



The California State University Office of the Chancellor



Telecommunications Infrastructure Planning (TIP) Standards

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Services and Capital Planning, Design, and Construction**

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Recent Changes

- Warning against humidity in wiring closets (2.6.2.2)
- One Wireless Access Point for every 50 Stations in Space (2.7.3.3)
- Zone Cabling Systems for flexibility (2.7.3.5)
- Recommendation for a network drop per student in dorms (2.7.3.6)
- Two (2) Cat6a cables per Wireless Access Point location (2.8.1)
- Data closet wallboard requirements (3.2.1)
- Grounding Requirements (3.2.4.1)
- Cable Fill Table Modifications (3.3)
- Fabric innerduct system like Maxcell (3.3.1.2)
- Labeling and alignment requirements for Pull Boxes (3.3.1.3)
- Floor box requirements added (3.3.3.3)
- Patch Panel termination instead of 110/66 blocks (4.2.3.2)
- Slack Loop requirement (4.2.3.3)
- Cable Color Coding recommended (4.2.3.5)
- Single-Mode Fiber preferred (4.3.2)
- Building Fiber strand-count modified (4.3.7)

Overview

The California State University System has been committed for many years to a significant investment in technology infrastructure, hardware, and software to serve system-wide mission-critical needs. The Technology Infrastructure Program (TIP) Standards were developed to protect the investments and ensure long-term viability when installing and deploying a myriad of advanced technologies.

The TIP Standards provide direction for information technology managers, facility planners, architects, and other design professionals in the design, technical integration and interoperability of telecommunications systems, media, pathways, and spaces. This document is intended to provide a foundation outlining minimum standards governing the development of technology resources and infrastructure across the CSU system. While providing topical information regarding certain specific solutions or design methods, it also serves to identify the range of components and issues covered by the telecommunications distribution requirements in a typical University building construction or renovation project.

Part One

Part one of the TIP Standards provides valuable background information about how this document came into existence and the principles that have guided its development. This section details the intent,

purpose, history, and strategies involved in creating the TIP Standards and its implications for the proper buildout of technology in the varying types of spaces encountered in CSU campus spaces.

Part Two

Part two defines the types of technology and information system-related spaces and distribution services that are in use or must be planned for in CSU construction projects (new or retrofit). The focus of this section is on the information required by architects and space and facility planners.

Part Three

Part three provides detailed information regarding the design of the telecommunications pathways and spaces in new construction and facility remodel projects. This section provides details on sizing of rooms and pathways, the electrical and mechanical services required, and other building construction (as opposed to technology-specific) materials and considerations. The CSU expects that this section will be used by architects and their sub-consultants during the detailed design phase of a project in the preparation of specifications and working drawings, and by campus telecommunications and facility planning staff as a checklist for construction design projects.

Part Four

Part four identifies a standard design approach centered on evolving industry standards for voice, data, and video communications transport media. This section is not intended as a tool to preclude a campus from developing its own University Telecommunication Infrastructure Program Standards (UTIP) to support specific requirements, but does establish baseline standards for the selection, design, and deployment of services universal to all CSU sites. These UTIP Standards should look to build on the TIP Standards and/or further clarify a University's unique requirements or methods of delivering Technology Infrastructure systems.

This edition of the TIP Standards includes updated content based on lessons learned from many campus projects, changing code requirements, updated industry best practices and standards and changing requirements from our faculty, staff and students. As the ways that higher education uses technology continues to evolve, we must anticipate potential new requirements, and ensure our facilities are prepared to support them.

It is recognized that the CSU combines more than a score of campuses of varied sizes, widely differing physical environments, and quite diverse academic objectives. Consequently, it may be necessary for local University planning and design personnel with review and approval from local telecommunications design designee to slightly deviate from strict adherence to these TIP Standards —but no departure from the implicit minimum level of quality is expected.

Editorial Contributors

The California State University is indebted to the individuals listed below for their contributions to the fifth edition of the TIP Standards. Their efforts have been expended to maintain and continue the viability of TIP Standards as a document important to future technology development in the CSU, following the tradition established by its original publication in 1993 and revision in 2014.

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1.0 PART 1 – Introduction and General Requirements

This section describes the circumstances leading to the CSU’s development and promulgation of the California State University’s Telecommunications Infrastructure Planning (TIP) Standards.

1.1. The TIP Standards Concept

1.1.1. Intent

The California State University System has been committed for many years to a significant investment in technology infrastructure, hardware and software to serve system-wide mission-critical needs. Prudent management of that investment of public resources requires that all possible strategies be adopted to assure its long-term viability. Among those strategies, a principal focus is, and will continue to be, assurance that the products and services being acquired are of the highest possible quality. The TIP Standards are only one of numerous specific statements of the University’s commitment to that goal.

It must be emphasized that the technical material incorporated in this document should be regarded by the planning and design personnel considering them as minimum standards governing the development of technology resources across the CSU system. At the same time, it is also recognized that the CSU combines more than a score of campuses of varied sizes, widely differing physical environments, and quite diverse academic objectives. Given that situation, it may be necessary for local University planning and design personnel with review and approval from local telecommunications design designees to slightly deviate from strict adherence to these TIP Standards —but no departure from the implicit minimum level of quality is expected.

Further, absolutely nothing in this document is intended to relieve design consultants of their basic professional and contractual obligations for careful project analysis, strict adherence to sound design principles and best practices, and responsible oversight of construction and installation activities.

1.1.2. Purpose of the TIP Standards

As was true of its several predecessor documents, the TIP Standards continue to incorporate input from a diverse group of CSU system and campus staff, engineering consultants, and product vendors. Its primary purpose is to provide a standardized approach to developing both intra- and inter-building campus telecommunications infrastructure physical plant systems essential to achieving the following mission-critical CSU goals:

- Facilitating teaching and learning
- Improving productivity and efficiency
- Enhancing research and scholarship
- Increasing the efficiency of institutional management.

A further purpose of the TIP Standards is to ensure the necessary development of intra-campus infrastructures adequate to support varied technical systems and communications between them including Building Management Systems (BMS) (SCADA, Lighting, Fire, Security, Access Control, and IoT), high-speed linkages with other CSU sites with various telecommunications providers, and with the Internet. The TIP Standards are not intended to be the sole source of CSU technology physical plant planning and design information; it is, rather, a tool for defining and explicating the specific telecommunications-related infrastructure requirements common to CSU facilities.

This document provides direction for information technology managers, facility planners, architects, and other design professionals in the design and technical integration of telecommunications media, pathways, and spaces. The objectives of the TIP Standards are to:

- Provide a universal framework for inter/intra-building infrastructure design, development, and deployment in the CSU.
- Define minimum standards for the spaces, pathways, and telecommunications-related infrastructure that must be programmed into either new building construction or retrofit projects.
- Outline specific media selection and design criteria.
- Highlight technical issues that must be incorporated into a campus design and procurement process; and
- Delineate methods and procedures for installing, testing, and documenting cable and related infrastructure.

This TIP Standards document is not intended to provide all the answers to information technology-related infrastructure design issues encountered within the CSU. The document's nature is such that, while providing topical information regarding certain specific solutions or design methods, it also serves to identify the range of components and issues covered by the telecommunications distribution requirements in a typical University building construction or renovation project. Most of the TIP Standards content is based upon various national standards and guidelines for telecommunications systems, such as those developed by the Electronic Industry Association (EIA), Telecommunications Industry Association (TIA), Institute of Electrical and Electronics Engineers (IEEE), and Building Industry Consulting Services International (BICSI). Great emphasis is placed herein on the idea that taking guidance from such sources is generally more desirable than using specific manufacturer's proprietary designs which may quickly become outdated or may be incompatible with other needed equipment.

1.1.3. Foundations of the TIP Standards

1.1.3.1. History

For over 20 years the California State University (CSU) has prepared a variety of planning documents, position papers, sample specifications, and guidelines to assist campus managers and design professionals in developing a standards-based approach to the deployment of a flexible and cost-effective telecommunication infrastructure.

In 1987, the CSU published the System-wide Cable Plan to establish a guideline for planning, installing, and maintaining telecommunications wire and cable in a uniform manner across its campuses. In 1993, the document was revised and expanded to include information on telecommunication support infrastructure and became the first version of the Telecommunications Infrastructure Planning (TIP) Standards. Since that time the TIP Standards have been updated, sample specifications prepared, and new funding and planning guidelines developed.

While previous TIP Standards were certainly successful at addressing portions of the telecommunications infrastructure issue, some provisions must almost continually be revised to encompass changes in technology and in CSU system strategies currently being implemented. These updates reflect the introduction of new methods for delivering network connectivity, new technologies, and the ever-changing academic needs. This edition of the TIP Standards is intended to continue the establishment of this document as a minimum Standard for CSU infrastructure designs. Additionally, this document is intended to reflect changes in the ITS (Information Transport Systems) industry that should at least be considered when implementing new technology infrastructure.

This version of the TIP Standards seeks to maintain the relevancy of the Standard by ensuring it is up to date with the latest national standards and CSU strategies.

1.2. Strategic Approach

1.2.1. The Integrated Technology Strategy

Learning in today's environment is based to a considerable degree upon access to various information resources. To meet faculty, student, and staff expectations, telecommunications infrastructure must support campus technologies at all levels and in a wide variety of formats. In response to this demand, the CSU developed the Integrated Technology Strategy (ITS) to outline the methods and goals for the development and distribution of technology within the framework of the CSU's mission. That mission is built on three basic goals:

- Provide quality programs.
- Provide access to an expanding number of learners; and

- Ensure affordability to those learners.

For a number of years, the CSU has been successfully implementing specific initiatives in support of the ITS. These initiatives require a strong, flexible, and cost-efficient infrastructure on which the technology can be constructed.

1.2.2. The CSU's Commitment to Technology Infrastructure:

CSU has a longstanding history of commitment to technology infrastructure. Between 2001 and 2007, the system invested nearly \$200 million to upgrade the physical infrastructure (cabling, pathways, spaces) at 23 campuses via an effort known as the Telecommunications Infrastructure Initiative (TII). Additionally, the CSU implemented new networking equipment on all campuses via a system-wide effort and continues to refresh the equipment via the CSU's Common Network Initiative (CNI). The scope of the CNI program originally covered the procurement and installation of routing and switching equipment and associated network management tools, training, and maintenance. Due to the evolving campus network technology needs, the program's scope now includes the implementation of wireless and network security equipment as well.

To provide a vehicle for system-wide technical consultation with campus personnel, the Network and Technology Alliance (NTA) was formed in 2001 as an advisory body to the Information Technology Services - Technology Infrastructure Services (ITS-TIS) section of the Chancellor's Office. The NTA's principal focus is the development and improvement of campus network infrastructure and services. NTA provides technical expertise and input in support of TIS staff activities and the activities of the Information Technology Advisory Council (ITAC), which is comprised of campus Chief Information Officers. The organization's contributions have been invaluable in pursuing network provisioning during the TII program and continues to address the technology areas defined for CNI.

