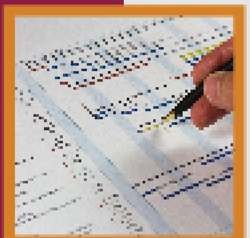
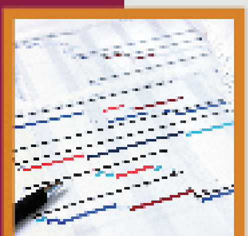
Telecommunications Project Management Reference Manual

BICSI Resource Material for RTPM Study

Second Edition





BICSI®

advancing the information and communications technology community

Telecommunications Project Management

BICSI Resource Material for RTPM Study

Second Edition

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- In some instances (e.g., optical fiber media specifications), the physical dimensions and operating wavelengths are designated.

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Section 1 Telecommunications Project Management

The following pages are taken from BICSI's *Outside Plant Design Reference Manual* (*OSPDRM*), *5th edition*. These supplementary pages have been isolated from the *OSPDRM* and directly reference material that is relevant for study for the Registered Telecommunications Project Manager (RTPM) credential.

Optical Fiber Cable Testing For Risk Management

Manufacturer's Responsibility

Production Test

The manufacturer conducts tests on all strands with full OTDR scan at 1310 nm and 1550 nm after cable assembly and spooled onto reel. A copy of this test is attached to each reel along with the shipment's packing slip. This ensures that the cable is good after manufacturing, but it does not include storage and inventory operations. This protects the manufacturer from claims about faulty production.

Contractor's Responsibility

Cable Reel Acceptance Test

The cable reel acceptance test is conducted upon the receipt of cable from the shipper. Test only from the inside end at 1310 nm and 1550 nm. This can be performed on all strands, or an abbreviated version can be performed on one strand per buffer tube.

The test is usually performed within three to five business days of delivery. Some shipping companies have a mandatory maximum contractual period in which they can be held liable for damage, so testing should be completed as soon as possible after delivery.

This test ensures that the cable is in good condition after the inventory storage, handling, and shipping.

Cable reel testing is considered part of risk management of the party responsible for purchasing the cable. Without a reel test cable, damage cannot, with any certainty, be isolated to shipping and handling or installation operations. This may protect the prime or interim cable owner from damage during the loading and shipping process.

Cable Installation Test

This test is conducted after the physical installation of the cable has been completed, but before termination or splicing. The test is performed on each cable section, from both ends, at 1310 nm and 1550 nm wavelengths and on all strands.

This verifies that the cable has not been damaged during the installation process. The installation test is optional and is intended to protect the prime or interim cable owner from the installation crews' or contractors' errors.

Final Acceptance Test

The final acceptance test is conducted after all splices and connectors are installed. Test from both ends with a full OTDR scan at 1310 nm and 1550 nm. The acceptance test is performed on all strands and shall be compared to the manufacturer's production test.

A final acceptance test proves that the cable is good after all work is completed, including dressing in racks and trays and splicing or termination work. A successful test will usually lead to the client's acceptance and final payment. This may protect the client from all damage or defects resulting from faulty workmanship or handling.

Optical Fiber Cable Testing For Risk Management, continued

NOTE: Copies of all of the tests shown above plus the packing slip should be kept for the length of the warranty period by the responsible contractor. Copies of test items shall become part of the clients' acceptance documents and will become part of their permanent records.

Similar tests by the contractor should be considered for multipair copper and coaxial cable to mitigate risk.

Site Survey

Site survey is one of the most important parts of any job. It allows the OSP designer to take the time to look at the overall picture and resolve any possible conflicts that could delay or stop the job. At this stage, the OSP designer gathers general information about the existing OSP conditions and begins to determine where the proposed OSP facilities will be placed. The OSP designer also draws detailed notes about the existing field conditions. Photos are recommended to document site conditions at the time of the survey and can be useful in potential legal disputes.

Pathway Considerations

In planning for OSP cabling, cable infrastructure must be determined first. The choices are underground, direct-buried, and aerial.

While being the most expensive system, underground plant usually has the highest cable placement capacity (dependent on the number and size of conduits placed) and the longest projected lifespan, typically in excess of 50 years. Despite the initial high cost, it is considered the most economical route placement system over the span of its service life.

Direct-buried plant has a lifespan of 30 years or shorter, depending on different conditions (e.g., the cable has no external protection from vermin damage or construction unearthing other than its own sheath and armoring).

Aerial plant (poles, cable, hardware, and guys) typically has an expected life of about 30 years.

While the expected service life of the selected facility is a factor in route construction so are the expected technical capabilities. Rapid technology development outdates products quickly. The OSP designer must factor in the expected useful life of the design and advise the owner of the latest developments. Ensuring a long life from a type of technology that has been bypassed by newer developments may have little value. However, this is a decision the owner must make.

Prior to performing a site assessment for a customer, the OSP designer should obtain permission from the customer to work at the facility. If sensitive/secure areas are involved, the OSP designer should determine specific security measures to satisfy customer requirements.

While performing the site survey for a current or potential customer, either for new construction or overbuilds, it is important to discuss the aesthetic requirements of the job so that both parties understand the expected end result. For example, if open cuts are used to cross streets, does the customer require repairing only the immediate path or replacing or repaving an entire section?

While determining the proposed route for cable or conduit, the OSP designer should discuss routing with the customer. The customer may have reasons not to use the proposed route (e.g., future plans for buildings and parking lots). Once the customer approves the proposed route, the OSP designer should identify splice or taper points for the new cable.

Site Survey, continued

Even after the customer has approved the proposed route, the following field conditions may force route changes:

- Adverse ground conditions
- Coordination with other utilities
- Missing easement or permits
- Customer space utilization issues
- Document errors or omissions
- Unusual or special land use or activities in close proximity to the route

It is not always necessary to build new pathways for cable placement. The existing route may be fully adequate. The OSP designer should evaluate the existing:

- Pole lines.
- Conduit.
- MHs.
- Handholes (HHs).
- Tunnels.

If space is available, these structures should be used to place the new cables, provided that the customer owns the structures. However, in equipment rooms (ERs) and EFs, EMI can couple itself onto telecommunications circuits and corrupt data packets transmitted on that medium. This may cause corruption of the transmitted and stored data. Corrupt data within a computer system or storage array can effectively reduce transmission rates. OSP designers must consider sources of EMI when designing or installing information and communications technology (ICT) systems equipment on walls, racks, or cabinets that share space with or near power equipment.

NOTE: One method to determine the amount of EMI interference is to use an extremely low frequency (ELF) gauss meter. The gauss meter will determine the magnetic field strength. The gauss meter is designed to measure only alternating current (ac) magnetic fields in the 30 to 300 hertz (Hz) frequency range.

Alternate Route Considerations

An alternative route may be considered if the field investigation indicates the proposed route would be exposed to heavy traffic, expensive pavement replacement, adverse soil conditions, or other factors that might create:

- High installation costs.
- An unsafe working environment.
- Future maintenance issues.

Except where safety is a concern, the OSP designer should determine whether a change should be made by deciding which is most cost efficient—the proposed route or an alternative route. When selecting the most cost-effective route, consideration must be given to legal fees and costs associated with delays because of the acquisition of permits, easements, and local approvals.

Even if the most direct route appears to require a greater initial cost (e.g., more excavation or restoration costs), this cost should be weighed against that required for a longer route, including larger cable gauges, longer cable loops, and additional splicing.

Flagging, Painting, and Marking Utilities

All subsurface utilities must be located prior to construction and may be required for proper design. The facility owners must be notified of all construction activities that may cause damage to their utilities. The period of time required for notifying facility owners will vary by jurisdiction. Small color-coded flags or color-coded paint is used to mark the locations. The Common Ground Alliance (CGA) recommends uniform color codes (see Table 1.1).

Table 1.1
Uniform color code for utility flagging, painting, or marking

The color…	Is used to identify…
White	Proposed excavation
Pink	Temporary survey markings
Red	Electric power lines, cables, conduit, and lighting cables
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Orange	Communications, alarm, and signal lines, cables, and conduit
Blue	Potable water
Purple	Reclaimed water and irrigation and slurry lines
Green	Sewers and drain lines

Test Holes (Potholes)

Obstacles located along the proposed route should be identified. Underground obstacles are located using either electronic means or test holes.

A test hole is created by hand digging or using other noninvasive methods described in CGA *Best Practices*. A test hole is a small hole either directly above or to the side of the obstacle's assumed position.

NOTE: An undocumented utility may be an obstacle.

A test hole is located within the tolerance zone. This zone varies between ≈305 millimeters (mm [12 inches (in)]) and ≈914 mm (36 in) from the marked obstacle. Local ordinances or state laws should be checked for tolerances and advance notice requirements. If the zone is not identified by law or code, the measured zone should be a minimum of ≈457 mm (18 in) measured horizontally from the center to each side of the facility.

When an obstacle is located, a plan and profile drawing should be created to identify its location. The route can be plotted using this information.

Documentation

A record should be made of the proposed route details (e.g., path, quantity, size, depth) with references to a fixed point, showing the condition of road surfaces and various adjoining structures. This record may be valuable if it becomes necessary to challenge future property damage claims. A video record or dated and notarized photographs showing preinstallation and postinstallation may also be useful for this purpose.

Right-of-Way

When working on public or private right-of-way, necessary permits and easements should be obtained before beginning construction. If construction is planned on a:

- Public right-of-way, permits should be obtained from an appropriate authority having jurisdiction (AHJ) (federal, state, county, city, or park) for the use of the proposed route.
- Private right-of-way or easement, the right to use the property must be negotiated with each land owner.

NOTE: Because of financial need, many local jurisdictions charge a fee based on the distance for permits on public right-of-way for applicants that do not have a franchise agreement with the AHJ or who are not exempt. This can be costly to the client and to the construction vendor if this is not considered and investigated during right-of-way research and the route selection process.

Joint Use Occupancy

To reduce the cost of multiple trenches and minimize the potential for damage to the existing facilities, the telephone company, community antenna TV (CATV) provider, and power company occasionally decide to dig a single trench and share it with one or all of the other parties. If joint trenching becomes an option in a particular situation, refer to publications such as the *National Electrical Safety Code®* (*NESC®*) for rules on cable separation.

NOTE: Under a joint use agreement, concordance of all involved parties should be established.

Right-of-Way

Overview

The concept of right-of-way or the use of land for the public good is rooted in antiquity. The royal road built in 4500 B.C. by Darius the Great, the king of Assyria, consisted of an ≈23.8 meter (m [78 foot (ft)]) right-of-way stretching from the Persian Gulf to the Mediterranean Sea (≈2857 kilometers [km (1775 miles [mi])]). This right-of-way was considered so important that the king declared that any person found to have encroached on the right-of-way would be impaled in front of the palace. Today, encroachment would more appropriately be handled in a civil court.

Although the contents of this section are written as BICSI® best practices, the outside plant (OSP) designer must understand the right-of-way laws of the countries that practice OSP design and installation. The OSP designer is advised to seek out right-of-way professionals to ensure compliance in the geographic area of the OSP design work.

Designers who deal with OSP construction will be involved in acquisition of right-of-way. Even if not directly involved in the actual right-of-way acquisition, OSP designers need to be aware of the responsibilities that other parties have in obtaining right-of-way, including:

- Acquisition processes.
- Types of right-of-way required.
- Legal ramifications involving clients.

Although clients can require that the contractor be responsible for obtaining the right-of-way documents, the clients must execute the documents because they own the physical plant to be installed.

The right-of-way acquisition process can be one of the greatest factors that affects a project's schedule. When choosing various construction alternatives, the OSP designer should consider the potential difficulty in right-of-way acquisition. As an OSP project becomes more invasive, the right-of-way acquisition process becomes more difficult and time consuming. For example, installing optical fiber cable in an incumbent local exchange carrier's (ILEC's) existing underground duct system has little adverse impact on a community and is likely to be supported by public officials. Conversely, trenching a roadway in an urban center to install new duct for optical fiber cable is likely to cause traffic delays and other associated impacts, creating a more difficult acquisition process.

Projects with more adverse impacts are likely to take more time because the right-of-way granting authorities will want a higher level of detail and may seek additional information, ensuring that impacts have been mitigated to the greatest extent possible. Depending on the locality, the right-of-way granting authorities may also negotiate an exaction (fee) for compensation because of the impacts they feel are particularly burdensome.

It is crucial to ensure that all right-of-way issues are properly identified. If one small segment of an OSP route is not properly authorized, that segment becomes the weakest link and prevents the entire OSP project from proceeding.

Overview, continued

One issue involving right-of-way is the terms under which the rights are acquired. Access to maintain the facilities that are placed to rebuild, reinforce, and expand or remove must be provided. The more difficult or undefined the terms are, the more likely access will be denied. The OSP designer must consider these issues before executing the right-of-way documents.

Definition

Right-of-way is the legal right to pass through or over property owned by another party. This includes the land on which facilities are built. These facilities can take the form of:

- Transmission lines.
- High-pressure gas lines.
- Railroads.
- Telecommunications facilities.

Right-of-way can be a:

- Fixed width (e.g., roads, railroads, utilities).
- Variable width (e.g., expensive land, permanent structures).

OSP has been defined as the facilities connecting buildings on contiguous property. However, in certain instances, there could be a requirement to bridge the gap between several pieces of property that make up the complex being served. In that instance, it is necessary to acquire the permissions of other landowners to cross the adjacent property. The legal document used to acquire this permission can be an easement, license, or permit. Permits are normally used when the right-of-way crosses public property (e.g., a roadway) or some private land (e.g., a railroad).

Usually, OSP facilities are placed on the customer's property. When placing a facility on the customer's property, only the customer's permission is required unless unusual situations exist (e.g., the presence of wetlands, railroad spurs on the property).

If a customer plans to continue facilities beyond the property's boundaries, permission is required from others, including the:

- Government (e.g., city, county, state, federal).
- Department of Transportation (DoT).
- Railroads.
- Utilities.
- Private property owners.

NOTE: Agencies have different requirements and restrictions for placing facilities. A government authority with legal jurisdiction is often referred to as an AHJ.

Definition, continued

Acquiring access to a public right-of-way is more difficult for customers who are not franchised utility providers. A public right-of-way is typically reserved for franchised utility providers such as:

- Power.
- Water.
- Sewer.
- Telephone.
- Cable TV.
- Gas.

Even franchised utility providers may be required to pay substantial annual premiums for the right to use the public right-of-way. These premiums can be based on the linear footage of the easement and facilities.

EXAMPLE: If multiple cables are placed in one trench, the premium could be based on the total cable footage of all cables placed in the trench as opposed to the length of the trench itself.

Types of Right-of-Way

There are two primary categories of right-of-way, but a third category shares the characteristics of the other two:

- Public right-of-way involves the land owned by government agencies.
- Private right-of-way involves the land owned by an individual, company, or corporation.
- Railroad right-of-way involves the land owned by railroad companies. Though privately owned, railroad companies are granted much greater power over land use and procurement than other private landowners and, in that respect, resemble public right-of-way.

Purchasing Right-of-Way

Purchasing private right-of-way grants the purchaser the same rights as any property owner as well as the responsibility to pay all related taxes and fees associated with ownership. Generally, right-of-way is purchased when placing structures such as:

- Buildings.
- Towers.
- Remote property locations.

Scope of Work (SoW) Documentation

Overview

SoW documentation encompasses the various items necessary to initiate and sustain a design and installation effort. Depending on the contract type, the documents can include a statement of work or a statement of objectives.

An SoW is a prescriptive (i.e., detailed and controlling) document developed by either a client or a collaborative client/OSP designer team for defining the project requirements. A well-defined SoW is very important for a successful project.

The critical elements of an SoW include the:

- Title.
- General statement.
- Objective.
- Performance requirements/outcomes.
- Specific tasks.
- Document deliverables.
- Qualification requirements.
- Place and period of performance.
- Construction management.
- Restrictions.
- Security clearance requirements.
- Contracting representative.
- Attachments.
- Assumptions.

This section outlines the major elements of a well-defined SoW.

Title

The title can be very important if an organization has multiple solicitations each year. Some procurement agencies choose to assign a number to each solicitation with the year embedded in the number to help with identification (e.g., 0012007).

General Statement

The general statement is a brief description of the overall project. An example of a general statement would be, "Furnish, install, and test a singlemode optical fiber cable from building 01 to building 02." General statements lengthen and become more comprehensive as the size and scope of the project increases.

Objective (Narrative)

The objective is a description of the overall project. An example of an objective statement would be, "The new 12-strand optical fiber cable will provide connectivity from the lab to the hospital so that doctors can read the x-rays without having to walk to the lab."

A well-written and accurate objective provides the OSP designer or contractor with a firm basis for further design and installation documents.

Performance Requirements (Outcomes)

Performance requirements are a key piece of the SoW, which provide the description of what the telecommunications system must accomplish. The client or client team must describe the desired outcome without specifying an engineering solution. This description should be based on industry and commercial standards, specifications, and codes.

Specific Tasks

The specific tasks identify each task that should be completed under this SoW. Some examples of important details that should be captured in the specific tasks section of the SoW are discussed below.

Type of Pathway

The OSP designer should identify if the OSP pathway will be underground, direct-buried, aerial, tunnel, or a combination. Some considerations for OSP pathways include:

- Type, size, and quantity of poles required.
- Type, size, and quantity of strand required.
- Depth and width of trench.
- Warning tape requirements.
- Type, size, and quantity of maintenance holes (MHs) required.
- Tunnel entrance and exit location.

NOTE: It is recommended to include a schematic of the MH.

Type of Cables

The OSP designer should identify the type and size of cables that need to be installed and specify the length of the cables, including slack, if known.

Splicing/Termination Requirements

The OSP designer should identify the type of termination methodology to be used for copper, optical fiber, and coaxial cables. Some examples include:

- Modular copper splicing.
- Single-pair copper splicing.
- Fusion optical fiber splicing.
- Mechanical optical fiber splicing.
- Optical fiber termination method.

Specific Tasks, continued

Associated Hardware and Material Required

Associated hardware includes cabling hardware, closures, pathways, and connecting hardware. Details for associated hardware should be listed in the material lists, and any special requirements for these items may be included in the descriptions.

Grounding Requirements

The OSP designer should identify any special grounding requirement as some systems have specific resistance-level requirements.

Permit Requirements

The OSP designer should identify any special types of permits that need to be obtained before starting the project. Depending on the jurisdiction, some permits can take a substantial amount of time to process.

Code and Standard Requirements

The OSP designer should identify the codes and standards to which the project must conform. Some geographic areas or project types require unique codes and standards. The OSP designer should also indicate where and how these documents can be obtained. Defining applicable codes and standards is a critical element in preparing an SoW. They describe the framework in which the work is to be performed.

Type of Restoration Required

The OSP designer should identify what type of restoration is required. Some examples of restoration include:

- Sod and hydroseeding.
- Concrete.
- Asphalt.
- Landscape.

Testing Requirements

The OSP designer should identify what type of testing will be required. Some examples of testing are:

- Fiber test.
- Copper test.
- Preinstallation tests.
- Existing infrastructure/equipment test.

Specific Tasks, continued

Document Deliverables

The OSP designer should identify what types of deliverables are required before, during, and after project completion. Some examples of deliverables are the:

- Safety plan.
- Test plan (before project start).
- Milestone designs (e.g., 10 percent, 35 percent, 90 percent, etc.).
- Final design (before project start).
- List of materials (before project start).
- Proof of concept (during project).
- Test results (post project).
- Hard and soft copies of test results.
- As-built/record drawings (post project).
- D-sized computer-aided design (CAD) drawings.
- Soft copy of CAD drawings.

Reporting Requirements

The OSP designer should identify what deliverables are due to the customer during the course of the project. Some examples include:

- Progress reports.
- Audits.
- Safety reports.
- Expenditure reports.

Qualification Requirements

The OSP designer should identify any special licenses, degrees, registrations, or special certifications that potential bidders must have as a minimum requirement for bidding on a project. Examples of licenses, degrees, or special certifications include:

- Professional engineer (PE).
- BICSI® credentials applicable to the project (e.g., Registered Communications Distribution Designer [RCDD], OSP Designer).
- Applicable trade licenses (e.g., low-voltage license).
- Senior Right of Way Agent (SR/WA).
- OSP project manager (PM).
- Project Management Professional (PMP).
- Telecommunication Project Manager (TPM).

Place and Period of Performance

The place of performance indicates the locations where the work will be performed, which is also indicated on the construction work prints in the form of work location numbers. The period of performance indicates both the first day and the final day of the contract. Additionally, the hours of operation during which the work can be completed by the contractor are identified. This also should be included in the project management documents (e.g., network diagram, program evaluation review technique [PERT] and critical path method [CPM] charts).

Construction Management

The OSP designer should determine whether an on-site construction manager (CM) is required for the project, and the OSP designer should indicate if there are any special or minimum requirements for the CM (e.g., 10 years experience, managing projects over $5 million, RCDD/OSP Designer).

The OSP designer should determine the level of independent quality assurance (QA)/quality control (QC) required for the project, and the OSP designer should indicate if there are any special or minimum requirements for the QA/QC (e.g., 10 years of experience, RCDD/OSP designer).

Restrictions

The OSP designer should identify any special restrictions that might be relevant to the job. Some examples include:

- Schedule.
- Environmental requirements.
- Prevailing wages (Davis-Bacon Act).
- Governmental restrictions.
- Precertification requirements.

Security Clearances

Some government and commercial work may require a variety of security clearances. The OSP designer should identify the client's security requirements for the project and delineate in the project plan how the requirements will be handled. Some aspects the OSP designer should consider are:

- Clearance process, including time frame.
- Escort requirements.
- Background check.

Contracting Representative

The OSP designer should identify who will be the customer's authorized representative to make contractual decisions for the project. The name, office or agency, address, telephone and fax number, and e-mail address of the customer's representative should be included.

Attachments

The OSP designer should list any attachments that are included in the SoW. Some examples are the:

- Schedule.
- Wage determinations.
- Construction drawings for pathways, spaces, media, and termination and splicing hardware for the buildings.
- Bonding and grounding (earthing) drawings for OSP and entrance facilities (EFs).
- Conceptual drawings.
- Test procedures for all media installed and terminated/spliced.
- System requirements documentation.
- QA/QC plan.

Assumptions

The OSP designer should include any project-specific assumptions that are required.

Section 2
Telecommunications Project Management

The following pages are taken from BICSI's *Information Technology Systems Installation Methods Manual* (*ITSIMM*), *6th edition*. These supplementary pages have been isolated from the *ITSIMM* and directly reference material that is relevant for study for the Registered Telecommunications Project Manager (RTPM) credential.

Common Safety Practices

Overview

It is every organization's responsibility to provide safety training for its employees and to ensure that safety procedures are strictly followed. Safety training should be given on a regularly scheduled basis and not as a result of an injury.

Because of the daily hazards to which information and communications technology (ICT) cabling systems installers are exposed, it is vital that all installers have a complete understanding of rescue and first aid procedures.

