Any changes required during the work are recorded on the worksheets and returned to the administration center. These changes are often not made to the computerized record immediately, so a manual method must be devised to keep track of the paper copies until the information can be properly coded.

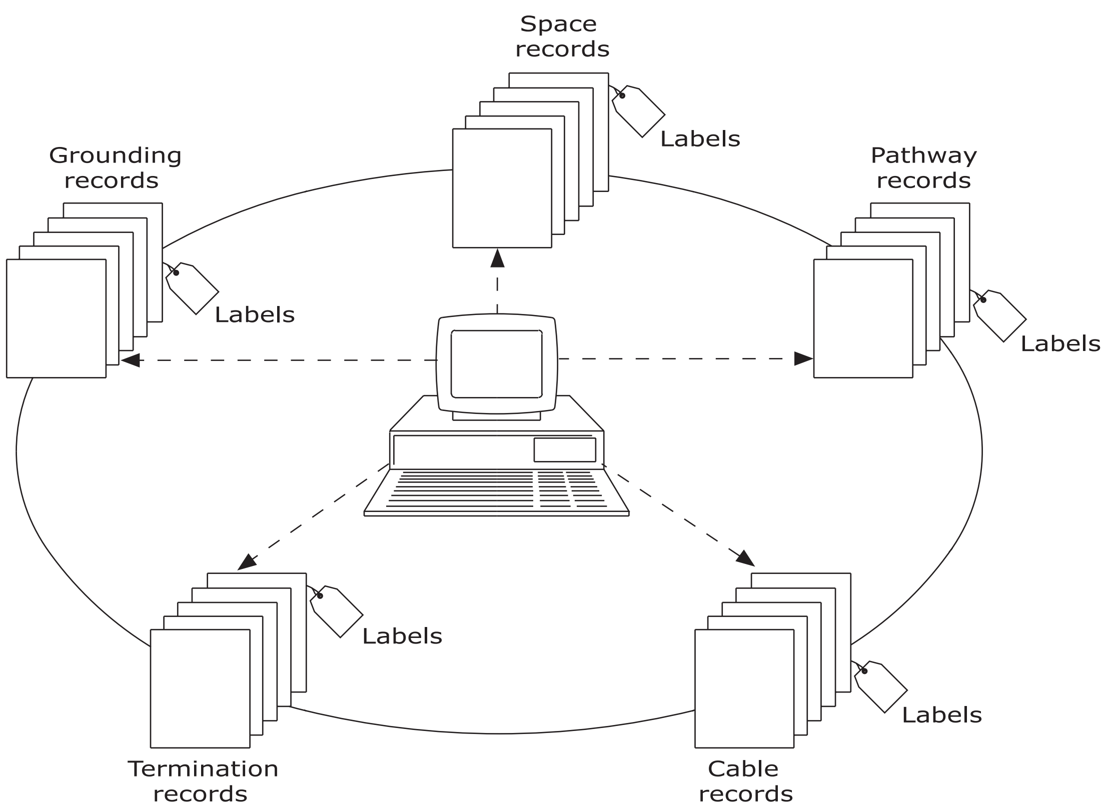
Recordkeeping System Components

Recordkeeping systems vary in scope. A basic system may include no more than the telephone number associated with each user. However, even in a basic system, such a list is deficient because it does not give position location of the station cabling terminals.

It is important that a recordkeeping system cross-reference or link all of the components (e.g., telecommunications spaces, telecommunications pathways, telecommunications cables, connecting hardware, grounding system, telecommunications equipment).

Figure 1.2 illustrates a recordkeeping system.

Figure 1.2
Recordkeeping system example



Some systems can display component positions on a graphical interface with each class of components on a different layer or in a different color.

The recordkeeping system may optionally include other records and cross-references, including:

- User records.
- Circuit records.
- Related equipment records.
- Building records.

Recordkeeping System Components, continued

User Records

User records may include:

- Names.
- Room or work area numbers.
- LAN port numbers.
- Voice telephone numbers.
- Workstation component types and serial numbers.
- Features.
- Software and hardware switch settings.
- Account numbers.
- Passwords.
- Network addresses.

Circuit Records

Some industries and government agencies use leased lines or dedicated cable for control and monitoring facilities in a quasi-campus environment.

For example, in the United States, an airport has an air traffic control tower and many navigational aids operated by the Federal Aviation Administration (FAA), adjunct facilities operated by the military, and a large number of lighting and radio systems operated by the airport authority.

Circuit records include tracking information for the leased lines and include:

- Function.
- Source address and location.
- Destination address and location.
- Account number.
- Circuit numbers.

Related Equipment Records

Some equipment or components (e.g., workstation furniture, modular furniture) may not be a direct part of the telecommunications infrastructure but related to it. Such equipment may be tracked separately or as part of the user records.

Recordkeeping System Components, continued

Building Records

Any building has a number of infrastructures including the:

- Electrical power systems.
- Mechanical systems (e.g., HVAC).
- Fire alarm (FA) systems.
- Lighting systems.
- Building automation systems (BAS).

The monitoring and control of these systems may use various parts of the telecommunications infrastructure and, therefore, need to be tracked. The record drawings for the building provide a snapshot of the site and building systems and should be placed in protected storage for future reference.

Required Records

Table 1.4 indicates the required records by class as specified in ANSI/TIA/EIA-606-A, *Administration Standard for Commercial Telecommunications Infrastructure*.

Table 1.4
Required records by class

Class of Administration Description of Identifier	**1**	**2**	**3**	**4**
Telecommunications space		X	X	X
Horizontal link	X	X	X	X
Telecommunications main grounding busbar		X	X	X
Telecommunications grounding busbar		X	X	X
Building backbone cable		X	X	X
Building backbone pair or strand		X	X	X
Firestop location		X	X	X
Campus backbone cable			X	X
Campus backbone pair or strand			X	X
Building			X	X
Campus or site				X

Alphanumeric Schemes

General

No universally accepted labeling scheme is used to number the telecommunications infrastructure and equipment. Every scheme depends to a great extent on:

- The size of the administered system.
- Whether it is for an old or new building or building complex.
- The type of components and equipment used and planned.
- The owner preference.

In basic telephone systems (a few lines), a basic scheme that labels each component with a sequential number may be used. Such a scheme gives each component a unique identifier. However, it is useful only in the most basic systems because it conveys no information about the component.

The preferred scheme provides a unique identifier and includes information about the component, such as the type and function of a cable and where the cable terminates.

Telecommunications Spaces Identification

The type of telecommunications spaces varies from building to building but all have at least some space for the telecommunications service entrance, cable terminations, and work area. Work areas may be open or individual rooms.

Larger buildings may have:

- An entrance facility (EF).
- A dedicated room for the service equipment (e.g., network interface devices [NIDs]).
- Separate equipment rooms (ERs).
- Telecommunications rooms (TRs).

Campuses may have controlled environment vaults (CEVs) and large maintenance holes (MHs) with repeater housings or other telecommunications equipment.

All of these spaces should be given a unique identifier:

- The identifier prefix should indicate the type of space followed by a sequential number.
- For multistory buildings, the identifier should indicate the floor number (e.g., a basement should be indicated by a “B” unless it is called Floor 1).

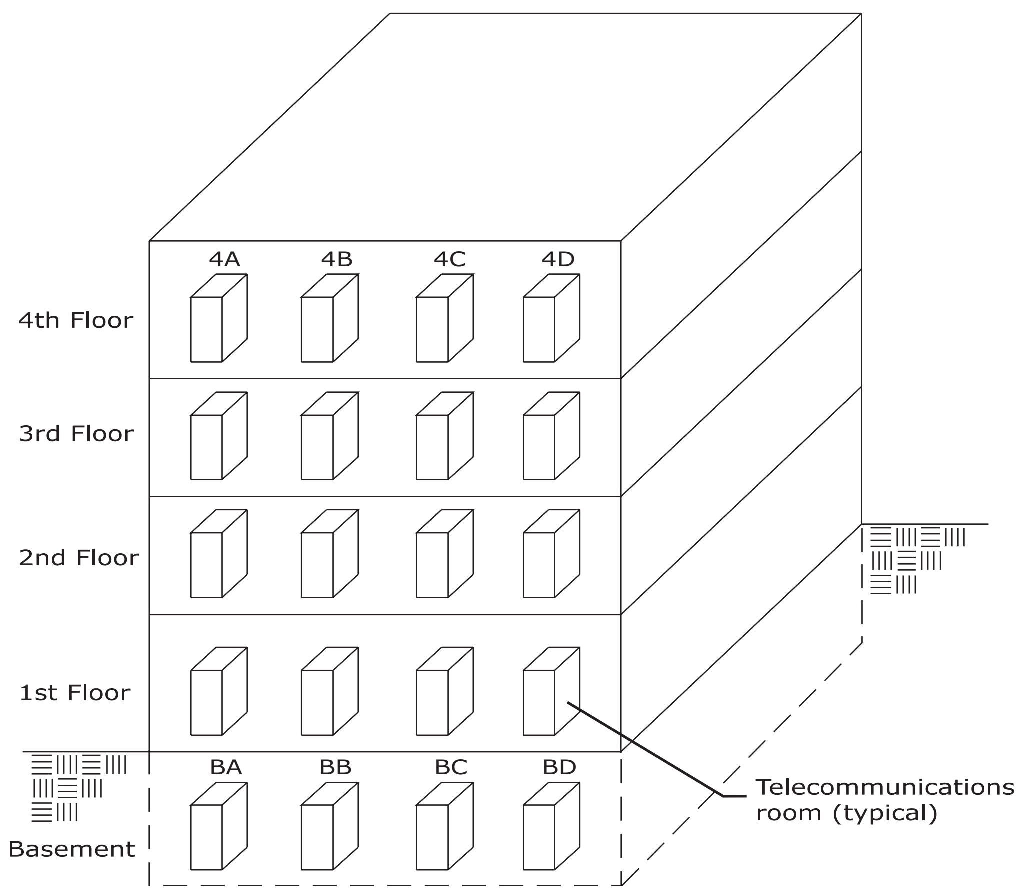
Telecommunications Spaces Identification, continued

Example

Using TRs as an example, consider a four-story building with a basement (see Figure 1.3). The building has four TRs on each level. The TRs are numbered:

- BA through BD in the basement.
- 1A through 1D on the first floor.
- 2A through 2D on the second floor.
- 3A through 3D on the third floor.
- 4A through 4D on the fourth floor.

Figure 1.3
Numbering telecommunications rooms



Telecommunications Pathways Identification

There are many types of pathways that may be installed in and between buildings. If equipment (e.g., repeater housings) is installed in MHs, the MHs may be classified as spaces rather than pathways.

The alphanumeric scheme should indicate the:

- Type of pathway followed by a sequential number.
- Floor in multistory buildings.
- Campus zone numbers for underground pathways on large campuses.

Example

Assume a four-story building with a basement has cable trays from each TR to each of two work areas. On the fourth floor, the two cable trays leaving the TRs 4A and 4Ds are numbered as follows:

- 4A trays are numbered:
  - PCT4A-1.
  - PCT4A-2.
- 4D trays are numbered:
  - PCT4D-1.
  - PCT4D-2.

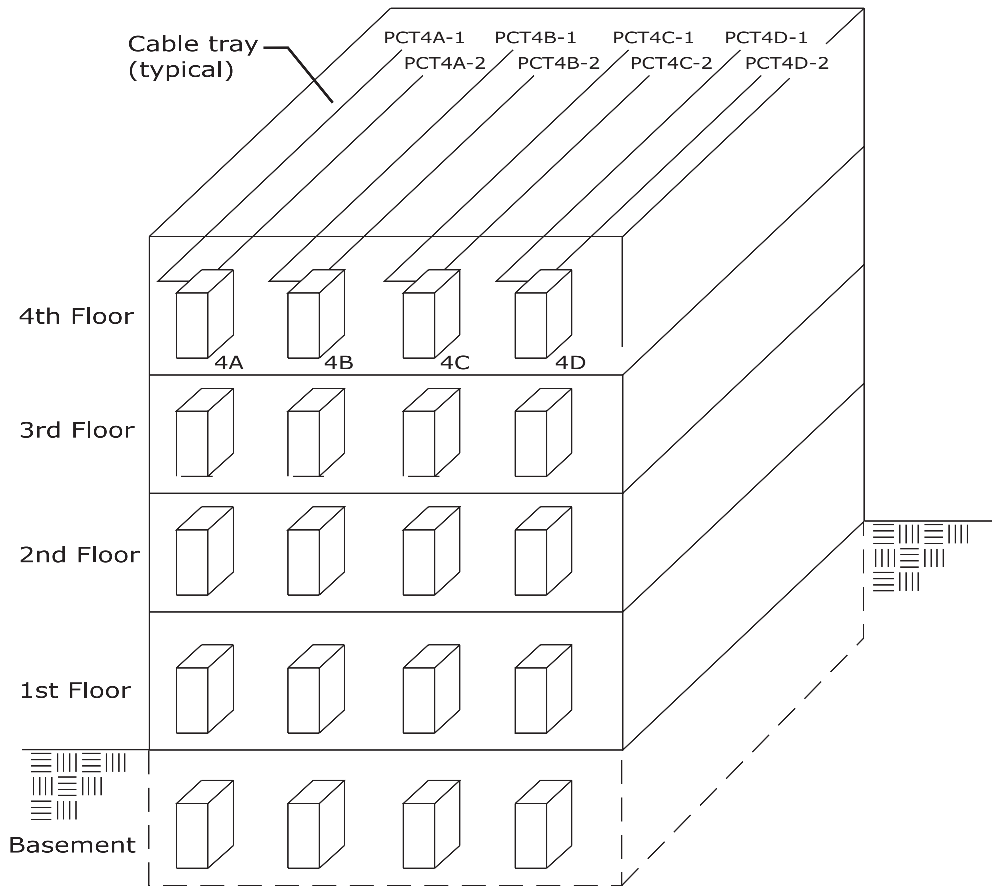
See Figure 1.4 for numbering cable trays.

Alternately, the cable trays could be sequentially numbered PCT-1 through PCT-40, where the:

- Basement cable trays are PCT-1 through PCT-8.
- First-floor cable trays are PCT-9 through PCT-16. The sequential numbering should be continued as needed.

Telecommunications Pathways Identification, continued

Figure 1.4
Numbering cable trays



Telecommunications Cable Identification

Cable Function Color Code

As an aid to troubleshooting, cables may be identified to indicate their basic function. The identifier should be applied at each termination and wherever the cables are accessible. An alternative choice is to purchase cables with the desired jacket colors.

Cable Alphanumeric Scheme

The alphanumeric scheme for cables should have a prefix that indicates the type of media (e.g., copper, coaxial, or optical fiber) followed by the termination field and a sequential number.

Connecting Hardware Identification

All balanced twisted-pair cables associated with building cabling systems use IDCs for termination. These can be installed in several row/column configurations for use with balanced twisted-pair cables, jumpers, and modular plug patch cords.

The alphanumeric scheme should identify the:

- Space in which the terminations are installed.
- Type of termination field.
- Termination function.
- Termination field row and column.
- Termination position.

Coaxial and optical fiber cables may be terminated on physically separate panels or in rack or cabinet-mounted panels with balanced twisted-pair cable terminations.

Connecting Hardware Identification, continued

Color-Coding

The color codes for cross-connect fields are shown in Table 1.5.

Table 1.5
Color codes

The Color…	Identifies…
Orange	Demarcation point (e.g., central office connections)
Green	Network connections (e.g., network and auxiliary equipment)
Purple	Common equipment (e.g., connections to PBX, main frame computer, LAN, multiplexer)
White	First-level backbone (e.g., termination of building backbone cable connecting MC [CD] to ICs [BDs])
Gray	Second-level backbone (e.g., termination of building backbone cable connecting ICs [BDs] to HCs [FDs])
Blue	Horizontal cable (e.g., horizontal connections to telecommunications outlet/connectors)
Brown	Campus backbone (campus cable terminations) NOTE: Brown takes precedence over white or gray for campus runs.
Yellow	Miscellaneous (e.g., auxiliary, alarms, security)
Red	Reserved for future use (also, key telephone systems)

BD = Building distributor
CD = Campus distributor
FD = Floor distributor
HC = Horizontal cross-connect
IC = Intermediate cross-connect
MC = Main cross-connect
PBX = Private branch exchange

NOTES: Industry practice varies according to local codes and practices (e.g., industry practice in Canada is to use white or silver for common equipment terminations and purple for first-level backbone terminations).

Industry practices in some areas reserve red for life-safety alarm systems.

Connecting Hardware Identification, continued

Accepted methods for color-coding cross-connect fields include the use of colored backboards, connections, covers, or labels.

These color assignments are for identifying only cross-connect fields. They are considered to be independent of media type and telecommunications services (e.g., voice or data) and do not apply to protection apparatus or other elements of the cabling system for which other (proprietary) color schemes may be used.

Bonding and Grounding System Identification

All but the most basic bonding and grounding systems have at least five components that should be identified:

- Telecommunications main grounding busbar (TMGB)
- Telecommunications grounding busbar (TGB)
- Telecommunications bonding backbone (TBB)
- Grounding electrode conductor (GEC)
- Equipment bonding conductor (EBC)

The following sections describe how to label the listed components. See Figure 1.5 for an example of the labeling.

Telecommunications Main Grounding Busbar (TMGB)

TMGB must be labeled by its acronym in compliance with standard requirements. Any given building has only one TMGB, so no further identification or numbering is required. Each building on a campus must have its own bar labeled TMGB. See the labeling example in Figure 1.5.

Telecommunications Grounding Busbar (TGB)

TGBs are subordinate to the TMGB and located in each ER and TR. The prefix must be TGB to comply with standard requirements, followed by a unique number. Either sequential numbering or other unique number may be used, as follows:

- Labels in a sequential numbering scheme are TGB-1 (or TGB-A), TGB-2 (or TGB-B), and so on.
- Alternately, the number of the room in which the TGBs are installed may be used. For example, if the TGBs are installed in rooms 110, 210, and 310, they are labeled TGB-110, TGB-210, and TGB-310.

See the example in Figure 1.5.

Grounding System Identification, continued

Telecommunications Bonding Backbone (TBB)

The TBB may be labeled by the prefix bonding conductor (BC), TBB, or other convenient identifier. The numbering may:

- Be sequential (TBB-1 or TBB-A, TBB-2 or TBB-B, and so on), or
- Indicate the TGB on which the conductor terminates, as in TBB-110, TBB-210, and TBB-310 from the example above. See the example in Figure 1.5.

Grounding Electrode Conductor (GEC) and Other Conductors

All conductors on the TMGB should be labeled. These include the:

- Telecommunications bonding backbone (TBB).
- Conductor connected to the electrical service entrance ground bar.
- Grounding electrode conductors (GECs).

In basic installations, there may be only one GEC, which may be labeled GEC or other convenient, but unambiguous identifier.

In many buildings, there may be more than one GEC connected to the TMGB and each should be identified with the earth electrode to which it is connected.

Grounding Electrode Conductor (GEC) Example

Assume a building has two earth electrodes:

- Perimeter ground ring
- Metallic water service pipe

If the TMGB is bonded separately to each electrode, the GECs may be labeled:

- GEC-GR for the ground ring.
- GEC-WP for the water pipe.

Equipment Bonding Conductor (EBC)

Any meaningful prefix, such as EBC, may be used for labeling.

In installations with more than one equipment rack or cabinet, the suffix should indicate the rack or cabinet in which the EBC terminates.

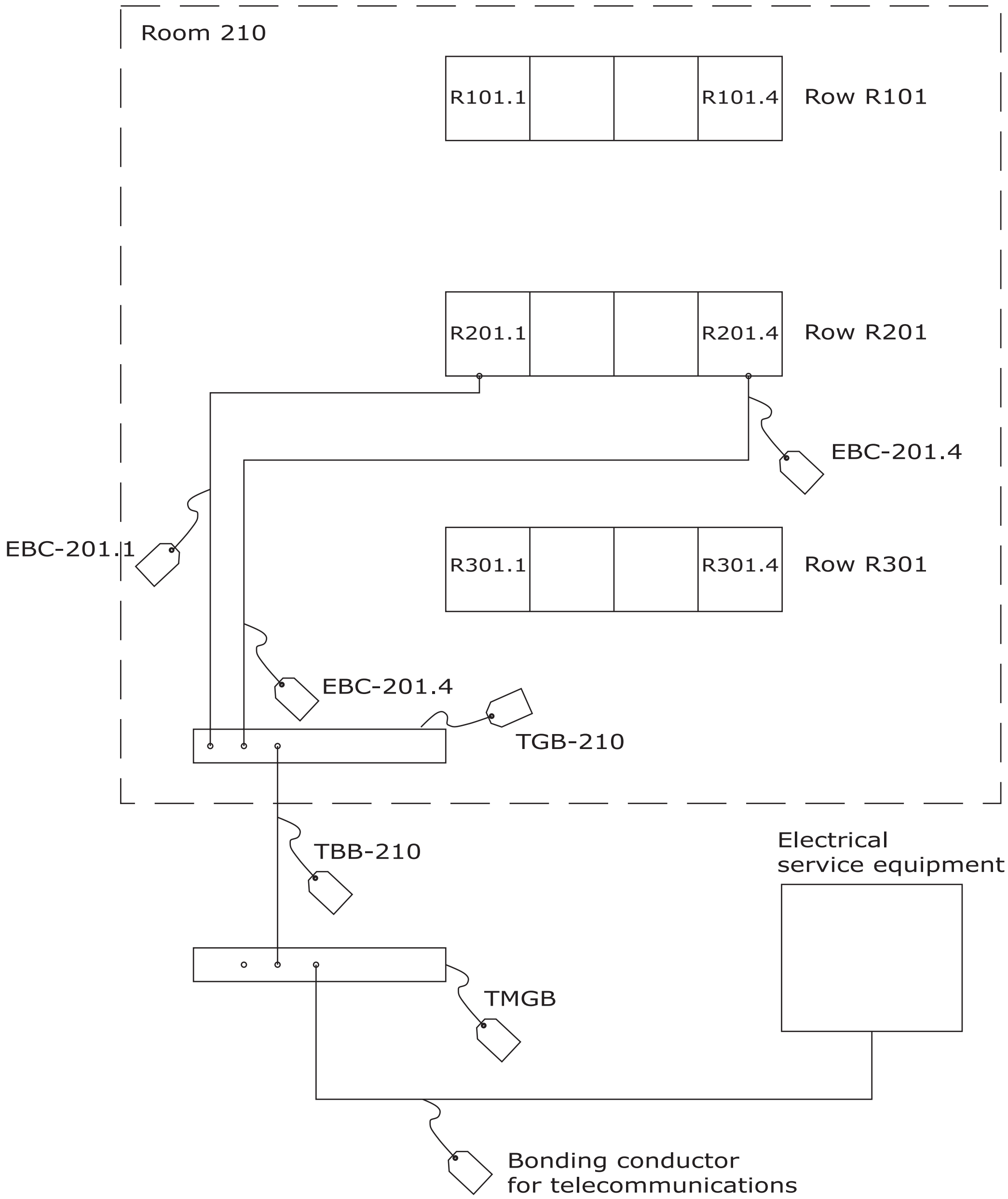
Equipment Bonding Conductor (EBC) Example

Assume the fourth rack or cabinet in line-up R201 is labeled R201.4. The EBC would then be labeled EBC-201.4 at both ends.

Grounding System Identification, continued

See the labeling example in Figure 1.5.

Figure 1.5
Labeling example



EBC	=	Equipment bonding conductor
TBB	=	Telecommunications bonding backbone
TGB	=	Telecommunications grounding busbar
TMGB	=	Telecommunications main grounding busbar

Telecommunications Equipment Identification

The alphanumeric scheme used to identify equipment depends on the equipment and its mounting configuration. A small amount of wall-mounted equipment is labeled differently than multiple rows of equipment racks or cabinets.

- In basic installations, individual cabinets should be identified by their function or use (e.g., where several different key telephone systems are installed in an ER to serve the building tenants).
- In complex installations with rack- or cabinet-mounted equipment, a more sophisticated numbering scheme is required. The preferred numbering scheme uses a row, rack or cabinet, shelf, slot, and circuit naming system.

An example equipment identification system is shown in Figure 1.6.