CSU's investment in technology infrastructure so far has allowed technology to be made ubiquitously available to all users on each campus. Going forward, the technology infrastructure will also enable the sharing of services between campuses. The Telecommunications Infrastructure Planning Standards constitutes an important tool in achieving such goals, in as much as it continues to define the CSU's minimum standards for technology physical plant retrofitting and new construction.

1.3. Design Implications

Although architectural planning must be based on defined needs, the cumulative impact of changes in instructional technology and of the increasing use of information technology services must be viewed as a rapidly moving target. It is unreasonable to assume that anyone can predict, with absolute certainty, the specific systems that will be installed in a building three to four years in the future. However, by taking a long-term view of the structure and focusing on the provision of a comprehensive system of pathways and spaces for telecommunications technologies, the

facility planner can limit the number of modifications that must be made during or shortly after construction. Efforts to understand future improvements, expansions, master plans, and known deficiencies in the area of the project must be taken into account while deciding on the needs of the specific project being developed.

The following sub-sections review the evolving circumstances in several the spaces in the university environment that have been impacted by the expansion of information technology services. It is also recommended to evaluate the amount of publicly available power receptacles in all areas with heavy wireless coverage.

1.3.1. Classrooms

All classrooms must now be equipped with voice, data, and video services in a wide variety of configurations. Increased use of multimedia-generated displays requires new techniques for providing technical interconnection (power and signal) between the instructor's location and room displays and beyond. Significantly improved methods of lighting, acoustical treatment, and heating and cooling must be adopted to permit the successful integration of technology into the traditional classroom learning environment.

1.3.2. Laboratories

In addition to "standard" classroom technology services, many laboratory spaces now require communications to every student workstation. This is especially important in those spaces with built-in counters and free-standing laboratory benches. If adequate pathways are not provided for these components during initial construction, the addition of future information technology improvements could well prove prohibitively expensive. In particular, computer laboratories must obviously be designed to support the constant evolution of technology, equipment, and student stations.

1.3.3. Libraries

Library facilities play a central role in the use and application of electronic information and are now often referred to as "information centers." Extensive support for both technology users and equipment is required at all levels, including public electronic access areas, image and other multimedia access points, and group research and study areas. In addition, library buildings frequently act as centers for: instructional media production, television head-ends, and distribution services; centralized and distributed computing; specialized computing and/or training labs; and teleconferencing resources.

1.3.4. Common Areas

Common areas throughout the university (such as lobbies, student unions, large hallways, and registration areas) must now be equipped to provide expansive voice, data, and video services. Wall phones for internal use are important, and should be accessible; however, as

cellular phones and wireless data access become ever more pervasive, these devices should be considered on a case-by-case basis. The availability of wireless networking also impacts the necessity of open public wired data ports in common areas. It is strongly recommended that consideration be given to limiting these common areas to wireless network access only, with wired ports only for specific or special event purposes (i.e., kiosks or temporary workstations for events).

1.3.5. Conference Rooms

All conference rooms should now have the capability to be utilized as teleconference or videoconference facilities and should be connected to the campus network. The increased use of voice and data communications for a variety of meetings suggests that conference rooms must support all forms of communications from multiple sources. For rooms likely to be designated as specific teleconferencing locations, particular attention must be paid to lighting, sound, room design, and HVAC parameters in order to establish an environment suitable to effective use of technology.

1.3.6. Office Spaces

Office spaces must be designed to support multiple technology configurations, different possible furniture configurations, and provide multiple media and telecommunications outlets. Telecommunications outlets should be closely coordinated through the project to ensure the proper count of locations and that connections are adequate. The technology infrastructure concept must focus on workspace support rather than simply “how many jacks are located in each room?” If the basic infrastructure makes it costly or difficult for an office occupant to operate a new type of information device shortly after that infrastructure is installed, the design obviously did not reflect adequate planning for the use of technology. Additional consideration may be given to wired network connection necessity based on the end device management method deployed on campus. Some technologies require a wired connection for end devices re-imaging.

1.3.7. Building Automation Systems

Building Automation Systems (BAS) or Building Management Systems (BMS) is a generic overview term used to describe network devices that are used for different aspects of control and/or monitoring within a building, building complex, or campus. Some of these systems are stand-alone, and some integrate with other systems, and some span an entire campus.

Some examples of BAS/BMS are:

- Access Control Systems
- Emergency Notification Systems
- Energy Management Systems
- Environmental Systems

- Fire, Life and Safety Systems
- Lighting Control Systems
- Security Systems

The cabling for these IP-based systems should be designed as part of the entire network infrastructure system as they are essential network devices. At the same time, full consideration must be given to the functionality of the BAS/BMS as a whole. It is recommended that campuses utilize either ITS design professionals who are familiar with BAS/BMS or ensure that the ITS designer is working closely with the BAS/BMS engineer/s and that the cabling of these systems be handled as structured cabling where IP based communication is utilized.

1.3.8. A/V & Broadcast Integration

Just as the Building Automation Systems are becoming networked devices, so are many of the audio/visual systems that are integrated into classrooms, conference rooms, and other locations with digital signage. Though the technology is rapidly changing, most of the network integration at this point is for monitoring and control purposes. In any case, the ITS or technology designer(s) must keep in mind the potential need for multiple network connections to support the A/V needs of an individual conference room, classroom, or other location. These network connections may be at various locations within the room (ceiling for a projector, conference tabletop, instructor station or lectern). The ITS or technology designer(s) must again work in close conjunction with campus A/V personnel to establish these requirements.

Similarly, a growing number of devices used for broadcast origination and transmission are moving to the IP network. Whether for athletics or other special events, ITS plans must account for these needs and should be considered regardless of the size of the individual campus or the particular project.

1.4. Document Overview

The remainder of this document is divided into sections embracing related topics of interest to facilities planners and designers. The CSU expects that design consultants retained by the University will give careful cognizance to the requirements, guidelines and practices presented in those sections.

1.4.1. Section 2 Facilities Planning and Programming

Defines the types of technology and information system-related spaces and distribution services that are in use or must be planned for in CSU construction projects (new or retrofit). The focus of this section is on the information required by architects and space and facility planners.

1.4.2. Section 3 Infrastructure & Pathway Design

Identifies specific design and construction requirements that must be followed as the minimum acceptable level of CSU building infrastructure support. This section provides details on sizing of rooms and pathways, the electrical and mechanical services required, and other building construction (as opposed to technology-specific) materials and considerations.

1.4.3. Section 4 Media Systems Design

Outlines specific media (i.e., copper, fiber optic, and coaxial cable) configurations and hardware support systems requirements intended to satisfy the current and future distribution technology needs of the University.

1.4.4. Appendix A Standardized Telecom Symbols for Documentation

A listing of standardized telecom symbols for all documentation.

2.0 PART 2 – Facilities Planning and Programming

This section defines both general and specific standards to be employed in planning the types of technology and information systems-related infrastructure services that are required for CSU facilities construction projects (either new or remodel/ retrofit).

2.1. General Goals and Objectives

2.1.1. Introduction

Section 2 of these Standards is primarily intended to provide guidance for architects and facility planners in achieving compliance with CSU requirements in technology infrastructure development. The focus of the material presented is on space planning, general architectural and other design criteria, and the identification of individual components required in a telecommunications distribution system serving a university campus environment. Section 2 also includes a list of the commonly used industry standards and related reference materials that constitute supporting resources for this Standards document.

Section 2 should always be used by the design team in conjunction with Section 3, Infrastructure & Pathway Designs, to assure a comprehensive investigation of both space and pathway issues and specific electrical, mechanical, and construction requirements. Section 3 contains detailed information on the major infrastructure components, to provide sub-consultants and other design team members greater direction in the preparation of actual working design documents.

2.1.2. Team Formation and Role Determination

The ultimate success of a project planning and/or design team is likely to be determined in large part by the quality and extent of the disciplines represented, and by the team's ability to share information. From its initial formation, the need is obvious to assure that the team incorporates sufficient overall expertise to address the scope of work in a comprehensive manner, and that the requirement for fully delineating its management structure and functional relationships are well understood. Basic responsibilities must be defined early in the process, such as those for schedule management and issue resolution—along with the procedures for addressing them. Code compliance requirements and controlling references (such as the Campus Master Plan, TIP Standards, local best practices, and procedures, etc.) must be reviewed and placed in perspective. Other information sources must also be established: for example, who will provide information on projected power and HVAC loads to guide the efforts of engineering personnel assigned to the project? Many such matters should be covered in the RFP or other formal selection process leading to the team's formation, but good project management dictates that all be addressed at an early date. As

the planning and design activities then progress, the flow of information must continue throughout in a timely and accurate manner according to established procedures. BICSI, one of the leading telecommunications industry associations, provides training, testing, and certification in the design and installation of telecommunications distribution systems. It is required that a BICSI Registered Communications Distribution Designer (RCDD) is employed by the architect or design engineer to assist with the initial program and space planning and to prepare the detailed telecommunications infrastructure design.

2.1.3. Design Concepts

A major goal for telecommunications infrastructure design within the CSU is to plan today's facilities to meet tomorrow's requirements without the need for costly renovations. Almost every campus within the CSU has gone through one or more major retrofits of its existing buildings to provide updated telecommunications and network services. These updates usually include new media (cable or wireless transmission systems), pathways and spaces, and terminal resources (network electronics). One of the costliest parts of that process is the renovation of pathways and spaces within and between buildings that is often required before any new media can be installed.

Frequently, the principal reason for the high costs of renovations is that the designs for the original structures supported specific systems and applications and were not a response to an overall media or cabling plan. Under such circumstances, rooms, connection points, and pathways to user locations were probably designed to meet very specific needs, with little allowance for future growth or technology changes. In the contemporary telecommunications world, growth and change are constant occurrences, and provision for them must be an integral part of any facility design concept.

Flexibility is a primary characteristic that must be incorporated into the design of any CSU campus facility. Due to rapid technology changes, the typical design cycle of a capital project covers multiple generations of network systems. This circumstance results in an obvious inability to recognize and incorporate specific equipment models during the initial design process for a new building.

Telecommunications design for renovation and new construction projects must be founded on standards-based concepts and on a basic infrastructure plan that will support changes and upgrades over the life of the facility. It must not be restricted to a single technology or distribution scheme that may no longer be supported in a few short years.

In the last decade, standards have been developed that lead the designer to improved infrastructure solutions. The American National Standards Institute (ANSI), the Telecommunications Industry Association (TIA), and the Electronics Industry Association (EIA) are the major providers of published telecommunications-related standards.