Installers must know their company's safety policies and practices, and they must follow them while working. Be aware of any site-specific safety issues that affect a task. Pay close attention, and ask questions during company and work site safety meetings.

Each employee should ensure that workplace safety is part of the job. Do not depend only on others' efforts to ensure job safety.

When working, consider the possible effects of every action. This is especially important for actions that could have consequences in remote locations (e.g., turning the power on or off, activating distant machinery).

This section is not intended to provide complete coverage of the issue of workplace safety. It is the installer's responsibility to be aware of regulations, standards, and local policies and to play a primary role in practicing safety.

Most countries have national and, often, local requirements that must be followed as a minimum. In all instances, the installer should seek guidance from the authority having jurisdiction (AHJ) on the minimum requirements for safe work and employee health at work. On most projects, a site-specific safety practice must be followed.

Safety Awareness

The rules regarding the size of a company that must provide a specific type of safety program or training vary by state and, at times, by city.

However, the common themes for safety are:

- Common sense.
- Training.
- Caution.
- Awareness.
- Cooperation.
- Participation.

Safety Awareness, continued

Workplace safety is not simply remembering to wear a hard hat or knowing how to secure a heavy load. It includes a full range of health-related issues as well as physical safety aspects.

Information about safety in the workplace is available for individual workers and companies of all sizes. In addition to local and national safety requirements, most industry trade organizations and labor unions offer extensive resources on safety and safety planning.

This section provides a limited overview of some common health and safety issues related to the ICT field. It is up to individuals to seek additional information from their company, trade organization, or regulating body.

First Aid

All installers should take courses in, and be capable of, providing:

- Basic first aid.
- Cardiopulmonary resuscitation (CPR).

The Red Cross and other nongovernmental organizations (NGOs) offer local courses in standard first aid and community CPR around the world.

First aid is the emergency aid or treatment given before medical services can be obtained. Training in first aid prepares individuals to act properly and to help to save lives in the event of an emergency.

CPR is the emergency procedure used on a person who is not breathing and whose heart has stopped beating (cardiac arrest).

First Aid, Cardiopulmonary Resuscitation (CPR), and the Law

Depending upon your location, the AHJ may have laws that govern how to approach and assist an injured person.

First aid and CPR certifications should be kept current. Certification cards have expiration dates, and they require refresher courses to renew certification.

First Aid Kits

First aid kits and portable eye wash stations must be part of the equipment for every job. Portable eye wash stations can provide fresh water to rinse debris or toxins from eyes when fresh water may not otherwise be available during certain construction periods.

Ensure that the first aid kits are restocked after each use. Ensure that eye wash stations have not passed their expiration dates. Promptly report any use of supplies from the first aid kit to the appropriate supervisor.

NOTE: Many companies keep additional first aid kits. At the end of each month, kits that have been used on the job are swapped with fully stocked kits. The used kits may then be restocked and prepared for reuse.

First Aid, continued

First aid kits and eye wash stations should be accessible to all personnel at the work site. Use precautions to ensure that eye wash stations and any liquids used for first aid services are protected from freezing temperatures.

Written copies of the first aid procedures for exposure to a hazardous substance (e.g., material safety data sheet [MSDS]) shall be brought to any job where installers might be exposed to that substance. It is the assigned individual's responsibility to request these documents if they are missing, lost, or mutilated. Review these procedures before work begins.

Emergency Rescue

Emergencies allow no time for asking questions or learning from mistakes. There may be only one chance to save a life. An untrained rescuer often becomes an injured person of the situation that caused the emergency. For example, if a rescuer attempts to assist an unconscious injured person who is lying across an energized electrical circuit, the rescuer can become part of the circuit with the injured person. In addition, an untrained individual can inadvertently cause additional harm or injuries to the injured person.

Training in emergency rescue and first aid is often provided in one comprehensive course.

There are six basic steps to safely assist others without endangering yourself:

- Survey the scene—Check for fire, toxic fumes, heavy vehicle traffic, live electrical wires, ladders, or swift-moving water. If the injured person is conscious, ask questions to get information.
- Notify someone—It is imperative to let someone know that assistance is required and where the assistance is required, especially when you elect to stay behind to attend to an injured individual in an emergency or life-threatening situation. If a person attempts the rescue alone and becomes overwhelmed by smoke, electrocution, or unseen gases, additional help is needed.
- Secure the area—Make the area safe for the rescuer and the injured person. Locate and secure the power to the energized circuits, and turn off the gas or water mains if necessary. Move the injured person to a safe area only if doing so would not further complicate the person's medical condition or if the person is in an immediate life-threatening situation.

  NOTE: Do not move someone with a neck or back injury unless it is a life-threatening situation.

- Complete a primary survey of the injured person—Check the injured person's ABCs:
  - A is for airway. Open the injured person's airway. This is the most important action for a successful resuscitation.
  - B is for breathing.
  - C is for circulation.

Emergency Rescue, continued

- Phone emergency medical services (EMS)—Direct someone to call EMS, and relay all the information collected in the initial survey.
- Complete a secondary survey of the injured person—Perform CPR as needed, and check for secondary minor injuries that may have been previously overlooked.

IMPORTANT: The rescue techniques outlined are basic and should only be used after receiving the proper training. Some rescues require specialized training and equipment.

Communication

Communication is an important part of any safety program. Attend and pay close attention to all safety meetings and safety equipment training. Ask questions.

On the job, installers must communicate freely and clearly with everyone affected by their work and those whose work may affect them. These people include:

- Coworkers.
- Supervisors and the building management.
- Building occupants (if any).
- Other workers (e.g., construction, electric utility) on-site.

When the work is being performed in two locations (e.g., electrical circuit is being switched off from one location to allow an installer to work safely in another location), workers in each location should repeat each message and secure the confirmation that it was heard correctly before acting on the message. Never assume that related tasks have been performed; always obtain the confirmation.

NOTE: Portable radios use a limited number of frequencies; therefore, it is likely that different crews will be using the same frequencies. When using radios to communicate between two locations, workers should always confirm that they are talking to the correct person.

Be alert, and read any warning signs or markings. Bring them to the attention of coworkers who may have missed them. Encourage communication by politely accepting repeated information. It is better to be notified about the same hazard several times than not to be notified at all.

If installers discover any defective or damaged equipment or facilities, installers must report them promptly to their supervisor or directly to persons qualified to handle the problem (e.g., report damaged electrical power lines to electrical workers on-site or to a building or construction supervisor who will contact electrical workers).

Communication, continued

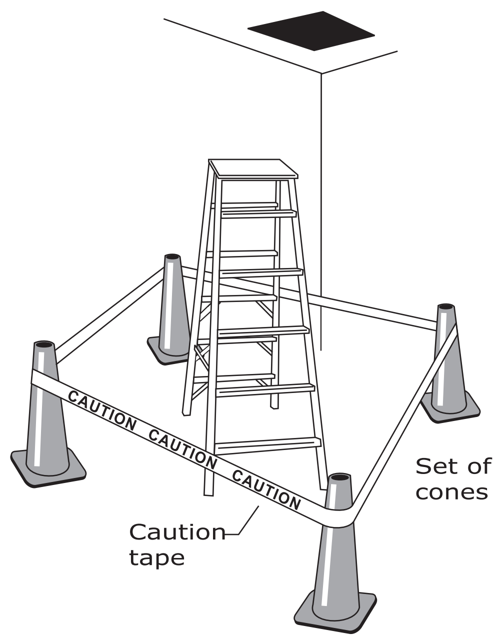
If the defect or damage poses an immediate hazard, the installer should do everything safely possible to ensure that others are not harmed by the hazard before qualified personnel arrive to troubleshoot the problem. This may involve notifying other workers in the area, putting up signs and barriers, or standing guard until qualified personnel arrive.

IMPORTANT: Installers must promptly report all accidents or injuries to their employers.

Designating Work Areas

Always use proper visible safety barriers or delineators to designate work areas and to restrict access (see Figure 2.1). Yellow caution tape and folding A-frame signs may be used. Leave enough room inside the safety perimeter to do the required work.

Figure 2.1
Designated work area



Consider the needs of the building occupants whenever possible. Try not to block a doorway or hallway for which there is no alternate route any longer than necessary. When working near doors or hallway corners, try to ensure that oncoming pedestrians can tell there is a work area ahead. If working behind a closed door, mark the door with a sign that informs personnel that you are on the other side. Do not leave open floor systems (e.g., trench ducts), access floor panels, open ceiling systems with dangling access panels, or unattended equipment.

Tools and Equipment

Installers must use only the tools for which they are trained or certified to operate. Manufacturers require users to be certified to use certain devices (e.g., powder-actuated tools). Never be afraid to ask questions about the proper use of any tools. Installers should not use a specific tool if they are uncomfortable or untrained in the safe use of that tool.

Use the tools only for the purpose for which they are intended (e.g., use a tool designed for cable stripping to strip cable insulation; do not use a pocketknife for this purpose). In addition, utilizing a screwdriver as a scrapper, chisel, pry bar, framed wall saw, hole punch, or a drill for wood can easily cause injury to the installer or others or damage to the materials or hardware being installed.

Examine both hand tools and power tools regularly to ensure that they are in safe working condition. Broken tools must be immediately tagged “broken” and removed from the work site. A detailed description of the problem should accompany the tag. This may help to prevent an injury to someone using the tool prior to the tool’s repair or replacement.

Wooden or plastic handles of hand tools must be kept free of splinters, sharp-edge cuts, or other surface damage that could injure workers’ hands. Do not use a hand tool if its handle is loose. Loose-handled tools can give way suddenly, causing injuries to people and damaging equipment.

When using powder-actuated tools, always verify that the area behind and around the work area is clear.

Do not attempt to drive nails or other fasteners into:

- Brittle or hard materials (e.g., glazed tile, glass block, face brick). The shattering of the material (fastener) can scatter dangerous shards across a wide area.
- Soft or easily penetrated materials. The nails or fastener can pass through the material and create a hazard for people on the other side.

NOTE: These precautions apply to both manual and powder-actuated tools.

Inspect power tools regularly to ensure that the automatic cutoff, guards, and other safety devices work properly. Follow the manufacturer’s recommended maintenance schedule to ensure reliable operation.

Before each use, examine power tools to ensure that all guards are in place and securely attached.

Safety codes often require a ground fault circuit interrupter (GFCI) when temporary electrical wiring is used. Temporary electrical wiring may be defined by the local AHJ as an extension cord or even a building’s entire internal electrical wiring prior to final inspection and acceptance.

Tools and Equipment, continued

Power tools that require a three-conductor power cable must be grounded. Never use a power tool if the ground prong of the plug has been cut off. Never use a power tool with an extension cord or adapter that eliminates the ground prong before the cord reaches the outlet. Never use a tool's power cord to lift or lower the tool.

Carefully follow all manufacturer's instructions when mounting, securing, and using potentially dangerous mechanical equipment (e.g., cable winches, tension arms, cable wheels, cable brakes, powder-actuated guns). Do not set up or operate this equipment without first receiving adequate training and having access to the manufacturer's instructions. Ensure that no personnel are working within the danger zone of a cable winch.

NOTE: Keep original instructions for tools on file at the office. Keep photocopies of the instructions with each tool. This ensures that a set of instructions is always available at the office and used to make additional copies for the work sites.

Ensure adequate lighting is available to safely and efficiently perform work. Proper lighting will help prevent accidents and rework. Use portable lighting, and keep it away from combustible materials. Ensure that any halogen lighting remains in a level position. Halogen bulbs get very hot, and some lamps, if tilted, can melt or cause a fire hazard. Read and follow manufacturer's instructions when using halogen lights.

Ladder Safety

ICT cabling systems installers must know how to choose, securely place, climb, and safely work on a ladder. The location of cabling and equipment requires that ladders be used often for both installation and repair work.

NOTE: The local AHJ often requires that manufacturers print ladder use guidelines on the ladders. Read and follow these guidelines.

The local AHJ does not always require workers to wear fall-arresting safety equipment while working on portable ladders. However, the local AHJ regulation enforcement at the site level may have unique requirements that add to the requirements set at the national level. Even though it may not be required, it is a good safety practice to tie off to a secure anchorage when working aloft with heavy equipment or over a prolonged period. Always place a ladder so that the ladder is between the user and any potential fall hazard, especially at the edge of a floor.

Use the correct type of ladder. Never use a conductive ladder if the installer or the ladder could come in contact with energized electrical cables or equipment. Use ladders made of a nonconductive material (e.g., fiberglass or wood, if dry) in these situations. Many construction sites will not allow metal or wood ladders on site for safety and insurance reasons. When working over three steps high, a fixed or mobile scaffold is recommended in place of a ladder.

Ladder Safety, continued

Inspect ladders before each use. Check to ensure that:

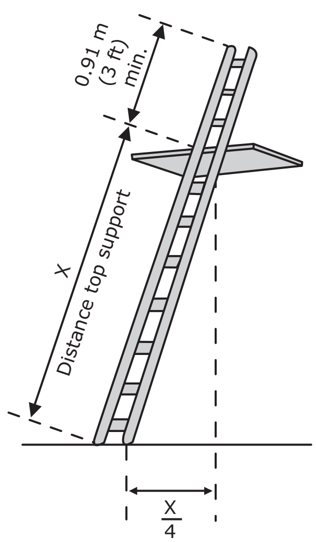
- Joints between the steps and side rails are tight.
- Anti-skid feet are secure and operating properly.
- Moving parts operate freely.
- Rungs are free of dirt, liquids, or other substances that could cause slipping.
- Side rails are not cracked, excessively bent, or dented.
- The ladder is designed and rated for the height and weight load it will be required to support.

Choose a secure location to set up the ladder that is solid and level and offers adequate traction for the ladder's feet. If adequate traction is not available, the ladder must be lashed in place or held in position by other workers. Never set a ladder on top of a box, furniture, or any other unstable surface to gain height.

For a stepladder, verify that the supports that link the ladder rails to the back rails are fully extended and locked in place.

For an extension ladder, ensure that both side rails are supported at the top. Verify that the extension ladder is set at the proper pitch (angle). The horizontal distance from the base of the ladder to the supporting wall should be one-quarter (25 percent) the working length of the ladder (length of ladder from bottom to top support) (e.g., a ladder extended ≈6.1 meters [m (20 feet [ft])] up a wall would have its base ≈1.52 m [5 ft] from the wall). See Figure 2.2.

Figure 2.2
Extension ladder



ft = Foot
m = Meter
min. = Minimum

Ladder Safety, continued

Extension ladders should always overlap between sections by at least three rungs. The top of the ladder should extend up to the work area and ≈.91 m (3 ft) above catwalks or lofts. This allows the installer to safely find the steps when getting back onto the ladder from the catwalk or loft. Lash ladders to anchors if the ladder will be used for an extended period of time.

Never paint a ladder. Doing so will hide any stress cracks or damage.

Try to place the ladder where it will be out of traffic's way. Use safety barriers or delineators to designate a restricted area around the base of the ladder. Never set a ladder in front of a door that opens toward the ladder unless the door is locked or can be blocked or guarded from the other side. When climbing up or down a ladder, always face it.

When using a ladder, never:

- Exceed the ladder's weight rating. Most ladders are designed for one person only. Consider the weight of any materials or tools being used as well.
- Stand on the top two rungs of a ladder.
- Leave any object (e.g., tools, gloves) on top or on any rung of a ladder.
- Straddle a ladder or stand on the rear rungs. The rear rungs are narrower than the front steps, and they are not designed to support weight.
- Drop or throw down anything (e.g., tools, excess wire, scraps) when on a ladder. Use a hand line and a grunt sack to raise and lower items.
- Fasten two or more ladders together to create a longer section unless they are specifically designed for such use.
- Move, shift, or extend a ladder while it is in use.
- Over reach or extend the center of your waistline beyond the sides of the ladder. Keep your belt buckle between the side rails at all times.
- Walk, bounce, or move a ladder while climbing or standing on it.
- Use a stepladder as a straight ladder as it may slip out from under you.
- Use a ladder as a platform, plank, or brace.
- Separate sections of an extension ladder to use individually.

Do not stand on furniture, boxes, or any other makeshift ladder substitute. If a ladder is broken or stressed, tag it according to company policies with a large "do not use" sign to keep others from becoming injured. Defective equipment should be removed from the work site immediately and returned to the office for repair or disposal. Consider the following guidelines:

- Never use a ladder with missing or modified parts.
- Never repair a damaged ladder without permission from the manufacturer.
- Read all labels, and only use a ladder if you are in good physical condition.

Personnel Lifts (Elevating Work Platforms)

A personnel lift is required when a ladder or scaffold cannot be used safely or is impractical because of the required working height, weight of personnel, and equipment or customer requirements.

IMPORTANT: All operators must be trained and have received proper instructions before operating aerial platforms. For your safety, warnings are on the platform and in the manufacturer's manual. Failure to obey warnings can cause injury or death. BICSI® recommends that the user be properly trained and certified in the use of lifts.

Two common types of lifts are:

- Boom-supported elevating work platforms (boom lift)—This is a basket mounted on the end of an extendable arm in which the user stands. The articulating arm allows the user to approach the work area from several angles and to avoid obstacles and possible safety hazards. These units are typically large and can be used in limited areas. A full-body harness and lanyard are required for anyone in the basket of this type of lift.
- Self-propelled elevating work platforms (scissor lift)—This is a work platform mounted on a large scissor jack. The scissor lift is very stable, but it is not very flexible in its use. As the scissors are extended, the platform moves straight upward. If there are any obstacles above it, the platform is unable to maneuver around them. The Occupational Safety and Health Administration (OSHA) does not require a body harness and lanyard for this equipment, but your company, the AHJ, or customer might require them.

Factors that determine if a lift is suitable include:

- Maximum working height of the lift.
- Size of the work area.
- Obstacles that may obstruct the lift.

Your lift may be equipped with:

- Stabilizers, outriggers, or extending axles.
- Chain, gate, or bar closures.
- Turntable lock.
- Emergency controls.
- Ground controls.
- Audible and visual alarms (e.g., tilt alarm).

Know which devices are required on your machine. Never remove or modify any of them. Setting brakes and using stabilizing legs or outriggers, if equipped, must secure lifts. Personnel must follow the safety requirements for fall-arresting personal protection devices described later in this section.

Personnel Lifts (Elevating Work Platforms), continued

Read, understand, and follow the danger, warning, caution, and other signs on your machine. Read and understand the manufacturer's operator's manual before using the machine. If there is no manual with the machine, obtain one. If there is something in the manual you do not understand, ask your supervisor to explain it to you.

Check the equipment before you begin to operate machinery, you must inspect your machine and report all deficiencies. Do not operate the machine until deficiencies are corrected and all systems are in good operational condition. The inspection should be conducted in this order:

- Walk-around inspection of the machine and work area before use
- Functional check of the ground controls and equipment in the base of the lift
- Functional check of the upper controls located in the platform or basket of lift

The walk-around inspection should include the following items:

- Missing, damaged, or unreadable equipment signage
- Broken, missing, damaged, or loose parts
- Tire cuts, bulges, and pressure as specified by the manufacturer
- Maintenance procedures outlined by the manufacturer of your machine
- Cracked welds or other evidence of structural damage
- Hydraulic system check for leaks and damage

General safety rules when using lifts include the following:

- Load limits for the platform or basket shall not be exceeded.
- Employees shall always stand firmly on the floor of the basket. Do not sit or climb on the edge of the basket. Do not use planks, ladder, or other devices for a work position.
- Scissor lifts must only be elevated on a firm and level surface.
- Close the gate, or fasten the entry chain after entering the basket.
- Do not tie off the machine or your body harness to an adjacent structure when using a lift.
- Stay at least ≈3 m (10 ft) away from exposed energized electrical conductors, such as wires or crane bus bars, operating at 300–50,000 volts (V). If necessary, lock out cranes and other equipment that may strike the lift when it is elevated.
- Check the path of travel for the lift. Do not drive the lift over hole covers unless you are sure they can support the weight of the lift.
- Ensure that adequate clearance is maintained around overhead obstacles and underneath the platform when lowering it.
- When driving the lift, lower the platform first, and keep a safe distance from drop-offs, holes, depressions, ramps, and other hazards.
- Keep people out from under the aerial work so that they are not exposed to a falling object hazard.
- The lift operator and others in basket should wear a hard hat, safety glasses, and boots.

Personnel Lifts (Elevating Work Platforms), continued

Consider having a ground person whenever doing aerial work. This person can do the following:

- Keep people away from the area around the bottom of the lift, and use barriers as necessary to establish a work area.
- Check the path of travel for the lift.
- Operate the ground controls of the lift in the event the upper controls fail.

NOTE: Clients may require specific types of powering for the lifts, depending upon working environments (e.g., electrical, fuel, mechanical).

Personal Protective Equipment (PPE)

Overview

When used correctly, personal protective equipment (PPE) greatly decreases the risk of injury. When PPE is used incorrectly or not used at all, it can leave the ICT cabling systems installer exposed to a wide variety of dangers.

The PPE that an installer is required to wear when performing a task depends on the:

- Hazards of the task.
- Hazards at the work site.
- Local, state, and national safety requirements.

PPE must fit well and be comfortable. Equipment that fits properly and comfortably ensures that the installer and the protective equipment can work at the same time.

Pay careful attention to the training for each item of PPE. Learn:

- When the equipment must be used.
- How to put on, adjust, and take off the equipment.
- What the equipment can and cannot protect against.
- How to care for and maintain the equipment.

It is important to inspect PPE each time it is used. Look for wear, cracks, tears, punctures, weak joints, or other signs that the equipment may not be capable of providing protection. Report any problems to the proper supervisor. Never use defective protective equipment.

Remember that no amount of protective equipment can provide complete protection. Often, the best personal protection comes from using caution, proper procedures, and common sense when working.

Headgear

Installers must wear protective headgear (hard hats) when working in any area where there is danger from:

- Falling or flying objects.
- Electrical shock.
- A blow to the head.

Generally, hard hats provided for installers afford both physical and electrical protection. Installers should ensure that their hard hats provide electrical protection before working near power lines or equipment (e.g., ANSI Z89 Class B). The hard hat must fit securely enough to ensure that it will not slip and block the installer’s vision or fall on the equipment the installer is working on. Installers may choose to use a chinstrap to secure the hard hat only if the chinstrap is thin enough to give way easily if the hard hat catches on something during a fall.

Headgear, continued

Before putting the headgear on, inspect it for cracks, weakness of the internal support structure, or other defects. The date of manufacture appears stamped on the underside of each hat's brim. The date allows easy identification if a certain run of hats has to be recalled because of a defect. Hard hats typically have up to a five-year life span if not subjected to abuse. Installers must wear properly rated hard hats.

Replace hard hats that show signs of scratches and cracking or if a shiny surface appears dull or chalky. Do not place stickers on hard hats because they may hide defects or their adhesive may react chemically and weaken the hat.

NOTE: Foil stickers could void the electrical protection of a hard hat.