Row/Rack/Cabinet Identification

Each equipment rack or cabinet may be:

- Numbered sequentially (R1, R2, …, R*n* or B1, B2, …, B*n*), or
- Coded by line-up (row) and rack or cabinet within each line-up (R1-1, R1-2, …, R*n*-*n*).

The latter scheme is preferable because it allows orderly expansion and changes. Other schemes identify individual racks or cabinets of equipment by function (e.g., common equipment, peripherals, and input/output). Stencils should be used to label each rack or cabinet.

Shelves, Slots, and Circuit Card Identification

Shelves, slots, and circuit cards should be identified as follows:

- Equipment shelves within a rack or cabinet are usually numbered starting at the bottom. Many manufacturers count the lowest shelf as shelf 0. Where equipment is built up on site, the bottom shelf may be numbered shelf 0 or shelf 1.
- Slots on equipment shelves are numbered sequentially.
- Where a printed circuit card consists of more than one circuit, the circuits are numbered starting at 0 or 1, depending on the manufacturer.

Example

Assume the following (see Figure 1.6):

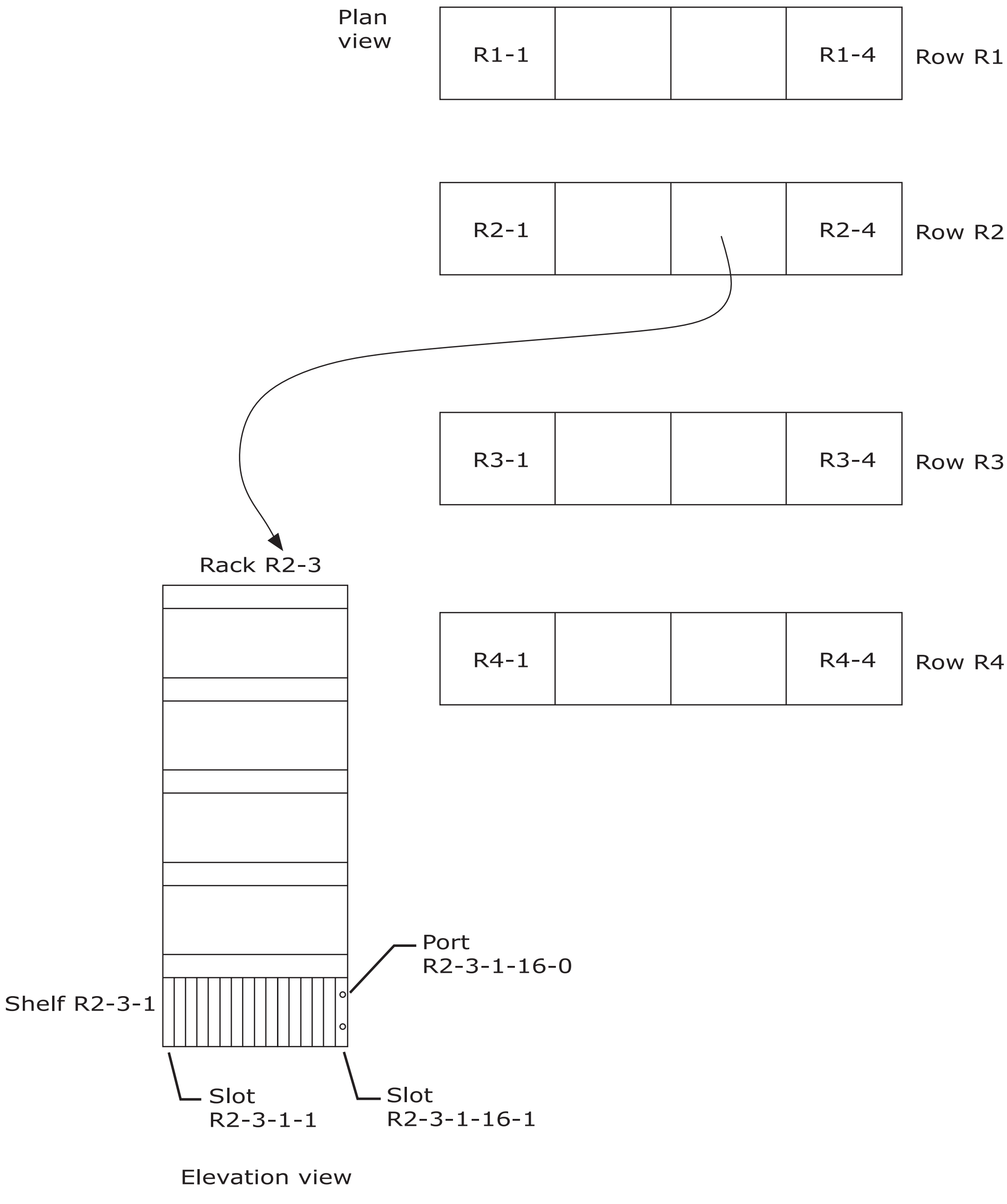
- An ER consists of 16 racks or cabinets arranged in four equal rows, R1 through R4.
- The first four racks or cabinets are numbered R1-1 through R1-4.
- The second four racks or cabinets are numbered R2-1 through R2-4.
- A new equipment shelf with 16 slots is to be installed in the bottom of the third rack in the second row.
- Each slot has two ports.

In this case, the:

- New shelf is identified by the number R2-3-1.
- Slots are numbered R2-3-1-1 through R2-3-1-16.
- Two ports in slot 16 are numbered R2-3-1-16-0 and R2-3-1-16-1.

Telecommunications Equipment Identification, continued

Figure 1.6
Example of equipment identification



Intelligent Patching

Intelligent cabling systems manage and protect an information technology (IT) investment. They can continuously monitor connections between the cabling system and network equipment in real time. These systems feature a combination of connecting hardware and software to provide a new dimension of network management capability.

Intelligent cabling systems are:

- Available in a variety of categories (classes) of cabling.
- Available in both copper and optical fiber cabling.
- Capable of monitoring cabling connections in real time.
- Able to discover and document cabling connections.
- Able to discover and document network equipment.
- Able to streamline troubleshooting and resolution of cabling/network issues.
- Capable of enhancing security by monitoring/preventing network access of unauthorized devices.
- Able to maximize network utilization through identification of unused ports.
- Capable of self-identifying the network assets to improve tracking and reporting.

Administration of Data Center Computer Rooms and Equipment Rooms (ERs)

This section provides administration guidelines for data center computer rooms and ERs.

Grid Coordinates

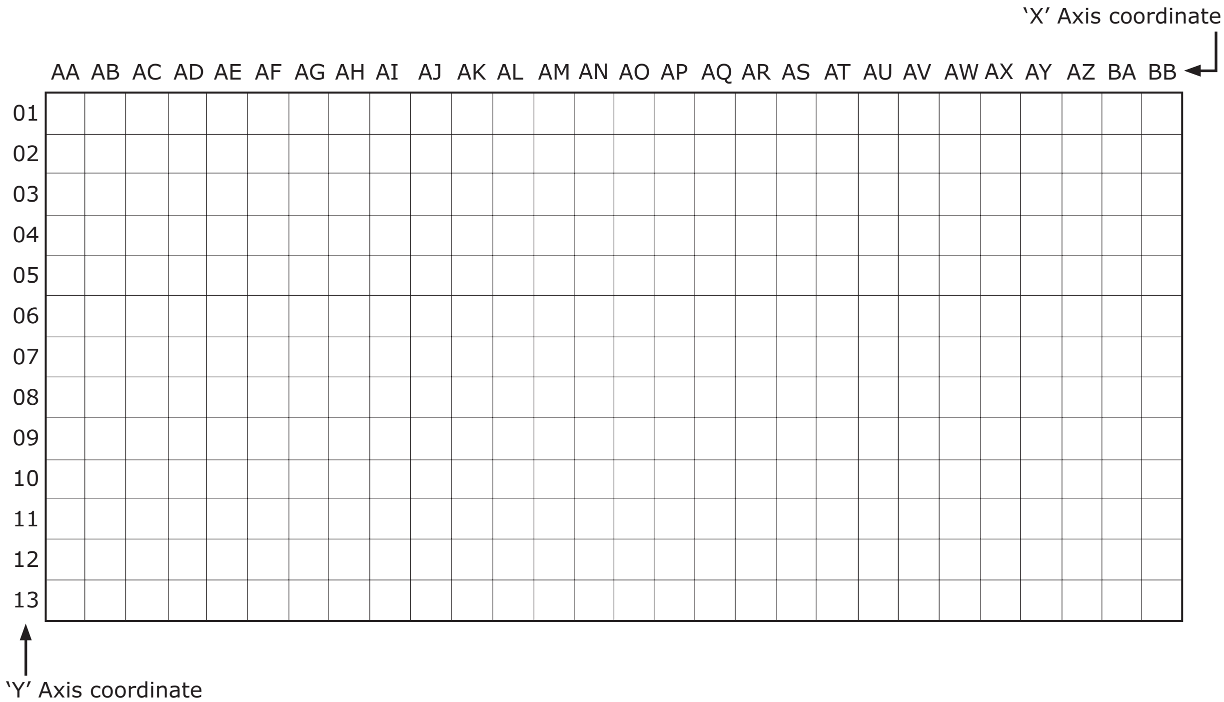
Use a grid coordinate system to identify floor plan locations for equipment cabinets and racks. When this is not practical, refer to the section titled “Alternative Guidelines to a Grid System.”

There are three methods to identify floor plan locations for equipment cabinets and racks. These three methods include:

- Use of the access floor tile grids.
- Use of the ceiling tile grid in rooms without access floor systems.
- Application of a grid to the floor plan (see Figure 1.7), if the room has neither an access floor tile grid nor ceiling tile grid.

Administration of Data Center Computer Rooms and Equipment Rooms (ERs), continued

Figure 1.7
Room grid coordinate example



Cabinet and Rack Location Identifiers

An example of grid coordinate location identifiers is shown with a format of fs.x_1y_1, where:

f = Floor (optional identifier).
s = Data center computer rooms or ERs (optional identifier).
x_1 = "X" axis coordinate of the rack or cabinet (required identifier).
y_1 = "Y" axis coordinate of the rack or cabinet (required identifier).

NOTES:

- If the X axis has 25 or fewer coordinates, label A-Z.
- If the X axis has between 26 and 676 coordinates, label AA-ZZ.
- If the Y axis has 10 or fewer coordinates, begin labeling at 0 or 1.
- If the Y axis has more than 10 but less than 100 coordinates, begin labeling at 00 or 01.

Administration of Data Center Computer Rooms and Equipment Rooms (ERs), continued

Alternative Guidelines to a Grid System

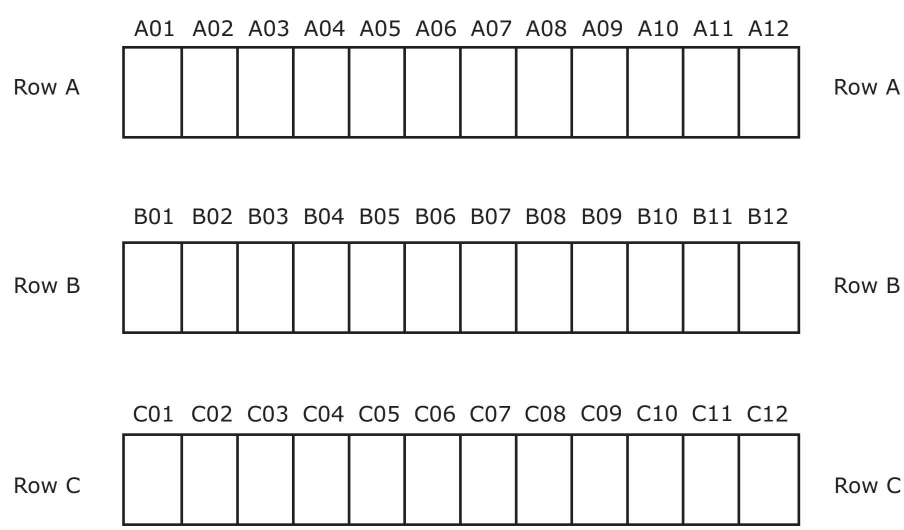
In rooms that are unable to utilize the grid identifier, cabinets and racks may be identified by their row number and location within the row (see Figure 1.8).

Where grid coordinates are not available, consider a location identifier using the format of fs.x_1y_1 where:

- f = Floor (optional identifier).
- s = Data center computer rooms or ERs (optional identifier).
- x_1 = X axis coordinate of the row identifier of the rack or cabinet (required identifier).
- y_1 = Y axis coordinate of the location within a row of racks or cabinets (required identifier).

NOTE: When the optional space identifiers are not used, the format of the location identifier for cabinets and racks is x1y1.

Figure 1.8
Sample rack and cabinet nongrid identifiers



References

American Society for Testing and Materials International. ASTM G153. *Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*. West Conshohocken, PA: American Society for Testing and Materials International, 2004.

Telecommunications Industry Association/Electronic Industries Alliance. ANSI/TIA/EIA-606-A. *Administration Standard for Commercial Telecommunications Infrastructure*. Arlington, VA: Telecommunications Industry Association, 2002.

Underwriters Laboratories Inc.® UL 969. *Marking and Labeling Systems*. Northbrook, IL: Underwriters Laboratories Inc., 1995.

Chapter 2
Design, Construction, and Project Management

Chapter 2 describes the key elements, roles, and processes associated with a construction project. Project management and the design, bidding, construction, and post-construction phases are covered.

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Overview

General

This chapter is an overview of the key elements, roles, and processes associated with each phase of a construction project. The chapter covers the design, bidding, construction, and post construction phases of a project. The basic concepts of project management also are discussed.

This chapter does not provide a detailed understanding of every aspect of the design and construction of a new building. However, the chapter helps the telecommunications consultant to understand the formal design and construction processes used by the construction industry. Additional resources and recommended readings are listed at the end of the chapter.

Information Technology Systems (ITS) Project Management

Project management is a discipline that encompasses planning, organizing, and managing resources to achieve successful completion of specific project goals and objectives. Project management has become an important part of the information technology systems (ITS) industry.

A large project usually has several project managers (PMs), each of whom are responsible for a different organization or activity.

For this reason, common tools and techniques have been developed, including:

- Program evaluation and review technique (PERT).
- Critical path method (CPM).
- Earned value cost-tracking method.

These tools allow a PM to use similar tools and tracking methods for the overall project and for the various subprojects.

Information Technology Systems (ITS) Project Manager (PM)

Becoming a successful ITS PM requires knowledge of the project management process and the telecommunications process (e.g., codes, standards, installation methods, telecommunications design). It also requires management, leadership, and communications skills.

Traits of a good PM include:

- Organizational skills.
- Ability to assume authority.
- Ability to focus on key issues.
- Good customer skills.
- Flexibility.
- Personal accountability.
- Interpersonal skills.

Project Management Steps

Managing an ITS project involves three basic steps:

- Building a plan
- Tracking and managing the project
- Closing the project

These steps seem simple, but many projects start without a plan or with a plan that exists only in the minds of the individuals involved in a project. Without a plan, a project cannot be controlled. The PM's role is to develop a team from among the individuals involved in the project, which requires both leadership and planning.

Project Management Knowledge Areas

There are nine generally recognized major areas of project management:

- Human resources management
- Scope management
- Integration management
- Time management
- Cost management
- Quality management
- Communications management
- Risk management
- Procurement management

These nine areas are not handled in sequence, but they need to be addressed at every stage of the project.

Human Resources Management

The human resource area of project management covers personnel issues, which involves engaging the right people to do the job and ensuring they are properly trained, equipped, and motivated. In addition, project safety, an area where the PM may have the greatest personal liability, also is covered by this area.

Scope Management

Scope management of a project involves development of a scope statement approved by both the customer and the company. The scope can include and go beyond the detailed specifications for the job.

NOTE: The scope may be understood as the fence around a project and includes a list of assumptions about the project.

Project Management Knowledge Areas, continued

Integration Management

Integration management of a project covers the breakup of a large project into multiple small projects or the reverse, running several small projects as one large one. It involves the integration of various subteams (e.g., electrical contractor, private branch exchange/local area network [PBX/LAN] vendors) into a project organization with an integrated plan.

Time Management

Time management of a project covers time estimates and schedules. It includes the integration of time schedules from various subteams and calculation of the critical path of events on the project. During the project, a current schedule must be maintained and communicated to the team.

Cost Management

Cost management of a project includes development of a cost estimate and project budget. During the project, costs are tracked and budgets are adjusted and updated to reflect a change order or additional service activity.

Quality Management

Each project should have a quality management plan that includes detailed review of the design documentation throughout the project. In the event that the ITS designer is also responsible for the build portion of the project, then physical quality (i.e., workmanship) and test results would also be a part of this area. Finally, customer value items (e.g., punctuality, appearance, and professionalism of the cabling installers) are included in this area.

Communications Management

Communications management of a project does not just happen—it is planned. A communications plan includes scheduled meetings and the use of electronic media. In certain situations, it may be a good idea to establish a "war room" for the project, where the schedule and actual results can be posted on a whiteboard.

Risk Management

Each project and project element carry various types of risks. Depending on the nature of the project, it could include injury, professional damage, scheduling conflicts, errors and omissions, and cost risk. If possible, a risk assessment should be completed before a company submits a proposal on the project. A risk plan should then be developed with a focus on mitigating the risk.

Procurement Management

This area of project management covers procurement of resources outside the team, including materials and subcontractors. It includes the transport and storage cost of bulk purchases versus just-in-time procurement on a construction-type project.

Developing a Project Plan

A simple method for developing a project plan is to answer the following questions:

- What went wrong on the last project (i.e., lessons learned)?
- What needs to be done (i.e., scope of work [SoW])?
- How will accidents be prevented (i.e., safety plan)?
- Who should develop a project plan (i.e., organization breakdown structure [OBS])?
- Who performs which task (i.e., work breakdown structure [WBS])?
- When is each job performed (i.e., PERT/CPM, milestone, Gantt, and calendar charts)?
- What is the budget (i.e., earned value tracking)?
- How will quality be checked (i.e., quality plan)?
- How will job status be tracked (i.e., communications plan)?

NOTE: Tools that will help to answer the questions are shown in parentheses.

Lessons Learned

End each project with a lessons learned meeting to discuss what went well on the project and what could be improved. It is important for the meeting to be constructive and positive. A corrective action program should be developed for the purpose of continuous quality improvement.

NOTE: The first step on a project should be a review of the lessons learned from the previous project.

Developing a Scope of Work (SoW)

The next step in the project plan is to develop an SoW. The SoW is based on the request for proposal (RFP), project specifications, or needs analysis and is normally included in a response to the RFP. An effective SoW sets clear expectations between the ITS designer and the customer. When these expectations are clear for both parties, deviations from this scope are more easily identified and negotiated as changes to the proposal's cost basis.

Further, when the project is completed, it will be easier to demonstrate to the customer the quality of work and obtain final payment if all the requirements of the SoW can be reviewed accurately and demonstrated as performed to the customer.

An SoW should contain the:

- Customer needs.
- Project objective.
- Project size.
- Project schedule.
- Assumptions.

Developing a Safety Plan

Having a safety plan and an active safety program sends a good message to the customer and all team members. On a project where an ITS designer is issuing only the design documentation, safety may be excluded from the scope. On the other hand, if you are responsible for construction as part of the scope, safety may be the area of greatest risk to the project.

When appropriate, based on the level of risk, a safety coordinator should be appointed for the project. The safety coordinator will review the current safety plan and apply the plan to the project. For a construction project, the safety coordinator also will contact the customer safety coordinator to learn what additional precautions are required at the site, site-specific emergency procedures, and contact numbers.

All subcontractors should be required to have a safety plan. The safety coordinator also should hold a safety meeting prior to the start of the project. The safety coordinator responsibility may be a part-time position and the PM may consider rotating the assignment among the team members.

Some areas that should be addressed by the safety plan are:

- First aid training.
- First aid kits.
- Emergency numbers.
- Motor vehicle safety.
- Work area protection.
- Ladder safety.
- Working with optical fiber.
- Safety glasses.
- Hard hats.
- Hazardous materials.
- Maintenance holes/confined spaces.

More detailed safety information is available in the most recent edition of BICSI's *Information Technology Systems Installation Methods Manual* (*ITSIMM*) and from the following organizations:

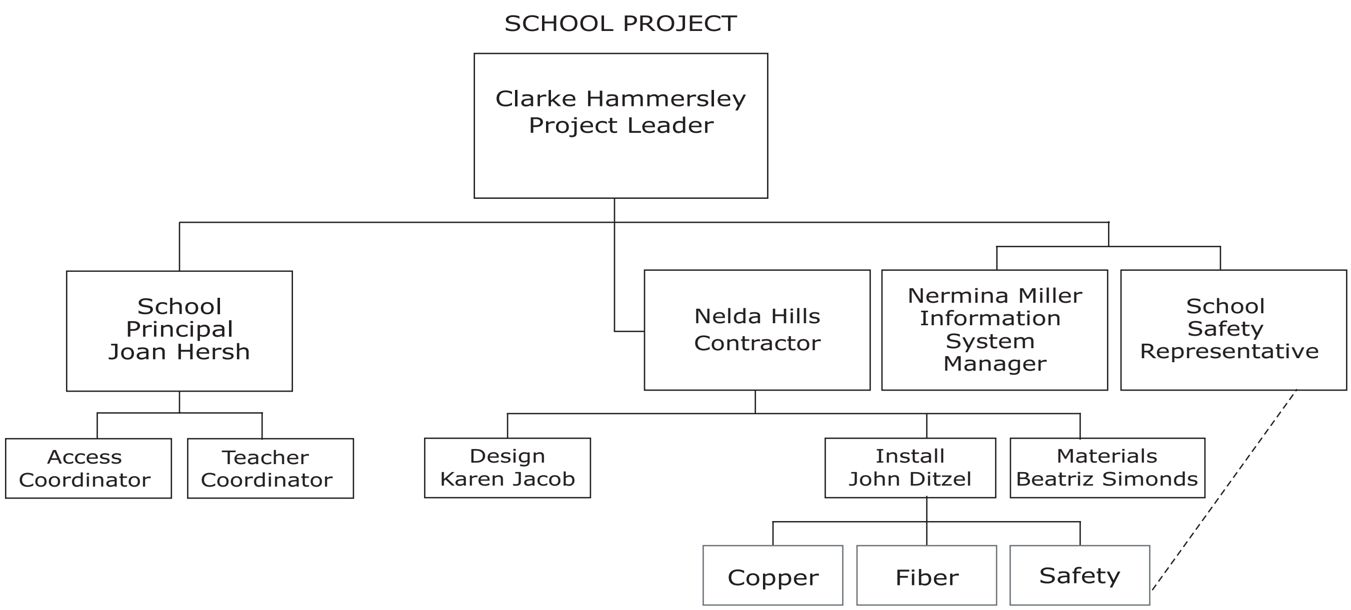
- Health and Safety Executive (www.hse.gov.uk)
- European Agency for Safety and Health at Work (www.osha.europa.eu)
- British Safety Council (www.britsafe.org)
- National Safety Council (www.nsc.org)
- Occupational Safety and Health Administration (www.osha.gov)

Developing an Organization Breakdown Structure (OBS)

Another step in the project planning process is to identify the people and organizations needed to complete the SoW. The recommended method for this is an organization breakdown structure (OBS). The OBS is similar to an organizational chart. However, the OBS differs from a traditional organizational chart because it covers everyone involved regardless of the company or organization. The OBS is the organizational chart for the project (see Figure 2.1).

The OBS shows who is responsible for other team members. The OBS may not correspond to a normal rank or pay chart (e.g., a vice president may report to a manager) but lets everyone know their role. The OBS should include telephone numbers and e-mail addresses for each team member—including the customer's team and others who might affect the team (e.g., the electrical contractor).

Figure 2.1
Simple organizational breakdown structure



Building a Work Breakdown Structure (WBS)

There are certain rules for developing a sound, usable, and consistent work breakdown structure (WBS).

The WBS must cover the elements of the project's end product or deliverable and also cover all the elements of the project, including:

- Starting (planning) the project.
- Conducting (implementing) the project.
- Completing (closing out) the project.

The content of a WBS should be as specific as possible. A WBS can be diagrammed as a tree structure or an outline. It starts at the topmost level as a single entry. In forming the tree or outline, the rule is that each parent may have multiple children but each child has only one parent. As the structure develops, each lineage or branch need not have the same number of generations or levels. The lineages or branches do not need to end at the same level of indent.