2.2. Reference Standards

In addition to recognized state and local building codes, a variety of reference materials is available to assist architects and facility designers with telecommunications infrastructure planning and design. Where pertinent, it is expected that such sources will be given cognizance and employed in connection with CSU infrastructure improvements to supplement the standards presented in this document. Some of the primary sources are:

- **ANSI/TIA/EIA-526** (Optical Power Loss Measurements of Installed Fiber Cable Plant)
- **ANSI/TIA/EIA-568-C-2012** (Commercial Building Telecommunications Standard)
- **ANSI/TIA/EIA-569-C-2012** (Commercial Building Standards for Telecommunications Pathways and Spaces)
- **ANSI/TIA/EIA-598-C** (Optical Fiber Cable Color Coding)
- **ANSI/TIA/EIA-604** (Fiber Optic Connector Intermate ability (Standard))
- **ANSI/TIA/EIA-606-B-2012** (Administration Standard for the Telecommunications Infrastructure of Commercial Buildings)
- **ANSI/TIA/EIA-607-B-2013** (Grounding and Bonding Requirements for Telecommunications in Commercial Buildings)
- **ANSI/TIA/EIA-758-B-2012** (Customer-owned Outside Plant Telecommunications Cabling Standard)
- **ANSI/TIA/EIA-854** (Full Duplex Ethernet Specification for 1000Mbit/s (1000BASE-TX) Operating over Category 6 Balanced Twisted-Pair Cabling)
- **ANSI/TIA/EIA-862** (Building Automation Cabling Standard for Commercial Buildings)
- **ANSI C80.3** (Specification for Zinc-coated Electrical Metallic Tubing)
- **ANSI/UL 797** (Electrical Metallic Tubing)
- **ANSI/ICEA S-83-596** (Fiber Optic Premises Distribution Cable Technical Requirements)
- **ASTM E 814** (Methods of Fire Tests of Through-Penetration Fire Stops)
- **ASTM E 136** (Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C)
- **BICSI TDMM** (Telecommunications Distribution Methods Manual) 14th Edition
- **BICSI OSPDM** Customer-Owned Outside Plant Design Manual, 6th Edition.
- **CEC 2010** California Electrical Code (Title 24, Part3) – 2016
- Federal Communications Commission (FCC) Part 15.

- Federal Communications Commission (FCC) Part 68.
- IEEE's National Electrical Safety Code – 2016
- **IEEE 1100-1000** (Recommended Practice for Powering and Grounding Electronic Equipment)
- **NEMA VE1** (Cable Tray Systems)
- **NFPA 101** (Life Safety Code)
- **NFPA 258** (Standard Test Method for Measuring Smoke Generated by Solid Materials)
- **NFPA 70** (National Electrical Code – 2010)
- **NFPA 72** (National Fire Alarm & Signaling Code – 2010)
- **RUS Bulletin 1753F-201** (Specifications for Acceptance Tests and Measurements of Telephone Plant)
- **RUS TE&CM** (Rural Utility Services, Telecommunications Engineering & Construction Manual)
- **UL 497** (Electrical Grounding and Bonding Equipment)
- **UL 1479** (Fire Tests of Through-Penetration Firestops)

2.3. **Americans with Disabilities Act**

The Americans with Disabilities Act (ADA) prohibits all state and local governmental agencies from discriminating against persons with disabilities and from excluding participation in, or denying benefits of programs, services, or activities to, persons with disabilities. All work is to be compliant with the Americans with Disabilities Act of 1990 which as revised in 2010 includes the 2010 Standards for Accessible Design. These standards are accessible online at:
http://www.ada.gov/2010ADASTandards_index.htm

2.4. **Construction Specifications**

The Construction Specifications Institute (CSI) is an organization that maintains and advances the standardization of construction language as it pertains to building specifications. The CSI designed MasterFormat is an indexing system for organizing construction data, particularly construction specifications. For many years MasterFormat consisted of 16 Divisions of construction, such as Masonry, Electrical, Finishes, or Mechanical. As there was no section for communications, telecommunications specifications were included either in section 16 with electrical, or in an unofficial section 17. In November 2004, MasterFormat was expanded to 50 Divisions, and that revision is referred to as MasterFormat 2004. Through this revision of the MasterFormat, communications has been included as its own division, Division 27. There are also

related items of interest to telecommunications in other divisions, most notably Division 28, Electronic Safety and Security.

Listing of MasterFormat Numbers & Titles: <http://www.csinet.org/masterformat>

2.5. Standardized Telecom Symbols for Documentation

A listing of standardized telecom symbols for all documentation is listed in Appendix A.

2.6. Telecommunications Design Elements

The CSU has adopted the ANSI/TIA/EIA and BICSI terms for telecommunications infrastructure. The major elements of a telecommunications distribution design are pathways and spaces. Each of these elements consists of multiple components. This section gives guidance on some minimum design requirements for telecommunications rooms; for more construction focused details, see the appropriate elements of Section 3.

2.6.1. Service Entrance Facility (EF)

The service entrance facility is a room in which outside cable is terminated and interconnected with the backbone cable used throughout the building. It provides facilities and supporting hardware for large splice containers, cable termination mountings, and copper cable electrical protectors.

2.6.1.1. Access & Location

Typically, a service entrance facility is located on a lower level and within 50 feet of an outside wall, allowing direct access by the Inter-building (entrance) conduit. It should be situated to provide a direct pathway to the telecommunications room or backbone (riser) distribution spaces. Access to the room should be provided directly from a central hallway, not through another room.

If at all possible, service entrance facilities normally should not be located in or directly adjacent to the building's electrical service entrance, transformer room, or mechanical room. If exceptions seem necessary, a mitigating technology may be employed.

The service entrance facility shall be situated to reduce the potential for electromagnetic interference to 3.0 V/m throughout the frequency spectrum. These spaces must not be located near magnetic field sources such as power supply transformers, motors and generators, x-ray and MRI equipment, or radio transmitters.

2.6.1.2. Room Size

The minimum floor space requirement for stand-alone service entrance facilities are described in the table below.

In some cases, a single space may fulfill the function of both spaces for a smaller building. However, it must be emphasized that the size and environmental support requirements are additive. If the size of a building calls for a telecommunications room to also serve as a service entrance facility, the floor area must then be increased by an appropriate amount to allow for the additional equipment and maintenance space.

Building Gross Floor Space	Entrance Facility Floor Size
Under 5,000	4' x 5'
5,000 – 10,000	5' x 8'
10,000 – 30,000	8' x 8'
30,000 – 50,000	8' x 10'
50,000 – 75,000	8' x 12'
75,000 – 125,000	12' x 12'

2.6.1.3. Room Design & Function

If the room is used only as a service entrance facility, and not combined with a telecommunications room, then it should not house any network or telecom equipment. Service entrance facilities must be clear of other equipment, access points, storage, or other maintenance areas.

2.6.1.4. Environmental Conditions

If the room is used only as a service entrance facility, and not combined with a telecommunications room, then it requires no special air handling provisions.

2.6.1.5. Fire Suppression

Defer to California Building Code.

2.6.2. Telecommunications Room (TR)

Telecommunications rooms are the space or spaces on each floor of a building that are utilized to interconnect the building backbone (riser) system to station (horizontal) locations on a given floor. Telecommunications rooms also provide the space for housing network electronics.

The terms BDF, IDF & MDF define a room's position in the logical and physical structure of a building or a campus, more than the design of the room itself.

Minimum CSU design requirements for a telecommunications room are as follows:

	Description	Definition
MDF	Main Distribution Frame	A TR containing core elements of the voice, video and data networks.
BDF	Building Distribution Frame	The main TR in a building.
IDF	Intermediate Distribution Frame	Additional TRs that connect to the BDF.
SDF	Supplemental Distribution Frame	Small special purpose TRs that serve a specific application.

2.6.2.1. Access

Access to the room should be provided directly from a central hallway, not through another room and must have adequate access to allow for the installation of large equipment.

2.6.2.2. Location

As one of the primary focal points for all communication services, the telecommunications room must be considered a fixed location. These rooms must be located near the center of the area the room will serve, must be stacked one above the other in multi-story buildings, and must be sized to accommodate the university's needs. The telecommunications room must be designed as an integral part of the overall building. It cannot be "fit in" wherever there is room left over after all other spaces have been defined.

In a multi-story building, telecommunications rooms must be stacked and should be centrally located, minimizing the distance from the room to all user locations.

While telecommunications rooms must be located near the center of the building, they must also be no farther than 295 feet/90m (cable pathway distance) from the most distant user telecommunications outlet. A good rule of thumb is the planned average distance should be 150 feet or less.

An additional room is required if the 295-foot (90m) cable maximum distance is exceeded on a particular floor.

The room must be designed and situated to eliminate overhead obstructions (including false ceilings) and minimize any potential damage from items such as water or drainpipes, electrical interference, dust or other airborne contaminants, and physical hazards. It is preferable to avoid locations in basements or at other low levels where there exists any possibility of flooding.

To further limit the possibility of flooding, water or drainage pipes must not be placed directly over or near the telecommunications room. In addition, telecom room should not be placed where the possibility of humidity or steam are present. Cooling unit chilled

water supply and return lines must be deployed so as to avoid danger to the room contents. The surrounding floor area should be configured to drain accidental leaks before the telecommunications room becomes involved, a curb at the entrance or a floor drain should be installed in the room if the danger of water entrance cannot be overcome in any other way.

The telecommunications room must be located away from potential sources of electrical interference, such as electrical power supply transformers, motors, generators, or elevator equipment.

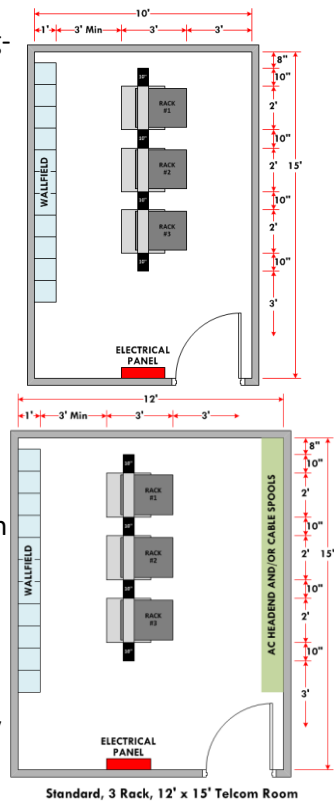
2.6.2.3. Room Size

The size of the telecommunications room is critical to the long-term support of technology within the facility. It must be adequately sized to support both existing and potential future services and applications. The minimum size for a telecommunications room is ten feet by twelve feet.

Physical location, campus requirements and/or specific use conditions may easily increase this requirement.

An additional room must be provided if the floor area to be served exceeds 10,000 square feet. If a multi-story building requires two or more rooms on every floor, each series of rooms should be stacked one above the other. Multiple telecom spaces on the same floor shall be interconnected with a min. 4" conduit or existing pathway.

- Additional sizing criteria are as follows:
- For buildings over 20,000 square feet, the minimum telecommunications space is .75 square foot for every 100 assignable square feet.
- Design situations that will increase the required size of the telecommunications room include the following:
- The building under design will act as an aggregation point for other campus buildings.
- The density of workstations within the building will exceed an average of one per every 100 assignable square feet.
- The telecommunications room will also serve as a service entrance facility.



Standard, 3 Rack, 12' x 15' Telecom Room

- To maximize the interior wall space, it should be considered whether to have the door swing out. If it does swing out, security implications should be considered.

2.6.2.4. Room Design & Function

Telecommunications rooms must be dedicated to the exclusive use of telecommunications equipment to provide a proper environment and adequate security. Telecommunications cannot share spaces within mechanical, janitorial or electrical rooms.