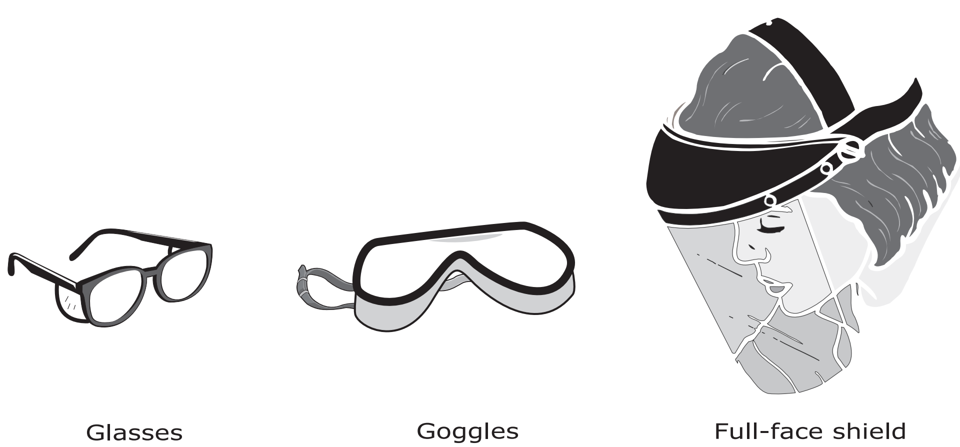
Eye Protection

Installers must wear eye protection (e.g., glasses, goggles, full-face shield). See Figure 2.3. If the installer must wear vision-correcting prescription glasses, prescription safety glasses with side shields may be required, or goggles that fit over personal prescription glasses can be used. All eye and face protection must meet or exceed local AHJ requirements (e.g., ANSI Z87).

A wide variety of work situations require eye protection, including:

- Working with batteries (e.g., wearing a full-face shield if there is danger of splashing chemicals).
- Using powder-actuated tools.
- Working with optical fibers.
- Working above eye level and looking up at the work.

Figure 2.3
Eye protection



Wear protective goggles or glasses that provide side protection as well as front protection when the hazards involve flying objects.

Breathing Protection

Installers must wear a respirator whenever harmful dust, gas, smoke, chemical vapor, or other pollutants are present at the work site. If you have reason to believe the air in the working environment may be hazardous, contact your employer. An assessment should be done to determine if a hazard is present and what kind of respirator is appropriate.

Never work without the proper breathing protection. The effects of breathing some harmful substances may not show up until hours, weeks, or years after the exposure.

Filter masks are used in cases where the atmosphere is only moderately hazardous and there is no asphyxiation hazard. Very hazardous atmospheres require the use of protective masks or positive pressure self-contained breathing apparatus (SCBA).

To provide appropriate protection, each mask must seal itself to the user's face. This may require removal of facial hair.

NOTE: Several chemical manufacturing plants and other industrial sites will not allow personnel with excess facial hair (e.g., heavy beards) to work on site.

Installers should not try to work while wearing a breathing protection device unless the:

- Installers have been fully trained to use the device.
- Device has been carefully fitted.
- Installers have been found physically fit to work while wearing the device.
- Device is designed for the specific breathing hazard or chemical to which it may be exposed.

When exposure is limited to nuisance dusts below the OSHA-permissible exposure limit, installers may wear dust masks.

Although employers are required to inspect and maintain breathing protection devices, the installer should inspect the device every time it is used. Report any problems to the supervisor in charge of breathing protection devices.

Lifting Belt

A lifting belt does not give the user any added strength; however, the belt does help to support the stomach muscles while encouraging good posture. It should be noted that these belts might give wearers a false sense of security. These belts do not enable wearers to lift heavy objects with a decreased chance of injury.

Use correct lifting techniques when lifting any object on the job. The following guidelines should be followed:

- Never bend to pick up a heavy object. This is the most frequent cause of back injury and strain.
- Lift with the legs, not with your back. Keeping your chin up helps to keep the back straight.
- Turn with your feet and not at the waist. Avoid twisting the torso.
- If possible, wear a lifting belt when lifting or moving heavy objects or equipment.

Lifting Belt, continued

When carrying or moving items, always know the path to the destination point, and ensure that the items do not block your vision.

A safe rule for supervisors to follow is to restrict lifting of loads to ≈25 kilograms (kg [50 pounds (lb)]) per person. If heavier materials need to be moved, two installers should provide assistance, or use appropriate lifting machinery.

Most government contracts in the United States require that workers wear lifting belts.

Protective Footwear

Wear protective footwear on work sites where feet could be injured by falling objects, rolling carts or cable reels, or stepping on sharp objects. A suitable pair of shoes will protect feet from injury and fatigue.

Safety toe footwear, which usually contains steel toe shielding, meets applicable standards (e.g., ANSI Z41) and will help protect toes while metallic or nonmetallic shanks will offer protection from stepping on sharp objects. Metallic or nonmetallic shanks help distribute weight across the base of the shoe. This reduces foot fatigue while standing on the thin rungs of an extension ladder. Leather-soled shoes are not advisable because leather conducts electricity when wet and can be slippery.

Check with the AHJ for the approved standard of protection regarding footwear.

Gloves

Wear protective gloves when performing any work that has the potential for hand or forearm injuries:

- Cut-resistant gloves are rated to provide protection against cuts and abrasions while providing some dexterity.
- Leather gloves provide protection against punctures, extreme temperatures, and limited protection against abrasion. They are not rated for cut protection.
- Rubber, plastic, or latex gloves provide protection from harmful chemicals.

NOTE: Rubber and leather gloves are not for high-voltage use. All high-voltage situations should be referred to qualified persons.

Detection Badges/Exposure Monitors

Some work sites may require that installers wear detection badges or use monitors to ensure that the exposure to a hazardous substance does not exceed safe levels. Understand how the badge or monitor works before entering the hazardous area.

Detection Badges/Exposure Monitors, continued

Some monitors or badges will provide real-time feedback; they show actual exposure levels as they happen. They may change colors or have a dark stripe that gets longer with the amount of exposure.

Other types will only absorb the toxins at the same level the installer is being exposed to them. These need to be inserted into a scanner to determine the amount of exposure. It is extremely important to check these types of monitors frequently to limit the installer's exposure levels.

Always observe time limits specified for working in a hazardous environment.

High-Visibility Vest or Jacket

On most construction sites, a high-visibility vest or jacket with reflective tape is required.

Hearing Protection

Hearing loss is one of the most frequent injuries encountered in the construction trades. The injured person does not feel pain, but after years of exposure to high levels of construction noise, varying frequencies of his or her hearing may be lost.

Wear hearing protection while working near loud noises. Even the sound of a hammer striking a metal clamp onto red iron requires hearing protection. If the installer experiences a ringing in the ears, adequate hearing protection has not been used.

There are three major types of hearing protection (see Figure 2.4):

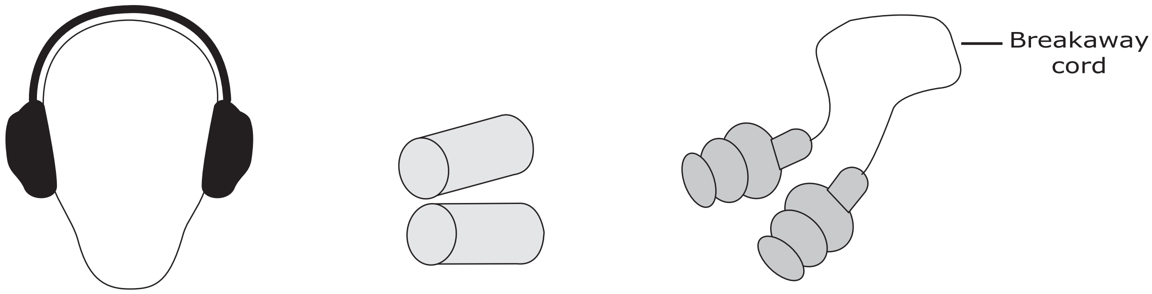
- Aural—These plugs resemble earmuffs, and they are available in passive or active models. When wearing the active models, normal conversation can be heard; however, when a loud noise occurs, the protection automatically dampens the louder sound.
- Foam earplugs (disposable)—These plugs can be rolled between the fingers and slipped into the ear canal.
- Rubber earplugs (reusable)—These may be on a breakaway cord or individually housed in a pocket-sized plastic container. These are convenient because they can be attached to a hard hat or around the installer's neck and tucked inside the installer's shirt. It is vital that they be on a breakaway cord to prevent strangling.

Certain sites require specific types of hearing protection. Check with the local AHJ for further information.

When working in a noisy work site (with or without earplugs), do not rely on hearing to detect the location of machinery, coworkers, or other hazards.

Hearing Protection, continued

Figure 2.4
Hearing protection



Fall Protection

Fall protection is required whenever a person is exposed to a fall hazard to another level of more than ≈1.83 m (6 ft). It can take the form of a hole cover, a safety net, guard rails, or a personal fall arrest system (PFAS). A PFAS includes a full-body harness, a shock-absorbing lanyard, and a secure anchorage point capable of supporting ≈2268 kg (5000 lb). If installers are required to work near fall hazards, their employer must ensure that they receive training on the proper use of PFAS.

Installers use elevating devices such as a boom or scissor lifts to reach their work location when ladders are impractical because of height or weight requirements.

To prevent falls, installers must wear a full-body harness and one lanyard any time they use a boom lift. OSHA does not require body harnesses for operators of scissor lifts under normal circumstances.

NOTE: The sides of a boom lift do not typically meet the requirements of a safety barrier because the bucket can tilt and may not provide a stable platform. Boom lifts usually require a full-body harness with one lanyard attached to the lift.

The use of a full-body harness and two lanyards is required whenever the installer leaves the safety of the elevating device or is using catwalks (see Table 2.1). Using two lanyards allows the wearer to always have one lanyard attached to a safety support. If the users have to move along a catwalk but run into an obstacle, they can simply attach their second lanyard beyond the obstacles prior to disconnecting the first one, allowing them to be safely attached to the structure at all times.

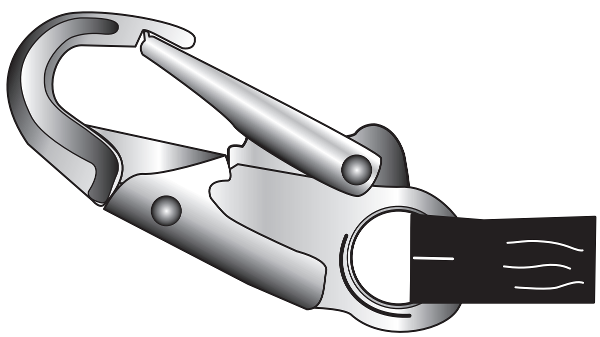
Fall Protection, continued

Table 2.1
Harness specifications

Lift Usage Description	Full-Body Harness Required	Number of Required Lanyards
Fully enclosed safety barrier	No	None
Open or no surrounding barrier	Yes	One
Leaving lift	Yes	Two (for 100% contact)

Safety lanyards are available as simple nylon ropes with self-closing and locking keepers (snap hooks) on each end, or they can incorporate a shock absorber into the line (see Figure 2.5). If a fall were to happen, the shock absorber would reduce the force of the sudden stop to the injured person.

Figure 2.5
Snap hook used on lanyards



All snap hooks must be self-closing and double-action.

Most codes, regulations, and AHJs do not allow the use of safety belts and lanyards equipped with the nonlocking type of self-closing keepers (snap hooks) within buildings and other types of structures.

Many work sites do not allow the use of safety belts. They do not provide the same level of protection as the full-body harness and may cause back injuries.

Before ascending or descending:

- Inspect the harness and its hardware carefully for signs of wear or damage.
- Ensure that the harness is properly secured to the elevating device's anchoring point and never to the supporting guardrail or platform.

Fall Protection, continued

Whenever securing the lanyard, always check the connection. The installer must ensure that the snap hook has captured the lanyard's rope or the equipment's safety ring and that it is securely fastened.

Anchorage for fall protection must be able to support ≈2268 kg (5000 lb) per person. Do not connect anchorage to construction materials (e.g., pipes, conduit).

Clothing

Work clothing should be reasonably snug but must allow the installer to move freely. Do not wear dangling or floppy clothing that may get caught on tools or surroundings. Keep shirttails tucked in and cuffs, if any, buttoned or neatly rolled up. This is especially important when the installer is working in a confined space, on an elevating device, or near operating machinery.

Clothing made of cotton is typically more comfortable and safer than synthetic materials that could melt to the worker's skin in the event of a fire.

Do not wear metal jewelry or metal watchbands when working on ICT cabling systems circuits or equipment. Field-damaged clothing shall be repaired immediately, or the individual must leave the job site. Duct tape may be used to temporarily mend torn clothing.

Grooming

Long hair can be extremely dangerous when working around operating machinery and working aloft. Hair can easily be pulled into machinery or become caught on ceiling grids. Pulling the hair back in a ponytail usually provides better protection while allowing the worker to wear safety equipment, but the safest way to ensure that hair does not get caught on or in something is to tuck it completely under a hat.

Working in Data Centers

Overview

Because of the critical functions typically performed in data centers, they have special security, safety, and change control procedures. Check with the data center owner or operator to determine the requirements for the data center before planning the work because the requirements may affect the schedule, the persons who can perform the work, and the type of work that can be performed.

Security

The data center owner or operator may have special security requirements for all persons who perform work in the data center. The extra security provisions vary, depending on the policies of the data center owner or operator. Examples of such provisions include:

- Criminal or other background checks, which may take several days or weeks.
- Security badges and biometric system access, which may be good for one day or a longer duration.
- Identification (e.g., driver's license, other government-issued identification) for each person requiring access to the data center to obtain a temporary badge.
- Escort by a security officer or other representative of the data center owner or operator.
- Special tools to lift access floor tiles or cable tray covers.
- Special tools, keys, badges, or codes required to access computer room cabinets.
- Prohibition of the following activities:
  - Taking photographs or videos
  - Eating, drinking, or smoking except in designated areas
  - Using radio transmitters in the computer room
  - Using mobile phones in the computer room
  - Cutting or welding metal in the computer room
  - Unpacking equipment in computer room spaces (e.g., to minimize or avoid airborne debris)
  - Using the computer room for storage
  - Leaving doors propped open

Safety

The data center owner or operator may have special safety requirements for all persons who perform work in the data center. For example, all persons working in the data center may be required to take a safety training class before performing any work.

Access floor systems are rated for maximum static loads and dynamic (rolling) loads. The stability of the access floor system can be compromised if any access floor stringers or if too many access floor tiles are removed. Perform the following:

- Confirm the static and dynamic load specifications of the access floor system before bringing heavy equipment into a computer room with access floor.
- Avoid removing any stringers in computer room access floor systems. If stringers must be removed, obtain permission from the data center owner or operator first and determine the maximum number of stringers that may be removed at any one time.
- Obtain permission from the data center owner or operator before removing any access floor tiles. Determine the maximum number of access floor tiles that may be removed at any one time.

Data centers typically have fire detection and suppression systems. Hot work permits may be required. Ensure that installation activities do not disable or cause activation of an alarm. Check with the data center owner or operator regarding the protection system and if the activity being performed can cause an alarm (e.g., dust created during installation/removal of cable, smoke created during welding of bonding conductors). Do not disable any alarm systems without the approval of the data center owner or operator.

Change Control

The data center owner or operator may have change control requirements for any activity performed in the data centers. The change request typically requires a description of the:

- Proposed time and date of the activity.
- Activity to be performed.
- Impact of the change or activity (e.g., systems or applications that may be down while the activity is being performed).
- Dependencies and related change requests or projects.

Depending on the organization, change requests may require days or even weeks to process. Check with the data center owner or operator or the project manager to determine the change control requirements, expected lead time for approvals, and person who will be responsible for submitting and confirming the approval of change requests.

If the data center has a change control process, confirm that the change request covering each activity is approved before starting work on that activity.

Do not perform activities not specifically covered in the change request, including opening of cabinets not covered by the change request.

Some data centers only permit work to be performed during specific times of the week, month, or year.

Consider lead times for the change control process and permitted data center change windows when planning installations in data centers.

Data Center Spaces

Relationship of Spaces within a Building and Data Center

See Figure 2.6 for an example of various spaces within a building housing a data center, spaces within the data center that are exterior to the computer room, and the computer room.

Computer Room

A computer room is the portion of the data center that actually houses the IT equipment and is defined as a room whose primary purpose is to accommodate data processing equipment.

Data Center

A data center is a building or portion of a building whose primary function is to house a computer room and its associated support spaces. Thus, the data center includes the data center electrical rooms, mechanical rooms, storage rooms, staging rooms, operations/command center, and other spaces whose primary function is to support the computer room.

Entrance Room (ER)

The entrance room (ER) may be a space within the computer room or exterior to the computer room that supports the interface between the data center cabling system and external cabling (e.g., campus cabling or entrance cables for access providers [APs (telecommunications carriers)]).

Security and change control procedures for data center ERs are typically the same as those for computer rooms.

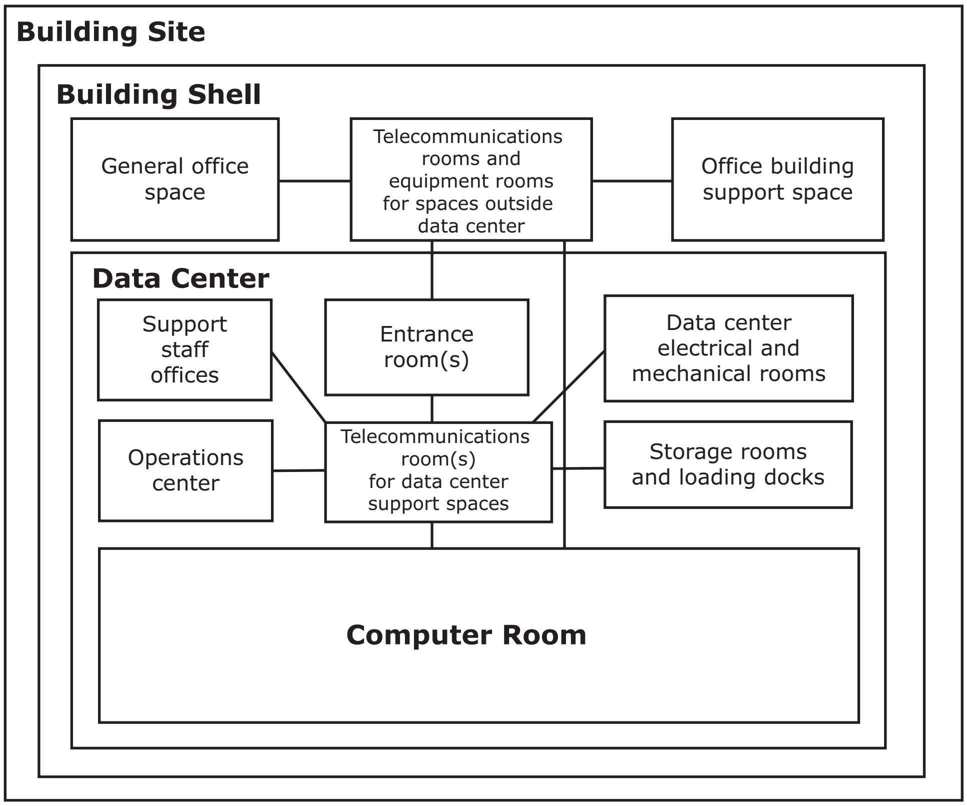
Telecommunications Room (TR)

Telecommunications rooms (TRs) support termination of horizontal cabling to the spaces outside the computer room. TRs outside the computer room but within the data center may support horizontal cabling for data center support spaces (e.g., electrical rooms, mechanical rooms, operations/command centers).

TRs outside the data center may support general office spaces and other spaces in the building that are not associated with the data center.

Relationship of Spaces within a Building and Data Center, continued

Figure 2.6
Relationship of data center spaces



Computer Room Spaces and Distributors

The names for the spaces and termination points vary between organizations and standards. The ones used in Figure 2.7 and described in this section are from the published BICSI Data Center Standard 002 and the draft of ANSI/TIA-942-A. The corresponding terms used in European (CENELEC EN 50173-5) and international (ISO/IEC 24764) data center telecommunications standards are provided in Table 2.2.

Table 2.2
TIA, CENELEC, and ISO data center distributors/termination points

TIA Term	CENELEC and ISO/IEC Term
External network interface	External network interface
Main distributor	Main distributor
Intermediate cross-connect	Not currently defined
Horizontal cross-connect in HDA	Zone distributor
Horizontal cross-connect in TR	Floor distributor
Consolidation point in ZDA	Local distribution point
Equipment outlet	Equipment outlet

CENELEC = Comité Européen de Normalisation Electrotechnique
HDA = Horizontal distribution area
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
TIA = Telecommunications Industry Association
TR = Telecommunications room
ZDA = Zone distribution area

No specific terms are defined in the European Committee for Electrotechnical Standardization (Comité Européen de Normalisation Electrotechnique [CENELEC]) and International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) data center standards for the rooms or spaces containing distributors (e.g., main distribution area [MDA], intermediate distribution area [IDA], horizontal distribution area [HDA], zone distribution area [ZDA], equipment distribution area [EDA]).

All spaces other than the MDA and EDA are optional. A data center must have at least one of each.

All distributors other than the main distributor (MD) and horizontal cross-connect (HC [floor distributor (FD)]) are optional. A data center must have at least one of each.

Active equipment (e.g., LAN and storage area network [SAN] switches) are often located in MDAs, IDAs, and HDAs. For top-of-rack switch configurations, switches may also be located in EDAs.

Computer Room Spaces and Distributors, continued

Telecommunications Entrance Room (ER) and External Network Interface (ENI)

The telecommunications entrance room (ER) is the room or space that contains the external network interface (ENI), the distributor that contains the interface between computer room cabling and external cabling (e.g., campus cabling, AP cabling). Thus, AP/carrier demarcation is typically located in the ER.

The ER may be located inside or outside the computer room. Additionally, the ENI may be located in the MDA in data centers that do not require separate ER spaces.

Data centers may have multiple ERs for redundancy to avoid exceeding maximum circuit distance limitations for circuits provisioned by APs (e.g., T1s, E1s, T3s, E3s).

Main Distribution Area (MDA) and Main Cross-Connect (MC [Campus Distributor (CD)])

The MDA is the room or space in the computer room that contains the main cross-connect (MC [campus distributor (CD)]) for computer room cabling. It also commonly contains core LAN and SAN switches.

The term main distribution frame (MDF) is sometimes used for this space. Although used in the industry, the term is not recognized in data center standards.

Every data center must have at least one MDA and MC (CD). The MDA also may contain ENI if there is no separate ER in the computer room and may contain an HC (FD) for horizontal cabling to nearby equipment cabinets and racks (EDAs).

A data center may have more than one MDA for redundancy and may have separate MDAs for LAN and SAN cabling to keep the size of the MDAs manageable.