The lowest level of each branch must end at or represent a unit or package of effort that can be uniquely scheduled and easily understood by all team members. It should be defined enough to be assigned to an individual (or team) for performance or execution. This level need not be the lowest level of estimate or schedule prepared, but must represent a unique assembly of components or elements. It is the level at which the schedule and budget meet to cover the same elements of work or effort.

Assembling the total progress for a WBS should require only the addition of weighted elements. Weighting for each element that combines into a higher level is preferably shown on the WBS, but it remains constant over the entire course of the project execution—unless and until there is an agreed and approved change of scope, budget, or schedule for the project's execution.

Preparing or assembling the input to the lowest WBS level—the level where cost and schedule represent identical things—may involve some allocating and proportioning from the raw information and should be done on a sound, consistent, constant, and published basis.

Building a Work Breakdown Structure (WBS), continued

A WBS is not:

- A code of accounts or a set of accounting codes. It is often useful to have a match, but to simply transfer one to the other is neither sound nor effective in project control. This is because accounting codes are designed for continued use, whereas the levels of the WBS have a very temporal usefulness and need to be tailored to the specific project.
- An organizational structure, nor is it a reflection of either corporate or project organizational structure. It is true that at the lowest level of each branch there should be a single responsibility, matching a position within the project's organizational structure.
- A time-scaled or time-based representation of either the project's execution or the development and assembly of its end product.
- Supposed to contain elements of effort, cost, schedule, or products that are not needed in or for the execution (e.g., implementation, doing, completion) of the project. It should include all the elements with which the project will be charged.
- Readily or easily standardized. Templates can be useful for the elements concerned with the project execution if the organization implements or executes projects in a relatively standard or consistent way. However, since the WBS also must contain all the elements of the project's product—largely the subject of client election and specification—such a template should never be considered either correct or complete for any given actual project effort.

  The elements relating to the execution steps or content are often individually influenced by the:

  – Client.

  – Product.

  – Market conditions at the time of any project's initiation and execution.

Building a Work Breakdown Structure (WBS), continued

Once the team required to complete the SoW has been identified, tasks are assigned to the team members. These can be further broken down into work packages (usually 40 hours) and summary tasks. Most PM software tools include the WBS as part of the Gantt chart (see Example 2.1).

Example 2.1
Work breakdown structure

Task Number	WBS Number	Task Name
1	1.0	School project manager
2	1.1	Develop scope
3	1.2	Resolve assumptions
4	1.3	Develop budget
5	1.4	Arrange access
6	1.5	Kickoff meeting
7	2.0	Our project manager
8	2.1	Develop scope
9	2.2	Assumptions
10	2.3	Build plan
11	2.3.1	Budgets
12	2.3.2	Schedules
13	2.3.3	Resources
14	2.3.4	Safety plan
15	2.4	Manage plan
16	2.4.1	Monthly meetings
17	3.0	Engineering
18	3.1	Design
19	3.2	Materials
20	3.3	Drawings
21	3.4	As-builts

Building a Work Breakdown Structure (WBS), continued

A WBS also can be built as a text outline (see Example 2.2).

Example 2.2
Work breakdown structure in a text outline format

School Project WBS

1.0 School project manager
- 1.1 Develop budget.
- 1.2 Identify locations.
- 1.3 Arrange access.

2.0 Our project manager
- 2.1 Develop design.
  - 2.1.1 Perform site survey.
  - 2.1.2 Prepare initial drawings.
  - 2.1.3 Prepare as-built drawings.
- 2.2 Install cable.
  - 2.2.1 Place cable.
  - 2.2.2 Terminate cable.
  - 2.2.3 Test cable.

3.0 Electrical contractor
- 3.1 Place conduit.

In the above example, “place cable” is a work package and “install cable” is a summary task.

Developing a Schedule Using PERT, Milestone, Gantt, and Calendar Charts

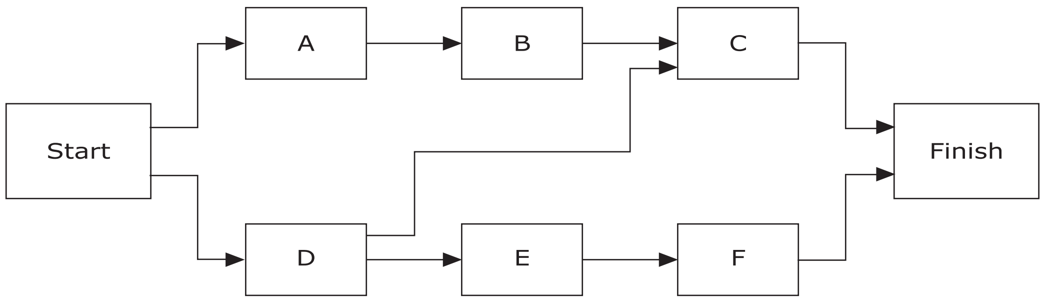
Program Evaluation and Review Technique (PERT) uses network diagrams to identify predecessor and successor relationships on projects—for example, if a permit is needed before installing cable, then “get permit” is a predecessor and “install cable” is a successor.

Another tool, Critical Path Management (CPM), uses a similar network diagram. CPM identifies the chain of events that take the longest time to complete on the project. The end date of the project is determined and identified as the critical path.

Developing a Schedule Using PERT, Milestone, Gantt, and Calendar Charts, continued

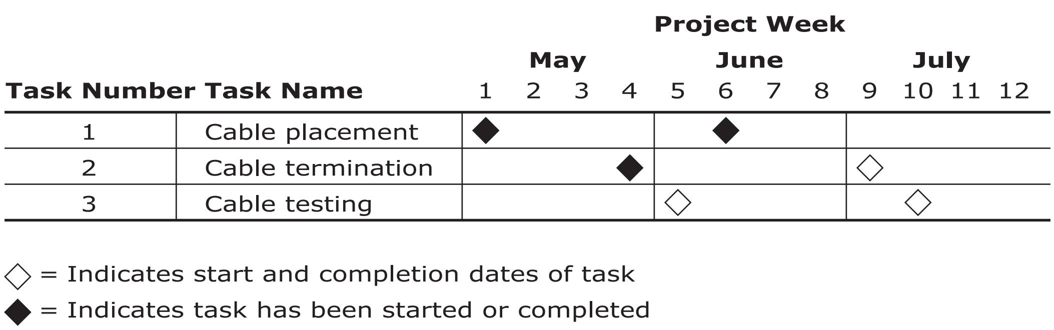
PERT diagrams are used to calculate the start and finish date for each activity on the project (see Figure 2.2).

Figure 2.2
PERT or network logic diagram using the precedence diagram method



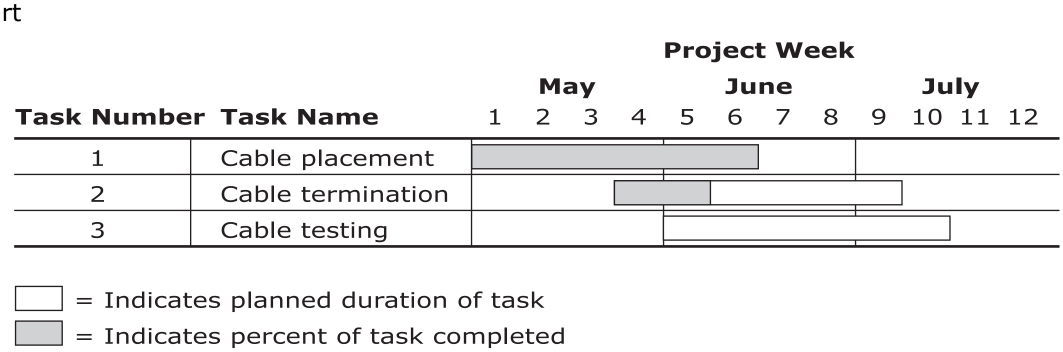
A milestone chart shows the start and finish date on a calendar graph (see Figure 2.3).

Figure 2.3
Milestone chart



A Gantt chart shows the duration of the activity by using a bar chart from start date to finish date (see Figure 2.4). Unlike the PERT chart, the Gantt chart does not show predecessor or successor relationships.

Figure 2.4
Gantt chart



Developing a Schedule Using PERT, Milestone, Gantt, and Calendar Charts, continued

It also is possible to show the schedule using a calendar (see Figure 2.5).

Figure 2.5
Calendar of schedule

May

<table>
<tr><th>Sunday</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th><th>Saturday</th></tr>
<tr><td></td><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Cable placement</td></tr>
<tr><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td colspan="7">Cable placement</td></tr>
<tr><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr>
<tr><td colspan="7">Cable placement</td></tr>
<tr><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr>
<tr><td colspan="7">Cable placement</td></tr>
<tr><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td></tr>
<tr><td colspan="7">Cable placement</td></tr>
<tr><td colspan="7">Cable termination</td></tr>
</table>

Developing Estimates

Developing the schedule and budget requires estimates of duration and cost. There are several methods of developing an estimate:

- Analogous—Analogous estimates are based on the time/cost it took to perform similar work in the past. The better the current costs are tracked, the more accurate the future estimates will be. Analogous estimates must be adjusted for current job conditions (e.g., building size and construction type).
- Parametric—Parametric estimates are based on dollar/foot, dollar/drop time, and cost. A parametric estimate is handy for developing a rough order of magnitude (ROM) estimate and is used to check an analogy estimate.
- Engineering—An engineering estimate, developed by the customer, will be put out to bid later.
- Subcontractor bids—Subcontractor bids are used to develop cost and time estimates for work that requires special tools or skills. The subcontractor will provide the customer a price that will not be exceeded. This provides an option to use the subcontract or to perform the work.
- PERT—The same program that developed the PERT chart develops PERT estimates. The program looks at the potential for overruns and underruns of time and cost and then develops a weighted average estimate. PERT uses three estimates for each activity:
  - Optimistic estimate—Lowest projected cost or fastest time
  - Most likely estimate—Average projected cost or time
  - Pessimistic estimate—Highest projected cost or slowest time

Studies show that the same activity repeated several times will have some variance in time and cost. On one job the material is late, and on another there may be access problems, asbestos in the building, or a ledge on a direct-buried cable job. These studies show that for the mathematical probability of every six jobs, four jobs are in the most likely range, one is in the optimistic range, and one is in the pessimistic range. PERT develops a fourth estimate using that probability.

The PERT formula is:

$$(\text{Optimistic} + (4 \times \text{Most likely}) + \text{Pessimistic})/6$$

A PERT estimate usually falls between the pessimistic and most likely estimates. The greater the difference between the estimates, the greater the risk.

PERT and Risk

If there is greater than a 10 percent difference between the most likely and pessimistic estimates, it is a high-risk project or activity. It may be possible to eliminate the risk by changing the assumptions in the SoW (i.e., asbestos removal is not included). Most companies require a higher level of approval to bid on a high-risk project.

It also is possible to develop four different versions of the schedule and budget:

- Optimistic view
- Most likely view
- Pessimistic view
- PERT view

Developing a Budget Using Earned Value Analysis

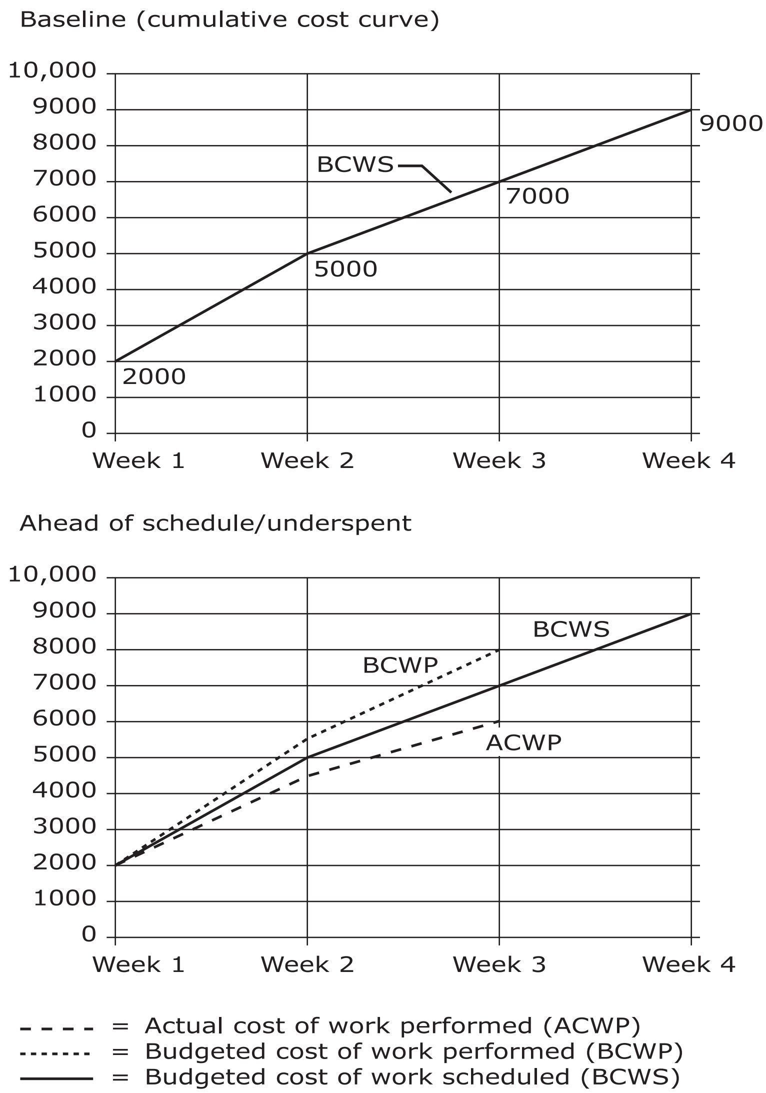
Cost estimates should be developed for each task on the PERT chart. Develop a baseline view of the budget—also called the cumulative cost curve or budgeted cost of work scheduled (BCWS). Another term for BCWS is planned value (PV). Earned value uses two other numbers to track the cost and schedule performance of the project. As each work package is completed, credit is given to a performance indicator called the budgeted cost of work performed (BCWP). Another term for BCWP is earned value (EV). By comparing the BCWS (PV) and BCWP (EV), a schedule performance index (SPI) is developed. An SPI is much easier to understand than tracking the days ahead or the days behind on every task.

The BCWS (PV) at any point in the project is the work planned. If the BCWP (EV) dollars at that point are lower than the BCWS (PV), the project is behind schedule. If the BCWP (EV) is higher than the BCWS (PV), the project is ahead of schedule. The actual cost of each task contributes to the actual cost of work performed (ACWP). Another term for ACWP is actual cost (AC). The ACWP (AC) is compared with the BCWP (EV) and gives a cost performance index (CPI [see Figure 2.6]).

NOTE: The ACWP (AC) is not compared with the BCWS (PV) since earned value only gives credit for the budget when the work is complete. If the project is ahead of schedule, the earned value method gives BCWP (EV) credit for the work performed.

Developing a Budget Using Earned Value Analysis, continued

Figure 2.6
Earned value analysis



Developing a Budget Using Earned Value Analysis, continued

The following are formulas for calculating earned value:

Cost variance	=	BCWP (EV) – ACWP (AC)
Schedule variance	=	BCWP (EV) – BCWS (PV)
Cost variance percent	=	Cost variance/BCWP (EV)
Schedule variance percent	=	Schedule variance/BCWS (PV)
SPI	=	BCWP (EV)/BCWS (PV) – (less than 1.0 = behind schedule)
CPI	=	BCWP (EV)/ACWP (AC) – (less than 1.0 = over budget)
EAC	=	ACWP + ETC or BAC × CV

Where:

BAC	=	Budget at completion
CPI	=	Cost performance index
CV	=	Cost variance
EAC	=	Estimate at completion
ETC	=	Estimate to complete

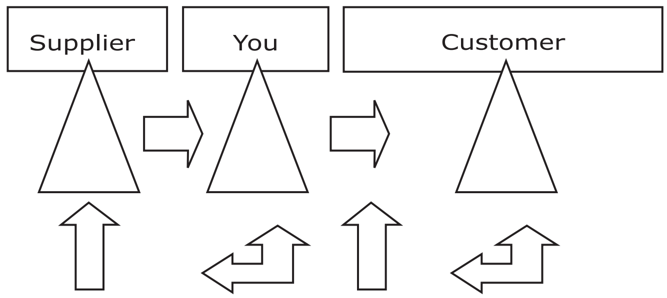
Developing a Quality Plan

For more than 10 years, the telecommunications industry has undergone a quality evolution, including some of the following points:

- Conformance quality—The first step in the quality evolution was called conformance, which focused on physical quality (i.e., neatness and test results). This step is still important, and requires workforce training and quality inspections of their work. It follows the principle of plan, do, check, and act.
- Customer satisfaction quality—The next quality stage is customer satisfaction, which involves asking customers whether they were satisfied with the service they received. Many restaurants, car dealers, and service businesses will ask the customer to rate them, often with some type of survey form. This information is then used to improve performance and provide feedback to management and, in some cases, bonuses to employees.
- Customer value quality—Customer value evaluates the relationship between the cost and quality. Customer value reviews the results on a relative basis as compared with the competition. Companies ask their customers to benchmark their performance against the competition. This works well in a long-term relationship, where the customer sees the ITS designer as a supplier.
- Customer/supplier model—One way of involving customers in helping to benchmark quality performance relative to competition is to use the customer/supplier model (see Figure 2.7). Suppliers (e.g., distributors, manufacturers, subcontractors) are expected to serve customers, so the contractor is a supplier to customers. Contractors provide outcomes to the customer. To understand what customers need, the contractor should build a feedback loop from them. Contractors depend on suppliers, and need a feedback loop to the suppliers.

Developing a Quality Plan, continued

Figure 2.7
Customer/supplier model



- Six Sigma® quality—The latest evolution of quality, Six Sigma takes customer value to the next level and tries to achieve a perfect performance level. The elements of a Six-Sigma quality program are:
  - Focus on the customer.
  - Data and fact-driven management.
  - Process focus, to manage and improve.
  - Proactive management.
  - “Boundary-less” collaboration.
  - Drive for perfection, tolerate failure.

Quality Benchmarking

Asking customers for the quality items they value and then rating the team against the company’s competition helps to develop a company’s quality plan.

Items that might be considered include:

- Experience.
- Cooperative attitude.
- Punctuality.
- Professional appearance.
- Responsive.
- Honesty.
- Adequate resources.
- Certified telecommunications installers.
- Proper tools.
- Standards compliant.
- Proper installation methods.
- Proper labels.

Developing a Communications Plan

The project team should develop a communications plan as part of the overall project plan. The plan should address the various ways the team will communicate status, change orders, and completion reports. The methods may include e-mail, shared LAN drives, whiteboards, meetings, and conference calls.

Project Planning

The amount of time spent developing the plan will vary depending on the size, complexity, and risk involved in the project. The more time spent in planning, the less time needed to track and manage the plan. Where possible, "templates" should be used to develop the plan.

Plan Review

Once the plan is developed, the plan should be reviewed with upper management and the customer. Changes in the plan may be necessary, but that will be better than resolving as unexpected events during the project.

Tracking and Managing the Plan

Having a detailed plan enables keeping the plan under control. Change orders must be communicated to the team and be approved by the customer.

Most project management software tools have built-in administration and tracking reports such as:

- Project summary reports.
- High-level tasks.
- Critical tasks.
- Milestones.
- New tasks.
- Tasks that should have started.
- Completed tasks.
- Pending tasks.
- Cash-flow reports.
- Budget reports.
- Tasks over budget.
- Earned-value tracking reports.

Architectural Design Process

In recent years, the ITS industry began integrating itself into this design process rather than performing its functions of design during the construction phase of the project. In many cases today, the ITS designer will only participate on a construction project from the perspective of a design team member.

Design Team Members

Following are the key individuals or group of individuals that comprise the design and construction team:

- Owner —The owner defines the requirements and provides approval at each design phase to ensure the design stays on track and reflects the desired objective.
- Architect—Typically, the lead design professional hired by the owner to assist with the planning and design. Often, the architectural team includes interior designers and landscape architects. Usually, the architect hires the engineers and consultants.
- Engineer—A licensed design professional, recognized by a state or local authority, who focuses on the design of a specific system or requirement (e.g., civil, structural, mechanical, or electrical engineer). Many members of an engineering firm are ITS designers who are supervised by a professional engineer (PE).
- Consultant—A design professional, recognized by an industry or industry association, who focuses on the design of a specific system or requirement that does not require a PE designation.

NOTE: In this chapter, the owner is the individual or entity with the need for a new building.

Construction Team Members

The key members of the construction team are the:

- Construction manager (CM)—A firm or individual hired by the owner to assist with the management of the bidding process and construction activities. Many CMs also are general contractors (GCs).
- General contractor (GC)—A firm or individual hired by the owner to complete the work required by the design documents. A GC usually hires a number of other contractors or subcontractors to complete portions of the work.
- Contractor and subcontractors—Firms or individuals hired by the owner or GC to complete portions of the work required by the design documents.

NOTE: In some cases, internal departments of the owner's organization may be involved with or manage portions of the design, bidding, and construction or completion of the work.

Design Phases

The various phases of design are a repetitive process whereby the owner's requirement for new space is progressively analyzed and solved with progressive levels of detail. This facilitates a process of discovery and clarification of owner requirements and aligns the availability of resources (cost) to the achievement of those requirements. In essence, it is a "drilling-down" process that leads from "big picture" items to detailed documentation that communicates design intent to a contractor.

Programming

During the design of the project, much of the emphasis is on higher-level analysis, feasibility studies, facility appropriation, budgeting, and space allocation.

Design Phases, continued

Schematic Design (SD)

Based on the program and budget, a schematic design (SD) is prepared for the owner. Sketches, graphics, general design criteria, and preliminary cost estimates are typically developed.

Design Development (DD)

Upon the owner's approval of SD documents, the design team begins detailed design development (DD) efforts. The design usually includes one or two formal reviews at 50 percent and again at around 80 percent of completion. These reviews include outline specifications, drawings, and estimates. At the completion of this phase, the design package should communicate the full intent of the project scope and all required elements of the ITS system.

Construction Document (CD)

Upon the owner's approval of DD documents, the design team prepares the construction documents (CDs). These are used to obtain pricing for the required work. CD documents communicate the owner's detailed requirements, coordination, and quality requirements in a set of CD drawings and specifications.

Bidding and Negotiating

The bid solicitation, instructions to bidders, bid forms, contract forms, and general conditions are prepared. The bid documents are distributed. The design team will prepare clarifications to the bid documents in the form of addenda. Bids are received and evaluated, and the contractors are selected.

The roles of the various team members are:

- Owner—The owner typically supplies the bidding and contracting requirements to be included in the project manual. The owner often coordinates advertising or sending invitations to the prospective bidders.
- Architect, engineer, consultant—The design team produces any addenda required to clarify the contract documents. The design team also may participate during the evaluation or negotiation of the bids and help the owner determine the successful bidder by considering alternates and substitutions.
- Construction manager (CM)—Depending on the nature of the project, the CM may lead or participate during the bidding process and the evaluation of the bids to help the owner determine the successful bidder.
- General contractor (GC) and subcontractors—The GC and other contractors prepare and submit their bids to the owner. Subcontractors prepare and submit their pricing to the GC or other contractors.

Design Phases, continued

Types of Bid Structures

Request for Proposal

A request for proposal (RFP) is an invitation for the architect/engineer/consultant (e.g. design professionals) or contractors to submit a proposal for services. The RFP dictates the scope of the project but leaves many of the design and construction decisions in the hands of the responding firm. The RFP will typically be used to procure one of the following types of structures noted below.

Design-Bid-Build

Design-bid-build (DBB) is a delivery method whereby the owner contracts with separate design and construction firms for a project. The three phases of the process are design, bid, and build. The design phase consists of design professionals working directly for the owner, providing services that include drawing and specification creation. The next phase is the bid phase. The owner solicits the documents for bidding by contractors. Once bids are received from the contractors, the owner and design professional will review these bids to award the contract. The final phase is the construction phase, which consists of construction of the facility. The design professional typically will also have a role in overseeing the contraction at the owner's request.