2.6.2.5. Environmental Conditions

The environment of these rooms must be equal to or better than a normal office (positive air flow/cooling, office-level lighting, sealed or tiled floor – no carpet). These rooms are intended to house terminal resources (network electronics) and must be equipped with adequate electrical service and cooling equipment to assure that equipment’s safety, dependability and functionality. Depending upon the room’s level of criticality in the campus network, the requirement may be 24-hour-a-day, seven- days-a-week support.

The air handling system for TRs must be designed to provide positive airflow and cooling even during times when the main building systems are shut down. This requires separate stand-alone cooling systems or separate temperature control zones. If the TR is served by an auxiliary power supply (generator), then the air handling system for this space should also be connected to the building’s backup power generation system.

2.6.2.6. Fire Suppression

If fire suppression is required, the methods and requirements are subject to California State Fire Marshal (CFM or SFM) review and approval. However, contingent upon such approval, the CSU’s strong preference is that a dry (pre-action or gas) fire suppression system be provided in telecommunications rooms along with installing wire cages to prevent accidental operation of sprinkler heads. Activation of the suppression system should be linked to the equipment’s serving electrical panel to disconnect power in the event of activation.

2.6.3. Pathway Element Definitions (Distribution System Elements)

Pathways include the Inter-building (between buildings) backbone distribution system, Intra-building backbone (riser) system, horizontal pathways, and telecommunications outlets (TO), as follows:

2.6.3.1. Inter-building Backbone Distribution System

The underground, aerial, and direct-buried pathways and support facilities used to distribute fiber and copper backbone cabling between buildings in a campus environment.

2.6.3.2. Intra-Building Backbone Distribution System (Riser)

The pathway or cable facility for interconnecting all telecommunications spaces within a building.

2.6.3.3. Horizontal Pathways (or Horizontal Distribution Systems)

The pathway systems that conceal, protect, support, and provide access to horizontal cabling on the floor serving telecommunications spaces and the telecommunications outlets.

Every building design must address each of these elements as both a stand-alone service and as an entire system. Problems occur when designs focus on only one or two of the components and do not consider how the entire distribution system will be utilized.

These distribution systems must be of a usable type, be properly installed, be routed to the best advantage of the cable (cable pathway must be readily accessible/unobstructed throughout its length), and be interconnected with the telecommunications rooms.

Building designs that require the cable installer to drill holes in walls and place sleeves through fire partitions after their construction should be avoided. While technology will certainly change between the time of the initial architectural planning and building occupancy, the pathways and spaces will be in place for the life of the building and must be capable of supporting multiple changes in technology without frequent modification.

The following sections outline the general design concepts for each type. For more in-depth information, refer to the appropriate subsection of Section 3 of this document.

2.6.4. Inter-building Distribution System

The Inter-building distribution system is composed of the conduit, utility vault, and/or tunnel systems that support the telecommunications media between buildings on campus. The design focus for the planner/designer of a new or remodeled CSU structure must include not only such matters as the distance from the new facility to the closest telecommunications utility vault, but also the condition of the overall distribution and feeder system back to the point of origin.

Although most design projects for new CSU campus buildings incorporate interconnection of telecommunications links from outside the building, the scope of the project rarely includes required renovation or expansion work on major Inter-building pathways impacted by the new facility. In some cases, a separate construction project may be required to provide adequate pathways up to the point at which the building project is to be interconnected.

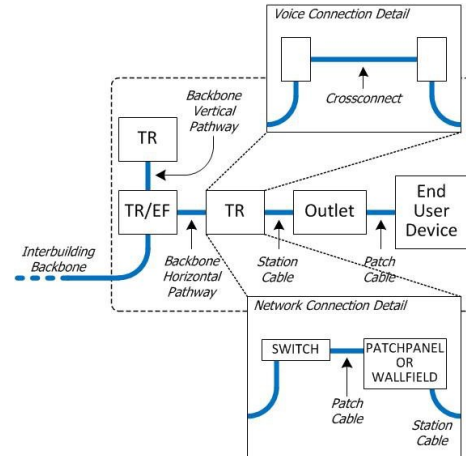
In the case of remodeling projects, it is vital to prepare a telecommunications transfer or cutover plan prior to the start of construction. Older buildings seldom have sufficient pathways to meet expanded needs. In addition, if the building is to remain occupied during construction, it may be necessary to install new telecommunications services prior to removal of the old. In those cases, additional pathways often are critical in meeting the ongoing needs of the university faculty, staff, and students for service during an active cutover (conversion). In general, the following points should be observed when developing plans for Inter- building distribution systems:

- Anywhere from four (4) to twelve (12) four-inch (minimum diameter), conduits are required to feed typical buildings, depending upon their size and functionality. (See Section 3 for details)
- The entrance conduits must be designed to allow the placement of various types of cables, including large copper, optical fiber, and coaxial cables.
- Telecommunications utility vaults(manholes) must be situated to allow the conduit to enter the building with no more than two (2) ninety-degree radius sweeps.
- The entrance conduits should enter the entrance facility space either directly from outside, perpendicular to the outer wall at a level above eight feet, or through the floor, parallel with the outer wall (keeping the conduit bend radius greater than forty-eight [48] inches) and sloped away from the structure to prevent water intrusion.
- Redundant paths are required into a building where the building will house a law enforcement facility, a campus datacenter, or serve as a fiber aggregation point.

2.6.5. Intra building Backbone Pathways

The term “backbone pathway” replaces the terms “riser” and “tie” conduit to reflect the need for both horizontal and vertical pathways in a building distribution system. In general, the building backbone is the path used for placement of telecommunications media between the service entrance facility and individual telecommunications rooms. These pathways must typically support copper, optical fiber, and coaxial cables connecting equipment and cross-connection hardware serving end-users located on each floor of the building.

- All backbone conduits and sleeves must be four (4) inches in diameter.
- Pathways must be designed with no more than two (2) ninety (90) degree bends, with a maximum distance between pull boxes of 100 feet.
- The minimum number of vertical backbone (riser) conduits is three (3). In addition, pathways for both telecommunications and power must be extended to the roofs of all buildings having the structural capability to support the installation and servicing of exterior equipment (e.g., wireless devices, television antennas, etc.). Section 3 of this document provides specific sizing requirements.
- A plenum-rated pathway is required between all telecommunications spaces within a building. Many of the large (shielded) copper cables used to distribute telecommunications within a building are not available with plenum-rated sheaths. This means an open cable tray cannot be used as the only horizontal backbone pathway, as most ceiling spaces are considered a plenum under the current California Electric Code (CEC).



2.6.6. Horizontal Pathways

The horizontal pathways between telecommunications rooms and telecommunications outlet locations receive the heaviest usage and are the source of the most complaints of any component of a telecommunications distribution system. Such pathways can be addressed in a number of alternative ways, but inadequate solutions are frequently adopted in efforts to meet budget restrictions. When working in this realm, the designer should identify specific methods for placing and supporting the initial cable, while at the same time providing the flexibility required to meet future changes in technology.

Almost no facility design concept exists that will permit the use of a single telecommunications distribution method throughout an entire structure. Structure-based systems, such as cell floors, raised floors, and trench and duct systems, all have limitations as well as advantages. Alternative systems, such as cable trays, zone or direct-run conduits, and floor monuments, must be analyzed for specific space requirements; it cannot simply be assumed that space will be available somewhere within the building structure to support adequate pathway installation.

The telecommunications designer must coordinate with all members of the design team to define specific pathway configurations that are founded on an understanding of the long-

term use of the facility, and which afford the flexibility for system modification over time. Section 3 of this document provides greater detail on the major alternatives for pathways. Unfortunately, there is no one correct approach to meeting the design requirements of horizontal pathway systems. There are some definite wrong answers, however, and the best approach is a review of the distribution needs coupled with a careful inspection of any limitations.

Important design considerations include:

- The preferred horizontal distribution method for new buildings and in most renovation projects is a cable tray used in conjunction with plenum cable in the false ceiling.
- Every telecommunications room must provide a minimum of twice the amount of horizontal pathway access as is required to support the initial installation.
- Any outlet separated from the main horizontal support system (such as a cable tray) by a fire or smoke partition must have a rated pathway, such as a sleeve that can be fire-stopped after cable is installed or an enclosed conduit or raceway directly from the outlet to the tray side of the partition. Refer to Section F, page 46 for Fire stopping recommended methods.
- Every room must be provided a specific pathway from the false ceiling area (used to access user jack locations) to the main horizontal distribution pathway (such as the cable tray).
- All station conduits, except as otherwise specified, must be at least 1.25" diameter
- All station conduits are to have no more than 180 degrees of bend before the placement of a pull box.
- Unless specifically allowed by a campus, on a case-by-case basis, non-continuous support (J-Hooks, bridle rings, and saddles) are not allowed in new construction, and open ceiling environments.

2.7. Specific Campus Facilities Support Requirements

In addition to telecommunications space and pathway issues, a variety of university environment-specific issues must be factored into the design of a new facility. Significant changes taking place in how education is being delivered are very frequently reflected by fundamental changes in information system-related infrastructure requirements.

This subsection provides an overview of the minimum telecommunications infrastructure requirements in specific areas of new construction and substantive remodel projects. They are intended by the CSU to be used during program planning if more specific local requirements are not identified.

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2.7.1. Offices

Office spaces range from the standard one-person space to multi-room office suites, and all need to be suitably equipped to afford access to various campus telecommunications resources. All offices must be designed to meet the need of the space to include multiple voice, data, and video outlets situated to allow changes in furniture layouts. Other specific design considerations include:

- All offices must be equipped with a minimum of two telecommunications outlet locations (each with a minimum of three cables) preferably on opposite walls and near electrical outlets.
- Larger offices and open suite areas should have multiple technology telecommunications outlets (each with a minimum of three cables, minimum of one cable) at every-other electrical outlet.
- If modular cubicle furniture layouts conflict with telecommunications outlet locations, the modular cubicle furniture shall have an access panel installed to allow continual access to the telecommunications outlet. It is required that at least three (3) network terminals are available at each workstation cubicle.

2.7.2. Conference Rooms

Conference rooms smaller than 12' by 12' should be equipped in a similar fashion to a standard office with a telecommunications outlet on each wall and, at a minimum, two video outlets on opposite walls. Larger conference rooms should be equipped as follows:

- Rooms longer than twelve (12) feet should be equipped with one or more floor outlet boxes that provide power and two 1 ¼" signal pathways. (One signal pathway is for connection to the building network, and the other is for room control equipment.)
- Separate lighting controls should be provided upon the entry to the room and at the front of the room (presentation area) to provide presenter with task lighting control and a switch-activated AC power outlet
- Signal and power needs and distribution methods must be coordinated with the selected furniture layout.

- Audio Visual applications need to be considered as they will share some infrastructure with the data network. Most current A/V devices are connected to the network at least for monitoring.

2.7.3. Instructional Areas

2.7.3.1. General Requirements

This Standards document is not intended to be a classroom design guide, nor does it purport to limit the application of technology within the educational setting. The material presented is a set of general standards and guidelines and is meant to be a starting point for the design professional in the definition of technology requirements.