Intermediate Distribution Area (IDA) and Intermediate Cross-Connect (IC [Building Distributor (BD)])

The IDA is the room or space in the computer room that contains the intermediate cross-connect (IC [building distributor (BD)]), a second layer backbone distributor that may be present in large data centers.

Horizontal Distribution Area (HDA) and Horizontal Cross-Connect (HC [Floor Distributor (FD)])

The HDA is the room or space in the computer room that contains the HC (FD). The HC (FD) is the distributer for horizontal cabling to equipment cabinets and racks (EDAs). The HC (FD) may be located in the MDA or IDA to support horizontal cabling to cabinets/racks located near MDAs or IDAs.

The term intermediate distribution frame (IDF) is sometimes used for this space. Although used in the industry, the term is not recognized in data center standards.

Computer Room Spaces and Distributors, continued

Zone Distribution Area (ZDA)

The ZDA is an optional interconnection where an equipment outlet or consolidation point (CP) may be located.

If equipment outlets are located in the ZDA, the ZDA is performing a function similar to a multiuser telecommunications outlet assembly (MUTOA) in a commercial office building. In this case, the ZDA might be used to terminate cabling for cabinets in which it is not possible or desirable to install a patch panel (e.g., mainframe, storage system).

The ZDA also may contain a CP to support cabling to an area of the data center where cabinet locations change frequently or are not yet known.

The ZDA only includes passive termination hardware (e.g., patch panels). It does not support active equipment (e.g., LAN switches).

The ZDA may be located within a cabinet, rack, or overhead space or under the access floor.

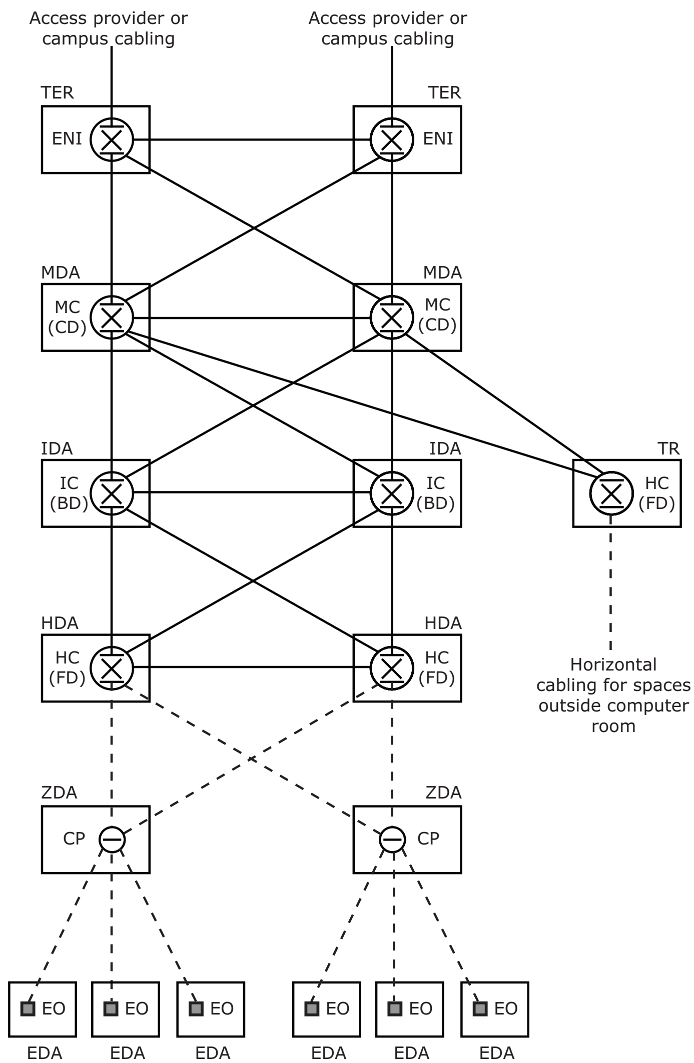
Equipment Distribution Area (EDA)

The EDA is the computer room space occupied by equipment cabinets or racks. Horizontal cabling terminates in the EDA in an equipment outlet (EO), which is typically mounted in a patch panel.

Computer Room Spaces and Distributors, continued

See Figure 2.7 for an example of a data center that illustrates the spaces and cabling termination points commonly found in a computer room.

Figure 2.7
Example of computer room spaces and distributors



— = Backbone cabling
⊠ = Cross-connect
- - = Horizontal cabling
⊖ = Interconnection
■ = Outlet
□ = Telecommunications space
CP = Consolidation point
EDA = Equipment distribution area
ENI = External network interface
EO = Equipment outlet

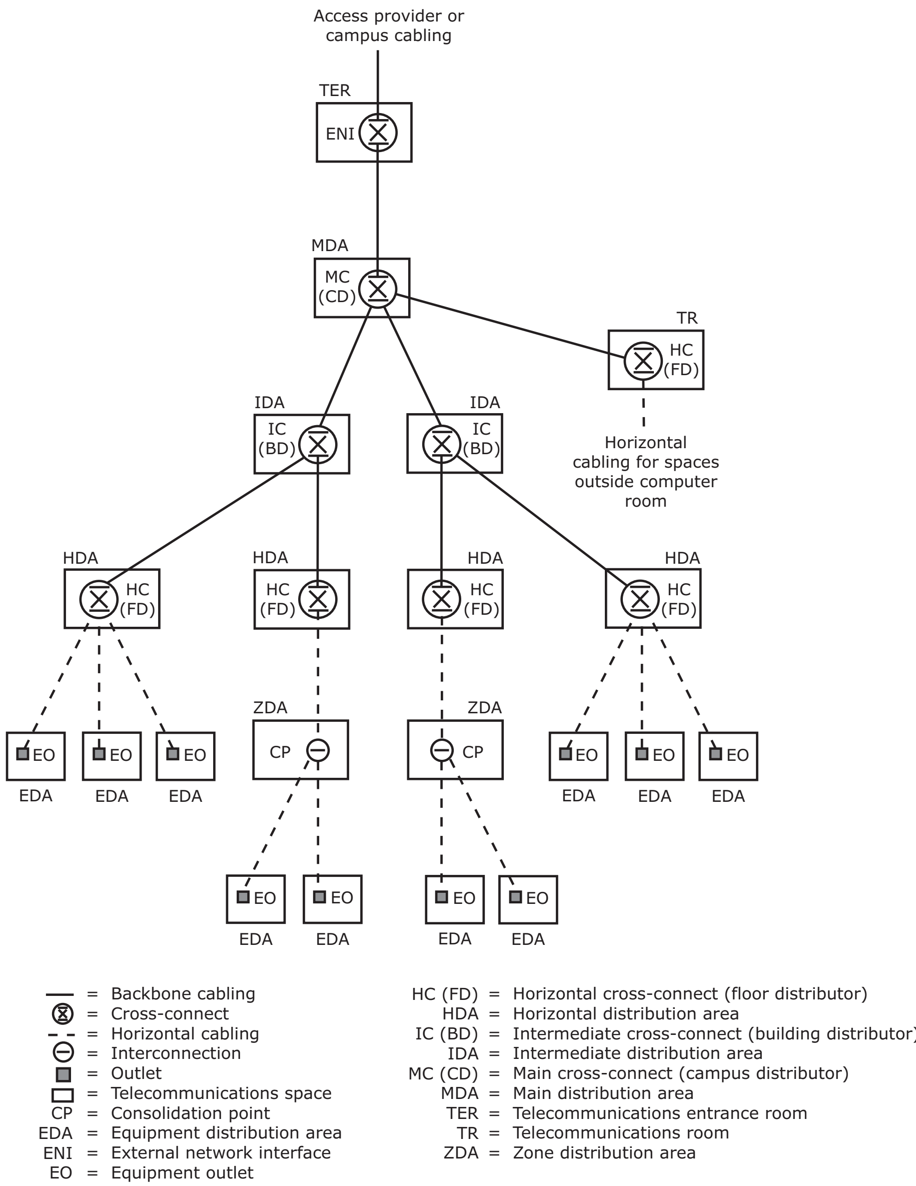
HC (FD) = Horizontal cross-connect (floor distributor)
HDA = Horizontal distribution area
IC (BD) = Intermediate cross-connect (building distributor)
IDA = Intermediate distribution area
MC (CD) = Main cross-connect (campus distributor)
MDA = Main distribution area
TER = Telecommunications entrance room
TR = Telecommunications room
ZDA = Zone distribution area

Data Center Cabling

Topology

The data center cabling requirements are described in the applicable standard (e.g., ANSI/TIA-942, CENELEC 50173-5, ISO/IEC 24764). The basic topology is a hierarchical star topology (see Figure 2.8). Additional distributors and cabling may be added to provide additional redundancy.

Figure 2.8
Example of hierarchical star topology



Topology, continued

Additionally, direct cabling from the ER to an IDA or HDA is permitted to avoid exceeding maximum circuit distance restrictions for circuits provisioned by APs (e.g., T1s, E1s, T3s, E3s).

Backbone cabling includes cabling between distributors located in the ER, MDA, IDA, HDA, or TR.

Horizontal cabling includes the cabling from the HC (FD), which may be located in the MDA, IDA, or HDA, to equipment outlets in the EDA or ZDA.

Cable and Connector Types

Overview

Data center equipment and technologies change rapidly. Thus, data center cabling should be provisioned to provide flexibility to accommodate anticipated variations and changes in configurations and technologies with minimum change. For example, it may be desirable to install enough cabling to each cabinet to handle 90 percent or more of the typical configurations. Additionally, the performance of this cabling should be high enough to handle anticipated future LAN and SAN technologies.

Cabling Types

The following types of cables are recognized in data center telecommunications cabling standards:

- 100 ohm balanced twisted-pair cables
- Multimode optical fiber cable
- Singlemode optical fiber cable
- 50/75 ohm coaxial cable

Cable and Connector Types, continued

Balanced Twisted-Pair Cabling

Balanced twisted-pair cabling performance is described using a scale based on classes or categories as defined by ISO/IEC and TIA, respectively (see Table 2.3).

Table 2.3
Balanced twisted-pair cabling channel performance

TIA Categories	ISO Categories/Classes	Frequency Characterization
Category 3	Category 3/class C	16 MHz
Category 5e	Category 5e/class D	100 MHz
Category 6	Category 6/class E	250 MHz
Category 6_A	Category 6_A/class E_A	500 MHz
N/A	Category 7/class F	600 MHz
N/A	Category 7_A /class F_A	1000 MHz

MHz = Megahertz

NOTE: TIA does not define cabling above category 6_A. Category 7/class F and higher cabling are defined by CENELEC and ISO/IEC. Each of these standards writing organizations defines component performance by the term category while ISO/IEC and CENELEC define system performance by the term class.

The draft ANSI/TIA-942-A recommends category 6_A/class E cabling for horizontal and backbone cabling and specifies a minimum of category 6/class E for balanced twisted-pair horizontal cabling. Category 3 is the minimum specification for backbone cabling.

CENELEC EN 50173-5 specifies a minimum of category 6/class E for balanced twisted-pair cabling in all but network access cabling (cabling extending from the ER to the rest of the data center).

ISO/IEC 24764 specifies a minimum of category 6_A/class E_A for balanced twisted-pair cabling except for public network access cabling.

Cable and Connector Types, continued

Optical Fiber Cabling Types

There are four classes of multimode optical fiber cabling (OM1, OM2, OM3, and OM4) and two classes of singlemode optical fiber cabling (OS1 and OS2). Table 2.4 shows the minimum bandwidth or optical performance for each cabled optical fiber cable by type.

Table 2.4
Optical fiber cable performance by type

Cabled Optical Fiber Type	Description	Performance
OM1	62.5/125 µm multimode	Minimum overfilled launch bandwidth of 200 and 500 MHz•km at 850 and 1300 nm, respectively.
OM2	50/125 µm multimode 62.5/125 µm multimode	Minimum overfilled launch bandwidth of 500 and 500 MHz•km at 850 and 1300 nm, respectively.
OM3	50/125 µm 850 nm laser optimized	Minimum overfilled launch bandwidth of 1500 and 500 MHz•km at 850 and 1300 nm and an effective modal bandwidth of 2000 MHz•km at 850 nm, restricted mode launch
OM4	50/125 µm 850 nm laser optimized	Minimum overfilled launch bandwidth of 3500 and 500 MHz•km at 850 and 1300 nm and an effective modal bandwidth of 4700 MHz•km at 850 nm.
OS1	Singlemode	Minimum bandwidth of singlemode optical fiber cable is not characterized in the same manner as multimode. Loss characterization is 1.0 dB per km at 1310 nm and 1550 nm for indoor and 0.5 db per km at 1310 nm and 1550 nm for outdoor.
OS2	Singlemode	Minimum bandwidth of singlemode optical fiber cable is not characterized in the same manner as multimode. Loss characterization is 0.4 db per km at 1310 nm, 1383 nm, and 1550 nm for both indoor and outdoor.

dB = Decibel
km = Kilometer
MHz•km = Megahertz kilometer
µm = Micrometer
nm = Nanometer

Cable and Connector Types, continued

Multimode Optical Fiber Requirements and Recommendations in Standards

ANSI/TIA-942 specifies a minimum of OM1 and recommends a minimum of OM3 for multimode optical fiber cabling. The draft ANSI/TIA-942-A specifies a minimum of OM2 and further recommends the use of LC connector and multifiber push on (MPO) connectors.

CENELEC EN 50173-5 specifies a minimum of OM2 for multimode optical fiber cabling except for public network access cabling. Additionally, this standard specifies the following connectors for termination of multimode optical fibers at the EO and ENI:

- LC connectors for termination of one or two multimode fibers
- MPO connectors for termination of more than two multimode fibers

ISO/IEC 24764 specifies a minimum of OM3 for multimode optical fiber cabling except for public network access cabling. It also specifies the LC and MPO connectors for termination of multimode optical fibers at the EO and ENI.

Singlemode Optical Fiber Requirements and Recommendations in Standards

ANSI/TIA-942, CENELEC EN 50173-5, and ISO/IEC 24764 permit both OS1 and OS2 singlemode optical fiber cables.

The draft ANSI/TIA-942-A recommends the use of LC and MPO connectors.

CENELEC EN 50173-5 specifies the following connectors for termination of singlemode optical fibers:

- LC-PC connectors for termination of one or two singlemode fibers at the EO
- Angled LC connectors for termination of one or two singlemode fibers at the ENI
- MPO connectors for termination of more than two singlemode fibers at the EO or ENI

ISO/IEC 24764 specifies the following connectors for termination of singlemode optical fibers:

- LC connectors for termination of one or two singlemode fibers at the EO
- Angled LC connectors for termination of one or two singlemode fibers at the ENI
- MPO connectors for termination of more than two singlemode fibers at the EO or ENI

75 Ohm Coaxial Cabling

ANSI/TIA-942 recognizes 734-type and 735-type coaxial cable for E1, E3, and T3 circuits. Such cables are terminated on BNC or TNC connectors. This type of cable is not recognized in CENELEC EN 50173-5 and ISO/IEC 24764.

Cable and Connector Types, continued

Testing

Cabling shall be tested as specified in the installation specification and the applicable standard (e.g., ANSI/TIA-942, CENELEC EN 50173-5, ISO/IEC 24764).

Test results should be saved in electronic format, preferably both in the format of the test equipment manufacturer's software and in another format that does not require the use of the vendor software (e.g., .xls, .csv).

Administration

The cabling system shall be labeled and documented as specified in the installation specification and the applicable standard. Each cabinet and rack shall be labeled on the front and back with its identifier. Power strips should be labeled with the power distribution unit or panelboard identifier and circuit breaker number.

Good documentation and labeling significantly reduce troubleshooting time and planning for moves, adds, and changes (MACs).

Data Center Pathways

Overview

Telecommunications cables should be installed in cable pathway systems to manage routing of cabling and to ensure that telecommunications cabling is adequately separated from lighting, electrical power, and moisture, which can impair the performance of the cabling.

Pathway Sizing and Installation

Cable pathway systems typically used in data centers include cable trays, cable matting, conduits, and noncontinuous supports (e.g., hooks, cable ties, other cable supports).

Cable pathways should be sized to permit growth. Cable trays should be planned for an initial maximum calculated fill ratio of 25 percent (ratio of cable area to ratio of tray area). At 50 percent fill ratio, cables completely fill the cable tray.

The depth of cables in pathways shall not exceed ≈152 millimeters (mm [6 inches (in)]).

Optical fiber patch cords should not be placed in pathways with solid bottoms rather than wire basket trays, cable ladders, and noncontinuous supports to avoid an increase in fiber attenuation for cables because of localized areas being exposed to higher compressive loads. It is recommended that optical fiber patch cords use separate pathways from other cables.

The cable trays, cable runways, and cable tray support system shall be free of burrs, sharp edges, or projections that can damage cable insulation. Threaded rods installed within the area where cables are placed shall have a smooth, nonscratching covering to prevent damage to cables.

At least ≈305 mm (12 in) clearance should be provided above the top of cable trays and cable runways to provide adequate space for the installation and removal of cables. The top of cable trays installed directly below access floor tiles should be at least ≈51 mm (2 in) below the bottom of the access floor tile to permit cables to be routed out of the cable tray without incurring damage from floor tiles installed above them.

Do not use cable trays and cable runways as walkways or ladders. See National Electrical Manufacturers Association® (NEMA®) VE2 for additional information regarding cable tray installation and support.

Abandoned cables shall be removed.

Pathway Segregation and Coordination

Cable pathway routing shall be coordinated with other trades to ensure that adequate clearances are provided and that adequate segregation from lighting and electrical power is provided. See local regulations and the applicable standard (e.g., ANSI/TIA-942, CENELEC EN 50173-5, ISO/IEC 24764) regarding segregation requirements.

Overhead cable trays are less disruptive to efficient cooling than underfloor cable trays.

Pathway Segregation and Coordination, continued

If cable trays are installed under the access floor, they should be installed in the hot aisles (aisles facing the rear of the cabinets) so as to not interfere with airflow in cold aisles. Additionally, cable trays should be placed so as to minimize disruption of airflow into or out of air conditioning equipment.

Consider using computational fluid dynamics (CFD) models to optimize the location of telecommunications pathways, air conditioning equipment, equipment enclosures, air return, air vents, and ventilated tiles.

If cable trays are installed overhead, they should generally be installed above cabinets and racks rather than above the aisles so as not to block lights and sprinklers, which should be placed above the aisles between cabinets.

Cable tray placement should avoid interfering with sprinkler spray patterns and other fire suppression and detection systems.

Data Center Cabinets and Racks

Overview

IT and telecommunications equipment should be placed in equipment cabinets and racks instead of being placed on shelving systems because cabinets and racks:

- Securely mount the equipment.
- Permit higher equipment density.
- Assist in managing cabling.
- Assist in managing air flow.
- Are typically more stable.

Cabinet and Rack Installation

Cabinet and Rack Placement

Cabinets should be placed so as to permit floor tiles in front and behind to be lifted. It is generally a good idea for cabinets to be placed with one edge flush with the floor tile to ensure that no more floor tiles than necessary get captured and to minimize the distance required to reach under cabinets. Additionally, rows of cabinets and racks should be placed parallel (rather than at an angle) to the rows of floor tiles.

Given a choice, where placing one edge of the cabinet creates unequal aisle sizes, the front aisle should be the larger one as it provides more working space for the installation of equipment into cabinets and a greater area for providing cool air to cabinets.

Cabinets and racks should be placed so that hardware used to secure racks and cabinets to the underfloor slab (e.g., threaded rods) does not penetrate access floor stringers.

Sharp edges at the top of the threaded rods should be capped using plastic covers, domed nuts, or other means. The exposed threads under the access floor should be covered using split tubing or other methods to avoid abrading cable.

In seismic zones, it is recommended that the design of the attachment methods and the installation be reviewed by a licensed structural engineer. Many jurisdictions will require a seismic certification report signed by a professional engineer.

The mounting surface should be prepared for the specific anchors required for the application. Refer to the recommended practices of the manufacturer and structural engineers, and verify that those practices are acceptable to the AHJ. Racks and cabinets in a lineup where they are properly attached together may require fewer anchors per unit than those installed as stand-alone units. When drilling into the mounting surface, use proper techniques to ensure that dust or particles do not become airborne. Vacuuming with a high-efficiency particulate air (HEPA)-filtered vacuum is effective in containing dust or particles while drilling in floors or walls.

Cabinet and Rack Installation, continued

Racks or cabinets should be set in place and leveled throughout the lineup. Shimming of any anchoring point should not exceed ≈12.7 mm (0.50 in) unless specified by the project engineer. If racks or cabinets require more than ≈12.7 mm (0.50 in) of shimming, use an engineered solution to ensure that rack or cabinet lineups are properly supported. Connect adjacent racks or cabinets together in the lineup before anchors or bracing is installed. Install anchors or bracing per the manufacturer's specifications, making sure all shims are properly located.

Some lineups require additional bracing to meet the customer's specifications or local codes. Required bracing may be based on rack style, equipment, and location. Bracing should be installed as a system to ensure proper fit and support. Install all parts hand tight, and then tighten fasteners in a series to prevent stress on rack lineup. All bracing should be installed before racks are populated.

Doors and panels that may interfere with leveling feet or anchor installation should be removed during installation.

On solid or slab floors, set cabinets in place and level throughout the lineup. Most cabinets are equipped with leveling feet. If leveling feet are not provided, consult the manufacturer for proper shimming hardware.

On access floors, if cabinets in the lineup are to be connected, install attachment hardware before anchors are installed. Install anchors per the manufacturer's specifications, making sure all shimming hardware is properly located.

Floor Tile Cuts

Where underfloor cooling is utilized, limit floor tile cuts both in size and quantity to minimize loss of underfloor air pressure.

Employ brushes, grommets, or other methods to minimize the loss of air through cable openings in floor tiles.

Hot and Cold Aisle Configuration

Install equipment cabinets and racks with rows oriented in a hot aisle/cold aisle configuration with the rears of cabinets/racks facing each other and fronts of cabinets/racks facing each other. Such a configuration avoids hot air from equipment mixing with cold air being directed into equipment intakes.

Avoid empty cabinet or rack positions in equipment rows. Replace removed cabinets or frames, and fill any gaps in a row of cabinets with a substitute blanking panel of the same height as the cabinet or frames to either side to avoid recirculation of air between hot and cold aisles. For the same reason, install cabinets and racks with no blank spaces between them. In the case of vacant cabinets and racks and where blank spaces exist in populated cabinets and racks, install blanking panels. Vertical cable managers can provide cable management and block recirculation of air between racks. Cabinets should be butted up against each other. Where possible, cabinets should share a side panel or include other means to seal the rear-to-front airflow path along the side of rack-mounted equipment.

Cabinet and Rack Installation, continued

Grounding (Earthing) of Cabinets and Equipment

Computer rooms typically have a telecommunications grounding infrastructure (e.g., telecommunications grounding busbar [TGB], mesh bonding network [BN], often called a signal reference grid).