Design-Build

Design-build (DB) is a delivery method whereby the owner contracts with a single-entity know as the design-build team. The DB team consists of the general contractor, subcontractors and the design professionals. In this delivery process, the construction typically is overlapping the design phase. This allows for an expedited schedule, while minimizing any potential risk for the owner. Unlike the DBB scenario, the design professionals generally work directly for the contractor.

Construction Manager at Risk

Construction manager (CM) at risk is a delivery method in which the CM contracts to deliver a project within a guaranteed maximum price (GMP). The CM acts as consultant to the owner in the design phase and as a general contractor during the construction phase. The CM is often the low bidder, who is then responsible for completing the project at or under budget. This means they are acting in both the owner's and their own best interests.

Integrated Project Delivery

Integrated project delivery (IPD) is a way to organize project teams to work in a more creative and productive manner. This approach integrates all aspects of the design and construction process into a single team effort. This includes design professionals, construction managers, and contractors. IPD uses a three-pronged platform with the owner as one entity, the design professionals as the second, and the contractors as the third. The owner, design professional, and contractor act as the core group that manages the integrated project delivery process.

Design Phases, continued

Types of Bids

Two types of bids are awarded: low-bid and negotiated bid. Typically, publicly funded projects and some private projects require that the lowest qualified and responsive bidder be awarded the work. Additionally, in the United States, bidding laws often require the mechanical, plumbing, and electrical portions of the work to be bid and contracted separately from the general construction contract. This is called a multiple prime bid or filed subbid.

Many projects are awarded to a contractor based on a negotiated bid amount. After the bids are received, the owner selects a contractor and begins negotiations. A contract is then executed.

Construction Administration

Once the agreements are executed between the owner and the contractors, the planning and scheduling of construction begins. Contractor mobilization and materials purchasing occur at the beginning of the project. Submittals, shop drawings, modifications, and record documents are produced. The ITS designer's responsibility is to ensure compliance with the construction documents. This is performed through review of the submittals from the contractor as well as site visits.

Punch lists (e.g., documents that summarize corrections a contractor must make prior to accepting the work as complete) and substantial completion surveys and documents are prepared by the contractor and reviewed by the ITS designer.

The roles of the various team members are:

- Owner—During the construction, the owner is obligated to make payments to the contractor under the terms of the contract. The owner can stop work, complete work the contractor fails to complete, clean the site (i.e., if not cleaned by the contractor), and partially occupy the building. The owner also can terminate the contract without cause.
- Architect, engineer, and consultant—The design team's role during construction usually includes inspection and observation of the work with the owner's representative, which ensures the work complies with the contract documents. The design team reviews submittals, interprets the contract documents, and modifies the contract documents as required. The design team also may prepare change orders.
- Construction manager (CM)—The CM coordinates construction activities and events and typically is in charge of the construction site with respect to access, safety, and items such as storage of materials. If the contractor has a guaranteed maximum price contract with the owner, the CM also may be subcontracting out portions of the project and managing the overall budget. The CM also may issue or manage the change order.

Design Phases, continued

- General contractor (GC) and subcontractor—The GC's primary role during the construction is to complete the work. Some of the contractor's specific responsibilities include:
  - Obtaining required permits and licenses.
  - Arranging for required tests.
  - Maintaining record documents.
  - Preparing submittals.
  - Maintaining a clean and safe work environment.
  - Correcting any work rejected by the owner's representative.

Types of Contracts

Three types of contracts are:

- Stipulated sum—A contractor submits a fixed price for the SoW required. Most low-bid contracts are stipulated sum contracts; however, a stipulated sum contract also can be the result of negotiations between the owner and the contractor.
- Cost plus fee—A contractor is reimbursed for actual costs plus a fee. To establish the absolute maximum price of the project for the owner, the contractor or CM may be required to state a GMP. With this form of contract, there can be a shared savings clause or incentives for early completion. This form of contract often leads to value engineering that can generate savings during the construction phase of the building. However, these savings can return as one-time or reoccurring expenses during the operation, maintenance, or repair of the building.
- Unit price—The unit price is used when the actual SoW cannot be determined at the time of the bid. The key to obtaining effective bids is to provide a realistic estimate of the quantities for a given type of activity.

Forms

Numerous forms and documents are used to administer a construction project. In the United States, organizations such as CSI, American Institute of Architects (AIA), Engineers Joint Contract Documents Committee (EJCDC), and Design Build Institute of America (DBIA) have developed comprehensive and tightly coordinated documents. Due to this close coordination, many of the forms are standard requirements.

Design Phases, continued

The following is a list of commonly required forms:

- Notice to proceed—Tells the contractor to begin work on a particular date.
- Meeting minutes—Keeps track of the issues raised in meetings and forms the agenda for subsequent meetings.
- Request for interpretation (RFI)—Used to obtain a formal response to the contract documents.
- Field order—Used to facilitate minor changes to the requirements that do not require a change order. However, a contractor may submit a change order request in response to a field order.
- Proposal request—Used to solicit a quotation from the contractor for a proposed change to the project scope.
- Change order request—Can be submitted by the contractor in response to a field order or as an uninitiated request for a change in scope.
- Change order—The formal document that defines the required changes in project scope and identifies associated changes to the time frame, the dollar amounts, or both.
- Punch list—A document that summarizes corrections that a contractor must make prior to accepting the work as complete.

Submittals

Submittals are required throughout the construction of the project. A submittal is essentially any information that a contractor must submit to the design team for review and approval.

Some of the items that the contractor will likely need to submit are:

- Certificates of insurance.
- Surety bonds.
- Lists of subcontractors and products.
- Schedules of activities.
- Shop drawings.
- Product data.
- Samples.
- Test reports.
- Manuals and user manuals.
- Project photographs.

Design Phases, continued

Post-Construction

Cutover and first-use activities begin as soon as construction is nearly completed or is complete. Training the owner's personnel on the use and adjustments of the installed equipment and warranty inspections occurs during this post construction phase.

The operation and maintenance of various systems in the new facility often begin prior to the completion of the construction phase. The as-built version of the drawings that are used to construct the building and prepared from the record copy drawings can be integrated or incorporated into the computer-aided facility management (CAFM) system.

Final payments and release of retainage amounts are usually made well after occupancy once the owner deems the project is complete.

The roles of the various team members during this phase are:

- Owner —At this point in the project, the owner is accepting responsibility for the operation of the building. The owner's staff is:
  - Learning how the newly constructed systems operate.
  - Finalizing move-in and first-use activities.
- Architect—The architect is involved with final acceptance and contract closeout activities. Final punch lists and reviews of the new facility are being prepared. Record copy drawings are being used to update the as-built documents.
- Engineer and consultant—The engineers and consultants are actively involved with the final punch list reviews, system turn-up, and testing. System as-built documentation is being prepared from the record copy drawings.
- Construction manager (CM) —The CM is involved with final acceptance and contract closeout activities. Final punch lists and reviews of the new facility are being prepared. Final accounting activities are being addressed. At this phase, the CM is accommodating the owner's staff on the job site and coordinating the removal of construction equipment, tools, and job trailers.
- Contractors and subcontractors—The contractors are finishing up the construction activities and resolving issues identified on the punch lists. Carpet contractors, furniture vendors, painting, site restoration, signage, telecommunications contractors, movers, and other contractors are working around each other to complete the final installation and activations.

Elements of Design Package

ITS designs should include three elements:

- Specifications
- Drawings
- Cost estimates

Elements of Design Package, continued

Specifications

Specifications are one of the elements produced during the design phase of a construction project.

The four main types of specifications that can be used to define the requirements are:

- Performance—The focus is on results. Contractors can choose the materials and installation methods to provide the desired results.
- Proprietary—Specifications call out brand names and models.
- Descriptive—The focus is on exact properties and installation methods.
- Reference—Requirements are based on an established standard.

Construction documents in North America use a standardized format jointly produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

These standards are currently being harmonized worldwide. The SectionFormat™/ PageFormat™ document standardizes how the text on each page in a specification is presented and organizes the information in each section and then organizes each section into three parts:

- Part 1—General
- Part 2—Products
- Part 3—Execution

The MasterFormat™ is a list of numbers and titles compiled to organize the activities and requirements of a construction project. Before the 2004 edition, the MasterFormat™ included 16 divisions, as well as a summary of the front-end requirements. Telecommunications scope of work was included within the electrical scope of Division 16 and work areas were found on the "E" drawings. This format is still prevalent within the North American design and construction industry.

The MasterFormat™ structure was developed by CSI because construction projects can use many different delivery methods, products, and installation methods. Successful completion of these large and complex projects requires effective communication among the people involved. Information retrieval is nearly impossible without a standard filing system familiar to each user. The MasterFormat™ serves as this standard filing system.

MasterFormat™ numbers and titles are suitable for use in project manuals, for organizing cost data, placing reference keynotes on drawings, for filing project information and other technical data, for identifying drawing objects, and for presenting construction market data.

When combined with the WBS numbering for task assignments, and tracked in a visual information system (VIS) or geographic information system (GIS), the end user will be able to track what was installed, who installed it, and when the installation was completed. The system also will link to test records, pictures, drawings, and other project information in the end customer computer aided cable management (CAFAM) system.

Elements of Design Package, continued

MasterFormat™ 2004—Numbering Revision

In 2004, the CSI published a new format for the organization of project information within the construction industry. Adaptation of this format continues today. One of the most significant changes in the MasterFormat™ 2004 revision is the adoption of a six-digit numbering system in place of a five-digit system for organizing various subcategories.

Table 2.1
MasterFormat™ 2004—numbering revision

Division	Title
PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP	
Division 00	Procurement and Contracting Requirements
SPECIFICATIONS GROUP	
General Requirements Subgroup:	
Division 01	General Requirements
Facility Construction Subgroup:	
Division 02	Existing Conditions
Division 03	Concrete
Division 04	Masonry
Division 05	Metals
Division 06	Wood, Plastics, and Composites
Division 07	Thermal and Moisture Protection
Division 08	Openings
Division 09	Finishes
Division 10	Specialties
Division 11	Equipment
Division 12	Furnishings
Division 13	Special Construction
Division 14	Conveying Equipment
Division 15	Reserved for future expansion
Division 16	Reserved for future expansion
Division 17	Reserved for future expansion
Division 18	Reserved for future expansion
Division 19	Reserved for future expansion

Elements of Design Package, continued

Table 2.1, continued
MasterFormat™ 2004—numbering revision

Division	Title
Facility Services Subgroup:	
Division 20	Reserved for future expansion
Division 21	Fire Suppression
Division 22	Plumbing
Division 23	Heating Ventilating and Air Conditioning
Division 24	Reserved for future expansion
Division 25	Integrated Automation
Division 26	Electrical
Division 27	Communications
Division 28	Electronic Safety and Security
Division 29	Reserved for future expansion
Site and Infrastructure Subgroup:	
Division 30	Reserved for future expansion
Division 31	Earthwork
Division 32	Exterior Improvements
Division 33	Utilities
Division 34	Transportation
Division 35	Waterway and Marine
Division 36	Reserved for future expansion
Division 37	Reserved for future expansion
Division 38	Reserved for future expansion
Division 39	Reserved for future expansion
Process Equipment Subgroup:	
Division 40	Process Integration
Division 41	Material Processing and Handling Equipment
Division 42	Process Heating, Cooling, and Drying Equipment
Division 43	Process Gas and Liquid Handling, Purification and Storage Equipment
Division 44	Pollution Control Equipment
Division 45	Industry-Specific Manufacturing Equipment
Division 46	Reserved for future expansion
Division 47	Reserved for future expansion
Division 48	Electrical Power Generation
Division 49	Reserved for future expansion

Elements of Design Package, continued

An example of the new six-digit format is:

27 13 00 Communications Backbone Cabling

As was the case with the old system, the first two digits, in this case "27," still represent the division number, also known as "level one." The next pair of numbers, in this case "13," and the third pair "00," represents level three. Generally, level four numbers are not defined, but when they are, an additional pair of digits is attached to the end, preceded by a "dot."

An example is:

27 13 43.33 DSL Services Cabling

Additional recommendations for the use of level four and level five is included in the MasterFormat™ 2004 application guide and throughout the full publication, preserving the level of user modifiable numbers for flexibility. More importantly, because each level of classification is represented by a pair of digits, there is room to address over 10 times as many subjects at each level, providing flexibility and room for expansion that the five-digit numbers could not provide, and addressing future needs for expansion for new subject matter.

MasterFormat™ 2004 Division Number Changes Affecting Information Transport

Division 16 has been reserved for future expansion and material has been relocated to Divisions 26—Electrical, and 27—Communications in the facility services subgroup.

- Division 21—Fire Suppression: Fire suppression subjects relocated from Division 13.
- Division 25—Integrated Automation: Expanded integrated automation subjects relocated from Division 13.
- Division 26—Electrical: Electrical and lighting subjects relocated from Division 16.
- Division 27—Communications: Expanded communications subjects relocated from Division 16.
- Division 28—Electronic Safety and Security: Expanded electronic safety and security subjects relocated from Division 13.
- Division 31—Earthwork: Site construction subjects, chiefly below grade, from Division 2.
- Division 33—Utilities: Expanded utility subjects relocated from Division 2.

Drawings

Drawings are the second of the three elements to a design. The drawings show the location of the work required in relation to other required elements, as well as the quantity and size. Drawings should be drawn to scale whenever possible. Drawings are generally grouped together by discipline.

Elements of Design Package, continued

The United States (U.S.) National Computer-Aided Design (CAD) Standard (NCS)

The NCS coordinates CAD-related publications of multiple organizations. The purpose of the NCS is to allow consistent and streamlined communication among owners and design/construction teams. Use of the NCS will result in reduced costs for developing and maintaining office standards and the transfer of building design data from design to facility management. The NCS offers greater efficiency in the design and construction process documentation.

Four major organizations are involved in the development of the NCS:

- American Institute of Architects (AIA)—The AIA produces the CAD Layer Guidelines.
- Construction Specifications Institute (CSI)—The CSI produced the Uniform Drawing System (UDS).
- National Institute of Building Sciences (NIBS)—NIBS wrote the introduction, and is responsible for the administration and development of the standard. Established by Congress in 1974, NIBS interfaces between the government and the private sector. Funded with both public and private money, NIBS brings together members of regulatory agencies, legislators, and the private sector in the interest of improving the built environment. Located in Washington, DC, NIBS is the authoritative source of advice on building science and technology.
- Tri-Services (Armed Forces)—Tri-Services published the Tri-Services Plotting Guidelines.

Components of the National CAD Standard (NCS)

The goal of the NCS is voluntary adoption of the standard to streamline and simplify the exchange of building design and construction data throughout the life of a facility.

The U.S. National CAD Standard Version 3.1 includes the U.S. National CAD Standard Project Committee Report, all amendments to 3.0, Introduction and Appendices (NIBS), and the following:

- Uniform Drawing System™ (UDS), Modules 1-8—Updated with MasterFormat™ 2004 numbers, it includes guidelines and standards for sheet layout, drawing conventions, schedules, and symbols.
- AIA CAD Layer Guidelines, NCS Edition—A key component of the NCS, Version 3.0 lists the recommended layers.
- Plotting Guidelines approved by the NCS Project Committee—The guidelines include the use of 256 color ID numbers assigned to plotted line-weights and plotted colors.

The NCS effort is based on 1997 and 2003 Memorandums of Understanding among the above organizations and the NIBS, Sheet Metal & Air Conditioning Contractors National Association (SMACNA), and the federal General Services Administration (GSA). A NIBS consensus project committee with representation from 12 public and private interest categories and the entire building construction community, was formed to peer review the existing documents.

Version 3.1 of the NCS features new discipline designators, new and improved layer lists to further increase the efficient exchange of building design data, and the incorporation of new symbols.

Elements of Design Package, continued

Adoption of the National CAD Standard

Adoption of the NCS by the building design and construction industry is voluntary. However, several government agencies have adopted the standard while dozens of public and private organizations are in various stages of implementation for the design, construction, and operation of building facilities.

The NCS has been adopted by the U.S. Naval Facilities Engineering Command (NAVFAC), U.S. Navy, U.S. Air Force, and the federal General Services Administration, and used by the Architect of the Capitol, Federal Express, American Express, the State of Utah, and thousands of architecture and engineering (A/E) firms nationwide.

Drawings are used for many purposes during the life cycle of a facility, from conception to completion of construction, through facility maintenance, to demolition and then return to the natural site. Often information in one cycle is the basis for the next cycle. Therefore, it is critical that the information is accurate and organized in a way that facilitates easy retrieval and reuse.

Expanded Listing of Components of the National CAD Standard

Uniform Drawing System™ (UDS), produced by the Construction Specifications Institute (CSI) is a standardized system for organizing and presenting building design information. This flexible off-the-shelf resource is used to organize and manage construction drawings for virtually any project and project delivery method. The UDS enables drawing professionals to streamline and simplify the exchange of building design and construction data during project development and throughout the life of a facility.

Just as MasterFormat™ and SectionFormat™/PageFormat™ provide uniformity for specifications, the UDS provides a standard for drawing and enabling users to understand and use graphic symbols already in common use.

The UDS, included with Version 3.1 of the NCS, includes eight interrelated modules consisting of standards, guidelines, and other tools:

- Drawing Set Organization (Module 1)—Establishes set content and order, sheet identification, and file naming for a set of construction drawings.
- Sheet Organization (Module 2)—Provides format for sheets. Includes drawing, title block, and production reference areas and their content. Also includes a coordinate-based location system and preferred sheet sizes.
- Schedules (Module 3)—Sets consistency in format, terminology, and content. Additional guidelines include how to “build” a project-specific schedule and an organizational system for identifying and filing schedules.
- Drafting Conventions (Module 4)—Addresses standard conventions used in drawings (e.g., drawing orientation, layout, symbols, material indications, line types, dimensions, drawing scale, diagrams, notation, cross-referencing).
- Terms and Abbreviations (Module 5)—Provides standard terms and standard abbreviations used in construction documents and specifications. It provides consistent spelling and terminology, standardizes abbreviations, and notes common usage.

Elements of Design Package, continued

- Symbols (Module 6)—Addresses commonly used standard symbols, classifications, graphic representation, and organization in creating, understanding and fulfilling the intent of construction documents. The symbols are categorized using MasterFormat™ 2004 numbers and titles for easy referencing, and are a product of a joint effort with the Computer-Aided Drafting and Design (CADD)/GIS Technology Center.
- Notations (Module 7)—Provides guidelines for notation classification, format, components, and location including use of notes, terminology, and linking to specifications.
- Code Conventions (Module 8)—Identifies types of general regulatory information that should appear on drawings, locates code-related information in a set of drawings, and provides standard graphic conventions. It can also be a tool to expedite code review by designers and plan review authorities.

AIA CAD Layer Guidelines: NCS Version 3.1, produced by The American Institute of Architects (AIA)—The guidelines allow building construction data to be organized and managed through the use of standard CAD layer and file designations. It includes the following:

- Introduction—Overview, history, and highlights of the changes to the AIA CAD Layer Guidelines
- Layer Name Format—Concepts and guidelines behind the layer types
- Layer Lists—Guidelines for 23 types of layers
- Commentary on the NCS and ISO 13567—Discusses the relationship between the NCS and the international standard, Organizing and Naming of Layers for CAD (International Standards Organization [ISO] 13567)

Plotting Guidelines developed by the US Coast Guard and promulgated by the U.S. Department of Defense Tri-Service CADD/GIS Center—The guidelines include the use of 256 color ID numbers assigned to plotted line-weights and plotted colors.

The purpose of the Plotting Guidelines is to allow consistent black-and-white plotting from various color configurations within CAD programs. The guidelines allow consistent color mapping and data translation between MicroStation and AutoCAD. They also allow other CAD vendors to develop color mapping to either or both of the above.

Hierarchy of Data Fields

The layer name format is organized as a hierarchy. This arrangement allows users to select from a number of options for naming layers according to the level of detailed information desired. Layer names consist of distinct data fields separated from one another by dashes. A detailed list of abbreviations, or field codes, is prescribed to define the content of layers. Most field codes are mnemonic English abbreviations of construction terminology that are easy to remember.

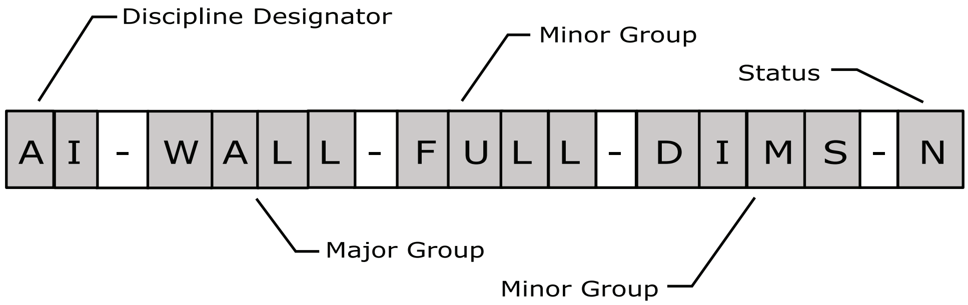
Four defined layer name data fields are:

- Discipline designator.
- Major group.
- Two minor groups.
- Status.

Elements of Design Package, continued

The discipline designator and major group fields are mandatory. The minor group and status fields are optional. Each data field is separated from adjacent fields by a dash for clarity (see Figure 2.8).

Figure 2.8
United States National CAD Standard layer name format



Level 1 (mandatory)

G	General
H	Hazardous materials
V	Survey/mapping
B	Geotechnical
W	Civil works
C	Civil
L	Landscape
S	Structural
A	Architectural
I	Interior
Q	Equipment
F	Fire protection
P	Plumbing
D	Process
M	Mechanical
E	Electrical
T	Telecommunications
R	Resource
X	Other disciplines
Z	Contractor/shop drawings
O	Operations

Level 2 (optional)

AI	Architectural interiors
AS	Architectural site
AD	Architectural demolition
CG	Civil grading
CP	Civil paving
SF	Structural framing
DP	Process piping
EL	Electrical lighting

Major Building Systems

WALL	Walls
DOOR	Doors
LITE	Lighting fixtures
FIXT	Plumbing fixtures

Drawing Views
(for layers organized by drawing type)

SECT	Sections
ELEV	Elevations
DETL	Details
FULL	Full height
PART	Partial
IDEN	Identification
PATT	Pattern

Status

N	New work
E	Existing to remain
D	Existing to demolish
F	Future work
T	Temporary work
M	Items to be moved
X	Not in contract
1-9	Phase numbers

Elements of Design Package, continued

Symbol Types

Six types of symbols in the NCS are:

- Reference symbols refer the reader to information in another area of the set of drawings. With the exception of the scale symbol itself, these symbols are scale independent.
- Line symbols indicate continuous objects and are either single or double lines. These symbols are also scale independent.
- Identity symbols indicate individual objects and are generally used in mechanical and electrical drawings. They often symbolize the object or work result without necessarily resembling the object. Consequently, these symbols are scale independent.
- Template symbols resemble the actual objects being symbolized. These symbols are scale dependent.
- Material symbols graphically indicate certain materials and are used to help the reader differentiate one material from another. These symbols can be either scale dependent or scale independent.
- Text symbols graphically indicate a word or words and may be used in notations on drawings. Text symbols are symbols that are commonly found on a computer keyboard or typewriter.

Cost Estimates

Materials and labor cost estimates should include all costs associated with furnishing and installing the specified material.

Costs should include:

- Labor and subcontract costs.
- Material and material waste.
- Shipping, storage, and staging.
- Equipment and tools required for installation.
- General conditions, such as:
  - Insurance costs.
  - Legal costs associated with agreements.
  - Advertising for bidding.
  - Bonding costs.
  - Contingency costs.
- Design and project management costs, such as:
  - Architectural fees.
  - Engineer and consultant fees.
  - Construction management fees.
  - Owner's internal costs.
  - Cutover and first-use charges.

Elements of Design Package, continued

Market or regional conditions that can dramatically affect actual construction costs are:

- Seasonal effects on the available labor pool or construction costs.
- Strong or weak general economy.
- Surrounding market conditions.
- Other large projects in a region.
- Construction time frame.

Existing conditions that must be considered in the cost of the project include:

- Soil conditions.
- Asbestos.
- Displacement and relocation.
- Hazardous materials.
- Environmental impact studies.
- Abandoned cable.