Trends within education are being impacted not only by technology but also by a different perspective on how people learn and share knowledge. Many faculty members are moving away from the traditional lecture mode of instruction. There is a trend to more interaction between faculty and students, between students, and with technology.

New approaches in teaching and learning will impact the size, shape, and use of classroom space across the university. The challenge to the building designer is to meet current requirements and budgets while still providing flexibility for change. The challenge for the designer of technology systems is in determining specific requirements and defining sufficient flexibility to meet emerging instructional trends.

Several issues related to the increased use and reliance upon technology in the instructional setting must be addressed in the planning process.

- Additional space is required to support even a limited number of workstations and/or multimedia display equipment. This equipment may also require secure storage facilities or simply additional floor space.
- Additional information telecommunications outlets and electrical service must be provided to meet the requirements presented by instructor and student equipment.
- Air handling systems must be modified to address the increased cooling load and to reduce the level of sound associated with air movement.
- Lighting and lighting controls must be modified to meet the needs of display systems, task lighting, and group work efforts. (Address hanging lights and zone lighting.)
- Each classroom must have the basic infrastructure to support instructor-controlled display and computing equipment, even if the systems will not initially be installed.

- Acoustical treatment of walls, ceiling, and floors is required to improve the student's ability to make use of display systems and allow for the origination of communications from any classroom.
- Assisted listening devices (where they are required) must be interconnected with all display systems and must be configured to allow for interconnection to changing technology.
- It is recommended that consideration be made as to whether built-in seating should be designed to provide pathways for both power and telecommunications to every seat, even if those services will not be initially installed.
- Instructor positions must have multiple pathways to link to lighting controls, multimedia control equipment, power, and network access. The layout of these pathways must be flexible enough to support changes in room configuration and technology.
- A central control panel location must be provided in each classroom linking the instructor's position(s) with expected display and computing systems. This can be a control room, wall panel, ceiling-mounted box, or freestanding equipment cabinet.
- Classrooms must be designed to support both the instructor and the student in their efforts to use technology and to learn. Some general guidelines for classroom design related to display systems or imaging systems are as follows:
 - The size of the display screen(s) must allow students at all locations within the room to obtain an unobstructed view. Without other specific requirements, the viewing distance should be between two and eight times the height of the image.
 - The location of seating in front of the screen should enable the student to remain at a workstation and still view the display. This means the end seats of the front rows should be at an angle of 35 degrees or less in relation to the centerline of the room and screen.
 - It may be necessary to install additional viewing screens or monitors to augment the central screen if viewing distance or angles cannot be met.
 - Room lighting must be configured and controllable to eliminate reflection and glare from and on display systems while still providing sufficient light for student work.

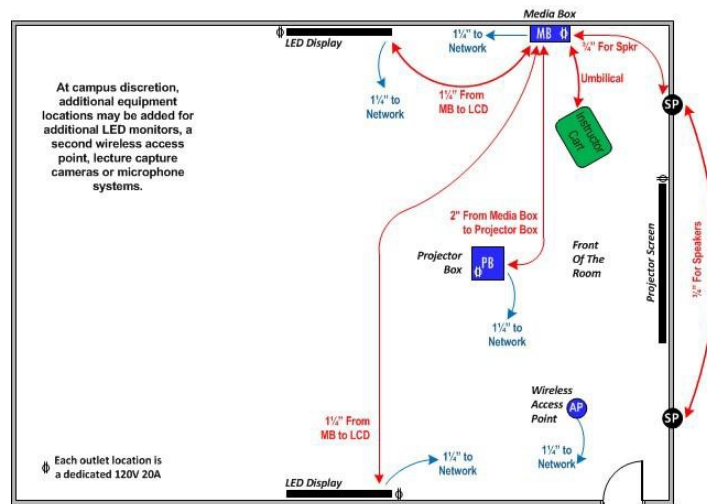
- An telecommunications outlet specifically placed and designated for a wireless access point should be placed in every classroom.

2.7.3.2. Small Classrooms (Less than 50 students)

The following types of media and computer equipment are typically scheduled for use in smaller classrooms with a seating capacity fewer than 50 stations:

- Video monitor/receiver(s) or video projector
- Television monitor/HDTV monitor
- Teleconferencing equipment
- Video camera presenter
- Assistive listening devices/microphone & amplifier
- Personal computer
- Motorized screen
- TV mount(s), stand(s) or cabinets

It is conceivable, if not probable, that an instructor will "cue up" all media resources before commencing a lecture -- e.g., turn on the TV monitor/receivers and/or video projector, power up and load the PC, and place the equipment in "hot standby."



Example of a Small Classroom Telecommunications Infrastructure Layout

Each instructor's "home base desk" workstation location must contain multiple outlets providing power, signal/control, and communications. From these positions, the instructor must be able to obtain, review, display, and distribute information of any form. This extensive array of technology must be adequately supported with the room

infrastructure. Telecommunications outlet locations must be identified at fixed intervals around the wall (minimum of one per wall), pathways must be provided for linking the instructor's location with the display and lighting system, and video outlets located in such a manner as to provide optimum viewing for the instructor and students alike.

2.7.3.3. Large Spaces and Lecture Halls (Greater than 50 Stations)

The following types of media and computer equipment are typically scheduled for spaces and lecture halls with seating capacity of 50 or more stations.

The standard hardware listed above for smaller classrooms, but with improved quality of certain equipment and/or facilities (e.g., TV monitor/receivers; two or more screens; and voice, data, and video connectivity). Enhanced hardware and/or facilities:

- Two video/data projectors
- Back wall, overhead and/or demonstration table video cameras
- Public address sound system
- Video and audio services to include front, side, and ceiling speakers, record/playback services
- Student response system
- Wired or wireless remote-control services
- Personal computer workstations
- Voice, data, and video connectivity
- At least one telecommunications outlet per fifty stations for deployment of wireless access points

Larger spaces and lecture halls utilizing extensive media equipment will require increases in the electrical and communications infrastructure design above that required for the smaller spaces. In addition, selected facilities will have additional requirements for control room spaces and supporting infrastructure in order to make the best use of the media. Such large spaces and lecture spaces may also require support for student workstation locations involving conditioned power and telecommunications outlets at each student's workspace.

2.7.3.4. Laboratories

Laboratories must be equipped to handle the same telecommunications and media presentation services as those defined for small classrooms. In addition, many laboratory locations will require student workstation facilities either built into the top of counter space or located at multiple locations along outer walls, or possibly both. Many of the

functions performed in various laboratories today require network links to measure or monitor experiments and/or record results.

Some lab spaces will utilize their own computer-based systems, and adequate space near the lab must be provided to house this equipment and terminate any locally-distributed cables. In addition, staff and control rooms, which generally surround a laboratory space, must be fully equipped with telecommunications outlets in a manner similar to faculty offices.

2.7.3.5. High Technology Facilities

Within the CSU planning process, the definition of a “high technology” (high tech) space is a room with a heavy concentration of workstations in which both the student and the instructor utilize computing equipment on a regular basis. This can range from a few high-end computing platforms used for specific applications, to a general use computing lab, or to a lecture hall with facilities for student access to power and network services.

High technology spaces must be designed and configured to support the on-going modification of technology and network connection within rooms and between similarly equipped rooms. If built-in furniture is used, it must support extensive power and telecommunications cabling. If freestanding tables are used, a specific pathway design must be prepared for each room including one or more of the following:

- A floor duct and trench system, separate from (but connected to) any pathway required for other services on the same floor, running the length of the room every five to seven feet apart.
- A wall-mounted raceway system at above tabletop height on all walls.
- A raised floor system with several pathways to the accessible ceiling space.

High technology facilities will require a significant amount of network, computing, and/or display hardware that must be secured and connected to equipment within the room.

Depending on the planned use of the space, cabling for a specific purpose beyond general networking (networking lab, etc.) can either homerun to the closest telecommunications room, or terminate in a local, appropriately secure cabinet. This arrangement will not provide the same level of physical security that can be provided by the typical arrangement but may meet the specific needs of the campus staff.

A recommended method of providing flexibility for ongoing changes in the room layout and modifications to the technology deployed is to install a cable distribution floor similar to a raised floor. Several manufacturers offer false floors with less than three

inches of rise, reducing the impact of seismic concerns and access/egress ramp problems in complying with the American with Disabilities Act (ADA).

These floors are generally not suited for use in a computer room environment due to the limited capacity for below grade cable and/or cooling pathways. Fortunately, high tech rooms usually need only a few inches of clearance, and if the system is well planned, it can support changes over many years.

Another method may be installation of zone cabling architecture, providing maximum flexibility for changes in furniture layout. A zone cabling design consists of horizontal cables run from the telecommunications room (TR) to an intermediate consolidation point (CP) that is typically housed in a zone enclosure located in the ceiling space, on the wall, or below an access floor. From the zone enclosure, shorter easy-to-manage links connect directly to devices or to outlets serving voice, data or other systems.

Zone cabling enables rapid reorganization and faster, less disruptive moves, adds and changes because changes are limited to the shorter cabling link between the zone enclosure and the device instead of the entire length of horizontal cabling. This highly flexible infrastructure is ideally suited for intelligent buildings and the convergence of devices such as LED lights, security cameras, wireless access points or building automation controllers over one unified network.

2.7.3.6. Residence Halls

Planning for residence hall communication services must be undertaken with the realization that expectations now go well beyond a telephone in each room. Additional space must be provided in each building to terminate cable and house communications components, and design consideration should be given to the infrastructure to support services such as voice, data, and video systems. Rather than "common" outlets shared by all users in a given room, every residence hall student should have his/her own voice, data, and video telecommunications outlet.

Careful consideration should be given to designing the residence hall infrastructure to allow for on-going installation of new services (i.e., emergency phones, elevator phones, security cameras, burglar alarms and door control systems that may not be needed or installed at initial build-out. These new services may require multiple outlets per housing unit based upon the number of students and/or potential work areas.

2.7.3.7. Residential Spaces

Planning for Residential Space ITS (Information Transportation Systems) services must be approached with a different eye than previously used. As many campuses continue to see a decline in POTS (Plain Old Telephone Service) usage, individual residents are expecting to use multiple wireless and multiple wired network devices each, the ITS

infrastructure needs to reflect this usage pattern. Considerations such as multiple data connection points per resident, including pervasive wireless coverage AND throughput, as well as the impact on Telecom Spaces, must be addressed.

Additionally, networked BAS systems are finding wider implementation within residential spaces and must be considered and planned for. Individual Campuses must consider if the residential spaces will be designed in a more “commercial” fashion, thus falling under the TIA/EIA-568 series of standards, or in a more residential fashion adhering to TIA/EIA-570 standards, or some combination of both. As residential buildings are constructed in a more permanent manner, the ITS design should consider and design for the maximum potential use of the space instead of designing to “grow into” a space as future upgrades will be more costly than in commercial spaces.

Other technologies should be considered as a potential cost savings method of service provision. However, each technology has its own advantages and disadvantages when compared to the traditional enterprise network model and should be weighed to what suits the campus best.