ANSI/NECA/BICSI-607 specifies that non-current-carrying metallic portions of telecommunications cabinets, telecommunications racks, and telecommunications pathways be bonded to the computer room grounding infrastructure. IT and telecommunications equipment and cable shields shall be bonded to the computer room grounding infrastructure per the manufacturer's instructions.

See ANSI/NECA/BICSI-607 for additional information regarding computer room bonding and grounding (earthing).

Installation of Equipment in Cabinets and Racks

Equipment should be installed in cabinets with the air intake oriented toward the front of the rack or cabinet and the air exhaust oriented toward the rear of the rack or cabinet. Pay careful attention to airflow for networking equipment, which often uses a side-to-side rather than front- to-back cooling scheme. For such equipment, consider cabinets that duct air into the hot aisle and in from the cold aisle. If ducting is not installed, ensure that the side clearances specified by the manufacturer are provided to ensure adequate airflow.

Ensure that equipment placed in a rack or cabinet does not exceed power circuit capacity. Power strips supporting only single-corded equipment should be loaded to no more than 80 percent of circuit capacity. A power strip supporting dual-corded equipment should be loaded to no more than 40 percent of circuit capacity so that the remaining circuit is at no more than 80 percent load if the redundant circuit has a failure. Load on circuits can be either calculated or preferably monitored (e.g., using power strips or power distribution units that permit monitoring of power levels).

Anticipate the weight of the equipment in the racks and cabinets. Ensure that the cabinets, racks, and floors (both access floors and slabs) are rated to handle the expected mechanical loads.

Equipment in the computer room should be mounted to cabinet or rack rails and should not be placed on shelves because equipment on shelves provides a return path for air between the rear and front of the cabinet or rack.

Blank panels should be installed in unused rack positions to maintain separation between hot aisles and colds aisles and prevent hot exhaust air from recirculating and mixing with chilled air at equipment intakes. Blank panels also improve rigidity of racks.

In active data centers, institute a process to identify and remove equipment that is no longer needed or to identify and consolidate underutilized equipment.

Cable Management for Cabinets and Racks

Routing of telecommunications cabling within cabinets, racks, and other enclosure systems should not hamper the proper cooling of the equipment within the enclosures (e.g., avoid routing of cabling in front of equipment and enclosure vents).

Shorter power, data, and keyboard/video/mouse (KVM) cables should be specified to reduce the cable management density in the back of the cabinet.

With nonangled balanced twisted-pair or coaxial cable patch panels, one rack unit of horizontal cable management should be provided for each rack unit of patch panel.

Each rack should have vertical cable managers sized for maximum rack capacity attached on both sides. Vertical cable managers between two racks should be sized to serve both racks simultaneously.

Planning and Project Management

Overview

Planning and project management are key to a successful ICT cabling systems installation project. Taking the time to develop a well-defined plan before a project starts will help deliver a proper installation on time, within budget, and ensure that the job can be performed and meets all customer requirements.

Project management is a discipline that encompasses planning, organizing, and managing resources to achieve successful completion of specific project goals and objectives.

A large project usually has several project managers (PMs), each of whom is responsible for a different organization or activity. In some cases, this individual may not have the formal title of project manager and may be called a team leader or a lead technician.

Larger and more complex projects require more time to plan. It is difficult to manage loosely defined objectives and the efforts of a large project team over an extended period of time.

The purpose of a project plan is to provide:

- An understanding of the work to be done and how the cabling installation fits into the overall project.
- A list of project objectives.
- A list of specific tasks.
- A project schedule to track time and resources.
- Staffing assignments and project responsibilities.
- The identification of potential roadblocks and strategies for addressing them.
- Definitions of the documentation forms and procedures used on the job.
- A tool for managing the project.
- A way to get commitment from the project team.

This section describes the components of a project plan and outlines how to use the plan to manage a project more effectively.

Developing a Project Plan

Overview

A project plan must address all aspects of the installation.

Developing this plan involves a series of tasks, including:

- Gathering and reviewing customer documents, including drawings, specifications, material list, scope of work (SoW), and contract.
- Developing the project schedule.
- Developing project documentation, including a project log, an acceptance plan, and forms for request for information (RFI), submittals, job change orders, and punch lists.
- Conducting a site survey to verify all gathered information.
- Reviewing and incorporating the company's safety plan.

An understanding of the following will contribute to the success and effectiveness of the plan:

- Cabling installation standards (structured wiring)
- National and local codes (safety issues)
- BICSI® manuals (design elements)
- Manufacturer's specifications (e.g., installation methods, product quality)
- Voice, data, and video fundamentals
- Customer's requirements

Gathering Information

Customer's Documents

When cabling installation is requested, the customer has several ways of soliciting bids—a request for proposal (RFP), a request for quote (RFQ), formal contract, purchase order (PO), or other document. These plans are transmitted to the cabling company.

The customer's plans typically contain drawings and specifications that identify the materials to be used, the standards by which they will be installed, and the individual installation locations.

In addition to these plans, the customer's documents may include the following:

- Designer's drawings (cabling installation drawings)
- List of materials
- SoW
- Contract that includes any other documents that dictate the progress or method of installation for the project
- Overall project schedule
- Customer safety plan

For some projects, the cabling company or a member of the team will be responsible for developing a set of installation drawings, a list of materials, and the installation SoW.

Gathering Information, continued

Customer's Drawings

Usually, the customer's drawings are scaled plans prepared by a licensed architect or registered professional engineer and other professionals. They usually will be accompanied by a document containing written specifications. The following can be used to determine which drawing set(s) are necessary:

- A—Architectural drawings, referred to as A drawings, show a plan (top) view of each floor in a building. Architectural drawings include all aspects of the physical construction of the building, which provide the detail for such items as walls, windows, ceilings, doors, flooring, cabinetry, and furnishings. If the architect employs interior decorators, their work will be reflected on these drawings.
- M—Mechanical drawings, referred to as M series drawings, indicate the size and route of the heating, ventilation, and air-conditioning (HVAC) and plumbing systems within the structures. In addition, the M series drawings may indicate potential obstructions to the installation of wires and cables inside the building. M series drawings may indicate if the main water pipe serving the building is metallic.
- E—Electrical drawings are very important to installers. The drawings indicate where the electrical services are installed inside the building and the pathways that may be installed by the electrical contractor for use by the cabling installation team. The drawings indicate the grounding system designed by the electrical engineer; the location of supporting structures installed by the general contractor (e.g., plywood backboards); and the layout of ceiling lights, called a reflected ceiling plan.
- T—With the MasterFormat®, use of telecommunications drawings will increase throughout the building trades industries.When separate electrical and telecommunications drawings are provided, the telecommunications drawings will show the pathways, distribution room layouts, and media required for the project.

Drawing packages provide the telecommunications pathways on E or T drawings and telecommunications outlet/connectors on a separate set of drawings. In large complex installations (e.g., school buildings, hospitals), there may be separate drawings for electrical, telephone, data, video, fire alarm, and intrusion detection systems.

In some cases, pathways shown on design documents are schematic in nature. They do not reflect the actual route or path but, rather, indicate beginning and end points. The specific cable installation routes are left up to the installers. If this is the case, it will be indicated on the drawings.

- S—Structural drawings are important because the drawings indicate the location of all components of the building structure itself—the steel beams, concrete floors, exterior walls, and other components that make up the basic structure. The plans contain detailed sectionalized drawings that give both a plan (top) view and an elevation (side) view of the structures.

Gathering Information, continued

The following are types of drawings that can be found within each set:

- Site drawings can be provided by civil, landscape, or electrical engineers or by other members of the design team. These drawings indicate locations of exterior pathways that are being installed for use by the ICT cabling systems contractor. The drawings indicate the size, quantity, and route of the pathways as well as the service each will support. Site drawings usually identify service entrance pathways that will be used by the local service providers (SPs) in bringing service to the building from the public network.
- Cross-sectional drawings (riser diagrams) show the building profile and the floor-to-floor relationships within each building. This should show all pathways and spaces.
- Floor plans are an overhead view showing dimensional relationships on each individual floor that provides telecommunications rooms (TRs), work area outlets, and cabling or pathway routes.
- Room detail drawings provide details of cable terminations, equipment locations, cross-connects, and electrical services within the room.
- The drawing package generally contains one or more sheets for general notes, legends, symbols, and abbreviations as well as a drawing list. It is important to check this information to:
  - Identify all plans that impact cabling installation work.
  - Understand how the overall project is expected to come together.
  - Note any special requirements or limitations.
  - Understand who is responsible for installing the pathways. Do not assume that others will be responsible.

Construction Specifications

Plans provide a pictorial representation of the project. The details required to accomplish such tasks (e.g., material ordering) are contained in the specifications. Specifications provide a written description of the work to be performed and the responsibilities and duties required of the architect, engineer, contractor, and owner. The plans identify the materials to be used as well as applicable standards, performance criteria, and testing methods. Together with the drawings, the specifications form the basis of contractual requirements.

Gathering Information, continued

Designer's Drawings

A BICSI Registered Communications Distribution Designer (RCDD®) may be employed by the customer, architect, engineer, or cabling installation company to develop the required telecommunications drawings and specifications. If not, a member of the installation team may develop the drawings and specifications.

These drawings and documents indicate the size, quantity, description, and route of the cables to be installed as well as the type of hardware used for supporting and terminating the cables. The drawings and documents should indicate the type of cable to be installed (e.g., performance rating, type of construction, fire rating), the splicing sequences (if any), and the cables to be terminated in all TRs. In addition, the drawings should show the type of connecting hardware by size, quantity, and configuration as well as the supporting structure required (e.g., cable tray, conduit, hangers).

At times, separate drawings may be prepared for each type of ICT cabling systems infrastructure to be installed. Separate drawings may be prepared for copper cables, optical fiber cables, coaxial cables, and other low-voltage cables. However, there should be a schematic showing the placement of the cables and sleeves so that backbone routing can be determined. If the project is small enough, all of the information may be contained on a single drawing.

Elevation drawings of the TRs and the placement of various equipment items should be part of these drawings. A detail of each wall and rack in each TR as well as a plan view of the floor-mounted hardware should be included.

Materials List

To submit an accurate proposal, a list of materials should be prepared during the bidding phase. This list should contain all of the installation items by:

- Description.
- Catalog number.
- Quantity.
- Unit price.
- Total price.

The list should have columns indicating the materials received and the materials dispensed. Field personnel can use these two columns to manage inventory during the actual installation work. Many contractors prepare similar lists for installation labor units, indicating the amount of time allocated for each portion of the installation. In addition, the list should contain labor hours allocated for the project by work process.

Gathering Information, continued

Scope of Work (SoW)

The SoW for the project covers the requirements for the team. The SoW document lists all of the elements of the installation, and it is usually generated by the customer or the designer. However, the SoW can be developed by the cabling installation company when bidding or responding to a customer's RFP.

The SoW should indicate:

- People and firms involved in the project and their responsibilities.
- Work.
- Time frame.
- Permits or licensing required and persons responsible for obtaining them.
- Materials.
- Methodology.
- Known limitations, restrictions, or potential problems with the job (e.g., notes, assumptions).
- Identification, labeling, and documentation systems.
- Testing and test documentation methods.
- When and how the installation will be turned over to the customer.
- Clarifications or understandings that elaborate on the various items involved in the installation.

Contract

A project contract documents the understanding between the customer and the contractor. Some customers generate a PO that refers to other documents associated with the project (e.g., SoW, materials list). If a contract is used, ensure that copies of the contract and any supplementary documents it lists are provided to the cabling installation team.

Contracts may list penalties associated with not completing the work correctly or delays in completion. Pay particular attention to liquidated damages. Performance bonds and insurance may be required as part of the contract. When a new or customer's contract is used, it is always a good idea to have an attorney review the document to determine if the installer's understanding is consistent with the actual legal issues involved.

Project Schedule

Once all of the items associated with planning a cabling installation have been identified, a project schedule needs to be developed. The schedule should list all project tasks, beginning with the award of the contract and ending with acceptance by the customer and collecting the final payment.

The detail required for each task is directly proportional to its importance in completing items that precede or follow it. The project schedule should indicate the planned time required for each item as well as provide space for inserting the actual time to perform the job task.

Developing the Project Schedule

When developing a schedule for cabling installation work, the first schedule to obtain and refer to is the general contractor's construction schedule. It includes all of the trades working on the project and indicates their specific timeframes for accomplishing the project work.

Of particular concern are the schedules for completion of the supporting structure inside the building. For example, installation of the backbone cables or the horizontal cables cannot be scheduled until the person or firm responsible has completed installation of the pathways and spaces used to house these cables.

With new building construction and many retrofit projects, coordination and communications with other trades is a must. For example, faceplates cannot be installed until the wall covering is completed. Racks may not be installed until the floor covering is installed. This can mean multiple trips to the work site for the cabling installation team.

The cabling project schedule should complement the general contractor's project schedule. Failure to coordinate the cabling project schedule with the general contractor's schedule may result in conflict between the two companies as well as related trades and could jeopardize timely completion of the project.

Companies use a variety of project management styles and software to develop project schedules and track installations.

Automated systems can reflect:

- Start and end times for specific tasks.
- Resources necessary to undertake specific tasks (e.g., some systems reflect people only while others tie into materials lists).
- Interrelationship of tasks (e.g., what tasks must be completed before others, what tasks must wait until several other tasks are completed).

Project Schedule, continued

As actual project information is entered in an automated schedule, the system can display:

- Percentage of completion.
- Progress payment schedule.
- Materials or other resources expended.
- Time delays or advancements.
- "What if" analyses to review the impact of moving dates or resources.

Manually generated project schedules can be used, especially when the project is small and not complex. Copies of the completed schedule should be provided to all concerned parties.

Developing the Project Documentation

All projects require documentation. Some documentation is required by the contract, and some is kept to ensure the project meets time and budget requirements. Documentation depends on project size and complexity.

Most projects will include the:

- Job log.
- RFI.
- Submittal forms and logs.
- Job change orders.
- Acceptance plan.
- Punch list.
- As-built drawings.
- Maintenance and equipment documentation.
- Test documentation.

Job Log

If a standard form for tracking daily activities is not available, a job log should be developed. This log should reflect all work undertaken each day, whether it is complete, and the plans for the following day.

It should provide a place to record detailed notes on any issues that arise, including the:

- Date.
- Time.
- Installation problems and individuals involved.
- Description of the problem.
- Resolution.

Developing the Project Documentation, continued

The person in charge at the project site will use the job log to record all activities associated with the project. It is especially important to log occurrences that may result in scope changes that could have a financial impact on the cabling installation company. Sometimes, a contract requires copies of this log to be submitted to the customer and general contractor on a periodic basis.

Request for Information (RFI)

The contract documents cannot cover every detail about the materials, procedures, and testing requirements to be used on the project. RFIs are used to request clarification, supplemental information, or approval of materials substitution. The RFIs can provide direction when unforeseen circumstances arise; however, they are not intended to be used to request information on time-critical issues (e.g., gaining access to a work site).

The RFI form must provide a place to assign an identification tracking number to the RFI and to record the date and time, a description of the request, who is sending the request, and who will receive the request. This information must be entered in an RFI log along with the date and time the response is received and the content of the response. This log provides a way to track when an RFI was sent, read, and acted upon.

EXAMPLE: The drawings indicate that all station cables are to be fished through existing office walls. However, the installer finds the walls are constructed with multiple fire barriers, prohibiting a top to bottom pathway. An RFI asking for direction from the owner or contractor should be prepared. If a surface raceway is installed without obtaining approval in writing, it may be difficult to receive compensation for the extra work and materials. In addition, the owner may state that a surface raceway should not be used in such a situation, and the work may have to be redone.

Submittals

Submittals are a form of communication between the cabling installation team and the contractor or owner defining the specifics of how a job will be undertaken. In the construction industry, these most often consists of two components—shop drawings and product cutsheet submittals.

Specialty contractors (e.g., HVAC, fire suppression, audiovisual installers) most often provide shop drawings. The drawings reflect the specific details of products to be used and the method of their installation within the new or renovated spaces. Shop drawings are often scaled drawings similar to the original construction blueprints showing the specific methods of interconnection, size of components, or individual routes that will be used when installing the product.

Developing the Project Documentation, continued

Product cutsheet submittals are used for documenting the specific items or product models that will be used on the job. These submittals note the product name or specification number and complete performance specifications.

Submittals that might be required of the cabling installation team are:

- Products, including:
  - Cable—each type and model.
  - Outlet components (e.g., jacks, faceplates, connectors).
  - Ladder racks.
  - Equipment racks.
  - Firestopping materials.
- Shop drawings, including:
  - Backboard layouts.
  - Equipment rack placement and component layouts.
  - Cable routing—horizontal and vertical.
  - Cable suspension methods.

Submittals that are a contractual requirement must be tracked to determine compliance with submittal methods and terms. This tracking can be a simple log defining when a specific submittal was made, when it was returned, and whether it was approved or requires resubmission.

Job Change Orders

Few projects are completed without changes to the original work plan. Even on small projects, changes occur. The changes may be insignificant, but they must be documented. When accounting for all materials and work operations at the completion of the project, unless the changes are documented and approved by duly authorized agents, compensation may not be received. A contractor should never perform additions, deletions, or material changes to the SoW without written authorization.

When submitting a change order, keep the original and provide copies to the customer and any other interested parties. Be aware of the consequences of change orders prior to implementing them, especially their impact on the project schedule.

The cabling installation company may have forms prepared for this purpose. If not, and if the attached form is not used, copies of an approved American Institute of Architects (AIA) change order form may be used on the project. For many projects, this may be the only approved change order form.

Developing the Project Documentation, continued

Acceptance Plan

An acceptance plan outlines the tasks, tools, staff, and skills necessary to test and document the successful completion of a project. Many manufacturers and individual project plans provide copies of the documentation required to fulfill the contract needs but leave the logistics of how to conduct the tests up to the ICT cabling systems contractor.

To reduce the duplication of effort and provide an effective plan, the following items must be defined:

- When the testing will take place (once, several times, every day).
- Who will conduct the tests (e.g., how many people with what type of training).
- Who will witness the tests (if required).
- What tools, supplies, or other materials are required.
- Who needs to be notified or forewarned of the testing.
- How the tests will be documented.
- How the results will be transmitted to the contractor or owner.

Punch List

As with an acceptance plan, many firms use a specific form to document the work that remains to be completed. A punch list is simply a formal listing of items or issues needing resolution before the project is designated as complete. The punch list should be prepared during a joint inspection of the work site and should reflect the agreements reached between the owner or contractor, the cabling installation firm, and any impacted subcontractors.

A punch list is not simply a list of all the problems or mistakes at the work site. The punch list needs to define clearly and dispassionately the specific steps or work tasks that need to be completed. Rather than stating, “Faceplate crooked on station 342,” the punch list should state, “Realign faceplate on station 342.” A punch list should clearly define the person(s) or firm responsible for that work.

To be effective, the punch list must be in writing and must reflect the expected time for completion. Using this approach, the installer knows exactly what needs to be done and has a document that defines when the work is finished. Once a punch list is completed and signed off, it becomes difficult for the owner or contractor to request additional improvements or changes without compensation.

Developing the Project Documentation, continued

Record Drawings (As-Built Drawings)

The format to be used for the as-built drawings must be agreed upon before beginning the project, so information can be gathered in a proper fashion throughout the project. The most common type of as-built uses the original floor plans and reflects the actual placement of outlets, the configuration, and the station or jack numbers. Other information, such as cable routing, backboard layouts and configuration, length of cables, and firestopping materials, may be required as part of the original contract.

The installer must keep in mind the need for this information and the format that will be used. It is generally a good idea to keep a set of drawings updated on a weekly or daily basis with completed work. Not only can these drawings be used for discussion purposes, but the form and content can be reviewed and approved by the general contractor or owner before a great deal of effort is expended.

As with any documentation required for submittal on a project, do not make assumptions (e.g., that the general contractor or the original designer will input all as-built information into electronic form). Some contracts require the cabling installation company to complete all computer-aided design (CAD) work and produce multiple sets of final drawings. The cost of this work must be taken into consideration before the proposal is submitted to the owner.

Maintenance and Equipment Documentation

An operations and maintenance (O&M) manual should contain the title of the project and the names and contact information for the architect or engineer, designer, and contractor. Information for each product or system should be included identifying the specific products and components installed for the project. Each sheet should include the manufacturer's installation steps and any maintenance procedures along with a list of replaceable parts. Mark each sheet to clearly identify specific products, component parts, and data applicable to the installation. Include a list of local suppliers from whom replacement parts may be obtained.

The installers should retain all printed material that comes packed with the components installed for inclusion in the O&M manual. The format to be used for O&M manuals must be agreed upon before beginning the project, so information can be gathered in a proper fashion throughout the project.

Test Documentation

Specific test documentation may be required under the terms of an agreement between a cabling installation company and a manufacturer's product warranty program. This should be discussed with the owner or contractor before the work begins to determine the documentation required. It may be necessary to negotiate with the owner, the general contractor, and the product manufacturer to develop an acceptable form of documentation.

The automated test sets used for documenting balanced twisted-pair cable generally provide a simple and clear method of identifying and documenting station cable. It is necessary for the installer to be aware of any additional procedural requirements that may be part of this testing (e.g., certifying the accuracy of the testing equipment, recalibrating the equipment).

Developing the Project Documentation, continued

Some contracts require tests to be witnessed by the owner's representative. In these cases, it is important for the installer to be aware that the witness has a specific contractual responsibility and is not simply looking over the installer's shoulder. It is always best to discuss procedural issues before beginning work and to maintain a dialogue as testing continues.

Conducting a Site Survey

After all of the contract documents are obtained and reviewed, a member (or members) of the cabling installation team will visit the installation site. The purpose of the survey is to:

- Ensure that local and national codes are met.
- Ensure that all telecommunications standards are met.
- Compare design documents with existing conditions.
- Identify potential conflicts or concerns.
- Define any additional support required (e.g., access, pathways, electrical services) and determine who is responsible for these additional services.
- Identify situations that will require special equipment or skills.
- Determine the amount of support material required to complete the project (e.g., hangers, cable ties, surface raceway).
- Determine the work hour requirements, including the number and skill level of the cabling installation crew needed.
- Locate storage and staging area space.

Reviewing Gathered Information

When preparing for the site survey, include the following items:

- Designer's documents—Allow identification of specific locations related to the project and the work to be performed there. The drawings may indicate obstacles not visible from floor level.
- Checklist—Based on the criteria for the project, a checklist is used to ensure that everything is taken into consideration during the site survey and to double-check development of the project plan. If problems are found, plans can be formulated to overcome them while still on site rather than having to return.
- Tools—To perform the work required for a thorough site survey, personal protective equipment (e.g., hard hat, safety glasses, leather gloves, leather boots, hearing protection) might be needed. Additional items that may prove useful are a ladder, flashlight, measuring wheel, handheld tape recorder, digital camera, or video camera.
- Contacts—List of site contacts, telephone numbers, and e-mail addresses.