Meetings

The coordination and approval of design documents are usually accomplished through a series of meetings scheduled during the design phase of the project:

- Design coordination—The design team should meet on a regular basis to review the progress of each team member and to ensure that all construction documents are being coordinated.
- Owner review and approval—Meetings should be held with the owner during all design phases to review the progress of the design. Formal submissions to the owner are often scheduled at the end of the schematic design and the design development phase. These submissions serve as critical milestones in the design process.

Conclusion

All ITS projects require project management. An ITS PM will sequence the work and ensure that the job proceeds as anticipated. As projects become larger and more complex, there is more risk. As projects become larger or new team members become involved in the work, project management tools provide great benefits. All projects benefit from the development of a complete project plan. The communications that take place between the team members while building the plan is often more important than the actual documents.

These techniques help ITS projects to be:

- On time.
- Under budget.
- Within specification.
- Above customer expectations.

Additional Resources

Following are useful resources for further reference:

- AIA (contracts):
  - A101. Standard Form of Agreement Between Owner and Contractor
  - A201. General Conditions of the Contract for Construction
  - B141. Standard Form of Agreement Between Owner and Architect
  - C141. Standard Form of Agreement Between Architect and Consultant
  - G701. Change Order
  - G702. Application and Certificate for Payment
  - G704. Certificate of Substantial Completion
  - Web site—www.aiaorg.com
- Association for Project Management (APM):
  - Web site—www.apm.org.uk
- BICSI® Publications
  - *AV Design Reference Manual (AVDRM)*
  - *Outside Plant Design Reference Manual (OSPDRM)*
  - *Electronic Safety and Security Design Reference Manual (ESSDRM)*
  - *Information Technology Systems Installation Methods Manual (ITSIMM)*
  - *Network Design Reference Manual (NDRM)*
  - *Residential Network Cabling Manual (RNCM)*
  - *Telecommunications Distribution Methods Manual (TDMM)*
  - *Wireless Design Reference Manual (WDRM)*
  - *Information Technology Systems (ITS) Dictionary*
- Construction Specifications Institute (CSI):
  - Manual of Practice—A reference containing theories, techniques, and formats to aid in all aspects of construction documentation.
  - MasterFormat™
  - SectionFormat™/ PageFormat™
- Design-Build Institute of America (DBIA):
  - Web site—www.dbia.org

Additional Resources, continued

- Engineers Joint Contract Documents Committee (EJCDC):
  - Web site—www.pubs.asce.org/contract.html
- InfoComm International®:
  - Web site—www.infocomm.org
- National Systems Contractors Association (NSCA):
  - Web site—www.nsca.org
- Project Management Institute (PMI):
  - Project Management Institute (Body of Knowledge [PMBOK])
  - Web site—www.pmi.org
- Telecommunications Project Management Association (TPMA):
  - Web site—www.telpm.org

References

Construction Specifications Institute. *Project Resource Manual—CSI Manual of Practice*. Alexandria, VA: Construction Specifications Institute, 2004.

———. MasterFormat™. Alexandria, VA: Construction Specifications Institute, 2004.

———. SectionFormat™/PageFormat™. Alexandria, VA: Construction Specifications Institute, 2008.

Chapter 3
Outside Plant

One of the most crucial areas of concern on a campus-type environment or merely the connection of two buildings is the outside plant (OSP) infrastructure. This is an area that offers the information technology systems (ITS) designer and the customer the most options, making it a unique opportunity. Unlike most intrabuilding backbone distribution systems, the OSP infrastructure needs to provide for future buildings, potentially hazardous situations, environmental issues, and road construction.

Choices include aerial, underground, direct-buried, coaxial cable, optical fiber, twisted-pair, maintenance holes, and handholes. Chapter 3 will introduce the reader to some of those choices from an overview perspective.

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Overview

Introduction

This chapter provides an overview of the parameters and guidelines for underground and direct-buried cable and for aerial installation. Although every effort has been made to avoid unnecessary repetition of material, the importance of underground and direct-buried cable in telecommunications distribution cannot be understated and makes it impossible to avoid redundancy completely.

The term outside plant (OSP) once referred almost exclusively to cable facilities placed and maintained by the original telephone companies operating on a capitalized (e.g., regulated) basis. After deregulation, the customer or a local access provider (AP) became responsible for the installation and maintenance of these cable facilities, for their use either directly or through contractors.

In a contiguous property environment (e.g., where campus backbone cables exist), critical factors to understand for maintenance and growth purposes are:

- Familiarity with the routes.
- Working capacity versus spare cable capacity.
- Cable composition.

In some cases, these routes are overhead on pole lines instead of underground or direct buried. Facilities on noncontiguous properties further complicate the issue.

Aerial-cable facilities offer immediate visual route identification and relatively easy service access. Underground and buried facilities require very careful planning due to hidden subsurface conditions—either natural or manmade—that can affect the facilities. This planning is required whether the facilities are newly installed or inherited.

Traditionally, OSP referred to both inside and outside capitalized cable facilities placed by the original telephone companies; however, this chapter addresses only outside designs.

Safety Procedures

The installation and maintenance of OSP facilities and associated supporting structures require the operation of heavy vehicles and equipment, which means following approved safety methods.

Using heavy equipment (e.g., oversized vehicles, digging machines, power winches) to place and maintain underground, aerial, or direct-buried plant requires trained operators and appropriate safety equipment (e.g., hard hats, safety goggles, work shoes). Certain special sites (e.g., mills, factories, nuclear power plants, government properties) require additional training and certification by a local safety representative.

In certain privately owned customer locations (e.g., steel mills and chemical plants) and public institutions (e.g., prisons and other high-security facilities), additional safety requirements may be mandatory. These may include safety items (e.g., special clearances, special protective gear) being certified by a local safety representative and escorts. These requirements must be determined before starting any work.

Careful attention to the operation of aerial bucket trucks, especially in winter, is required for the safety of the operator, the truck, and the surrounding public. Basic vehicle checks (e.g., headlights, brake lights, turn signals, emergency flashers, warning lights, washers and wipers, tires) should be made.

The following checks also should be made:

- Aerial lift power source, emergency stop, and lower functions
- Fuel levels including level of propane tanks
- Weather protection and organization within the aerial bucket
- Supply of cones, flags, and reflective tape for work-area protection
- Safety-belt lanyard and bucket-eyehook attachment

NOTES: In addition to protecting life and property, adhering strictly to safety practices and regulations (e.g., using common sense) will help avoid strict financial penalties from governmental agencies (e.g., Occupational Safety and Health Administration [OSHA], Health, Safety, and Environment [HSE], or country equivalents).

For additional information (e.g., electrical protection), refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM*) and applicable codes, standards, regulations, and authority having jurisdiction (AHJ) rulings.

Underground Pathways

Underground facilities are cables, which are placed in subsurface conduits using maintenance holes (MHs), handholes (HHs), and/or pull boxes. Underground pathways use conduit to provide out-of-sight facilities. The building owner provides the conduit.

The advantages of underground conduit are that they:

- Preserve the aesthetic appearance of the premises.
- Are adaptable for future facility placement or removal.
- Are economical over a long life.
- Provide the security of additional physical cable protection.
- Minimize the need for possible subsequent repairs to the property when growth is required for existing facilities.

NOTE: An underground pathway runs between building entrance locations and also to a pole, pedestal, or MH.

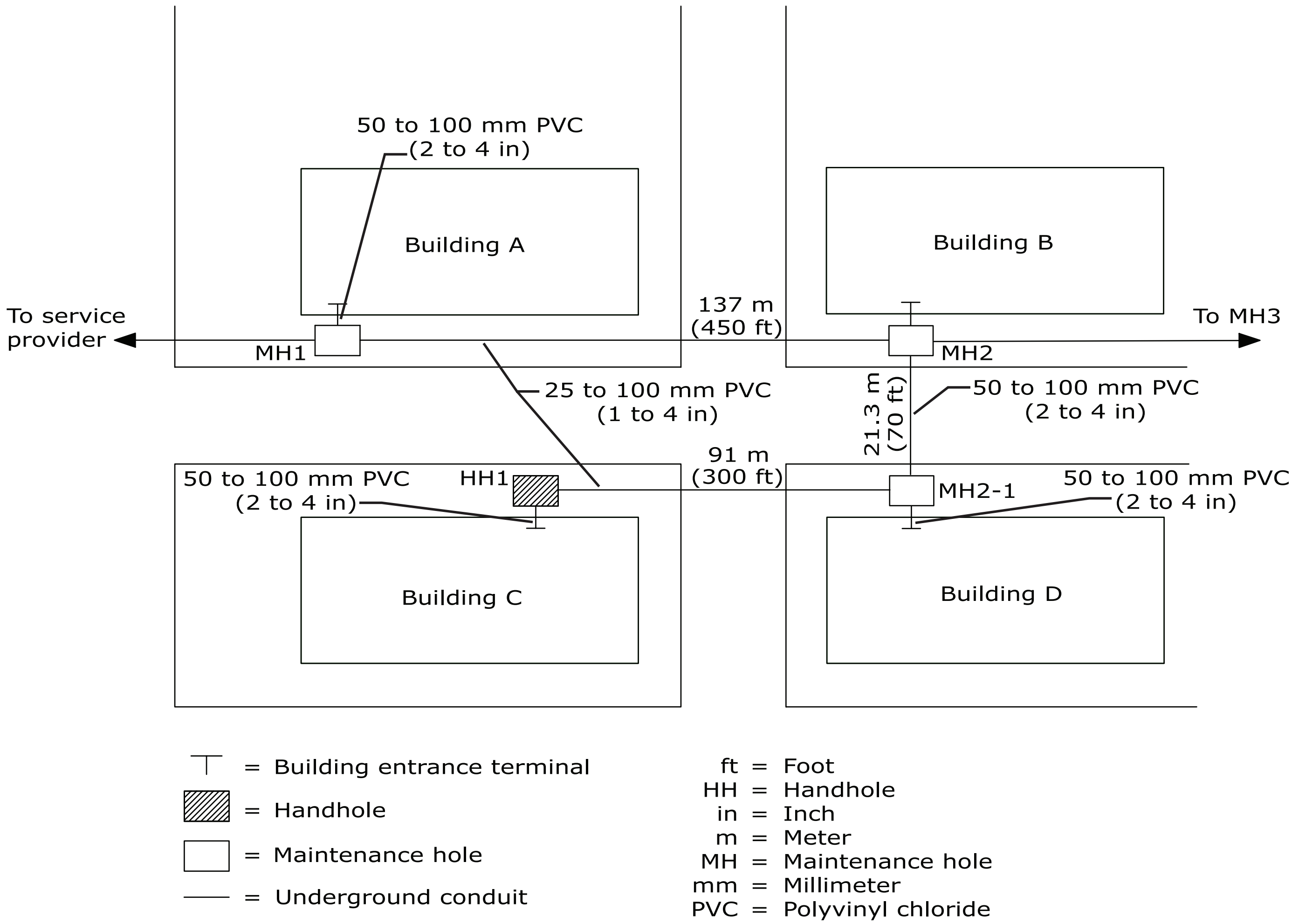
The disadvantages of underground conduit are that they:

- Have a high initial installation cost.
- Require careful route planning.
- Provide a possible path for water or gas to enter the building if improperly sealed. It usually takes more time to install where facility provisioning must be expedited.

Underground Pathways, continued

Figure 3.1 illustrates an underground pathway plan.

Figure 3.1
Underground pathway plan



NOTES: Locate maintenance holes out of road for traffic and safety considerations.

See BICSI's *Outside Plant Design Reference Manual (OSPDRM)* for right-of-way/easement information when designing routes in the public domain.

Other Telecommunications Service Entrance Considerations

Multibuilding Developments

Multibuilding developments may include AP, closed-circuit television (CCTV), and other connecting facilities.

These facilities could be served by:

- Balanced twisted-pair.
- Optical fiber.
- Coaxial.
- Microwave.
- Satellite.
- Other state-of-the-art techniques.

Planning for Campus Arrangements

Designs for large tracts of land often consist of several buildings rather than one high-rise building. These designs are sometimes referred to as campus arrangements because they resemble a college campus.

Both initial service and continuing service should be addressed in the initial planning for this type of complex.

Each building may be treated as:

- A stand-alone project.
- Part of the overall design.

Any stand-alone building should be designed according to the information in other sections of this chapter.

One-Tenant Campus

If only one tenant occupies a campus arrangement complex, the main AP or wide area network (WAN) terminal for the complex may be located in one of the buildings. In this case, route AP or WAN facilities through a centrally located MH, HH, tunnel, or conduit system.

Right-of-Way Easements and Permits

Easements (e.g., written rights-of-way) from individual property owners are required before any excavation on private property begins. In some cases, owners may wish to perform such work themselves, which would lift the requirement for an easement. In either case, the party responsible for the work must be clearly stipulated in a contract before excavation begins.

Where adjacent property owners are affected, a perpetual easement (e.g., a recorded easement) must be obtained. APs have a standard easement agreement, which applies for any method by which facilities are provided on private property.

When pursuing easements, it is important to remember that the building owner, building user, and property owner are often different parties.

Most local municipalities require that construction permits be obtained before any excavation begins. Other locations (e.g., government property, power pole attachments, railroad crossings, airports, bridges, navigable waterways, wetlands) also require special permits and/or environmental impact studies. These items are high-cost elements. Submittal of these elements does not guarantee route approval. Some processes take years and end with disapproval.

NOTE: Refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM)* for detailed information on easements and permits.

Locating Other Utility Facilities

Any existing underground utilities should be located and marked before excavation begins. Marking is usually done with marker paint, flags, or stakes. Even apparently undisturbed property could be crossed by buried utilities that inaccurate property records may not show.

Utility disruption can result in:

- Loss of life.
- Service outages for area residents/businesses.
- Heavy fines for the disrupting contractor.
- Heavy construction fees to the disrupting contractor for damages.

A telephone number or Web site is available that will assist in locating underground facilities. Every state has underground utility protection laws that have specific fines, rules for locating facilities, and legal ramifications if an underground utility is not located and is disturbed.

NOTE: All utilities may not belong to a one-call system. Before assuming, ask the locating system which utilities belong.

The information technology systems (ITS) designer should seek out an appropriate underground locating service in their area and provide the information on drawings. Typically, the contractor doing the work is responsible for calling in the utility locates.

NOTE: Refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM)* for detailed information on locating existing utilities.

Service Diversity

Certain military, public safety, and prime telecommunications centers require special attention concerning service provisioning.

Some levels of service diversity, which is the placing of alternate facilities to temporarily replace the main system in case of failure, are described in Table 3.1.

Table 3.1
Service diversity

Level of Service Diversity	Assign Circuits
Count	Among different binder groups within one cable.
Sheath or cable	Among different sheaths or cables.
Route	Along entirely different cable paths to a building.
Backbone	Among different intrabuilding backbone cables.

Balancing cost versus risk should be the most critical factor in considering the level of service-diversity and requires close analysis by all parties involved.

In addition to addressing disasters (e.g., water, fire, lightning, wind, construction damage), the ITS designer should consider the less likely but equally serious possibilities (e.g., earthquakes, nuclear attack, sabotage). Obviously, the cost of additional protection increases in proportion to the level desired.

Full route diversity occurs only when there is a 100 percent physically separated route such that the damage to the first route cannot affect the second route.

Dual Entrances

The ITS designer should consider installing dual (e.g., duplicate) service entrances (e.g., two 100 percent diverse routes) as emergency backup for buildings that provide continuous services, including:

- Hospitals.
- Airports.
- Police and fire stations.
- Military installations.
- Radio and television (TV) stations.
- Data centers and telephone central offices.

Although the duplicate entrance route may be left vacant initially, the customer might request fully installed duplicate facilities for immediate activation in emergencies. It is more cost effective to build the second entrance during new building construction, than to install one later. The AP will add special charges (e.g., up-front and possible recurring) for such dual installations.

NOTE: See Service Diversity in this chapter for more information.

Entrance Cable Guidelines

OSP cables are typically unlisted because of the sheath material and filling compounds used within the cables. However, cable manufacturers recently have designed code compliant indoor/outdoor rated cables. These can be brought into the building and installed away from the limitations required by OSP-type cables.

BICSI recommends that OSP-type cable must be terminated or transitioned to listed cable as close as practical upon entry to the building. In no case must this termination or transition exceed 15 m (50 ft) from the point of entrance. Indoor/outdoor *National Electrical Code®* (*NEC®*) rated cables can be installed past the 15 m (50 ft) from the point of entrance.

NOTE: The ITS designer must meet or exceed all applicable codes, standards, regulations, and AHJ that may be more stringent than BICSI's recommendation.

OSP cables routed inside a building are influenced by fire codes. Often a choice must be made between:

- Planning a splice point at the building entrance to transition from outdoor non-listed to indoor listed cable designs. The added loss of the copper or optical fiber splice is small and usually not significant in the link loss budget.
- Enclosing conductive outdoor cables in rigid or intermediate conduit that extends beyond the wall or floor and is properly sealed and bonded to a grounding electrode, or running nonconductive optical fiber cable in a raceway. This effectively extends the point of entrance into the building.

Types of Entrances

Introduction

Although optical fiber cables are specified in many situations, the most common medium for providing connections to the AP is balanced twisted-pair cable.

The AP may bring either of these cable types onto the customer's property through:

- Underground entrances that use conduit to provide out-of-sight service to a building.
- Buried entrances (e.g., trenched or plowed) that provide out-of-sight service to a building without conduit.
- Aerial entrances that provide overhead service to a building, typically from poles.
- Tunnel systems.

Underground Entrances

Sizing Underground Entrance Conduits

Conduit quantity and size for a given underground telecommunications service entrance should ultimately be based on the number, size, and types of cable used to serve the telecommunications service entrance.

BICSI recommends a minimum of four 100 mm (4 trade size) conduits, with at least one spare 100 mm (4 trade size) conduit that should be considered for each telecommunications service entrance point. In addition, three 50 mm (2 trade size) conduits should be considered.

Placing Innerducts

Where optical fiber cables will be used, the ITS designer should consider placing innerducts inside each 100 mm (4 trade size) conduit designated for this purpose to ensure physical cable protection.

An innerduct is a smaller pathway within the conduit available in:

- Various diameters (typically 25 to 50 mm [1 to 2 in]).
- Various reel lengths.
- Fabric or mesh.

Each innerduct should be equipped with a pull cord. A copper conductor should be placed within an innerduct when non-metallic optical fiber cable is installed.

Channelized innerducts compartmentalized into separate sections are also available. In such compartmentalized innerducts, each innerduct should be equipped with a pull cord.

Additional Conduits

In some cases, additional service entrance conduits will be required to meet other needs, such as:

- Video.
- Tie cables.
- Dual feeds.
- Miscellaneous circuits.

Sharing Conduit

In some cases, community antenna television (CATV), AP, or other connecting facilities providers may want to share a telecommunications service entrance conduit to reduce installation costs.

Sharing entrance conduits:

- Could reduce the APs ability to provide additional entrance facilities (EFs).
- Could damage both facilities by subjecting cable sheaths to abrasion if they are not placed simultaneously.
- Saves major construction costs for building a new entrance.

In cases where the AP supplies the conduit from the property line to the building and retains ownership of the conduit, the AP may have the right to:

- Require the other conduit occupants to post insurance and abide by access agreements and liability bonds.
- Charge the other conduit occupants a fee.
- Require them to build their own EFs.

NOTE: Building entrance conduits are usually installed to the property line or easement or to the outside edge of the building during building construction by the owner. In all cases, the building owner owns and retains the rights to the use of those conduits—not the AP.

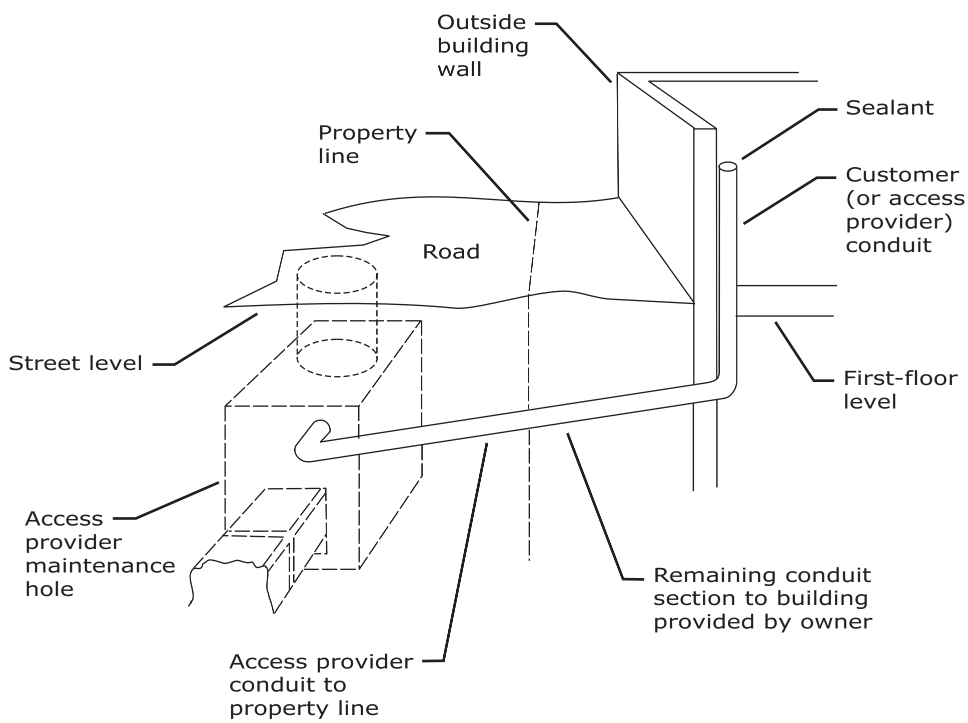
General Recommendations for Underground Entrances

Choosing Pull Points

No more than two 90-degree bends should be included between pulling points when installing underground entrances. A 90-degree bend should never be exceeded.

An example is shown in Figure 3.2.

Figure 3.2
Installing underground entrances



When a building is not on the property line, the building owner should provide two or more conduits from a point inside the building to the property line or easement. The AP will connect its underground conduit to the building owners' conduit at the property line or easement. The size and location of the conduit must be coordinated with AP engineers and the building owners' architect.

Buildings without basements must have conduit for access from the property line or easement to inside the building. This minimizes service interruption caused by physical damage and maintains a good appearance. A poured-within-the-slab conduit entrance is designed for this purpose.

Other Conduit Considerations

NOTE: For information related to regulating bends, reaming conduit, preventing conduit shearing, minimum depth, and encasement, refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM)*.

Terminating Conduit at a Designated Property Line

Determining Cover Depth

Terminate underground conduit at the designated property line or easement with a minimum cover of 610 mm (24 in).

NOTES: Check local codes for additional requirements. In cold climates, minimum burial depth may be greater based on the posted 50-year freeze point, if applicable.

Coordinate depth with the AP.

Preparing for Tie-In Connections

The AP will make the proper tie-in connections at the designated property line termination. The end of the conduit should be wrapped or plugged with a suitable material to prevent clogging until the cable or additional conduit is placed.

The end of the conduit should be flagged to designate the point of connection between the AP and the entrance conduit. For a typical connection between the AP and an owner-provided conduit, see Figure 3.2.

Terminating Conduit Inside a Building

Designing Termination Points

The ITS designer should design conduits entering from:

- Below grade point to extend 100 mm (4 in) above finished floor (AFF).
- Ceiling height to terminate 100 mm (4 in) below the finished ceiling.

NOTE: The 100 mm (4 in) penetration is specified for entrance facilities, as opposed to 25 mm (1 in) to 75 mm (3 in) penetration specified for intrabuilding conduit.

Fastening Entrance Conduits

All entrance conduits should be securely fastened to the building so they can withstand a typical placing operation performed by the AP.

The area around an entrance conduit should be kept free of any construction, storage, and mechanical apparatus.

Sealing Conduits

The inside-the-building end and the pole or MH end of a conduit should be sealed to prevent rodents, water, or gases from entering the building. Use rubber conduit plugs, a water plug, or duct sealer depending upon the conditions.

Unlisted innerduct and inside the building end conduit must be terminated and firestopped.

Reseal conduits after or when additional cable is placed in them.

Bonding and Grounding (Earthing)

Requirement

NOTE: All cables entering a building must conform to the bonding and grounding (earthing) requirements described in the National Fire Protection Association, Inc.® (NFPA®) and *National Electrical Code*® (*NEC*®).