2.7.3.8. Public Spaces

The term “public space” refers to various areas within a campus environment where faculty, staff, and students may wait for services, stop to gather, or even pause to be alone. This includes such spaces as those outside offices, walkway or open entry areas, common meeting areas, or group study areas. In keeping with the concept of improved access to information throughout the educational experience, public spaces need to be equipped with the necessary infrastructure for full wireless network coverage, and the support for future display monitors and interactive information kiosks.

2.8. Specific Campus System Support Requirements

There are several specific systems that are implemented campus wide, which have their own unique infrastructure requirements. Systems such as wireless networking, network elements of physical security systems, emergency alert and safety camera systems, and control networks for various building networks will each provide their own set of implementation challenges.

It should be assumed that all systems that involve any level of remote control or programming will have the capability to be controlled over the network. To facilitate this control, network infrastructure should be placed convenient to any locations that are planned to house system control elements.

These systems, including but not limited to, the systems described below may be considered “specialty systems” and outlined in the Construction Specifications outside the scope of Division 27. Many of these systems will be supported by campus IT personnel for the life of the system long after initial installation. As such, these systems shall be installed as Structured Cabling

Systems and adhere to the CSU TIP standards. All installed systems shall be qualified by the campus Telecommunications infrastructure designee prior to commissioning.

2.8.1. Wireless Networking Systems

All new construction and substantive remodel work are to contain infrastructure for wireless networking. Each wireless access point installation location is required to have two CAT 6A connections terminated on modular jacks in an appropriate telecom outlet extending to the nearest telecommunications room that has network infrastructure. Future wireless network standards may require the equivalent of a wireless access point per covered room. For more specific information on the placement of indoor and outdoor wireless networking devices, refer to the CSU Route-Switch Network Baseline, Standard Design – Wireless Addendum.

2.8.2. Physical Security Infrastructure

2.8.2.1. Emergency Notification / Mass Notification Systems

Outlet locations for these systems are essentially the same as a standard telecommunications outlet, except that they are placed at an appropriate height as determined by the location and specific use. Typically, these outlets should be placed in areas such as lobbies or building entrances, and typically at 84" above the floor. Further coordination with local campus representative will be required as cable quantities/requirements may differ from campus to campus.

2.8.2.2. Fire & Life Safety Systems

Fire Alarm Control Panels (FACP) should have a dedicated 1¼" conduit placed directly from the panel to the nearest telecom room for media connection, media type shall be coordinated with campus representative. Three wired network jacks are also to be placed at the panel, with their cabling routed through the normal distribution system. Other significant control elements of Fire & Life Safety systems such as Fire Pump Controllers should also be provided an infrastructure for wired-network jacks.

2.8.2.3. Alarm System Control Panels, Card Access System Panels

Outlet locations for these systems are essentially the same as a standard telecommunications outlet, except that they are placed immediately adjacent to the supported panel. Three wired network jacks are also to be placed at each panel, with their cabling routed through the normal distribution system.

2.8.2.4. Safety Camera Network

Safety camera outlet locations are essentially the same as a standard telecommunications outlet, except that they are placed at an appropriate height as determined by the location and specific use.

Although the above is considered a CSU standard, each campus may differ on the cabling infrastructure requirements. =

2.8.3. Facilities Device Infrastructure

It is recommended that all systems that involve any level of remote control or programming will have the capability to be controlled over the network. The list below contains a number of systems that can be described as “Building Control/Automation Systems”, and network infrastructure or a cabling pathway should be run to them if warranted.

Examples include the following but are not limited to:

- Card Access/FOB’s
- Sprinkler Controllers
- Water Pumps & Valves
- Lighting Controllers
- HVAC Controllers
- HVAC Devices
- Elevator Controls
- Refrigeration Monitors
- Barrier Entry Gates
- Key Checkout Boxes
- Solar System Controllers
- Electrical Monitoring Systems
- EV Charging Controllers
- Generator Control Panels
- IP Clock Systems
- Digital Signage
- Door Hold Open Devices

2.9. Summary of Key Design Considerations and Requirements

There is no such thing as a "perfect" telecommunications distribution design. Building planners, however, can provide a robust and flexible design, while minimizing future cost impact, by keeping four things in mind:

- Telecommunications pathways and spaces are to be designed for the life of the building, not for a specific system or technology.
- Adding additional capabilities to a newly constructed building to provide additional services is expensive and time consuming. A few additional feet of conduit initially designed into a new building will involve minimal cost. During or after construction, that same conduit could cost several times as much.

- The telecommunications infrastructure should accommodate and reflect the university's probable need to embrace a significant number of new (and as yet undefined) technologies and services subsequent to construction of the building. Changes in technology do not stop when the construction of the building is complete, and the design must take that into consideration.
- Telecommunications infrastructure is of no less importance to the operation of a building than other systems like electrical, plumbing or HVAC.

3.0 PART 3 – Infrastructure and Pathway Design

This section of the TIP Standards identifies specific design and construction requirements that must be met as the minimum acceptable level of building infrastructure support.

3.1. General Considerations

3.1.1. Introduction

This section provides detailed information regarding the design of the telecommunications pathways and spaces in new construction and facility remodel projects. The CSU expects that it will be used by architects and their sub-consultants during the detailed design phase of a project in the preparation of specifications and working drawings and by campus telecommunications and facility planning staff as a checklist for construction design projects. Section 3 outlines various sizing and selection criteria, provides sample designs and "typical" configurations, documents various construction-related specifications, and highlights recommendations for improving the methods used to address telecommunications issues.

3.1.2. Reference Sources

Refer to Section 2 for Reference Sources and Relevant Standards.

3.1.3. Documentation Standards

As the need for greater detail in plans and specifications has become apparent during more recent construction and implementation of new facilities and systems, each design firm has developed its own criteria for developing and documenting telecommunications infrastructure. However, as a public agency committed to the public works approach in project contracting, the CSU expects a high level of detail in its plans and specifications. This subsection provides some direction to be used in conjunction with the Project Management documents, and the designer's professional services contract scope of work in preparing formal design documents.

Construction documents for all CSU capital projects involving telecommunications infrastructure are expected to provide at least the following information:

- Statement of Work for each building – A brief overview (2 to 3 paragraphs) of the scope of work for each building, the planned method of transition to the new media, and any restrictions or limitations for working within the building.
- Statement of work for the inter-building pathways and media – A brief synopsis of the scope of work, by pathway, with an indication of any unique or particularly difficult building entrance sites. Unique restrictions or limitations of particular routes or building entrance points should be included.

- Building floor plans – The floor plans should reflect the location of telecommunication spaces, all backbone pathways, and any unique construction requirements. The end result is that the bidder must be aware of the designer’s expectations for all pathways, and there should be no question of how cables should be placed to any outlet location. Required telecommunications outlets must be identified, by type and location, prior to the start of construction.
- Building construction and system plans – Details regarding architectural, electrical, mechanical, or plumbing work must be documented as with any capital project. Such details should be separate from the telecommunications design unless the work to be undertaken is very minor and will not cause confusion to bidders. The CSU expects that telecommunications designers will fully coordinate their efforts with designers from other disciplines in pursuing any particular project and that all designers will recognize the requirements of adopted campus master plan documents.
- Inter-building media and pathway details – All inter-building media must be documented following BICSI, EIA, and RUS methods and standards. If splices are required to relocate specific pairs, either that work should be documented in sufficient detail to allow a splicer to start work or the scope of work must outline the need for the Contractor to identify, test, and document existing cables prior to undertaking any splicing. Details or typical drawings should be provided defining how conduits are to enter a vault, how cable is to be placed and racked, and how duct space is to be utilized.
- Construction Standards Institute (CSI) format specifications – Depending on the level of local adoption of the CSI Master Format conversion from 16 to 50 divisions, CSU specifications may be prepared in either format. Designers are however strongly encouraged to consider the newer version. Construction work such as building a wall or painting a room should be specified under individual sections, not as part of a telecommunications specification section.

3.1.4. New Construction vs. Retrofit

Planning and implementing an up-to-date telecommunications infrastructure has become a relatively straightforward task in new construction. Retrofit projects, however, are not as simple to address. It can sometimes be difficult to identify and/or obtain the funds needed for telecommunications infrastructure improvements in existing buildings because of unforeseen conditions that can inhibit the placement of the required infrastructure. This TIP Standards document provides a series of recommendations for telecommunications infrastructure, pathways, spaces, and media. While the standards are more easily implemented in new construction, much can be done within existing facilities to provide a similar level of support for technology. It will usually be more costly per square foot to provide an updated infrastructure in an existing facility than to install similar support in new construction.

The major areas of design impacted in a retrofit situation are the pathways and spaces within existing facilities. In addition to a detailed understanding of the existing conditions, the designer must be aware of the limitations imposed by older electrical and HVAC systems, outdated ceiling systems, existing wiring methods, and hazardous materials. The CSU expects design professionals to completely evaluate all such circumstances, including detailed field investigation of all spaces where doubts exist.

The most frequent and challenging consideration in retrofit design, however, is often the requirement to continue telecommunications service while a new system is being installed. With only a few exceptions, university buildings are occupied almost year-round. There is seldom a time when a building is truly empty, unless a full-scale renovation is being conducted.

Questions the designer must answer in programming a retrofit project to include the following:

- What is the real scope of work when taking into consideration the daily operation of the facility? Are there limits on noise, dust, movement of equipment or furniture, specialized systems?
- How will the current systems be kept running if new media is to be installed in existing pathways?
- How will a transition be made from old media to new, assuming a re-use of pathways and equipment? Which group (Contractor or University) will be responsible for making the transition, testing and troubleshooting, and documentation?
- Will the work have to be undertaken at night? If so, how will it be managed and tracked? How will the university address the security and general disruption concerns of faculty, students, and staff?
- If existing spaces are not adequate, where will space be found and how will it be assigned and coded?
- Will the work undertaken within the facility necessitate review in terms of Americans with Disabilities Act (ADA) requirements?
- Will the work undertaken within the facility necessitate review in terms of current fire code compliance, hazardous materials management, etc.?
- Will the required changes fit within the university's mandated master plan requirements and architectural guidelines? Who will make decisions on aesthetics?
- If additional electrical or air handling services are required to support the telecommunication improvements, should such additions factor in the impact of all forms of technology throughout the building?

3.2. Telecommunication Space Design

The minimum configuration for spaces within a standard CSU academic or administrative facility should include one or more telecommunications rooms and a service entrance facility (or space added to a TR for it to also serve as a service entrance facility).

In many existing buildings, telecommunications equipment is found forced into spaces not suitable to house sensitive electronic components. These poor environments cause equipment failures, limit the ability of users to obtain the services they need, and can be a hazard to the people who must maintain the equipment.