Conducting a Site Survey, continued

Reviewing Responsibilities with Team Members

The first stop at a work site should be at the general contractor's site office. While at the office:

- Introductions can be made.
- Work to be performed for the customer can be explained.
- Other contractors working for the general contractor can be identified, and the impact of their work can be discussed.
- A copy of the general contractor's construction progress schedule can be obtained.

NOTE: Use this document to determine how the installation schedule can be coordinated with other contractors working on the project site.

It is important to review responsibilities with the general contractor's representatives so that they understand the role the cabling installation company will play in the completion of the overall project. Remember, the general contractor owns a new building until the owner accepts it and has ultimate authority and responsibility for the project.

Verify who will construct the pathways and spaces. The customer's documents should state whether they would be provided by the general contractor or by others. In many cases, the pathways and spaces of a new building project are part of the responsibility of the general contractor or the electrical subcontractor. It is important to discuss the details of the pathways and spaces with the person or firm responsible. Do not assume they know the impact of their work on the installation of cabling.

The contractor responsible for the pathways must determine how to install these pathways, observing what obstacles and obstructions must be overcome. Failure to make this determination might result in additional site surveys.

Some of the obstacles that may be encountered include:

- HVAC ducts and equipment.
- Elevators.
- Stairways.
- Fire- or smoke-rated walls, floors, ceilings, and partitions.
- Sprinkler systems.
- Structural forms or beams.
- Interstitial space.

Conducting a Site Survey, continued

Examining the Site

While on site, be sure to observe all locations where the cabling installation work will be performed. Determine the physical location of all TRs; the size, type of construction, and configuration of utilities within TRs; and the responsibilities required to interface with other trades.

Identify the location of pathways that have been constructed by the general contractor or the subcontractors, and determine the state of completion.

Determine, at a minimum, the answers to the following questions:

- Have the subcontractors adhered to the architect's and designer's drawings and specifications?
- Are there any change orders that will affect the pathways and spaces? If so, how do they affect the project?
- How is the bonding and grounding (earthing) infrastructure installed? Does the infrastructure comply with codes, regulations, and standards?
- When will the telecommunications spaces be completed?
- When will the pathways be completed?
- When will the inspector or fire marshal be on site to perform interim inspections and the certificate of occupancy inspection?
- When will the project be turned over to the owner (tenant)?

Answers to many of these questions should come from the materials contained in the customer's and the designer's documents. However, do not leave anything to chance. Review all requirements of the project before concluding if additional pathways, spaces, or building facilities are required. If they are and they have not been included in the original plans and specifications, job change orders may be required. At the very least, these concerns need to be documented and discussed with the general contractor or the owner's representative.

All information gathered during the site survey should be carefully documented and placed in the project file. This information will become invaluable later, especially if new team members are assigned to the cabling installation after it starts.

NOTE: If the project is a retrofit, identify all of the existing pathways and spaces used for ICT cabling systems and their size, capacities, usability, congestion, and compliance with local codes and standards.

Project Safety Plan

The safety of workers, the customer's personnel, and the subcontractors is of paramount importance. Workplace accidents can disrupt the best-planned job and cause costly delays.

Each company should have an occupational safety plan. Before beginning any work operation, the contents of that safety plan should be reviewed with each employee working on the project. Each employee should fully understand how the rules of safety should be implemented as each cabling installation task is performed. Take the time to ensure that each employee is equipped with the proper safety equipment and has the knowledge to use the equipment safely. As a contractor or subcontractor, attending periodic safety meetings may be contractually required.

All employees should attend an initial safety meeting prior to commencing the work. All safety plans should be reviewed. Many general contractors and customers have safety orientation and drug screening programs that all employees must complete prior to beginning the project work. Only through knowledge, understanding, and on-the-job awareness can employees perform their work safely.

Project Implementation

Overview

Just as a drawing provides a blueprint for cable installation, a good project plan is a blueprint for managing and tracking the project. From the initial construction meeting to closeout activities, the plan helps assess the progress and monitor the project. This section defines the typical tasks included in a plan and the methods used for implementing them.

Initial Construction Meeting

After completing the site survey and formulating the project plan, the cabling installation PM should hold an initial meeting with the entire cabling installation team. At this meeting, the PM and the team leader should lay out the responsibilities of everyone involved. The project plan can be reviewed and updated as necessary. Communication between all personnel involved in the project is critical to its success.

Updates to the project plan and minutes of all meetings should be maintained, and printed copies should be provided to each person attending and additional persons having a position of responsibility on the project. Meeting minutes must be prepared and distributed shortly after each meeting and must provide a mechanism to allow attendees to update or correct the material.

Preinstallation Meeting

After the initial construction meeting is held and the project plan is updated, the PM should conduct a preinstallation meeting. This meeting should include the cabling installation team and appropriate contractors. All aspects relating to the project should be addressed and discussed. If necessary, adjustments should be made to the project schedule based on the results of the meeting. To ensure that the work is performed in a timely and professional manner, the project should be reviewed in detail so that team members can work in concert with each other and with the other contractors.

Progress Meetings

Periodic progress meetings should be held for every project. These meetings can occur as often as once a week or as necessary to ensure that team members know the status of the project and what is expected of them. Work progress as well as roadblocks and ways of overcoming them should be discussed and agreed upon by all concerned parties. Each team member can contribute to the success of the project by thoughtful participation in these meetings.

When a project involves several contractors, the general contractor and subcontractors should attend and participate in these meetings. The PM should attend the general contractor's construction meetings to ensure that all concerns are addressed. This facilitates proper coordination between the cabling installation team and other contractors working on the project.

If the owner or general contractor does not keep meeting minutes, the PM should keep notes of the meeting and submit them as the PM's understanding of items discussed. This applies to all meetings.

Ordering Materials

The person responsible for ordering the materials should place the order as soon as possible after the project plan is accepted. Easily overlooked are items termed consumables. Consumables are normally shown as a lot on the materials list because they are too small to be detailed as a line item. Items could include tape, screws, tie wraps, and similar materials.

An order for materials is often placed using a PO. The PO should be in writing, and a copy of each material PO should be kept in the project file. These POs can be used to develop the inventory for the project and to check against materials received and stocked.

Receiving Materials

Receiving materials is one of the most important tasks on a project. It can affect the cost of the project just as much as the labor employed. Determining where to store the materials, how they will be dispensed, how to secure them from theft or damage, and how to dispose of unused materials is critical to the project's success.

As the materials arrive, the responsible team member must receive the materials, inventory them, and stage them in preparation for transportation to the work site. If the materials are delivered to the work site, a company representative should be there and should be responsible for receiving, documenting, and storing them in a secure location.

All received items should be inspected and inventoried upon receipt. Each package should be checked against the packing slip for quantity, identity, and condition. If the packaging is damaged in transit, the contents of the package may be damaged. Verify this with the delivering agent prior to signing for the package. This is especially true with large reels of copper and optical fiber cable. If damaged materials are kept, indicate the extent of damage on the packing slip and the shipper's manifest for future claims processing.

If there is a visual indication that reels of cable are damaged, consider refusing to accept responsibility for them, or immediately notify the supervisor to determine the proper course of action. When optical fiber cables are received, check the cable even when no damage is visible, using an optical fiber flashlight, optical loss test set (OLTS), or some other type of testing device to determine the continuity of the strand end to end. Copper and coaxial cable may require testing with a time domain reflectometer (TDR) or other device to identify and document unseen damage.

Check the project plan for specific methods to be used in accepting costly materials. It may be necessary to conduct and document physical tests on various types of cable prior to accepting them. For example, it is a common practice to conduct an optical time domain reflectometer (OTDR) test on optical fiber cable while it is on the reel.

If materials delivered to a work site are visibly damaged upon arrival, the materials should be refused and the delivery service instructed to return them to the distributor or manufacturer. If materials are accepted and then found to be defective, they should be stored separately from other materials and returned to the appropriate source via prearranged instructions from that distributor or manufacturer. If it is not possible to identify the defect and document it, enclose a copy of the documentation with the materials to aid the distributor or manufacturer in properly replacing it and correcting the problem that caused the defect.

Storing Materials

Three basic locations for storing materials for a project are the:

- Work site.
- Company-controlled location.
- Distributor from which the materials were purchased.

Each has its advantages and disadvantages. These storage options should be of prime concern when considering how to plan for materials distribution and use on a job. Depending on the size of the project, the best alternative may be a combination of all options.

Work Site

The work site offers immediate availability of materials. However, there are risks associated with storing materials at a work site. Is a secure space inside the building available? Is an exterior space (e.g., trailer, other building) available and secure? Will only authorized persons have access to the space? Most of the time, the security of materials is the first concern. Until the materials are installed and accepted by the customer, they are the property and the responsibility of the contractor installing them.

Some customers may make space available for storing job materials, but few, if any, will agree to accept liability for loss or damage until the materials are installed and accepted. Risk of loss insurance may be needed to protect against loss of both materials and tools. Although this insurance will cover the loss, delays in obtaining replacement materials may make it undesirable to store them on the work site unless significant security can be assured.

If space is not available for storage inside the building, a job-site trailer might be needed. In most locations, a permit is required prior to locating a job trailer on a construction site. If the trailer will be used only for materials and tool storage, temporary utilities will not normally be required.

Office trailers requiring temporary electrical power, telephones, and sanitation utilities may require additional permits or coordination with the local utility companies providing these services. In most cases, local telephone and power companies will bill the contractor requesting the temporary service for the actual cost of constructing the facilities. The contractor's company may be required to sign a contract for a minimum period of time that the service will be used.

If large cable reels are to be used on the project, a security fence may be required. Fencing can be rented, and the rental company will usually install the fencing. The degree of security associated with job-site fencing will depend on what is stored inside the fence and the social environment associated with the job-site location. In most locations, chain link fencing will be adequate. In other locations, concertina wire may be needed for maximum security. In some cases, private security might have to be hired during nonworking hours.

Storing Materials, continued

Company Location

If the project is in the same city as the cabling installation contractor's office and adequate space is available, materials can be stored at the company location and sent to the job on a daily basis. Security may be less of a concern at the contractor's home location. Break-ins, however, occur even at the most secure locations. The cabling installation company should have insurance to protect against losses when materials are stolen or lost.

Distributor

Most distributors are in the business of stocking materials. Most distributors will deliver materials to a work site or to a company location on demand. Distributors use a process called assemble and hold, which allows companies to order materials for a specific project and stage them at the distributor's closest branch location until picked up or delivered.

Security is not an issue for the contractor in this situation because the materials are the property of the distributor until they are picked up or delivered. In addition, distributors generally have adequate space to hold materials for specific jobs and can deliver them in bulk or by partial order. Normally, the contractor is not billed for the materials, regardless of how long they stay in the staging area, until they are picked up or delivered.

Distributing Materials on Site

Control of the access to job materials will determine who is allowed to distribute them to the installer. Only designated persons should be allowed to distribute materials on the work site or receive them at the end of the workday. Allowing full access to the job materials by the entire work crew invites abuse and loss of materials.

When materials are distributed, some record of accountability should be made to track where the materials are used. Excess materials should always be accounted for at the end of each workday and stored for use later on the job or returned to the company storage area for use on another project. They may eventually be returned to the distributor or manufacturer for credit after the project is completed and accepted. In addition, the records of the distributed materials must be returned to the company PM to ensure proper accounting.

Plan for a distribution area on site regardless of where the bulk of the materials and tools are being staged. The installers will always know where to get their materials, and accounting and control are easier from a single location.

Managing the Project Schedule

Once the project has started, the original project schedule should be compared with the other construction schedules, and the various schedules should be updated at least weekly for accuracy.

The cabling installation schedule should be updated daily, indicating the progress of the day's work and whether the project is on schedule, ahead of schedule, or behind schedule. Any supporting documentation that will lend credibility to delays encountered in the project should be referenced in the project schedule updates.

Managing the Project Schedule, continued

Revise the schedule after each meeting or activity where revisions have been recognized or made. Issue the updated schedule concurrently with the report of each meeting.

The project schedule should include all materials and services required from the sources that are not under the cabling contractor's direct control to include actions required by the owner. The PM should describe any dependencies upon the owner and third parties as well as all project assumptions, expediting methods, active system interfacing requirements, and other management-related issues critical to the timely and successful completion of this project. The plan should describe the manpower and mobilization requirements in terms of functional responsibility, level, and head count.

Maintaining the Project Log

A person on site should keep a project log during all work operations. This log should begin on the first day of activity on the project site and continue until the company vacates the site. All activities relevant to the work should be logged on a daily basis, including the work completed and any problems encountered.

Contractual obligations that are affected by the work of others should be logged and accompanied by detailed notes. This document could prove valuable when others have caused delays. Accuracy and timeliness are, therefore, critical to the credibility of the log.

It is good practice for the PM to document certain elements of the project on a weekly basis and to record the following information concerning events at the site:

- List of subcontractors at the site
- Approximate count of personnel at the site
- Accidents and unusual events
- Meetings and significant decisions
- Stoppages, delays, shortages, and losses
- Emergency procedures
- Change orders received, implemented, and in process
- Services connected and disconnected
- Equipment or system tests and start-ups
- Status of material orders
- As-built documentation status report
- Status of punch list
- Weather conditions
- Timesheets
- Daily job reports

Summary

All ICT cabling systems projects require project management. A 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.

A good project plan is essential for the successful completion of the work. The communication that takes place between the team members while building the plan is often more important than the actual documents.

These techniques help projects to be:

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

The project plan should reflect each aspect of the work and the company's effort to ensure that this work will be performed in a timely, safe, and efficient manner.

It should include:

- Customer documents.
- Documentation to be submitted to the general contractor and customer.
- Job requirements.
- Security and safety plan.
- Acceptance plan.
- Materials list.
- Tools list.
- Task list and description.
- Labor estimates.
- Overall job schedule.
- Cabling installation schedule.
- Scheduled meetings.
- Inspection schedules.
- Resources required for compliance with the schedules.
- Materials staging.
- Coordination with other trades on the project.

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Section 3
Telecommunications Project Management

The following pages are taken from BICSI's *Telecommunications Distribution Methods Manual* (*TDMM*), *13th edition*. These supplementary pages have been isolated from the *TDMM* and directly reference material that is relevant for study for the Registered Telecommunications Project Manager (RTPM) credential.

Telecommunications Administration

Introduction

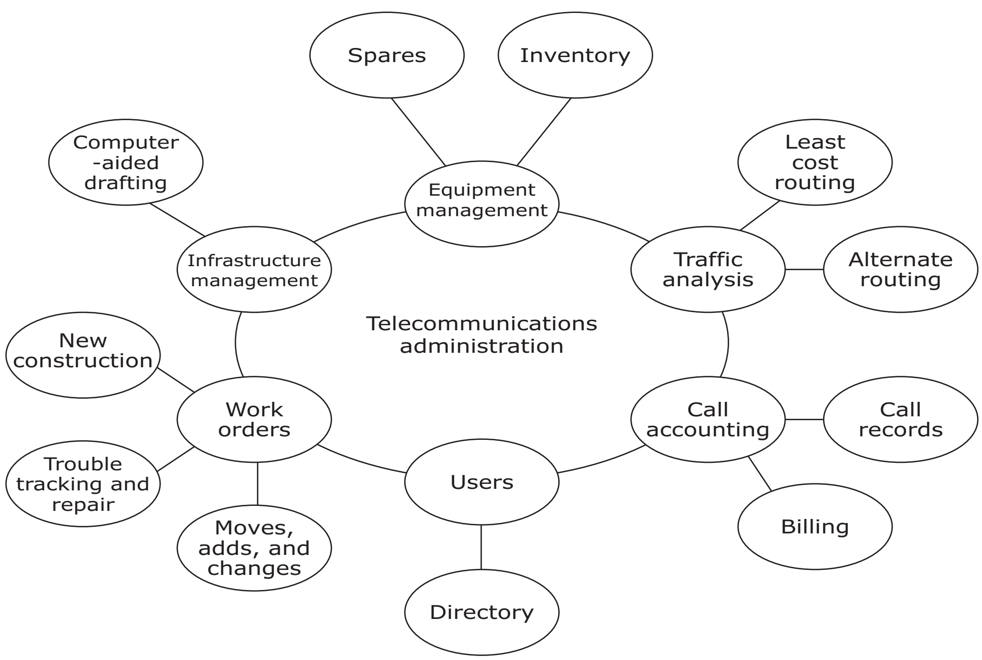
This section describes some telecommunications administration methods and numbering schemes. It does not describe complex administration systems in detail.

Telecommunications Administration Systems

An effective telecommunications administration system is crucial for the efficient operation and maintenance of telecommunications infrastructure elements and telecommunications infrastructure equipment. Telecommunications infrastructure elements include equipment racks and cabinets, cabling pathways, cables and connecting hardware, bonding and grounding (earthing), and much more. Telecommunications infrastructure equipment includes network switches, servers, routers, service provider equipment, power systems, and a host of peripheral telecommunications equipment.

Telecommunications administration systems vary greatly in scope—from simple paper records to software driven databases to complex computer and active hardware-based systems. These complex systems can integrate telecommunications infrastructure and equipment records, inventory, traffic analysis, call accounting and billing, directory information, and work orders, as illustrated in Figure 3.1.

Figure 3.1
Telecommunications administration systems



Benefits of Telecommunications Administration Systems

A telecommunications administration system provides both operational and maintenance benefits:

- Operationally, an effective telecommunications administration system simplifies moves, adds, and changes 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 new cabling.
- 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 Systems

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

General

Four classes of telecommunications administration systems 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 can be managed using:

- Paper-based systems.
- General-purpose spreadsheet software.
- Special-purpose cable management software.
- Automated infrastructure management (AIM) systems.

Classes of Telecommunications Administration Systems, 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 or an AIM system. The special-purpose cable management software and AIM system typically store the infrastructure information in a configuration management database and provide reports and schedules comprising information from groups of records.

Floor plans, risers, and logical diagrams are examples of drawings that should be available showing all identified elements of telecommunications 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 larger than ≈7000 square meters (75,347 square feet) or multi-tenant buildings, administration of pathways and spaces and outside plant (OSP) elements is recommended.

Description of the Four Classes

The following section describes four classes of telecommunications administration. The information and communications technology (ICT) cabling systems designer should implement telecommunications infrastructure administration standards that apply to the geographic region in which the telecommunications infrastructure administration occurs (e.g., ANSI/TIA-606-B, ISO/IEC 14763-2, ISO/IEC 14763-2-1).

Class 1

Class 1 administration addresses the 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. The presence of simple cabling pathways is assumed; therefore, their administration is not required. To administer cabling pathways or firestopping locations, a class 2 or higher administration system should be used.

Class 2

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 space (e.g., 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. The presence of cabling pathways may be assumed, so the administration of these elements is optional.

Classes of Telecommunications Administration Systems, continued

Class 3

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 4

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 intercampus elements (e.g., wide area network connections) are included. For mission critical systems, large buildings, or multi-tenant buildings, administration of pathways and spaces and OSP elements is strongly recommended.

Systems of all classes can be managed using a paper-based system, general-purpose spreadsheet software, special-purpose cable management software, or AIM system. Class 1 systems typically are managed using a paper-based system or general-purpose spreadsheet software. Special-purpose cable management software or AIM systems should be considered for more complex class 3 and class 4 systems.

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.

For example, a designer may specify that the telecommunications infrastructure administration for a given project shall be completed in accordance with a specific industry standard such as ANSI/TIA-606-B. If so, the telecommunications infrastructure administration scheme shall be followed by the appropriate contractor (e.g., electrical contractor, communications contractor) and delivered to the owner as specified.

ISO/IEC 14763-2, *Information technology—Implementation and operation of customer premises cabling—Part 2: Planning and installation*, specifies an alternative scheme regarding the complexity of the administration system and the resulting required identifiers. This scheme can be used where the contract or owner requirements specify that the installed cabling system complies with ISO/IEC 11801, *Information technology—Generic cabling for customer premises*, or ISO/IEC 14763-2.

Classes of Telecommunications Administration Systems, continued

Regardless of the choice of telecommunications administration standards to apply to a given project, there are required identifiers for telecommunications infrastructure elements by class of administration (see Table 3.1).

Table 3.1
Required identifiers by class

	Class of Administration			
Description of Identifier	**1**	**2**	**3**	**4**
Telecommunications space	X	X	X	X
Cabinet, rack, enclosure, or wall segment	X	X	X	X
Patch panel or termination block	X	X	X	X
Port on patch panel or termination on termination block	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
Bonding conductor for telecommunications	X	X	X	X
Telecommunications bonding backbone		X	X	X
Grounding equalizer		X	X	X
Building (intrabuilding) backbone cable		X	X	X
Building backbone termination position, pair, or strand		X	X	X
Firestop location		X	X	X
Campus (interbuilding) backbone cable			X	X
Campus backbone termination position, pair, or strand			X	X
Building			X	X
Campus or site				X

Labeling and Recordkeeping

Components

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

- Be able to be read uniquely without disconnection of cables or components after installation.
- Be labeled within ≈300 millimeters (12 inches) of the connecting hardware terminated to the cabling. Once these cabling elements have been labeled, they must be handled gently in order to read the identifiers applied to the labeling.
- Be labeled on the user side and the cabling side of the connecting hardware in a manner that provides a means to read the identifiers applied to the labeling.
- Provide a direct link to the identifier of the component with the administration system. This direct link may be the identifier itself or a code that uniquely links to the record for the component.

The following infrastructure and equipment components should be labeled:

- Telecommunications spaces
- Cabinets, frames, and racks (at the top front, also at top rear if not in direct contact with the wall at the rear)
- Telecommunications pathways
- Telecommunications cables
- Zone boxes, consolidation point, horizontal connection point, and wireless
- Connecting hardware (patch panels, termination blocks, and outlets)
- Patch cords and equipment cords (at both ends of the cord)
- Grounding (earthing) system (busbars and bonding conductors)
- Telecommunications equipment

Telecommunications Spaces

Telecommunications spaces include:

- ERs.
- TRs.
- Telecommunications enclosures.
- Telecommunications EFs.
- Computer rooms (CRs).

Telecommunications spaces often contain infrastructure that is critical to the function of the building. Space labeling should always be developed within the security plan of the building.

Spaces should be labeled at their entrances, as follows:

- In small, single-story buildings, a simple sign on the door (e.g., TR) 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 may be valid only during construction. Final room numbers should always be confirmed prior to labeling spaces. A remodeled building or space may utilize a different numbering scheme.

Telecommunications Pathways

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

Table 3.2 shows guidelines for identifying telecommunications pathways.

Table 3.2
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, ventilation, and air-conditioning. • Security. • Energy management systems. • Fire-life-safety systems.	Uniquely identify each system.
• Each compartment in ductbanks innerduct. • Each innerduct (duct liner) placed in conduits or ductbanks.	Uniquely identify each compartment or use colored innerduct.