Buried Entrances

Avoiding a Sunken Trench

When refilling a trench, the earth should be tamped properly to avoid a sunken-trench appearance later. The areas should be revisited to ensure that the trench is solid with the surrounding undisturbed earth.

Identifying Subsurface Facilities

All subsurface facilities (e.g., electrical power, gas, water, outdoor lighting) should be identified before trenching to avoid damaging them while trenching for a direct-buried cable. The local underground utilities center should always be called before digging. The building owner should be consulted about sprinkler systems, outdoor lighting, or other facilities buried on private property.

Clearing Foundation Landscaping

All conduit stubs entering the building should be designed to extend beyond the foundation landscaping. All conduit ends adjacent to the building should be flagged so the AP can identify them.

Requirements for Direct-Buried Methods

In most locations, the AP requires rights-of-way permits or easements before placing EFs by the direct-buried method. Local policies and tariffs may specify charges for trenching and backfilling on private property when the AP completes the work.

Shoring Requirements

BICSI recommends that any trench 1.5 m (5 ft) or more deep must:

- Be shored to prevent cave-in.
- Have a minimum clearance of 0.6 m (2 ft) from the edge of the excavated dirt pile to the nearest edge of the trench.

Refer to the local AHJ or OSHA for safety regulations.

Aerial Entrances

Limitations

Limit aerial entrances to small buildings requiring:

- One hundred cable pairs or less for SP connection.
- No other telecommunications entrances.

Problems

Aerial entrances tend to be undesirable because of their:

- Lack of mechanical protection for the facility.
- Effect on the aesthetics of the building.
- Clearance requirements.
- Storm-loading requirements.

Maximum Span

When aerial entrances are used, the span from the last pole to the building must not exceed 30 m (100 ft). Use slack-span construction (i.e., no guying at either end).

These requirements are designed to place as little pulling tension as practical on building attachments and support structures.

Separations and Clearances

Ensuring proper clearance and separation from electrical power lines and traffic is one of the main considerations when designing an aerial entrance. The ITS designer must review each aerial entrance to assure that all safety factors are considered.

NOTES: The ITS designer should refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM)* and the *IEEE® National Electrical Safety Code®* for the separations and clearances for aerial entrances. All local codes should be checked for special requirements.

All separations and clearances for aerial entrances must meet or exceed applicable codes, standards, regulations, and AHJ rulings.

Aerial Cable at a Building

Introduction

Aerial cable can be attached to a building in several ways. The illustrations in this section show details of several of the methods used by building designers.

Types of Exterior Walls

The types of exterior walls covered by these examples are brick, concrete, block, and wood. Each material has a specified method for using these attachments.

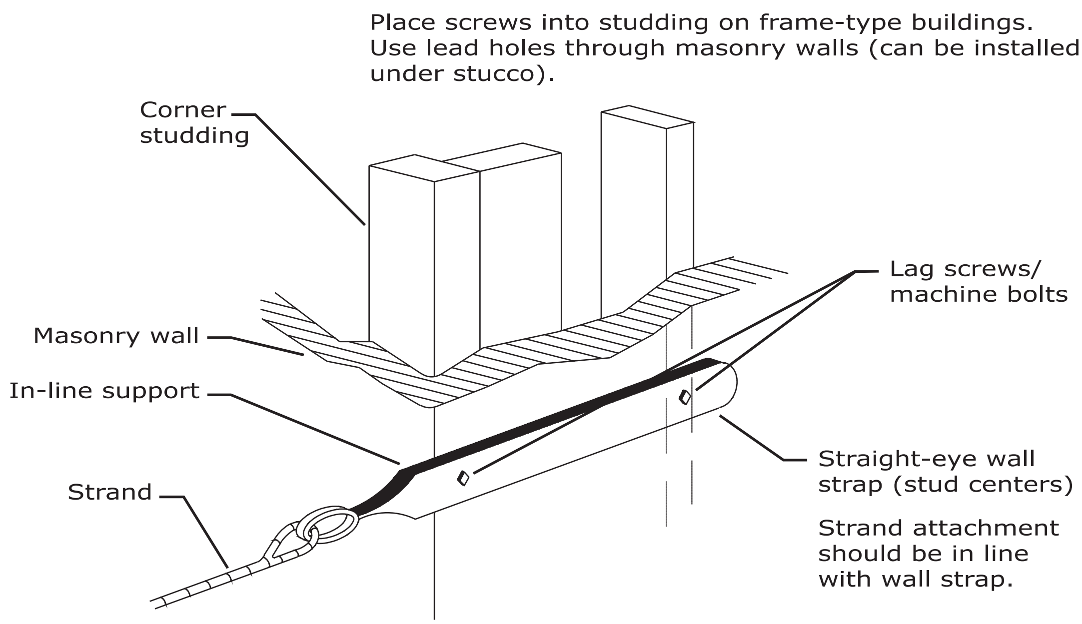
Vertical Wall Attachments

In Figures 3.3 and 3.4, the entrance cable is supported by a vertical wall attachment. The ITS designer should consider the type of wall construction when choosing a wall attachment.

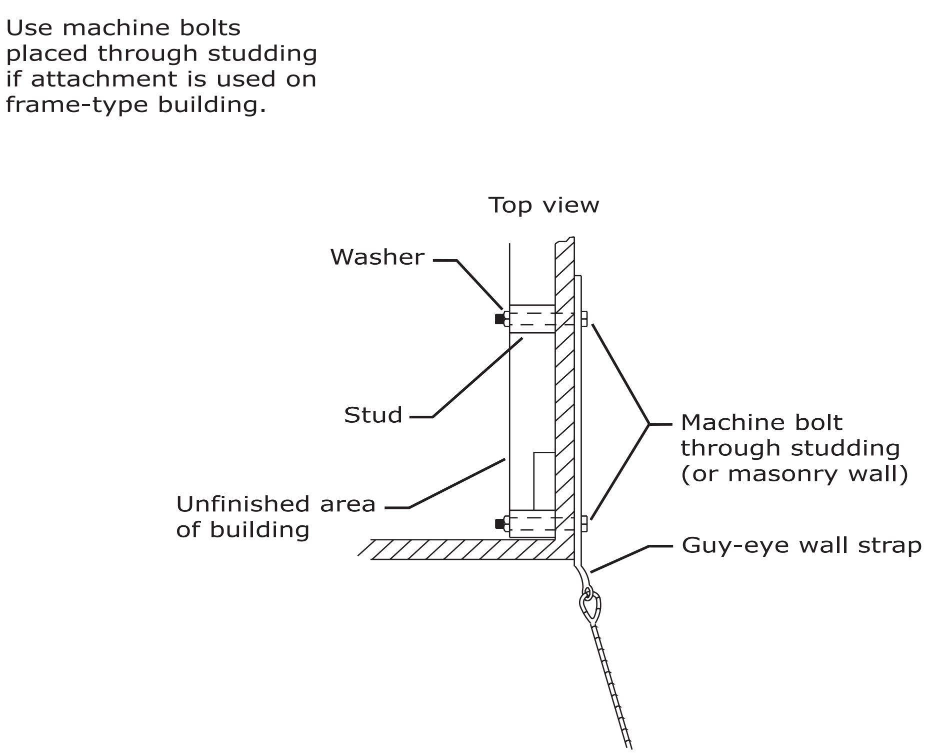
These figures also show typical ways to attach to an outside wall structure. Consult with a licensed structural engineer or AHJ for approved attachments.

Vertical Wall Attachments, continued

Figure 3.3
Building attachment



Building attachment for small cable and short pole-to-building span

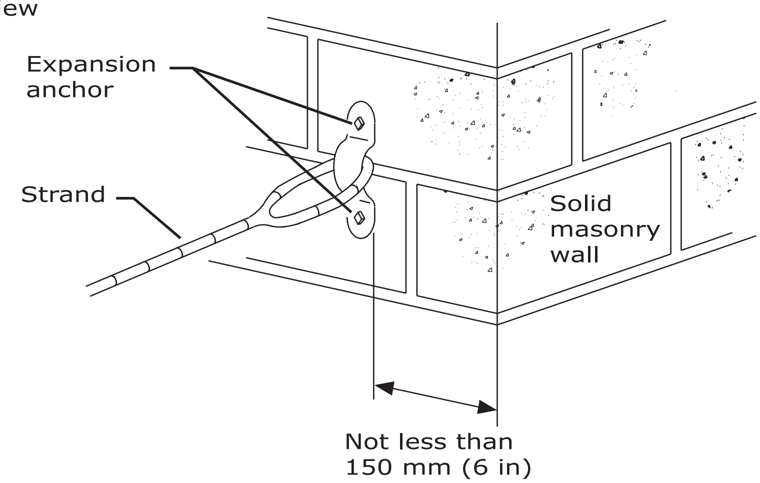


Building attachment for small angle support

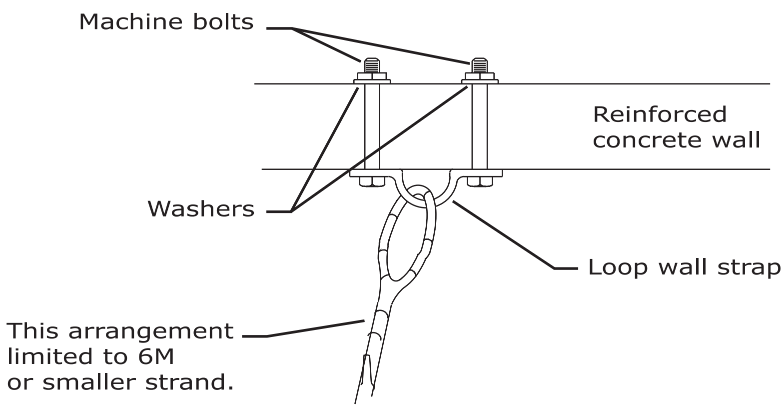
Vertical Wall Attachments, continued

Figure 3.4
Building attachments for small cables and short pole-to-building span

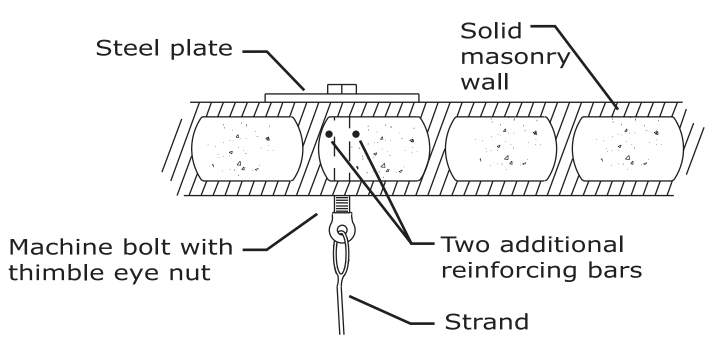
Corner view



Plan view



Plan view



Small-Diameter Cable Drop

In the small-diameter drop method of attaching an aerial cable to a building, a drop hook attached to a conduit mast supports the cable.

A conduit mast can:

- Terminate in a protector box.
- Enter the building through the roof.

Use small-diameter drops only for minimal circuit requirements. Where the cable enters the building, it must be sealed from rodents, moisture, and insects with the appropriate material.

Vertical Conduit Masts

Aerial cable must enter a building through a raceway (e.g., conduit) with an approved service head.

A vertical conduit may either:

- Terminate in a protector box mounted on the exterior wall.
- Enter the building through the roof.

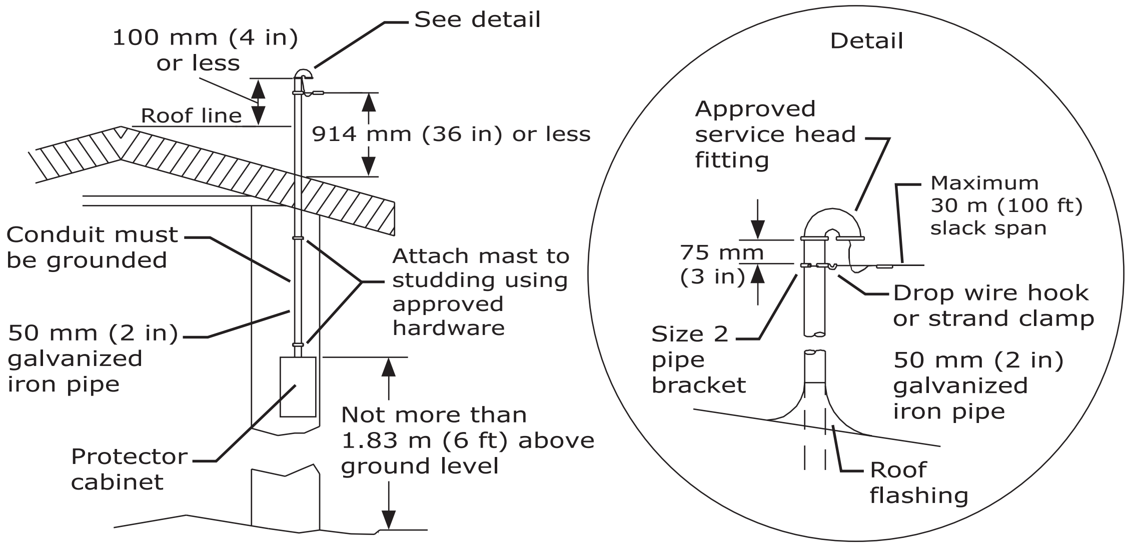
Figure 3.5 illustrates how a typical vertical conduit mast may enter the building.

NOTES: To ensure proper support, do not extend the mast more than 100 mm (4 in) above the roof line.

Where the cable enters the mast, the mast must be sealed from rodents, moisture, and insects with the appropriate material.

Vertical Conduit Masts, continued

Figure 3.5
Vertical conduit mast



ft = Foot
in = Inch
m = Meter
mm = Millimeter

NOTES: Iron pipe must be effectively grounded.

This arrangement is limited to drop-wire attachments of up to four lines.

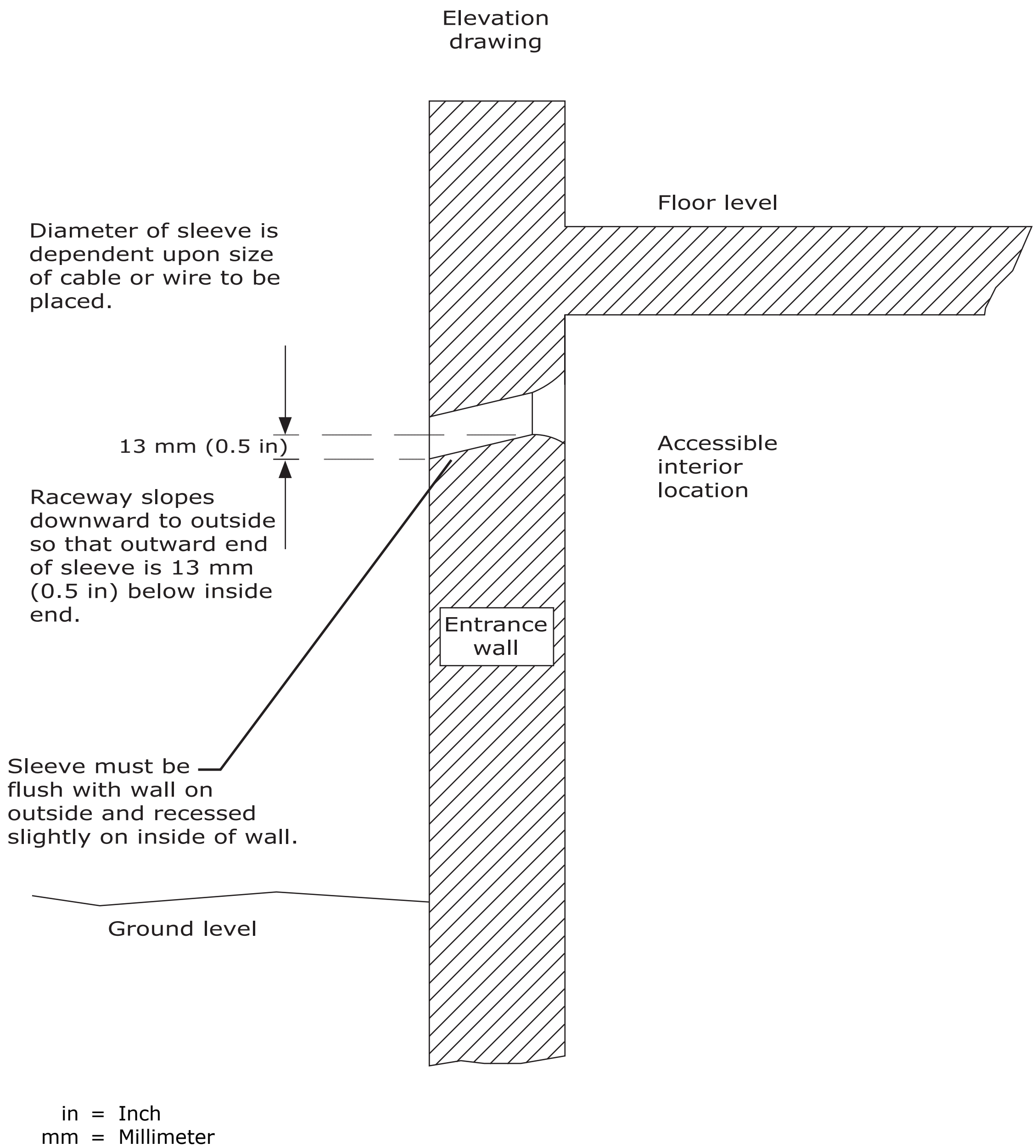
The service mast must be sufficiently high to provide drop-wire clearance over sidewalks, streets, or roadways in compliance with codes, standards, and regulations.

Where the cable enters the pipe, the pipe must be sealed from rodents, moisture, and insects with the appropriate material.

Entrance Through a Wall

Figure 3.6 shows a cable entrance sleeve placed through a building wall. When this method is used, ensure that the raceway slopes downward toward the outside of the building. Seal the entrance sleeve on both ends from rodents, moisture, and insects with the appropriate material.

Figure 3.6
Cable entrance sleeve through a wall



in = Inch
mm = Millimeter

Terminating Space for Telecommunications Entrance Facilities

Requirements for Inside Space

Space provided for terminating EFs inside a building must be well-planned. Use this space for electrical protection and cable distribution.

Terminating space must be physically protected. Standard posts, bollards, or barriers help to protect the termination equipment when placed in locations where motor vehicles or other moving equipment is used (e.g., in a garage, if no better location is available).

In such cases, the posts should be:

- A minimum of 100 mm (4 in) in diameter.
- Filled with cement.
- Encased to a minimum depth of 914 m (36 in).
- Extended a minimum of 1067 mm (42 in) AFF.

Terminating space must be equipped with an AC grade or better, void-free plywood backboard, 2.4 m (8 ft) high with a minimum thickness of 19 mm (0.75 in), securely fastened with the grade C surface facing the supporting wall.

BICSI recommends the following (see Table 3.2).

Table 3.2
Terminating space

Gross Floor Space Served (m^2 [ft^2])	Wall Length (mm [in])
929 (10,000)	991 (39)
1860 (20,000)	1067 (42)
4000 (40,000)	1727 (68)
4600 (50,000)	2285 (90)
5574 (60,000)	2400 (96)
7432 (80,000)	3050 (120)
9300 (100,000)	3658 (144)

ft = Foot
in = Inch
m = Meter
mm = Millimeter

Requirements for Inside Space, continued

The backboard should be painted with at least two coats of fire-retardant paint. Fire-retardant plywood is also acceptable except in nuclear power plants or other restrictive locations.

Allot additional backboard space for multiple network interface units at the AP's minimum point of presence (MPOP) only if local tariffs or practices permit.

Terminating space must be located in a dedicated room. Buildings larger than 9300 m^2 (100,000 ft^2) must contain a dedicated room for entrance facilities.

The size of the room is determined by the:

- Type of facility.
- Terminating hardware selected.

The door to the dedicated room should:

- Open outward (e.g., if local building codes permit).
- Have the same fire rating as the room wall.
- Not be less than 0.90 m (3 ft) wide by 2 m (6.5 ft) high.

Larger buildings require close coordination with the AP and the customer's telecommunications vendor.

Outside Building Terminals (Pedestals and Cabinets)

Pedestal Hardware Mounted on Outside Walls

Certain types of pedestal hardware are mounted on the outside walls of buildings. The base of the pedestal usually has some type of anchoring device.

These pedestals should serve only single-story office or office warehouse structures and should be installed within 45.8 m (150 ft) of each tenant space.

Ground-Supported Terminals

Ground-supported terminals require 1 m (3.28 ft) of maintenance clearance on all sides that might require access by a technician.

Pedestal Terminals

A majority of pedestal terminals are designed so that both entrance service and distribution service enter from the bottom. Every effort should be made to provide conduit for all cabling associated with these installations.

Access to an approved ground is required because station protectors are components of these terminals.

Seal the bottom and other openings of the pedestal from rodents, moisture, and insects with the appropriate material.

Surface-Mounted Cabinets

Surface-mounted cabinets are another means of serving smaller buildings. Surface-mounted cabinets must be at least:

- 1 m (3.28 ft) tall.
- 0.6 m (2 ft) wide.
- 150 mm (6 in) deep.

Cabinets must provide full access from the front and be equipped with an AC grade or better, void-free plywood backboard, sized to fit the cabinet, with a minimum thickness of 19 mm (0.75 in). The plywood should be installed with the grade C surface facing the wall. All top entry boxes must include the gaskets or equipment necessary to maintain a weatherproof enclosure. The cabinet should be equipped with a door latch and lock.

Access to an approved ground is required.

Network Interface Locations

A network interface is the point of connection between the public network and private network and is often called the demarcation point (DP).

Placement of network interfaces can vary based on local public network practices and space available by the owner. When the DP is established, the private network owner is required to build their network connecting cabling to this point.

In most cases, the building entrance room becomes the network interface location if there is space planned for plywood or an electronics equipment rack. ITS designers meet with architects, building owners, and the public networks engineers to plan and design this space (e.g., particularly a multi-tenant building). When this is the network interface or DP, private networks must cable to this location for their connection to the public network.

In a single tenant building, the interface location for demarcation may be a telecommunications or server room.

The public network is then extended to the location. The location must be:

- Conveniently accessible by both public and private network owners.
- Well-lighted, safe, and environmentally clean.
- Physically secure.
- Environmentally designed if electronics are present.

In special types of construction (e.g., handicapped units), the telecommunications interfaces should be given the same importance with regard to handicapped access. In some instances, for example, the location may require an interface connection height of no less than 375 mm (15 in) AFF.

Older and other building types may have the network interfaces mounted onto the exterior of the building within a housing. Typically, the public network cabling ends within a protected housing on the exterior of a building. The network interface is then branched from the protected housing to a weatherproof network interface housing.

Centralization—Advantages versus Disadvantages

The advantage of a centralized network interface panel or housing is that it offers the public and private networks owners a single, convenient test location for all premises circuits.

The disadvantages are:

- Access to the centralized network interface panel may cause some inconvenience to the public or private network owners when security or building engineers must be called for access.
- When the interface is located within an unsecured area it compromises privacy and security. Unauthorized personnel could easily access circuits.

Hardware

The network interface location often determines the type of hardware to use. Interior applications may consist of separate terminating hardware for both the network interface (e.g., AP circuit) and the switch or inside cabling (sometimes called the entrance bridge). Other interior network interfaces can be a direct connection to equipment.

Exterior building network interface hardware must be weatherproof and can have both the network interface and entrance bridge in separate chambers within a common housing.

Direct-Buried Cable

Direct-buried cables are cables placed directly in the earth.

Direct-buried cable (e.g., trenched, bored, or plowed) is a means of providing out-of-sight service to a building without conduit (see Figure 3.7). The trench typically runs between building entrance locations to the pedestal or pole. From here, the AP takes it to a pole or MH on the provider's system.