3.2.1. Room Construction

- The walls must be covered with void-free 3/4-inch AC plywood, sanded smooth and painted with at least two coats of fire-retardant paint (fire-retardant plywood may be required by local fire codes) mounted vertically starting a minimum of 6" above the finished floor to a height of 8ft, and secured to the walls. All plywood panels must be mounted in contact with one another, leaving no gaps between sheets. All fasteners must be flush with the surface of the plywood. The room must be open from floor to true ceiling. No drop tile or false ceiling should be installed.
- A floor loading of 150 lbs. per square foot (distributed loading) must be the minimum structural design standard for this space.
- The floor must be sealed concrete or must be tiled with anti-static tile to reduce airborne contaminants.
- If raised flooring is used, it must be cross-braced, and drilled anchors must be utilized to fix the pedestals to the structure's floor. This is required in order to permit the installation of equipment cabinets and racks up to eight feet tall while limiting the potential for damage during a seismic event. The raised floor must also be designed to support a minimum load of 150 lbs. per square foot.

3.2.2. Lighting

- Sufficient overhead lights must be installed to provide a minimum of 540 lux (50 foot candles) of illumination measured 3 feet above the finished floor or lowest termination point. These lights must be separately switched (within the room) and must be mounted a minimum of 8.5 feet above the finished floor unless cable racks or trays are used. If that scenario occurs, lighting should be placed underneath the trays or at rack height.
- Fluorescent light fixtures should be installed parallel to the network equipment racks and never directly above equipment racks which obscures the available light.

3.2.3. Doors & Access Control

- The door to the room must be a minimum of 36" wide by 80" high and must be equipped with a separate lock.
- Consideration should be given to utilizing double doors opening out on larger-sized rooms.
- The room should also be pre-wired for card key control and/or intrusion alarm (even if not installed day one).

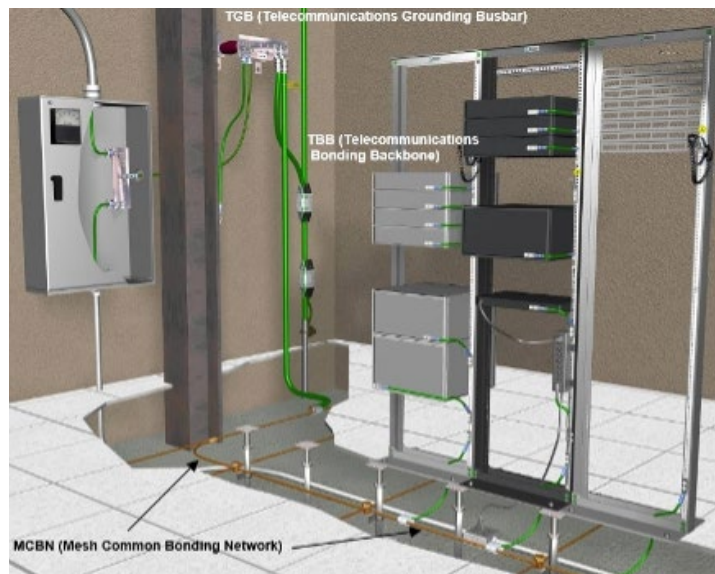
3.2.4. Electrical Requirements

The need for additional electrical service to support telecommunications systems requires a substantial analysis of the capabilities of existing facilities, structures, and feeder systems. In addition to the increased load for network (telecommunications) related equipment, the dramatic increase in end-user equipment imposes a significant requirement for greater capacity in both new construction and remodel projects.

3.2.4.1. Grounding

For safety reasons, low-voltage systems—such as electrical services and/or telecommunications equipment—are required to be bonded to ground per national and local electrical codes and industry standards. At the same time, grounding screened or shielded cabling systems affects performance. In a telecommunications room, typically a grounding infrastructure. The last sentence here is a fragment—an incomplete thought. Needs to be finished or deleted. The sentence before while not a fragment seems to be orphaned in thought from the opening sentence.) (Also wondering if this section would be better below in section G that discusses in greater detail the “Telecommunications Grounding System”?)

According to TIA-607-B, Each data center (computer room or equipment room) will have a MESH-bonding network (MESH-BN). The MESH-BN is a conductor grid that covers the entire computer room or equipment room space. The ideal spacing for the grid is between 2 and 4 feet. The computer or equipment room will include a TMGB or a TGB to bond the TBB to the computer room or equipment room MESH-BN. Local area network (LAN)



equipment, such as switches and routers, should be grounded and bonded per the manufacturer's installation instructions. If the rack that holds the LAN equipment is properly grounded to the TGB, the LAN equipment can be bonded to the rack. RGBs are recommended for cabinets and racks that need to support multiple equipment bonding conductors. (Previous sentence: RGSs haven't been mentioned yet in this section, so the acronym should be expanded in parenthesis.) Each telecom grounding and bonding conductor must be labeled.

3.2.4.2. Future proofing

Of particular concern in the electrical design of telecommunications rooms are the changing electrical power requirements as new and different devices are added to the network. In anticipation of these changing requirements, campus planners and design consultants must also consider power provisions for the following:

- Network management equipment, security devices, VoIP and Video equipment
- Requirements driven by network convergence (VoIP and Video)
- Additional UPS runtime and associated requirements created by the E911 issue related to VoIP deployment
- Changing power requirements of Wireless AP deployment.
- Other Security, CCTV & BAS devices requiring additional PoE.

3.2.4.3. General Requirements

Conduits for the electrical outlets and any other electrical service must be contained within the wall structure or routed at ceiling or floor level. Electrical conduit should not be placed where it might have to be crossed by a communications cable or where it disrupts backboard utilization.

Convenience outlets should be located close to equipment for support staff use with power diagnostic equipment or laptops. These outlets should be placed 18" (or matching campus height standards) above the finished floor, at six-foot intervals around the perimeter walls. A maximum of four of the auxiliary outlets may occupy a single branch circuit.

3.2.4.4. Specific Electrical Requirements for Service Entrance Facilities

If the service entrance facility is stand-alone, a separate electrical panel is not required. There must be a minimum of two 20 Amp, 110 volt ac duplex electrical outlets, each on separate circuits, installed in the service entrance facility.

3.2.4.5. Specific Electrical Requirements for Telecommunications Rooms

A separate dedicated electrical service panel, sized to support a minimum of 100 amps, should be installed in each telecommunications room. A dedicated circuit for primary equipment power should also be provided, the specifics of which are determined by campus standards. Exact location to be coordinated with designated telecommunications representatives.

All circuits installed in support of a telecommunications space should be dedicated to that space and not shared with auxiliary services. A prime goal of the dedicated electrical service design is to reduce or eliminate power-related problems to the sensitive network equipment, while providing adequate power for current and future applications.

Consideration should be given to whether serving electrical panels should be equipped with power suppression shunts to protect equipment from overloads.

Additional electrical needs exist for equipment specific to each campus. Some PBX systems use 48 volts DC to power the equipment, and the telecommunications room must be configured to support directly connected power to rectifiers, backup systems, or local power supplies frequently needing multiple 30 amp 208 volt circuits.

3.2.5. UPS Requirements

It is common to utilize UPS units of various types to provide a temporary source of power to communication equipment in the event of a commercial power failure. Small UPS units may power individual computers or department servers and are designed to last long enough to provide a controlled shutdown or continued service through a minor outage.

At a minimum, the telecommunications infrastructure design must include the following:

- All telecommunications rooms must be equipped with at least a thirty-minute battery backup system (UPS) capable of supporting three times planned capacity.
- All UPS units must be equipped and configured with network- based monitoring.

3.2.6. Telecommunications Grounding System

3.2.6.1. General Requirements

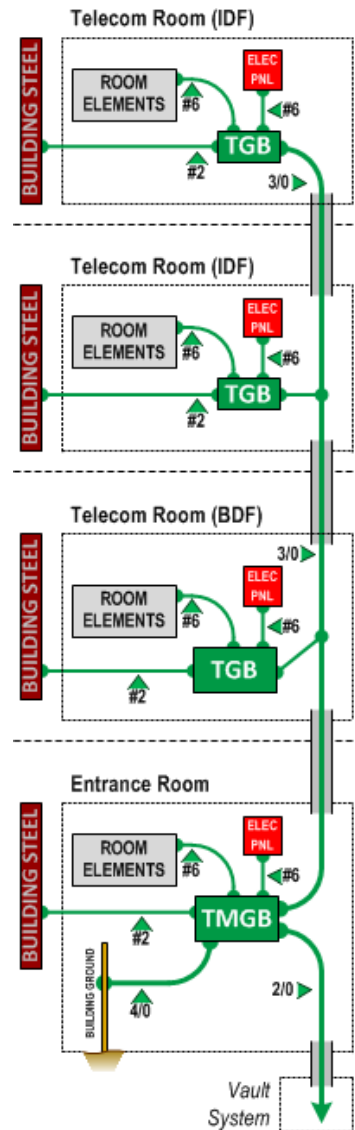
Proper grounding of telecommunications related infrastructure requires a very specific design prepared in coordination with (but separate from) the overall electrical grounding system within a building. The major sources for details of required grounding system design are:

- **ANSI/TIA/EIA-607-B-2013** (Grounding and Bonding Requirements for Telecommunications in Commercial Buildings)
- **BICSI TDMM** (Telecommunications Distribution Methods Manual) 13th Edition
- **CEC 2010** California Electrical Code (Title 24, Part3) – 2016
- **IEEE 1100-1000** (Recommended Practice for Powering and Grounding Electronic Equipment)
- **NFPA 70** (National Electrical Code) Section 210 - 2017

Neither this document nor any of the referenced material replaces or supersedes any national or local code. Some of the normal grounding and bonding issues to be addressed in any telecommunications design are:

- All cables entering a building must be grounded as close as practical to the point of entry of the cable into the building. In general terms, this means within the fifty-foot limit for the extension of an outside plant cable into a building.
- All backbone (riser) cables must be grounded at all splice locations and at any point at which pairs leave the sheath.
- All cables must be bonded end- to-end and through any splice.

All hardware supporting telecommunications cable, such as ladder racks, cable trays, and conduits, must be grounded. It is absolutely necessary to design and install the telecommunications grounding system as defined in ANSI TIA/EIA-607 and to use only a single point of ground for all services (power and telecommunications) within the same building. Each rack/cabinet shall have an independent AWG 6ga ground cable installed from the TMGB or TGB. Each ground cable will have a wraparound label installed and



shall indicate origination and destination information on each end. Standard TIA 606 labeling standards apply.

Much of the major network equipment used on campuses, especially PBX systems, requires a clean, low impedance ground (defined as low electrical noise and low resistance to earth ground) to function properly. The combination of electrical power grounding, backbone cable grounds, and general equipment and racking grounds can create a situation in which faults occur and/or electrical interference can become a problem. The telecommunications ground must provide a direct path to ground for all telecommunications equipment and media. This does not necessarily require installation of a new or separate electrode or grid system. An initial step is to determine how well the current grounding electrode/grid system meets the defined needs. The California Electric Code (CEC Article 250.56) stipulates that a building electrical ground provide no more than 25 ohms resistance as measured between the grounding electrode system and actual earth reference ground. This requires the use of a specialized grounding tester and the temporary placement of reference ground rods.