Telecommunications Pathways, continued

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.
- Pathways should be labeled at crossovers, connections, junctions, and changes of direction.
- In a basic system, the conduits should be marked by painting or using colored tape wrap made for this purpose.
- In systems utilizing zone boxes, each zone 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, preferably using a scheme such as ANSI/TIA-606-B or ISO/IEC 14763-2-1, which identifies the spaces at both ends of the pathway.
  - All wall or floor penetrations should be labeled.

Telecommunications Cables

When labeling telecommunications cables:

- Cables shall be identified at each end with a permanent label. The same alphanumeric identifiers shall 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 (e.g., space with a single TR such as a home or small office), the labeling scheme can be a simple number sequence.
- Complex, the labeling may indicate the type, function, and terminating position, preferably using a scheme such as ANSI/TIA-606-B or ISO/IEC 14763-2-1.

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 termination points, telecommunications outlets) require a unique, alphanumeric identification such as that specified in ANSI/TIA-606-B or ISO/IEC 14763-2-1.

Grounding (Earthing)

Grounding (earthing) system components (e.g., ground bars, 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 component (e.g., rack, cabinet, cable tray, equipment).
- 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. See ANSI/TIA-606-B or ISO/IEC 14763-2-1 for an identifier scheme for grounding (earthing) system components.

Telecommunications Equipment

In basic systems, the equipment may consist of a single wall-mounted 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., cabinet, rack).
- Rack unit location within the cabinet or rack.
- Equipment module slot or shelf number.

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

Recordkeeping

A recordkeeping system should be implemented. The system should reference related infrastructure and equipment components in a logical way:

- For basic systems, the records usually are paper based; however, simple spreadsheet or database programs can be used to minimize paper records and simplify updates.
- Complex systems are best administered by computer programs specially designed for the purpose because of their relative economy and greater accuracy.

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 often 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.

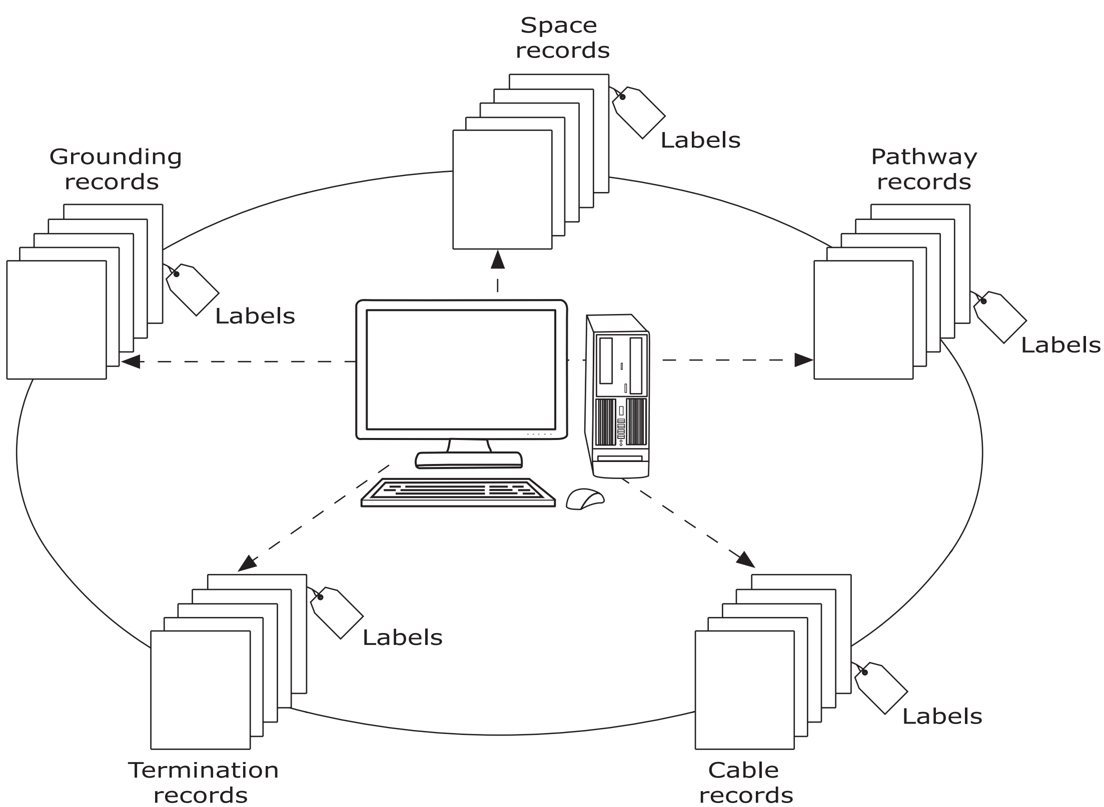
Recordkeeping System Components

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 [earthing] system, telecommunications equipment).

Figure 3.2 illustrates a recordkeeping system.

Figure 3.2
Recordkeeping system example



Recordkeeping System Components, continued

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.
- Campus records.

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.
- 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, 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 or 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., heating, ventilation, and air-conditioning).
- Electronic safety and security systems.
- Lighting systems.
- Building automation systems (BAS).

The monitoring and control of these systems may use various parts of the telecommunications infrastructure elements 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.

Campus Records

Records for campus environments may include:

- Drawings and diagrams of how buildings are physically and logically interconnected.
- Maps, location records (e.g., MHs, handholes, span distances), and cable records (e.g., cable number, cable size between splices, pair count assigned to each terminal) for underground and buried plant.

Required Records

Table 3.3 indicates the required records by class as specified in ANSI/TIA-606-B, *Administration Standard for Commercial Telecommunications Infrastructure*.

Table 3.3
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
Firestop location		X	X	X
Campus backbone cable			X	X
Building			X	X
Campus or site				X

Automated Infrastructure Management (AIM)

AIM systems document, monitor, and automate the management of information technology. They can continuously monitor connections between the cabling system and network equipment in real time and update the documentation and records automatically with any changes when they occur. These systems may feature a combination of hardware and software to provide an added dimension of network management capability and interaction, especially when linked or configured to organizational asset and process controls.

AIM systems:

- Support a variety of categories (classes) of cabling.
- Support both balanced twisted-pair and optical fiber cabling.
- May be capable of monitoring cabling connections in real time.
- May be able to discover and document cabling connections.
- May be able to discover and document network equipment.
- May be able to streamline troubleshooting and resolution of cabling/network issues.
- May enhance security by monitoring and preventing network access of unauthorized devices.
- May be capable of generating labels.

AIM systems can be designed to support standards based and freeform identification and label generation. While these features may not be available in every supplier's product offering, AIM systems can report on the utilization of patch panels and network hardware assets.

In terms of integration capabilities, AIM systems can interface to peripheral management systems for integrated process control and management (e.g., data center infrastructure management, power and environmental monitoring, BAS, work order systems, layer 2-7 network management platforms). AIM systems can track and report the location and movement of network devices, providing conditional alarms for specific activities and unauthorized or unplanned changes that can support auditable event logs for regulatory compliance review.

AIM systems can support an integrated (paperless) work order process, improving project management efficiency. AIM systems can support mobile application interfacing and remote feedback while supporting task planning and telecommunications design tools, including the depiction of:

- Rack elevations.
- Floor plans with key telecommunications locations (e.g., TR, faceplates, racks).
- Complete end-to-end physical layer circuit traces.

Telecommunications Project Management (TPM)

Overview

This section is an overview of the key elements, roles, and processes associated with each phase of a construction project. It covers the design, bidding, construction, and postconstruction phases of a project. The basic concepts of telecommunications project management (TPM) also are discussed.

This section does not provide a detailed description of every aspect of the design and construction of a new building. However, this section helps the ICT cabling systems professional to understand the formal design and construction processes used by the construction industry.

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 telecommunications industry.

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

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

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

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

Telecommunications Project Manager (PM)

Becoming a successful telecommunications 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.

A good PM has:

- Organizational skills.
- The ability to assume authority.
- The ability to focus on key issues.
- Good client skills.
- Flexibility.
- Personal accountability.
- Interpersonal skills.

Telecommunications Project Management (TPM) Steps

Managing a telecommunications 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.

Telecommunications Project Management (TPM) Knowledge Areas

There are nine generally recognized major areas of TPM:

- 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 resources area of TPM covers personnel issues, which involves engaging the right people to do the job and ensuring that they are properly trained, equipped, and motivated. Project safety, an issue where the telecommunications PM may have the greatest personal liability, also is covered by this area.

Scope Management

Scope management of a project involves the development of a scope statement approved by both the client 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.

Telecommunications Project Management (TPM) Knowledge Areas, continued

Integration Management

Integration management of a project covers the breakup of a large project into multiple small projects or conversely, running several small projects as one large one. It involves the integration of various subteams (e.g., electrical contractor, private branch exchange/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 the 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 designer is also responsible for the build portion of the project, then physical quality (i.e., workmanship) and test results would be part of this area. Finally, client 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 helpful 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 carries 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 TPM 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 project.

Developing a Telecommunications Project Plan

A simple method for developing a telecommunications 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., EV tracking)?
- How will the quality be checked (i.e., quality plan)?
- How will the 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.

Creating a Scope of Work (SoW)

An SoW is developed as a response to a statement of work provided by the client and establishes requirements for the performance of work to achieve the project objectives. The SoW is part of a request for proposal (RFP). The SoW must be clear, accurate, and complete. It must be able to be read and interpreted by various project staff, including contractors and suppliers, PMs, and the construction management company personnel.

A well-written SoW that is logical enough to be understood by the respondent and the owner’s personnel who will administer it can do more for the success of a project than any other part of the contracting process. A quality SoW describes the details of performance; it is the benchmark against which the respondent’s performance is measured. That is why using a qualified ICT cabling systems designer should be the focal point for developing the SoW. The designer is responsible for monitoring the respondent’s performance and should start the process by consulting with appropriate department heads for the owner so their concerns and requirements for issues impacting their facilities are fully understood.

Creating a Scope of Work (SoW), continued

When drafting an SoW, the guiding factor must be to clearly communicate what is expected from the respondent. Define any term that could be misunderstood so that all parties have the same understanding. Avoid using phrases or terminology whose meaning is arguable or ambiguous (see the General Scope of Work [SoW] Guidelines). The words “should” or “may” have no place in the SoW unless the action requested is purely optional. When action is mandatory, use the word “shall.”

An SoW describes the work to be performed or the services to be provided. It describes tasks, directs methodologies to be used, and establishes the period of performance. It should contain only qualitative and quantitative design and performance requirements.

Developing an SoW presents unique challenges. Because each SoW is intended for a specific project, the designer should not rely solely on boilerplate language to create an SoW.

If an SoW is not adequately definitive, some capable contractors may decline to bid on the project because of uncertainty about the risks involved or the relationship of the work to their capabilities. As a result, some contractors may dispute responsibilities during construction if the SoW is unclear and they underbid the project. However, if an SoW is too restrictive, competent contractors may feel that their resourcefulness for alternative approaches will be inhibited and may choose not to bid on the project.

To be successful, the designer must manage expectations at the beginning of every project. The challenge is that people hear and interpret the same message in different ways. To protect the client and the distribution designer, develop detailed documents on the front end of any project to manage expectations.

The difficult and sometimes controversial function of proposal evaluation and contractor selection is based largely on the SoW, which is the baseline standard for evaluating all proposals. Evaluation criteria are based on an SoW that defines the project objectives and requirements for their achievement. Challenges to the proposal evaluation and contractor selection are almost always attributable to an uninformative or ambiguous SoW.

Specifications must be included in the contract documents to provide a clear and accurate description of the technical requirements for the materials used and the installation of those materials, including the procedures for commissioning the final product.

Basic Requirements of a Scope of Work (SoW)

The SoW directly affects the quality of proposals submitted. The SoW must be clear, precise, concise, and complete. A well-worded definitive SoW is essential for a contractor to accurately determine the cost of performance. The SoW will also be the basis for measuring performance under a contract. An inadequate SoW will lead to problems with contract administration that may result in costly contract amendments.

The SoW is the contractual vehicle for expressing the specific agreement between the contractor and the owner of the project. Because the SoW defines the actual work to be performed, its accuracy has a direct impact on effective contract administration.

Basic Requirements of a Scope of Work (SoW), continued

To be enforceable as a part of the contract, the SoW must be detailed. It must define the entire extent of work to be performed and all tasks. At a minimum, the SoW must cover:

- What needs to be performed.
- Who is responsible.
- When the work will be completed.
- Where the work will be performed.
- How the contract performance will be judged.

An SoW may be a performance type, a design type, or a combination of both. The performance type tells the contractor the objectives and parameters to be accomplished and the end goal or desired achievement. The contractor proposes how these objectives will be accomplished. In a design type of SoW, the contractor is directed to use specific products and materials (e.g., make, model, manufacturer) to incorporate into the project.

The extent to which an SoW is a performance or design type will affect the degree of detail required and the flexibility allowed the contractor to complete the project. It generally is best to place maximum responsibility for performance on the contractor since the contractor is being retained for expertise and ability to perform. Any provision that removes control of the work from a contractor, even temporarily, may result in relieving the contractor of responsibility.

Contractual/Administrative Requirements

The SoW is only one part of the procurement process and contract development. Do not include in the SoW requirements for legal, financial, or contract administration matters. These requirements more appropriately belong in the RFP.

Preparing an SoW involves the following:

- Basic planning
- Outlining the SoW process
- Organizing the project team
- Writing and reviewing

Basic Planning

The “why” and “what” of a project should be answered during basic planning activity. A telecommunications PM shall review the specific planning and program documents that are the basis for the project. A schedule should be developed to complete the SoW document, including meetings with the client.

Basic Requirements of a Scope of Work (SoW), continued

Outlining the Scope of Work (SoW) Process

Outline the entire SoW process before writing the SoW to help ensure the organization and completeness of the document. The following should be considered for inclusion in a comprehensive working outline:

- Objectives:
  - Precisely identify the objectives of the project.
- Context of the project:
  - Provide background information that will aid the contractor in understanding the nature and origin of the requirements.
- Technical considerations:
  - Include any specific methodologies or results of previous related work that may influence a contractor's efforts.
- Tasks:
  - List the specific tasks to be accomplished by a contractor to satisfy the objectives together with the required sequence of tasks to express order of accomplishment.
- Acceptance:
  - Establish milestones in the sequence of tasks where the owner takes actions for review, approval, acceptance, or rejection. These baselines will serve to:
    - Prevent a contractor from performing tasks that are not applicable to the effort.
    - Measure the results of completed work.
    - Assist in defining whether or not subsequent changes or a redirection of effort is required.
    - Assist the telecommunications PM in monitoring progress.
  - These milestones are particularly important for phase types of contracts where it is necessary to detect unsatisfactory performance at an early stage. It will allow a telecommunications PM to inform the owner's personnel and propose prompt actions before their effect compromises the entire contract effort.
- Schedule:
  - Generate a schedule for the sequence of tasks to be performed by a contractor and a similar schedule for related responsibilities of the owner.
- Deliverables:
  - Identify the contractor delivery requirements, and schedule a delivery date for each.
  - Include details about the type and quantity of all deliverables.

Basic Requirements of a Scope of Work (SoW), continued

Develop the outline to:

- Allow full attention to be directed to the technical content.
- Help guard against significant omissions.
- Aid in achieving continuity throughout the project.
- Help eliminate redundant material and work.

Organizing the Project Team

The project team members can extend beyond the PM and PM's staff. Part of the project team's function will be to maintain the scope of the project while verifying timelines and measuring performance to obtain the identified deliverables. This team would provide functions performed by consultants, supervisors, contractors, electricians, engineers, electrical inspectors, architects, and owners' representatives. Such a large pool of potential team members requires identifying specific members to be included in the team and a careful assignment of duties to maximize the project team effectiveness.

A selection process can be used to identify the impact of the team member on the project and gauge the level of involvement in the project. Some members may need only information updates while others will be closely involved in the project's daily operations; others will monitor and quantify performance. Each selected member will have to be included in the communication process and agree to provide the duties as part of the team. Once the team has been established and confirmed, the communication process for team members must be included as part of the organization. With the members chosen and the communication paths identified, the writing and reviewing process can proceed with minimal interruption and delay.

Writing and Reviewing

During the development of the SoW, the PM should ensure that the content is adequate by coordinating the efforts of the SoW writing team. All concerned members of the owner's staff, including specialists, should review the SoW to ensure that all of the requirements fulfill the stated objectives. After all comments are incorporated, the SoW writing team will review the documents. The telecommunications PM must ensure that changes are coordinated before a final draft is prepared for review by a program manager for consistency with program requirements.

For a less complex SoW, an individual writer may specify the program requirements and seek the assistance of the owner's staff in ascertaining that the SoW is sufficient to accomplish the procurement and to provide a sound basis for contract performance and administration.

The designer's main objective should be to arrange and present the information in a manner that:

- Is logical and readable.
- Emphasizes the most important elements.
- Conveys exactly what is required of the contractor.

Basic Requirements of a Scope of Work (SoW), continued

Description of Format

The background should:

- Provide a general description of the requirement.
- Briefly discuss why the particular project is being pursued and how the project will relate to previous, ongoing, and future projects.
- Discuss any known difficulties, constraints, or methodologies used on previous projects that were ineffective.
- Provide sufficient information to enable a prospective contractor to understand how the requirement arose and how it fits into a broader series of events.

If prospective contractors need detailed background materials, the designer should either list the materials and state where they can be obtained or reviewed in a separate References section of the SoW or provide specifications of the materials and methodologies included in the RFP as an attachment to the SoW.

The scope is a summary that describes the purpose of the work and end product desired. The SoW writers should be certain that the scope and objectives are consistent with the funding available for the effort. In the scope, the primary objectives are presented in concise form. Use broad, nontechnical terms and summarize the actions to be performed by the contractor and the results or products expected by the owner.

The designer can define the overall boundaries of the effort (e.g., time frames, special areas of interest). If the work is to be divided into phases, define each phase and make clear the relationship between the work to be undertaken in each phase and the specific project objectives. If appropriate, given the nature or complexity of the project, first state an overall goal and then make clear specific objectives falling under that goal.

Basic Requirements of a Scope of Work (SoW), continued

End Result Deliverable

Specify the deliverable end result that is expected at contract completion. When applicable, specify the use to be made of this deliverable.

Spell out the criteria that the deliverable must meet in order to be considered acceptable by the owner. Periodic progress reports are not considered deliverables because they are not the final result of the task; rather, they are a management tool for monitoring progress toward the completion of a deliverable.

A key factor is how the designer will determine compliance for a particular requirement. If the requirement lends itself to verification of compliance, examine the requirement closely to determine its validity.

Depending on the nature of the service, a wide range of compliance options are available to the SoW writer. In some cases, the designer may monitor the contractor's work by requiring periodic progress reports, conferences with the PM, attendance at construction meetings, or by having an inspector periodically examine the contractor's work. In any of these cases, the SoW must provide the means of determining that the contractor is doing the job properly.

The SoW should specify:

- The number of copies of reports and the person to whom they will be delivered.
- Any physical arrangements necessary to assure the owner's capability to examine end products.

Basic Requirements of a Scope of Work (SoW), continued

General Scope of Work (SoW) Guidelines

Catchall phrases should be avoided. Be specific about what is required to satisfactorily complete the project. Do not rely on ambiguous language such as “good industry practice” or “workmanship shall be suitable for the purpose intended.”

Do not use open-ended requirements such as “subject to approval,” “as directed,” and “satisfactory to.” A contractor cannot predict what will be satisfactory or approved but must assume the risk that after the contract has been signed, the client will accept the completed project.

Be consistent by using the same words or phrases throughout to express the same meaning. Be particularly careful to use descriptive labels consistently.

Avoid open-ended phrases such as the following:

- Accurate workmanship
- As determined by the PM
- As necessary
- Carefully performed
- Good materials
- Good working order
- In accordance with best practices
- Installed in a neat and workmanlike manner
- It is assumed that
- Kinks and bend may be cause for rejection
- Of standard type
- Products of a recognized, reputable manufacturer
- Properly assembled
- Reasonable period of time
- But not limited to
- Securely mounted
- Tests will be made unless waived
- The finished product shall be practically free from dirt
- To furnish if requested by the PM
- Where feasible
- Workmanship of the highest quality

Developing a Safety Plan

Having a safety plan and an active safety program sends a good message to the client and all team members. On a project where a designer is issuing only the design documentation, safety may be excluded from the scope. On the other hand, if the designer is 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 client 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's 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 editions of BICSI's *Telecommunications Project Management Reference Manual* (*TPMRM*), *Outside Plant Design Reference Manual* (*OSPDRM*), and *Information Technology Systems Installation Methods Manual* (*ITSIMM*) and from organizations such as the:

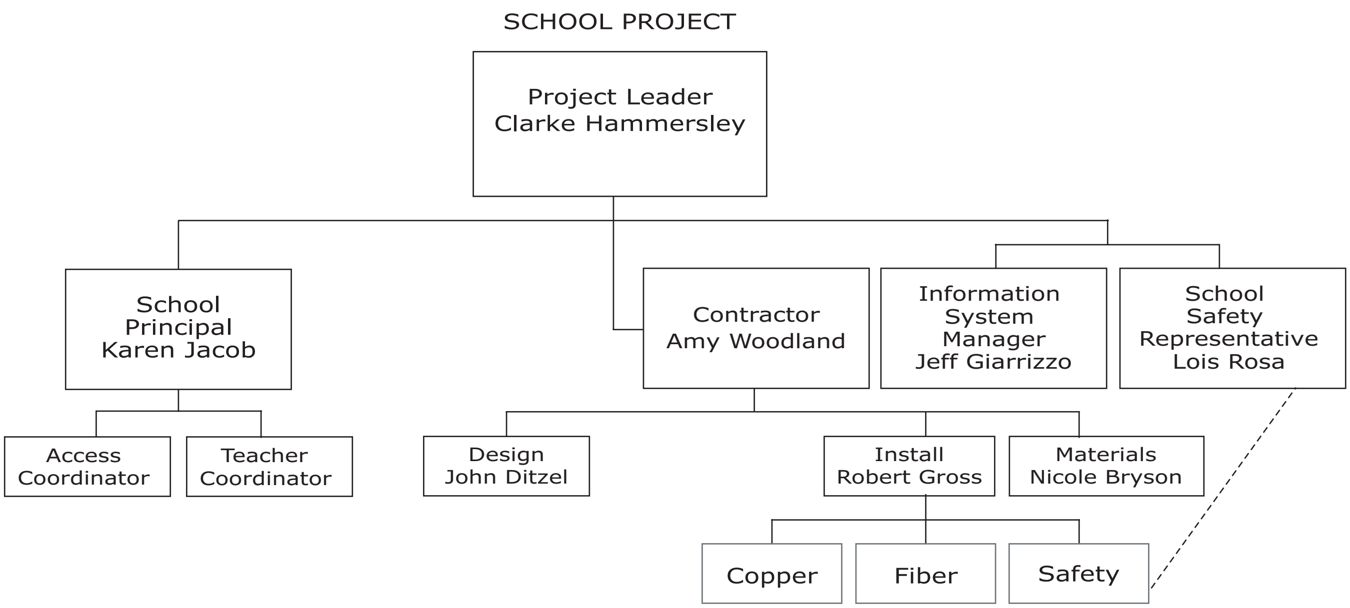
- Health and Safety Executive (www.hse.gov.uk).
- European Agency for Safety and Health at Work (www.osha.europa.eu).
- British Safety Council (www.britsafe.org).
- National Safety Council (www.nsc.org).
- Occupational Safety and Health Administration (www.osha.gov).