The advantages of direct-buried cabling are that it:

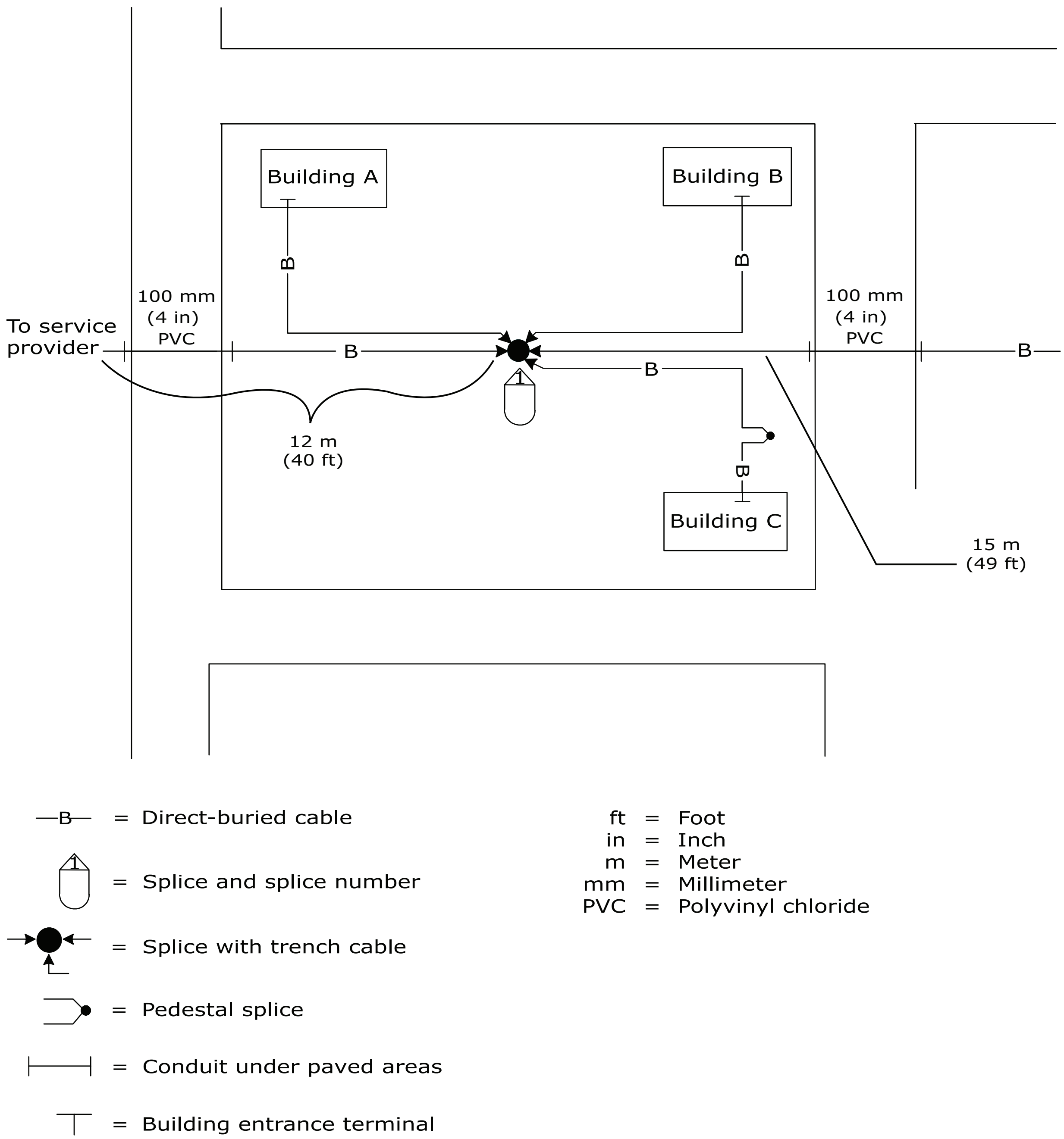
- Preserves the aesthetic appearance of the building.
- Usually has a low initial installation cost.
- Can easily bypass obstructions.

The disadvantages of direct-buried cabling are that it:

- May be inflexible for future service reinforcement or changes.
- Does not provide physical protection to the cable sheath.
- Discourages accurate route planning and recordkeeping.

Direct-Buried Cable, continued

Figure 3.7
Direct-buried pathway plan



NOTE: Refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM)* for right-of-way/easement information when designing routes in the public domain.

Aerial Pathways

Aerial pathways are another means of supporting campus cabling. The advantages of aerial pathways are that the pathways:

- Usually can be installed quickly.
- Are readily accessible for maintenance.

The disadvantages of aerial pathways are that they:

- Affect the aesthetic appearance of the property.
- Are subject to traffic and pedestrian clearances.
- Can damage building exterior.
- Are susceptible to environmental conditions (e.g., falling tree limbs, lightning, and ice).

Direct-Buried and Underground Pathways

Trench Depth

The minimum depth of a trench should allow 610 mm (24 in) of cover from the top of the cable to final grade. In cold weather regions, cables (e.g., especially optical cables) should be placed below the area's 50-year frost line. Regions with permafrost require special techniques and must be closely coordinated with the region's authorities.

NOTE: Local standards or codes may permit other depths based on certain conditions and should be reviewed.

Avoiding a Sunken Trench

When refilling a trench, tamp the earth properly to avoid a sunken-trench appearance later.

Locating and Identifying Subsurface Facilities

Identify all subsurface facilities (e.g., power, gas, water, outdoor lighting) before trenching to avoid damaging the facilities while trenching for a direct-buried cable. Always call the local underground utilities call center before digging.

Direct-Buried and Underground Pathways, continued

Locating and Identifying Criteria

Information for locating underground utilities is generally classified into four methods:

- Locating by the use of nondestructive vacuum-excavation equipment, or other means, to expose buried utilities at critical points.
- Designating the professional selection, application, and interpretation of surface geophysical techniques to identify virtually all utilities within the project limits.
- Surveying visible above-ground utility facilities (e.g., MH, posts) and correlating this information with existing utility records.
- Using existing utility records. This is the most basic information. It may provide an overall feel for the congestion of utilities; however, it is often highly limited in terms of comprehensiveness and accuracy.

Properly locating utilities will benefit both construction contractors and utilities. Conflicts with other utilities are reduced, which:

- Reduces delays to the contractor.
- Reduces redesign costs and delays.
- Eliminates repair costs to existing utilities.

Locating Methods

Electronic

Generally, energy-field detection devices are used for subsurface electronic location of utilities. The technician places a signal or tone on the utility to be located. A special receiver is moved along the ground until this signal is detected. The technician infers the location of the utility from the strength and distribution of the radiated field.

Water Vacuum

Where there are several layers of underground services possible, and adequate identification may be questionable (e.g., polyvinyl chloride [PVC] pipes), water vacuuming is recommended. This method uses a special truck that carries a high-pressure water spray-vacuum system.

This system will excavate a small 150 mm (6 in) wide hole to the desired depth in spots along the routes to positively identify buried facilities.

Air Vacuum

The air-vacuum system works by sending a high-pressured supersonic air stream into porous soil. When the air stream contacts the soil, it enters microscopic holes and then expands, causing the soil to break into a powder. A powerful vacuum system removes this powder as it is deposited in the test hole and stores the powder in a large tank. The air stream does not damage the utilities because of their impermeability. The hole has a diameter from 150 mm (6 in) to 255 mm (10 in) and can go several meters (feet) vertically.

Direct-Buried and Underground Pathways, continued

Requirements for Direct-Buried Methods

In most locations, the AP will require right-of-way permits or easements before placing cable by direct-buried methods. Local policies and tariffs may specify charges for trenching and backfilling on private property when the AP (or their subcontractor) performs the work.

Shoring Requirements

BICSI recommends that any trench 1.5 m (5 ft) or more deep must:

- Be shored to prevent cave-in.
- Have a minimum clearance of 610 mm (24 in) from the edge of the excavated dirt pile to the nearest edge of the trench.

NOTE: Always check with your AHJ for possible additional requirements.

Joint-Trench Required Separations

When a joint-trench method is used, the following vertical or horizontal separations between telecommunications facilities and other facilities must be maintained. See Table 3.3.

Table 3.3
Vertical/horizontal separations

Adjacent Structure	Minimum Separation
Power or other foreign conduit	• 75 mm (3 in) of concrete, or • 100 mm (4 in) of masonry, or • 300 mm (12 in) of well-tamped earth.
Pipes (gas, oil, water)	• 150 mm (6 in) when crossing. • 300 mm (12 in) when parallel.
Street railways	• 1 m (3.28 ft) below top of rail.
Railroads	• 1280 mm (50 inches) below top of rail.

NOTES: Place cable in rigid PVC conduit for a distance of 3 m (10 ft) on either side of the pipeline crossing. If multiple pipelines exist, then extend conduit 3 m (10 ft) from the outside pipes.

Place rigid steel conduit for a minimum distance of 7.6 m (25 ft) on either side of the center of the track (e.g., rails) crossing. If there are multiple tracks, the conduit should extend out 7.6 m (25 ft) on either side of the center of the outside tracks. For casings, the minimum is 4.6 m (15 ft) from top of rail.

Warning Tape Requirements

To reduce the chance of an accidental dig-up, place plastic warning tape a minimum of 300 mm (12 in) below grade, but high enough above cables to allow detection before cables are damaged.

Warning tape is either:

- Nondetectable (e.g., containing no metallic elements).
- Detectable (e.g., containing metallic tracings).

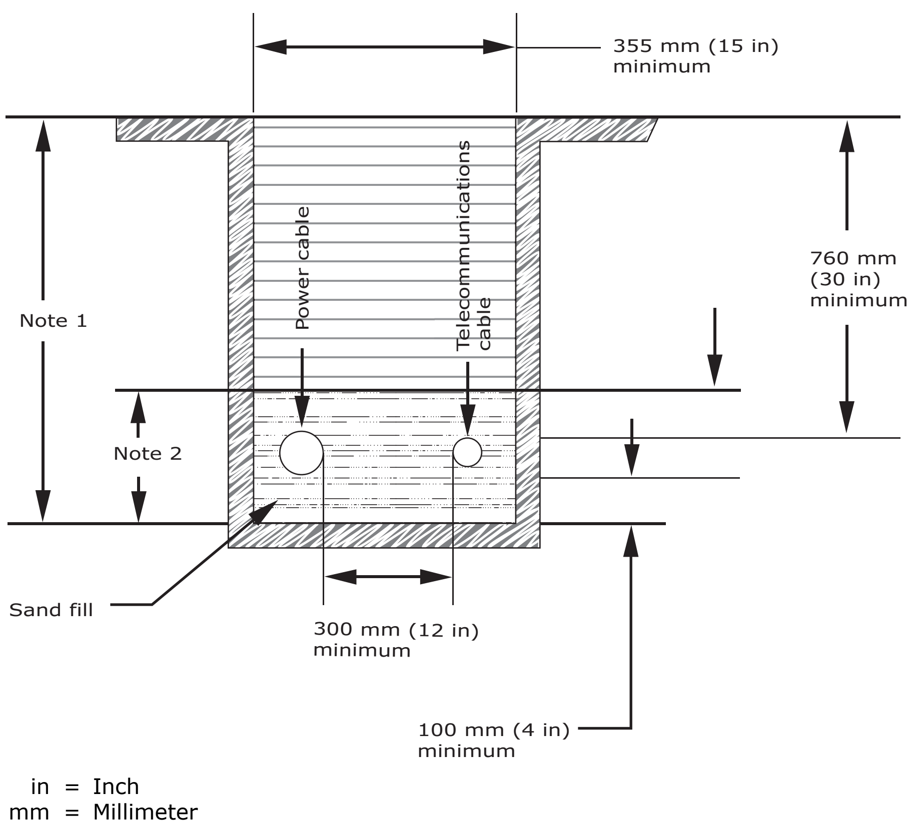
Traditionally, nondetectable tape has been used since the cable sheath or copper itself provides detection. However, with optical fiber cable, detectable tape is recommended.

The Common Ground Alliance (CGA) has adopted the color orange for telecommunications and CATV cables.

Coordinating Joint-Trenching

Close coordination is necessary when joint-trenching. Figure 3.8 illustrates typical trenching dimensions.

Figure 3.8
Typical joint trenching dimensions (section view through trench)



NOTES: 1. Excavation and backfill.
2. Fill to be clear of rocks and sharp objects.

Alternatives to Trenching

Advances in the technology for placing buried and underground facilities have provided a variety of improvements over the traditional backhoe method.

These alternative excavation methods use:

- A compact trencher.
- A vibratory plow.
- Horizontal directional boring (e.g., drilling or thrusting).

Backhoe Disadvantages

The backhoe is usually the most appropriate way to dig large trenches for multiple ducts or cables.

However, the disadvantages of using a backhoe include the:

- Frequent repositioning to accommodate the backhoe's reach.
- Substantial space required beside the trench to temporarily hold the excavated dirt.
- Extensive surface restoration requirements after installations are completed.
- Restriction to open areas (e.g., useless in confined areas or beneath existing structures).

Compact Trencher

A compact trencher is an engine with a heavy-duty chain drive attached to its front or rear. The chain drive has cutting teeth that produce a narrow, smooth trench, usually 150 mm (6 in) wide. Operating continuously, it can be set to dig a trench to a specific depth and can be equipped with backfill blades for prompt surface restoration.

Compact trenchers are available in a wide range of sizes, from the size of a hand-operated snow blower to a tractor-sized, driver-operated machine.

Vibratory Plow

A vibratory plow has a vibrating plow blade that cuts into the ground, functioning like an electric knife. The cable is fed into the ground through a chute behind the blade as the slit is being made.

A vibratory plow is best for placing a small conduit or a direct-buried cable. Interchangeable blades for various types of cables are available.

Because the slit is small, virtually no surface restoration is required. The weight of the plow, a roller, built-in tampers, and subsequent rainfall will soon return the slit to the level of the surrounding surface.

Directional Drilling

Directional drilling is a technology for placing underground cable. In directional drilling, a surface-operated drilling device is angled into the ground from the surface and subsequently directed to its destination by remote control.

The operator, who is on the surface, monitors the drilling device's direction and depth. The drill bit contains a beacon that transmits a radio signal to the operator, who can adjust the drilling device's path and even move around obstacles. The ability to change directions is provided by a beveled edge on the drilling unit's head. After the drilling unit reaches its destination, cable or flexible conduits can be attached to the unit and pulled back to the origination point.

Directional drilling is particularly valuable where traditional excavation is impossible (e.g., under buildings or rivers). These drilling devices are available with a variety of heads that can allow penetration of various types of soil (e.g., chalk and limestone).

While locating existing underground utilities before excavating is always important, it is crucial when directional boring is planned, because of the potential for the drilling unit to encounter high voltages. Although directional drilling machines are manufactured with electrical strike-sensing devices that warn the operator visually and audibly of any contact with a high-voltage source, accidents may still occur.

Directional drilling can involve the application of fluids, which can cause certain types of clay to swell. This swelling can affect surface slabs, streets, runways, and conduit bank crossings.

Operators of directional drilling machines require special protection due to the potential for direct exposure to high voltage. Operators must always have a ground mat grid underfoot as insulation protection. In addition, operators must wear insulating boots and gloves, as well as hard hats and safety glasses.

Conduit Guidelines

Bends

All bends must be long, sweeping bends with a radius not less than 10 times the internal diameter of conduits.

Reaming Conduit

All ends of metallic conduit must be reamed. All protruding ends must be fitted with bushings at both ends.

Preventing Conduit Shearing

Metal sleeves through walls must extend to undisturbed earth to prevent shearing, particularly where such backfill is susceptible to load-bearing tension.

Minimum Depth

Top of conduit must be buried at least 610 mm (24 in) below the ground surface.

NOTE: In areas where frost conditions could damage cables in conduit, greater burial depth is desirable. As a minimum, the depth should be based on the 50-year frost line.

Encasement

Consider encasing conduit in concrete when:

- Minimum conduit depth cannot be attained.
- Conduits pass under roads, driveways, or railroad tracks.
- Bend points might be subject to movement.

Consider using rebars (e.g., reinforcing bars) within the concrete at any location subject to potentially extreme stress.

Using Corrosion-Resistant Conduit

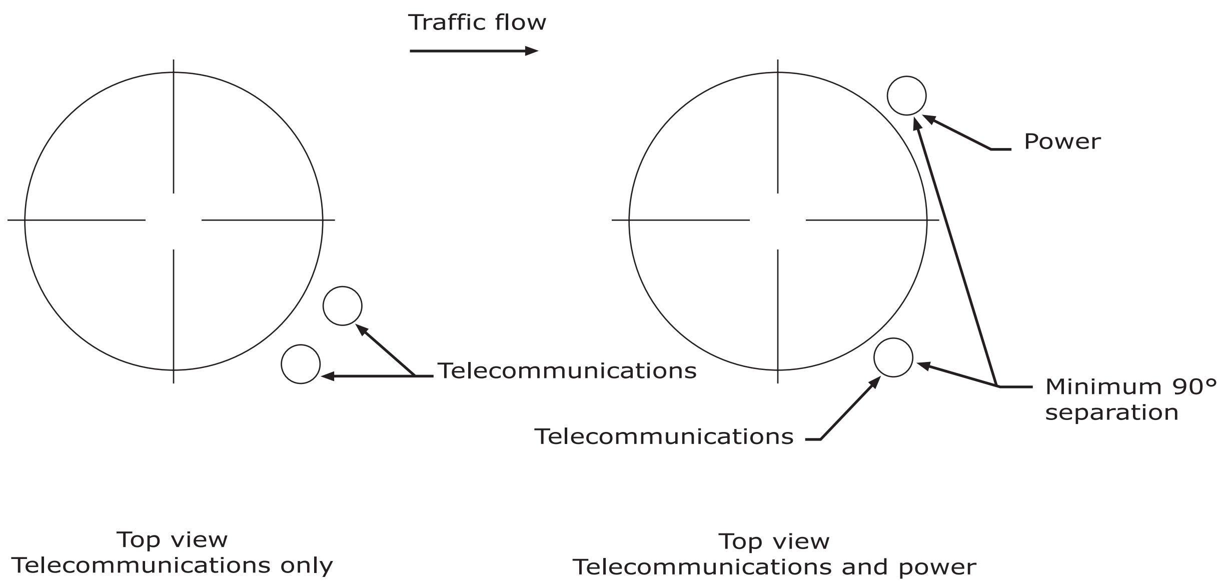
Use corrosion-resistant conduit of one of the following types:

- Fiber and/or fiberglass
- Concrete
- Rigid galvanized metal
- Rigid and nonrigid nonmetallic

Positioning Underground Conduit Risers on Poles

When practical, position the conduits on the field side of the pole (i.e., the side that is protected from the normal flow of traffic). This is illustrated in Figure 3.9.

Figure 3.9
Positioning conduit on poles



Choosing a Pull Cord

Provide a plastic or nylon line with a minimum test rating of 90 kg (200 lb) pulling tension in all entrance conduits. This facilitates pulling wire or cable.

Placing Innerducts

Where optical fiber cables will be used, consider placing innerducts inside a conduit for the purpose of ensuring physical cable protection. Each innerduct should be equipped with a pull device.

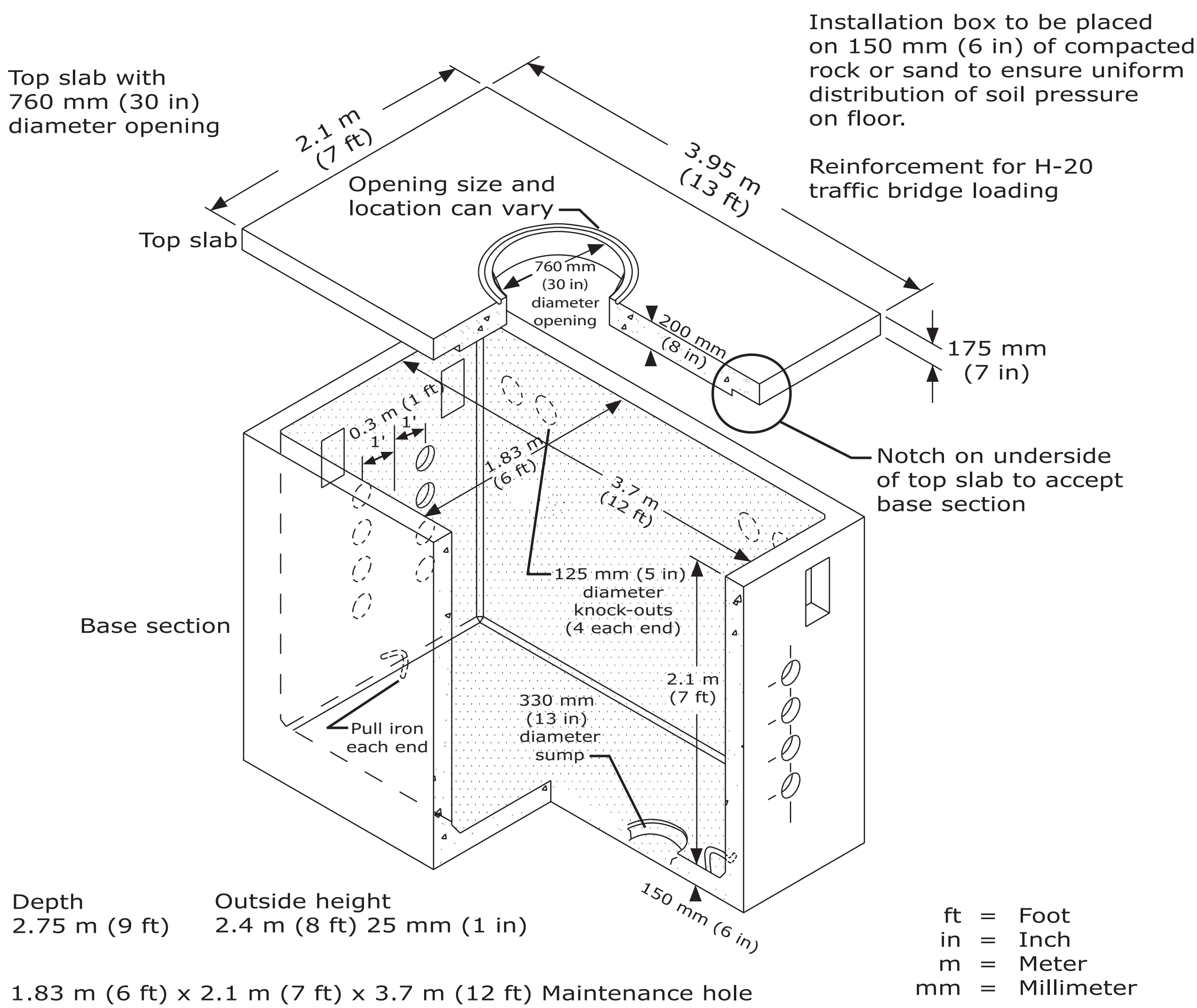
Maintenance Hole Guidelines

Avoiding Joint-Use Maintenance Holes (MHs)

Do not terminate conduit placed on private property in joint-use MHs with electrical cables (see Figures 3.10 and 3.11).

A separate MH should be provided for telecommunications facilities to ensure the safety of all personnel.

Figure 3.10
Typical maintenance hole diagram

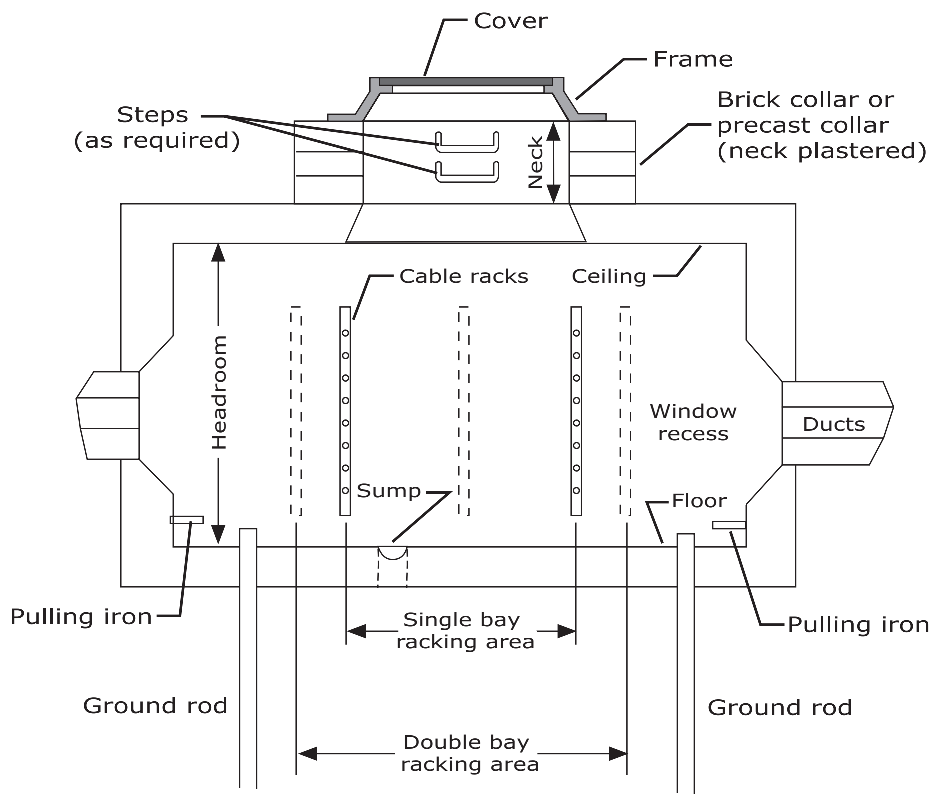


NOTES: Specify the locations of the holes on precast pull-boxes.

Inside dimensions are shown (150 mm [6 in] wall typical).

Avoiding Joint-Use Maintenance Holes (MHs), continued

Figure 3.11
Typical maintenance hole on private property



Frames and covers used in roads or driveways must be rated to withstand vehicular traffic.

Conduit Entry Points

The general recommendation is to place conduit entry points at opposite ends of a MH, HH, or pull box, instead of through the sidewalls.

While placing the conduit entry points at opposite ends may require an additional conduit sweep, it provides the following benefits:

- Allows neater cable formation in the MH/pull box.
- Maximizes the available working space at the center of the MH/pull box.
- Permits splaying (e.g., offset closer to the side walls) the entry points in certain situations.

Multiple Covers

For MH over 3.7 m (12 ft) long, follow these guidelines:

- Between 3.7 m (12 ft) and 6 m (20 ft), use two covers.
- Over 6 m (20 ft), use three covers.

Identifying Covers

Mark all telecommunications MH or pull box covers for easy identification. Mark covers with:

- T for telephone.
- S for signal.
- TV for CCTV/CATV.

Place all MH/pull box numbers on the covers. When premarked covers are not practical, weld the numbers on the covers.

Maintenance Hole (MH) Interior Hardware

All hardware in MHs must be galvanized. MHs should be equipped with:

- Bonding inserts and struts for racking.
- Pulling eyes at least 22 mm (7/8 in) in diameter.
- A sump of at least 200 mm (8 in) in diameter.
- An entry ladder (e.g., where feasible).
- A noncorrosive metal tag in MH collar with MH size or MH volume.

Concrete Strength and Reinforcement

The strength of concrete used for MHs shall be at least 24,000 kPa (3480 psi). The location of the MH will impact the type of MH used.

NOTE: Stronger concrete may be stipulated in certain installations. A civil engineer or other qualified ITS designer should be involved in the design of cast-in-place MHs. Rebar sizing, spacing, and beaming patterns and concrete thickness are based on loadings for the roof, floor, and walls. Whenever possible, precast MHs should be used.

Channelized innerducts compartmentalized into separate sections also are available. Use precast MHs wherever possible for uniformity, economy, and installation efficiency.

Use site-cast MHs whenever:

- The size required exceeds precast sizes.
- Obstructions prohibit placing precast MHs.

Underground Considerations

The following outlines some underground considerations:

- Place initial cables in bottom conduits to facilitate easy subsequent cable placement.
- Plug all underground conduits to prevent gases and/or water from entering the building or other MHs via the duct bank.
- Label each cable in the MH and buildings with an identifier.
- Provide draglines for all conduits (i.e., preferably pull-strength measure tape).
- Place the leader guard (shoe) in the duct before placing the cable to prevent damaging the cable sheath on the sharp edges of the duct.
- Vacuum and/or blow the contents of the pipe duct toward the MH to avoid contaminating the customer's building.
- Always ventilate MHs based on its volume where gas has been detected before entering the MHs.
  - Never enter an MH before it tests clear.
  - Never pump water from an MH before it tests clear.
  - Continue MH ventilation until all workers have exited.
- Always call the local underground utilities' call center before digging.

WARNING: Whenever a vent hole is present in the cover, test MHs for hazardous conditions prior to opening the cover.

Separating Transmission Media

When multiple transmission media are encountered, they should be separated to provide:

- Ready identification.
- Individual mechanical protection.
- Individual growth potential.

Cabling Placement

Planning and Design Factors

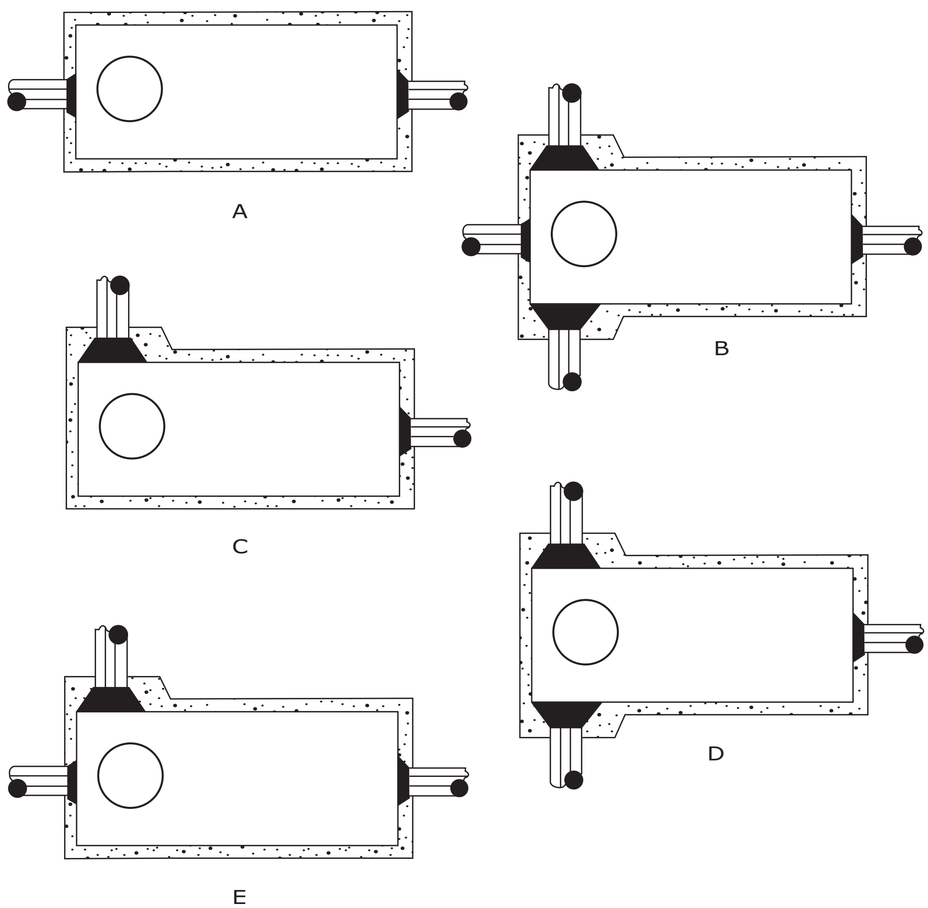
In any MH system, the MHs must be:

- Sized to meet the maximum conduit requirements.
- Located to optimize the use of the associated conduit routes.

Basic Maintenance Hole (MH) Configurations

Figure 3.12 illustrates overhead views of five basic MH configurations.

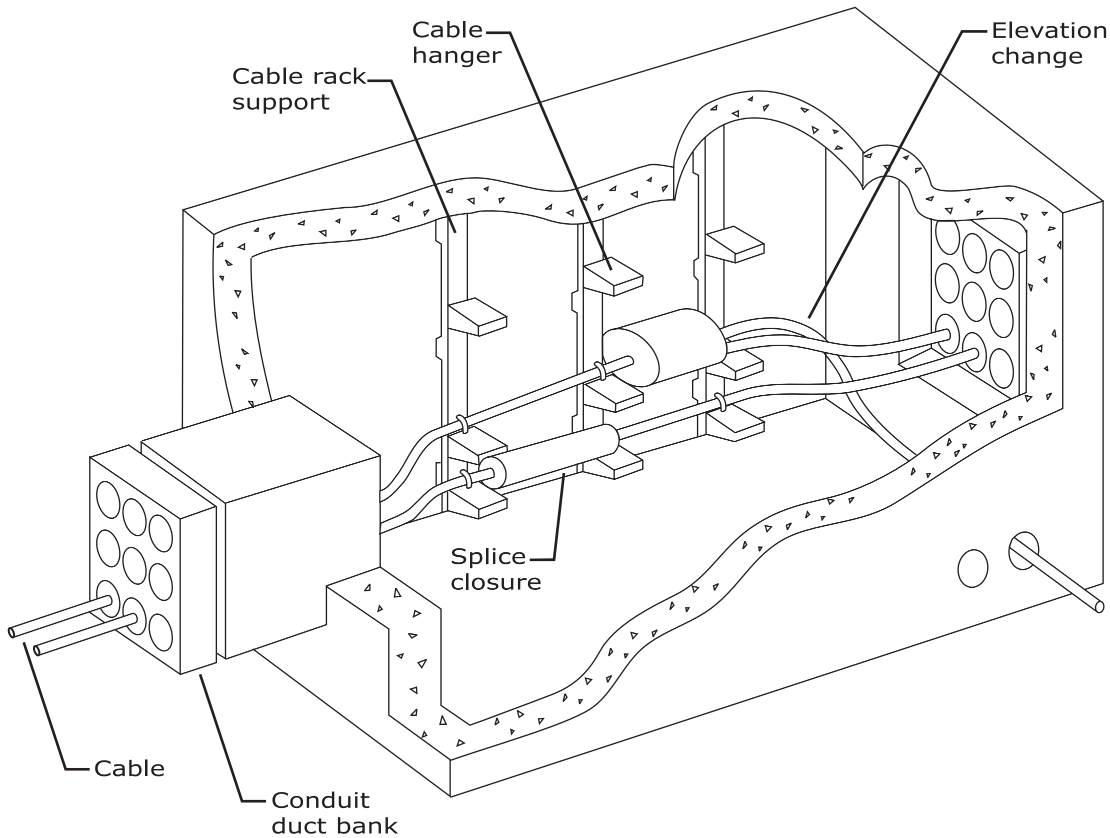
Figure 3.12
Basic configurations



Typical Cable Maintenance Hole (MH)

Figure 3.13 illustrates a cut-away view of a typical cable MH.

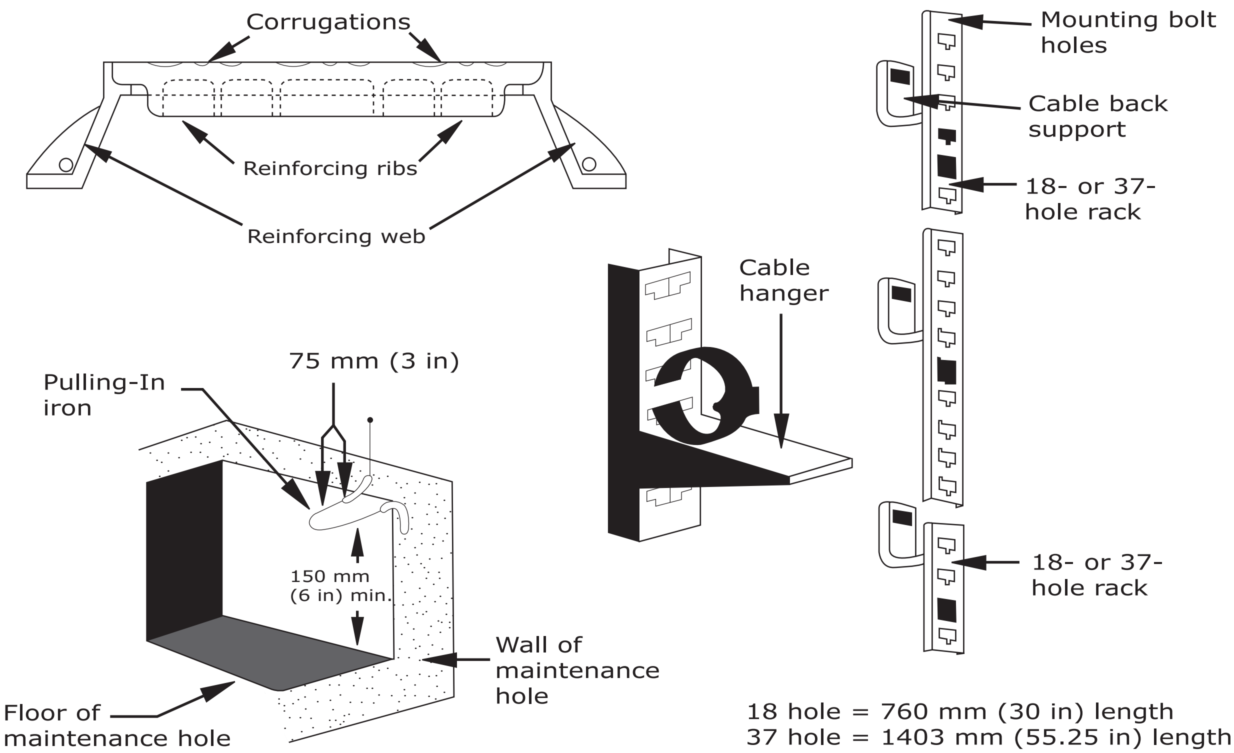
Figure 3.13
Typical cable maintenance hole



Maintenance Hole (MH) Hardware

Figure 3.14 illustrates the elements of the MH.

Figure 3.14
Maintenance hole racking



in = Inch
mm = Millimeter

MHs can be ordered or constructed with a wide variety of configurations. Each MH may be referred to using a simple one-letter designation such as “A type” or “J type.”

NOTE: Refer to the latest edition of BICSI’s *Outside Plant Design Reference Manual (OSPDRM)* for further clarification.

Aerial Plant Criteria

Planning and Designing Guidelines

The following are suggested planning and designing guidelines for aerial plant:

- Consider aerial design if buried design is significantly more expensive or is not feasible due to temporary area construction.
- Select permanent locations for pole lines while considering:
  - Future road widening or realignment.
  - Expansion of other utilities.
  - Special problems (e.g., road, railway, and power line crossings).
  - Safety and convenience of workers and the general public.
- Obtain necessary permits and easements for:
  - Building and maintaining pole lines on private property and public right-of-way.
  - Crossing railroads.
  - Crossing over navigable waterways.
- Coordinate with other utilities with respect to possible inductive interference.
- Design pole line for ultimate needs, considering:
  - Pole-line classification.
  - Storm loading.
  - Clearance requirements.
- Use the most economical span length within the constraints imposed by the design guidelines while allowing for maximum growth of future interoffice cable feeders.
- When adding cable to an existing line or when establishing a joint-use line, check that the pole strength and clearances are adequate.
- Existing pole-line owners:
  - May require make-ready work to provide space for new cable.
  - Usually require reimbursement for any expenses incurred preparing the pole line.
- Use self-supporting cable rather than lashed cable if:
  - It is available in the required size.
  - There is no existing strand.
  - New cable cannot be lashed to an existing cable.
  - Adequate space exists for future growth.

Suspension strand and cable should usually be placed on the roadside of the pole line. However, if due to a known road moving where a cable line will be relocated, the field side should be used.

Poles

Specify poles by strength or class number (e.g., the strongest-rated pole at 00 and the weakest-rated pole at 10) and length (e.g., 10.7 m [35 ft] class 6). All poles of the same class, regardless of length and timber species, must be able to withstand the same horizontal load applied 610 mm (24 in) from the top of the pole.

The class of pole for a given installation is based on its design load not exceeding a percentage of the breaking strength. The pole-line class determines that percentage.

Aerial cable design includes the consideration of storm-loading areas based on frequency, severity, and damaging effects of ice and windstorms.

Pole Loading

Poles are subjected to the following three types of loading:

- Transverse storm loading due to wind pressure on the attachments and on the above-ground portion of the pole. (In heavy and medium storm-loading areas, loading includes the wind force on the ice-coated attachments but not on the ice coating of the pole.)
- Vertical loading due to the weight of the attachments and, on guyed poles, the vertical component of the tensions in the guys. (In heavy and medium storm-loading areas, loading includes the weight of the ice coating on the attachments.)
- Bending moments due to eccentric loads or to unbalanced tensions at unguyed corners and deadends.

NOTE: For guidance on pole-setting depth, slack span design, and pole-line guying and anchoring, refer to the latest edition of BICSI's *Outside Plant Design Reference Manual (OSPDRM)*.

Optical Fiber Cables

Because the sag of an optical fiber cable span is small, a new strand for the optical fiber cable should occupy the uppermost telecommunications space on the pole line. Construction of aerial optical fiber cable routes on joint-use pole line is not recommended unless sufficient space is available to provide the required vertical clearance from power wires. Because optical fiber cable weighs very little, the sag in an aerial optical fiber cable span is relatively small (e.g., not much more than the sag of the strand alone). Increasing the sag by stringing the strand at lower than recommended tension causes increased fiber stresses under storm loading and is not recommended.

If copper aerial cables exist on the pole line, do not sag the optical fiber cable to the same sag as the other cable(s).

Aerial Duct

Another method of placing aerial optical fiber cable is to place the cable through an aerial duct manufactured with a built-in support strand. This combination, also known as "figure 8 duct," which it resembles when viewed from the end, allows quick installation of strand and duct in one step. The prelubricated polyethylene conduit usually is equipped with a pull wire and can be pulled continuously for a substantial distance.

Separations and Clearances

Ensuring proper clearance and separation from power lines and traffic is one of the main considerations when designing an aerial entrance. The ITS designer must review each aerial span to assure that all safety factors are considered.

The ITS designer also is liable for reporting any existing hazard that must be corrected to the responsible utility company.

References

Consult the local AHJ for separation and clearance information. For example, in the United States, the *National Electrical Safety Code®* (*NESC®*) provides specifications regarding aerial construction to and between buildings.

NOTE: All clearances and separations must include the effects of temperature variations and ice loading on the sag.

References

AT&T Network Systems. Customer Education and Training. *Outside Plant Engineering Handbook*. Edminster, NJ: AT&T Network Systems, 1994.

Bell Atlantic Network Services. *Outside Plant Engineering Reference Manual*. South Plainfield, NJ: Bell Atlantic Network Services, 1987.

BICSI. *Outside Plant Design Reference Manual*. Tampa, FL: BICSI, 2007.

Ground Alliance. *One-Call Systems International*. Alexandria, VA: Common Ground Alliance, 2003.

GTE. *OSP Engineering*. Volumes I and II. Dallas, TX: GTE Technical Documentation, 1991.

Institute of Electrical and Electronics Engineers. *National Electrical Safety Code®*. Piscataway, NJ: Institute of Electrical and Electronics Engineers, 2007.

Insulated Cable Engineers Association. ANSI/ICEA S-85-625. *Aircore, Polyolefin Insulated, Copper Conductor Telecommunications Cable*. Carrollton, GA: Insulated Cable Engineers Association, 2007.

———. ICEA S-83-596. *Optical Fiber Premises Distribution Cable*. Carrollton, GA: Insulated Cable Engineers Association, 2001.

———. ANSI/ICEA S-84-608. *Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor*. Carrollton, GA: Insulated Cable Engineers Association, 2007.

———. ANSI/ICEA S-90-661. *Category 3, 5, & 5e Individually Unshielded Twisted-Pair Indoor Cable for Use In General Purpose and LAN Communication Wiring Systems*. Carrollton, GA: Insulated Cable Engineers Association, 2002.

———. ANSI/ICEA S-98-688. *Broadband Twisted-Pair Telecommunications Cable, Aircore, Polyolefin Insulated Copper Conductors*. Carrollton, GA: Insulated Cable Engineers Association, 2006.

———. ANSI/ICEA S-99-689. *Broadband Twisted-Pair Telecommunications Cable Filled Polyolefin Insulated Copper Conductors*. Carrollton, GA: Insulated Cable Engineers Association, 2006.

———. ICEA S104-696. *Standard for Indoor-Outdoor Optical Cable*. Carrollton, GA: Insulated Cable Engineers Association, 2001.

National Fire Protection Association. *National Electrical Code®*. Quincy, MA: National Fire Protection Association, 2008.

———. NFPA 72®. *National Fire Alarm Code®*. Quincy, MA: National Fire Protection Association, 2007.

———. NFPA 75®. *Standard for the Protection of Information Technology Equipment*. Quincy, MA: National Fire Protection Association, 2009.

———. NFPA 101®. *Life Safety Code®*. Quincy, MA: National Fire Protection Association, 2009.

References, continued

Telecommunications Industry Association. ANSI/TIA/EIA-568-B.1. *Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements*. Arlington, VA: Telecommunications Industry Association, 2001.

———. ANSI/TIA/EIA-568-B.2. *Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted-Pair Cabling Components*. Arlington, VA: Telecommunications Industry Association, 2001.

———. ANSI/TIA/EIA-568-B.3. *Optical Fiber Cabling Components Standard*. Arlington, VA: Telecommunications Industry Association, 2000.

———. ANSI/TIA/EIA-569-B. *Commercial Building Standard for Telecommunications Pathways and Spaces*. Arlington, VA: Telecommunications Industry Association, 2004.

———. ANSI/TIA/EIA-570-B. *Residential Telecommunications Cabling Standard*. Arlington, VA: Telecommunications Industry Association, 2004.

———. ANSI/TIA/EIA-606-A. *Administration Standard for Commercial Telecommunications Infrastructure*. Arlington, VA: Telecommunications Industry Association, 2002.

———. ANSI/J-STD-607-A. *Commercial Building Bonding and Grounding (Earthing) Requirements for Telecommunications*. Arlington, VA: Telecommunications Industry Association, 2002.

———. ANSI/TIA/EIA-758-A. *Customer-Owned Outside Plant Telecommunications Infrastructure Standard*. Arlington, VA: Telecommunications Industry Association, 2004.

Underwriters Laboratories. UL 94. *Test for Flammability of Plastic Materials for Parts in Devices and Appliances*. Northbrook, IL: Underwriters Laboratories, 1996.

———. UL 497. *Standard for Protectors for Paired-Conductor Communications Circuits*. Northbrook, IL: Underwriters Laboratories, 2001.

———. UL 497A. *Secondary Protectors for Communications Circuits*. Northbrook, IL: Underwriters Laboratories, 2001.

U.S. Department of the Army. FM 11-486-5. *Telecommunications Engineering Outside Plant, Telephone*. Washington, DC: U.S. Department of the Army, 1978.

U.S. Department of Labor, Occupational Safety and Health Administration. *Code of Federal Regulations*, Title 29, Part 1910: *Occupational Safety and Health Standards*. Washington, DC: U.S. National Archives and Records Administration's Office of the Federal Register, 2001.

———. *Code of Federal Regulations*. Title 29, Part 1926: *Safety and Health Regulations for Construction*. Washington, DC: U.S. National Archives and Records Administration's Office of the Federal Register 2003.

References, continued

U.S. Government Printing Office. Bulletin 1751F-630. *Design of Aerial Plant*. Washington, DC: Rural Utilities Service, 1996.

———. Bulletin 1751F-635. *Aerial Plant Construction*. Washington, DC: Rural Utilities Service, 1996.

———. Bulletin 1751F-640. *Design of Buried Plant-Physical Considerations*. Washington, DC: Rural Utilities Service, 1995.

———. Bulletin 1751F-641. *Construction of Buried Plant*. Washington, DC: Rural Utilities Service, 1995.

———. Bulletin 1751F-642. *Construction Route Planning of Buried Plant*. Washington, DC: Rural Utilities Service, 1995.

———. Bulletin 1751F-643. *Underground Plant Design*. Washington, DC: Rural Utilities Service, 2002.

———. Bulletin 1751F-644. *Underground Plant Construction*. Washington, DC: Rural Utilities Service, 2002.

———. Bulletin 1751F-650. *Aerial Plant Guying and Anchoring*. Washington, DC: Rural Utilities Service, 1996.

———. Bulletin 1751F-815. *Electrical Protection of Outside Plant*. Washington, DC: Rural Utilities Service, 1995.