Developing an Organization Breakdown Structure (OBS)

Another step in the project planning process is to identify the people and organizations needed to complete the project as detailed in the SoW. The recommended method for this is an 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 3.3).

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 it lets everyone know their role. The OBS should include telephone numbers and e-mail addresses for each team member, including the client's team and others who might affect the team (e.g., electrical contractor).

Figure 3.3
Simple organizational breakdown structure



Building a Work Breakdown Structure (WBS)

There are certain rules for developing a sound, usable, and consistent 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 it 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 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 3.1).

Example 3.1
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

WBS = Work breakdown structure

Building a Work Breakdown Structure (WBS), continued

A WBS also can be built as a text outline (see Example 3.2).

Example 3.2
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.

WBS = Work breakdown structure

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

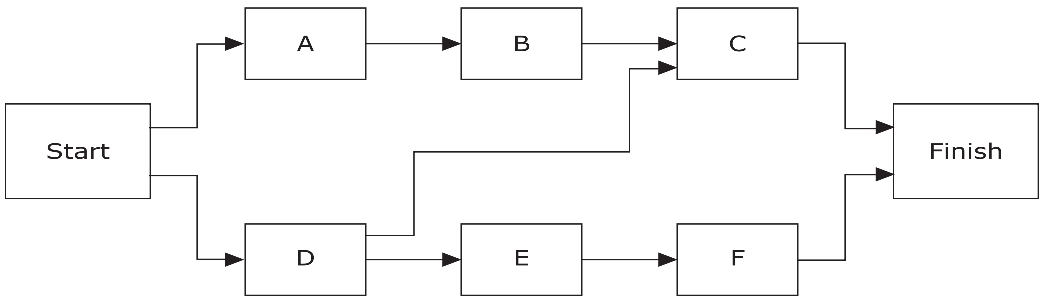
PERT uses network diagrams to identify predecessor and successor relationships on projects. For example, if a permit is needed before installing cable, then “get permit” is a predecessor and “install cable” is a successor.

CPM uses a similar network diagram by identifying 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 3.4).

Figure 3.4
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 3.5).

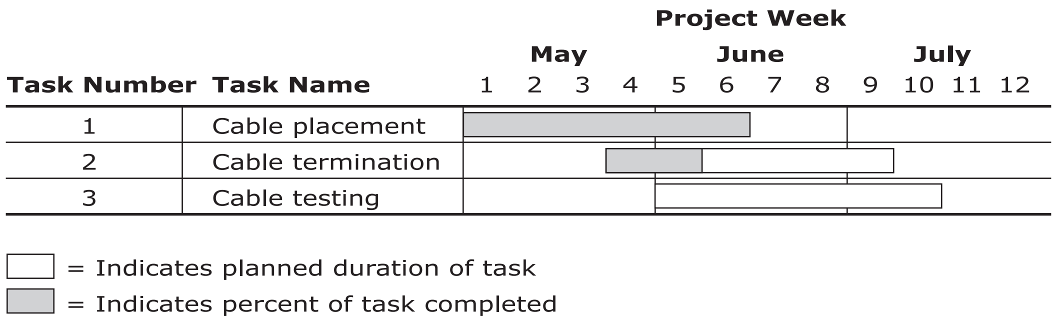
Figure 3.5
Milestone chart

		Project Week											
		May				**June**				**July**			
Task Number	**Task Name**	1	2	3	4	5	6	7	8	9	10	11	12
1	Cable placement	◆					◆						
2	Cable termination				◆					◇			
3	Cable testing					◇					◇		

◇ = Indicates start and completion dates of task
◆ = Indicates task has been started or completed

A Gantt chart shows the duration of the activity by using a bar chart from start date to finish date (see Figure 3.6). Unlike the PERT chart, the Gantt chart does not show predecessor or successor relationships.

Figure 3.6
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 3.7).

Figure 3.7
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 or 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, 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 estimate and is used to check an analogy estimate.
- Engineering—An engineering estimate, developed by the client, 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 client 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 (e.g., 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

Using the Budget to Determine Project Performance

Cost estimates should be developed for each task on the PERT chart. As each task has a defined time of occurrence, total costs for a set period of time (typically 1 week) can be plotted. When these costs are plotted in a cumulative fashion (e.g., the value for Week 3 is the sum of Week 1, Week 2, and Week 3), a cumulative cost curve or budgeted cost of work scheduled (BCWS) is developed, as shown in Figure 3.8. BCWS is also known as planned value.

Earned value occurs as work is performed. As each task is completed, the budgeted amount is accumulated similar to the BCWS, but is called the budgeted cost of work performed (BCWP). The key distinction with BCWP is that while it uses the same budgetary amounts, the completion of the actual work may be completed earlier or later than the initial budget plan. Therefore, when the BCWP is plotted on the same chart as the BCWS, differences between the two curves are common.

By comparing the BCWP with the initial BCWS, one can visually determine if the project is behind or ahead of schedule. For example, if the BCWP is higher at Week 3 than the corresponding BCWS, the project is ahead of schedule. Similarly, if the BCWP is below the BCWS, then the project is behind schedule. Figure 3.9 shows an example of how the BCWS and BCWP curves may look when a project is ahead of schedule.

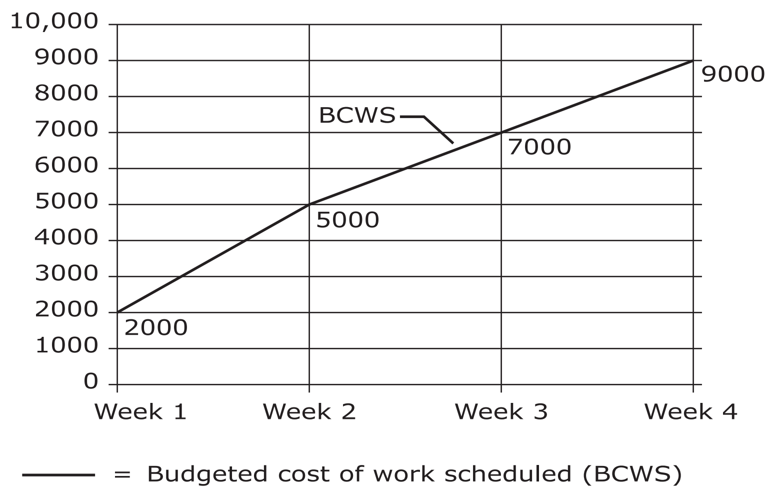
Using the Budget to Determine Project Performance, continued

The schedule performance index (SPI) may be used to represent the amount a project is ahead or behind schedule. SPI is calculated as follows:

SPI = BCWP / BCWS

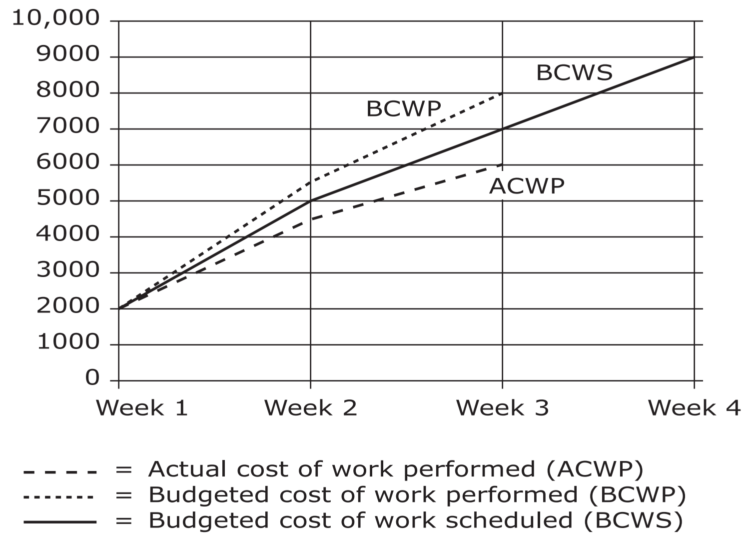
A SPI value of 1 indicates a project is on schedule, whereas SPI values less than 1 indicate being behind schedule with values greater than 1 being ahead of schedule. The benefit of using SPI is that it is easier to calculate than tracking the number of days ahead or behind schedule each task is and then trying to derive the current position of the project.

Figure 3.8
Example of budgeted cost of work schedules



Using the Budget to Determine Project Performance, continued

Figure 3.9
Example of plotted BCWP, BCWS, and ACWP



Besides knowing if one is ahead or behind in terms of time, one can also determine if a project is performing to the established budget. By determining the actual cost of work performed (ACWP) for each task that is completed and then accumulated similar to the BCWP, a cost performance index (CPI) can be calculated by using the following equation:

$$CPI = BCWP / ACWP$$

A CPI values less than 1 indicates the project is over budget, while a value greater than 1 is under budget. The ACWP can also be plotted with a BCWP curve, with Figure 3.9 showing a project that is currently under budget

Note that the CPI does not use the BCWS, as tasks may be completed ahead of schedule. While usually a positive event, if a budget overrun occurred in achieving the early completion, the use of BCWS would not reflect this until later in the project, where there is less time or opportunity to mitigate earlier overages.

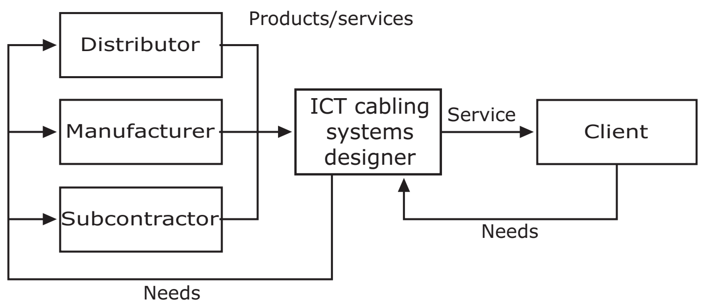
Developing a Quality Plan

Over a period of time, 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 (e.g., neatness, test results). This step is still important and requires workforce training and quality inspections of the work. It follows the principle of plan, do, check, and act.
- Client satisfaction quality—The next quality stage is client satisfaction, which involves asking clients whether they were satisfied with the service they received. Many restaurants, car dealers, and service businesses will ask the client 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.
- Client value quality—Client value evaluates the relationship between cost and quality. Client value reviews the results on a relative basis as compared with the competition. Companies ask their clients to benchmark their performance against the competition. This works well in a long-term relationship where the client sees the designer as a supplier.
- Client/supplier model—One way of involving clients in helping to benchmark quality performance relative to competition is to use the client/supplier model (see Figure 3.10). Suppliers (e.g., distributors, manufacturers, subcontractors) are expected to serve clients, so the contractor is a supplier to clients. Contractors provide outcomes to the client. To understand what clients 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 3.10
Client/supplier model



ICT = Information and communications technology

Quality Benchmarking

Asking clients 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.
- Responsiveness.
- 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 client. 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 documented and communicated to the team and formally approved by the client.

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 telecommunications 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 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 that 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, electrical engineer). Many members of an engineering firm are 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 section, 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.
- 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.

Design Phases, continued

Programming

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

Schematic Design (SD)

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

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. CDs 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 (RFP)

An RFP is an invitation for the design professionals (e.g., architect, engineer, consultant) 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 typically will be used to procure one of the types of structures noted below.

Design-Bid-Build (DBB)

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 (DB)

Design-build (DB) is a delivery method whereby the owner contracts with a single entity known as the DB team. The DB team consists of the GC, subcontractors, and 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 (CM) at Risk

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 GC 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 that CMs are acting in both the owner's and their own best interests.

Integrated Project Delivery (IPD)

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, CMs, 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 IPD 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.

A contractor who submits a bid to the owner and is awarded a contract for payment from the owner is a prime contractor. Contractors who includes their price in another contractor's bid and is paid by another contractor who is paid by the owner is a subcontractor.

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 designer's responsibility is to ensure compliance with the CDs. 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 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 (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 that 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 GMP 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 GC'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 ACs 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 the Construction Specifications Institute (CSI), American Institute of Architects (AIA), Engineers Joint Contract Documents Committee, and Design Build Institute of America have developed comprehensive and tightly coordinated documents. Because of 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 information (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.
- Technical and user manuals.
- Project photographs.

Design Phases, continued

Postconstruction

Cutover and first-use activities begin as soon as construction is substantially completed. 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 work 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

Telecommunications designs should include three elements:

- Specifications
- Drawings
- Cost estimates

Elements of Design, 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.

CDs in North America typically use a standardized format jointly produced by the CSI and Construction Specifications Canada. SectionFormat™ and PageFormat™ standardize how the text on each page in a specification is presented and organize the information in each section into three parts:

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

Utilized with SectionFormat™ and PageFormat™, MasterFormat® is a list of numbers and titles compiled to organize the activities and requirements of a construction project (see Table 3.4). By serving as a filing system or taxonomy, the MasterFormat facilitates communication among architects, specifiers, contractors, and suppliers, a requirement for the successful completion of large and complex projects.

Before the 2004 edition, the MasterFormat included 16 divisions as well as a summary of the front-end requirements. Telecommunications SoW 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.

Besides CDs, MasterFormat numbers and titles are suitable for other aspects in construction, including project manuals, organizing cost data, filing project information and other technical data, and presenting construction market data. When combined with the WBS numbering for task assignments and tracked in a visual information system or geographic information system (GIS), the end user is able to track what was installed, who installed it, and when the installation was completed. The system may also link to test records, pictures, drawings, and other project information in the end client CAFM system.

Elements of Design, continued

Table 3.4
MasterFormat® 2012 numbering

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, continued

Table 3.4, continued
MasterFormat® 2012 numbering

Division	Title
Facility Services Subgroup:	
Division 20	Reserved for future expansion
Division 21	Fire Suppression
Division 22	Plumbing
Division 23	Heating, Ventilation, and Air-Conditioning (HVAC)
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 Construction
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 and Waste Control Equipment
Division 45	Industry-Specific Manufacturing Equipment
Division 46	Water and Wastewater Equipment
Division 47	Reserved for future expansion
Division 48	Electrical Power Generation
Division 49	Reserved for future expansion

Elements of Design, continued

MasterFormat uses a six-digit format to represent three levels of hierarchy. An additional two levels are provided; the fourth is reserved for assignment by MasterFormat, and the fifth is open for user definition. The full five-level format is typically represented as:

11 22 33.44.55555

Levels one through four are represented by a digit between 0 and 9, whereas level five can be a combination of one to five alphanumeric entries (a-z, 9-9).

To illustrate further, an assigned four-level MasterFormat entry is as follows, with corresponding level entries listed after the following can be determined:

27 13 23.13

- 27 represents the first level or division, which is Telecommunications.
- 13 represents the second level entry, which for Division 27 is Communications Backbone Cabling.
- 23 represents a third level entry, which for this particular second level is Communications Optical Fiber Backbone Cabling.
- 13 is the fourth level, which has been assigned for this level three as Communication Optical Fiber Splicing and Terminations.

Additional recommendations for the use of level four and level five are included in the MasterFormat 2012 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.

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, continued

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

The National Computer-Aided Design (CAD) Standard® (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:

- AIA produces the CAD Layer Guidelines.
- CSI produced the Uniform Drawing System (UDS).
- The National Institute of Building Sciences (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-Service (armed forces) published the Tri-Service Plotting Guidelines.

Components of the National Computer-Aided Design (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 3.5 includes the U.S. National CAD Standard Project Committee Report, all amendments, introduction and appendixes (NIBS), and the following:

- Uniform Drawing System (UDS), Modules 1-8—Updated with MasterFormat 2012 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 3.5 lists the recommended layers.
- Plotting Guidelines approved by the NCS Project Committee—The guidelines include the use of 256 color identification numbers assigned to plotted line weights and plotted colors.

Elements of Design, continued

Adoption of the National Computer-Aided Design (CAD) Standard® (NCS)

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, U.S. Navy, U.S. Air Force, and U.S. General Services Administration and is used by numerous groups and architecture and engineering 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. Information in one cycle often 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 Computer-Aided Design (CAD) Standard® (NCS)

The UDS, produced by the 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 the 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 3.5 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 create 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 abbreviations used in CDs and specifications. It provides consistent spelling and terminology, standardizes abbreviations, and notes common usage.

Elements of Design, continued

- Symbols (Module 6)—Addresses commonly used standard symbols, classifications, graphic representation, and organization in creating, understanding and fulfilling the intent of CDs. The symbols are categorized using MasterFormat 2012 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 also can be a tool to expedite code review by designers and plan review authorities.

The AIA CAD Layer Guidelines: NCS Version 3.5, produced by the AIA, 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 International Organization for Standardization (ISO) 13567—Discusses the relationship between the NCS and ISO 13567, the international standard for organizing and naming layers for CAD

Plotting Guidelines have been developed by the U.S. Coast Guard and published by the U.S. Department of Defense Tri-Service CADD/GIS Technology Center. The guidelines include the use of 256 color identification 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 CAD programs (e.g., 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.

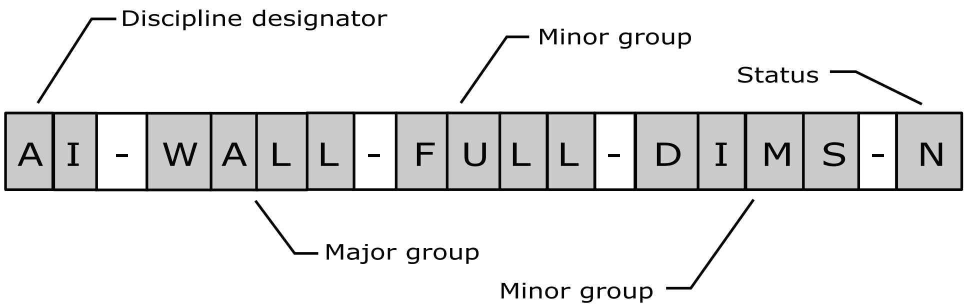
Four defined layer name data fields are:

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

Elements of Design, 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 3.11).

Figure 3.11
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, continued

Symbol Types

The types of symbols in the NCS are:

- Reference—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—Indicate continuous objects and are either single or double lines. These symbols are also scale independent.
- Identity—Indicate individual objects and generally are 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—Resemble the actual objects being symbolized. These symbols are scale dependent.
- Material—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—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.

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, continued

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

- Seasonal effects on the available labor pool or construction costs.
- Strength of 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 CDs 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 SD and DD phases. These submissions serve as critical milestones in the design process.

Vendor and Contractor Coordination

Completing a timely and cost-effective telecommunications construction project requires the careful coordination of contractors, suppliers, and others who will be working on the project simultaneously.

Coordination with these contractors and vendors is key to successful project management and must be planned well in advance of the construction start date. It is also imperative to coordinate with the building management or GCs for the use of the shipping and receiving dock, elevator, and general building facilities and to integrate trash removal and cleaning schedules into the overall plan.

Using the GC's master schedule as a baseline, short interval schedules are created and updated regularly. Daily activities should be logged in diary form as the basis for measuring progress and meeting construction milestones. A two- or three-week look ahead should be produced every week, creating a tightly focused framework for coordinating all work on-site between trades.

Vendor and Contractor Coordination, continued

The GC's project superintendent is critical in synchronizing the daily activities of all trades through daily or weekly meetings with individual trade PMs, foremen, and supervisors. From the future schedule, all daily activity can be coordinated so that materials arrive on time.

This focused scheduling also enables the project team to quickly evaluate any change orders, avoid bottlenecks, schedule inspections, and keep the owners informed of the project status.

Anticipate the interrelationships of all subcontractors and their involvement with the project. Resolve differences or disputes between subcontractors and material suppliers concerning coordination, interference, or extent of work between trades. The GC's decisions, if consistent with the contract documents, shall be final. The architect is not required to coordinate work between trades and typically will not do so.

The work should be coordinated with all trades to ensure that tasks are accomplished as rapidly as the progress of the project will permit and with minimal delays.

Coordinate all schedule conditions involving the tasks of various trades in advance before installation. If necessary, and before work proceeds in these areas, prepare supplementary drawings for review showing all work in tight areas (e.g., above ceiling coordination drawings).

If specific questions arise regarding coordination of the installation with structural, architectural, and site conditions and work between trades, submit RFIs to the GC with appropriate documentation to demonstrate the concern along with the proposed installation.

Once a response has been issued, final coordinated shop drawings shall show that all trades affected have made reviews and understand any approved changes. This change should be a priority topic for discussion at the weekly construction meeting.

At the initial stage of construction, the GC typically holds two critical meetings to begin the project and allow all parties to introduce themselves. The first meeting usually is conducted with the owner and design team, and the second meeting is with the field personnel and subcontractors.

Vendor and Contractor Coordination, continued

Kickoff Meeting

Before starting construction, the GC should conduct a kickoff meeting during which all subcontractors should be prepared to address the following topics:

- Meeting schedule and protocol
- Project team introductions
- Project contact information
- Permit submission status
- Construction start date
- Project scheduling and completion date
- Building rules and regulations
- Material delivery procedures
- Debris removal
- Weekly meeting schedule
- Contract issues
- Project submittals list
- Submittal approval process
- RFI process
- Change order process
- Authorized client/architect
- Payment requisition procedures
- Closeout procedures and documentation

Prime Contractor and Subcontractor Coordination Meetings

Before starting construction, the PM and field superintendent typically hold a mandatory preconstruction conference with all contractors involved in the project to address the following topics:

- Building rules and regulations
- Work site safety meeting schedule
- Weekly foreman’s meeting schedule
- Project scheduling and long lead items
- Shop drawing and samples submissions
- Insurance certificate submissions
- Invoicing procedures
- Change order processing
- Project closeout procedures
- As-built drawing submissions
- Final waivers of lien requirements
- Warranty and operations manuals submissions
- Punch list completion and status

Vendor and Contractor Coordination, continued

Weekly Progress Meetings

Weekly progress meetings will be conducted by the GC with the client, contractors, and design team in attendance. These on-site progress meetings are used to review budget concerns, maintain scheduling, and identify, address, and track issues. The GC is responsible for the following:

- Preparation of meeting agendas
- Preparation of meeting minutes
- Preparation of action lists
- Review of all open RFIs
- Review of all unapproved submittals and shop drawings
- Change order review
- Weekly construction updates and review of current issues
- Schedule review and completion date projections

Conclusion

All telecommunications projects require project management. A telecommunications 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 communication between team members while building the plan is often more important than the actual documents.

These management techniques help telecommunications projects to be:

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