The target resistance level for a telecommunications ground is less than 5 ohms. This can be a difficult figure to reach, especially in particularly dry locations. It is often necessary to install supplementary electrodes (following NEC Section 250), chemical enhancers (such as bentonite or chemical ground rods), or grounding grids to obtain a suitable measurement. Any supplementary grounding electrodes must be bonded (directly connected) to each other and the central ground. Bonding provides a single ground reference into a building.

The standard for telecommunications grounding contains some key elements:

- An isolated electrical ground must be provided on a copper bus bar mounted six inches above the finished floor, unless otherwise specified. This grounding bar should be connected with a 3/0 copper wire to the building's main electrical grounding grid and may also require a separate concrete-encased electrode, or a buried ring ground. The isolated ground must be uniquely identified by a recognized technique, such as the use of green insulation with yellow stripes for all isolated ground conductors.
- Sometimes attaining the ground resistance value target of 5 ohms or less is not possible. The ultimate goal is to achieve the lowest ground resistance value possible that makes sense economically and physically.
- All grounding conductors must be securely installed in a direct manner and protected from damage or accidental disconnection. Telecommunication grounds are not to be served through an electrical panel grounding bus, but must be

directly cabled to the building service entrance ground, and then bonded to the local electrical panel ground.

- The connection of all grounding conductors must be made using materials and methods as defined in the National Electric Code.
- Specific, stand-alone copper busbars must be installed in all telecommunications spaces and be bonded to the power service panel ground and building steel in each location.
- Other specific grounding requirements that may be more restrictive than these Standards exist for antennas, some types of radio and video transmission equipment, and highly sensitive computing and testing equipment. Provisions for lightning and lightning surge protection should be considered. Design professionals must be particularly cognizant of such circumstances.

3.2.7. Mechanical Air Handling System

Sufficient heating, ventilating, and air conditioning (HVAC) sensors and control equipment must be installed to provide a consistent environment in telecommunications rooms. Unless specific requirements otherwise dictate, the room environment should be designed to maintain a range of temperature between 60°F and 85°F, with a relative humidity at equipment manufacturer's recommended levels. It is suggested that campus physically display the required room temperature and relative humidity levels in a visible location. If the actual heat rejection from the telecommunications equipment is not known, then the designer should assume a 10 w/ft² equipment load. As network equipment changes, a designer must assess whether or not 10 w/ft² is sufficient based on the anticipated load of the room.

General Contractor/Mechanical Engineer will meet the guidelines of design temperatures utilizing best construction/engineering practices. Mechanical systems must be able to meet heat rejection to maintain space temperature and/or humidity requirements 24 hours a day, 7 days a week. Mechanical systems can be building dependent, utilizing Air Handling Unit VAV, or passive airflow with exhaust to reject heat. Mechanical systems can be independent from the building air handling unit for heat rejection to meet the designed space temperature/humidity range using best practices and energy efficiencies. General Contractor/Mechanical Engineer will design and install to Campus standards and Specifications 15 and 27. Ensure that all applicable building code is followed.

3.2.8. Specific Requirements for Service Entrance Facilities

The building service entrance facility provides a location in which to terminate cables entering the building by grounding the sheaths as required by code, by providing electrical protection, and/or converting from outdoor to indoor cables. Such rooms require sufficient

space and structural additions to support the installation of a variety of cables, as well as space for splice cases and electrical protectors.

All conduits entering the building from outside must be sealed with reusable compression-style plugs to eliminate the entrance of water or gases into the service entrance facility. All spaces around conduits through a concrete wall or foundation must be sealed using a moisture barrier, plastic expansion foam (not insulation) and the outer wall moisture barrier repaired and resealed. All conduits leaving the service entrance facility for other portions of the building must be fire-stopped whether or not they contain cable.

3.2.9. Specific Requirements for Telecom Rooms

The telecommunications room on each floor serves not only as part of the vertical pathway system on a multi-story building, but also must support all horizontal cabling and cross-connects, electronics, and specialized distribution equipment such as wireless facilities, video systems, local area network devices, and fiber optic termination equipment. It is extremely important that this room be designed with an understanding of the role that telecommunications plays in today's educational institutions as well as in the future. These rooms will have frequent access by ICT personnel installing and maintaining various telecommunications infrastructure and network services and must be sized and equipped to meet this demanding role.

Due to the importance of this room to the various campus networks, it is critical that the design be treated as a formal "space utilization" requirement in the planning and design process. In addition to being equipped as defined, this room must have access to the service entrance facility and must be the starting point for the building's backbone distribution system.

3.2.10. Other Telecommunications Spaces

There are other telecommunications-specific or related spaces that may only occasionally need updating or modification. These include the main distribution frame (MDF), generally the location in which the serving utilities terminate lines and where the campus backbone network originates, network management and control centers, and video distribution centers.

While each of these and other high technology spaces will require specific design inputs from other sources, some considerations should be viewed as common with other segments of the telecommunication's infrastructure. Some of these considerations are:

- Each space must have clear and direct access into building and campus backbone pathway systems for a variety of media.
- Each needs to be part of the telecommunications grounding system for the building in which it is located.

- Each should be included in security and support systems such as auxiliary power generation, backup air handling, emergency lighting, special fire suppression, and physical security and monitoring.
- The campus MDF should be designed following guidelines similar to a telephone company central office facility in terms of structural systems, support requirements, security provisions, cable entrance support systems, and future growth capabilities.

3.2.11. Telecommunications Space Security

CSU audit findings have repeatedly stressed the need for increased security in telecommunications facilities. Should an unauthorized person gain access to the physical infrastructure supporting the campus network, available electronic security options are limited. To prevent such intrusion, it is imperative that the spaces housing the infrastructure be provided with substantial controls for restricting access to authorized individuals only. For maximum utility, such controls should include both the ability to monitor access incidents involving the spaces and the physical protective devices necessary to prevent unauthorized access. The following are general requirements:

- Only individuals who require and are authorized to have access should be able to enter a telecommunications room
- Telecommunications rooms must contain only equipment related to the telecommunications function and required to implement the cable plan, with exceptions being items of diagnostic equipment or devices for improving security;
- Telecommunications rooms are not storage facilities, and their design and utilization shall not support other uses
- Telecommunications rooms are not Computer Rooms or Data Centers, and it is important to assure that other IT equipment (e.g., servers, printers, etc.) belong in their own specialized rooms
- Physical security must be maintained through the use of an auditable access control system such as card access.
- In areas such as MDFs, Data Centers, Network Centers and other critical spaces consideration should be given towards an appropriate level of video supervision.

3.3. Telecommunications Pathway Design

Telecommunications pathways include the inter-building conduit and utility vaults used to transport cables between buildings and the conduit and cable trays used to distribute cable within a building. Such pathways must be designed as an integral part of an overall telecommunications infrastructure plan, not as a vendor-specific system or technology component. For example, a new building at the edge of campus may only require minimal voice, data, and video services initially, but future growth in the building or in that portion of campus can rapidly exhaust the capacity of a small Inter-building pathway designed only for those initial needs.

Cable Fill Table

Conduit Size	CAT-6 .231"	CAT-6A .285
1-1/4"	21/14/9	13/9/6
2"	47/31/22	31/20/14
4"	209/139/97	137/91/64
Sleeve < 2' / Straight < 100' / Two 90° Bends & > 100'		

3.3.1. Inter-building Distribution Systems

The Inter-building distribution system consists of the utility tunnels, conduits, and utility vaults that interconnect buildings on a campus. The selection of the routes and the sizing of the Inter-building distribution system must be based upon existing conditions, known problem areas, and the growth associated with the campus master plan.

In most cases, designers find themselves directed to expand existing Inter-building distribution systems to serve new construction or to resolve a congested pathway between specific buildings. Without the ability to conduct a detailed inspection of the current conditions and identify alternative strategies for meeting the identified needs, the solution is generally to add new conduit and vaults. This approach does address the immediate needs, but frequently leads to cable maintenance problems or additional limitations in the future. In some instances, it may be possible to reroute services to other cables, combine services into a single new cable while removing several older cables, or simply remove unused cables from congested pathways. The alternative to trenching several hundred feet across a campus may be a detailed analysis of the media within the pathway and a couple of evenings or weekends of splicing. That alternative can be very cost-effective and take significantly less time to implement.

When a campus undertakes a utility project, it is important that the telecommunications distribution system undergo both a visual and physical inspection. Historically, when construction of many CSU campuses was initiated, telecommunications or “signal” conduit

was often clay, steel, or concrete-encased paper. All three of these conduit types have failed in recent years and, unfortunately, most are damaged in locations that cannot be seen during a normal inspection.

The only sure way to determine the usefulness of a conduit route is to pull a mandrel through the conduit to determine the actual cable size that can be placed. A conduit that appears to be three or four inches in diameter often has been damaged or corroded over time, reducing the useful size to half or less the original.

This subsection provides some general guidelines for the design of Inter-building pathways. More detailed information can be found in the referenced standards, particularly the BICSI Outside Plant Design Manual. The designer must also take into consideration the California Electrical Code (CEC), campus specific constraints, and project funding guidelines.

3.3.1.1. Utility Tunnels

Some CSU campuses have utility tunnels that are used to transport power, water, steam, and other utilities between core parts of campus buildings. When utilizing these tunnels for telecommunications pathways, the following issues must be addressed:

- Space and supporting hardware, such as eye-hooks and T-bar, must be provided to facilitate the placement of large copper cables within utility tunnels. A centerline-ceiling rail can be used to attach pulling wheels designed to bring large cables into the tunnel. Space must then be made available to allow the cable to be moved from the pulling wheels into a tray system or attached to the wall of the tunnel. If a centerline rail is impractical, T-bar may be placed in the ceiling on ten (10) foot centers. Pulling eyes should be installed at ground level at the end of any long straight run of the tunnel.
- The preferred method of distribution within a tunnel is one or more wall-mounted steel trays (NEMA rated 12C or better) 18" to 24" in width with three (3) inch sidewalls. These trays should be mounted no less than 36 inches above the floor and no higher than eight (8) feet above the floor and should be supported every ten (10) feet. The tray must be solid bottom, galvanized, and must be properly grounded. Changes in direction, either vertical or horizontal, should be accomplished whenever possible with wide sweeps. If that is not possible, factory-made ninety-degree bends of not less than a 36-inch radius can be used. Any vertical rise or fall should utilize a ladder rack or rack bottom tray to allow lashing straps to be used to secure the cables into the tray.
- Spacing as required by code must be observed when placing communications facilities in a tunnel in close proximity with electrical power lines. To reduce the potential for electromagnetic interference, a minimum separation of six (6) inches between signal and high power (≤ 480 volts, 5 kVA or less) must be

maintained, even when both are contained in grounded metal conduit pathways. If the communications lines are in a grounded but open pathway (such as a cable tray), the minimum separation is twelve (12) inches.

- Conduits leaving the utility tunnel at right angles must be placed either above or below the level of the cable tray to allow free passage and placement of cable. Conduits must be separated by a minimum of three (3) inches and, if stacked, must be offset and stacked no more than two rows high. The designer must take into consideration the bending radius of the cables that could be placed in any conduits leaving a tunnel.
- Large 1,200 pair cables need a 36-inch radius, which can be difficult to obtain in a five or six foot wide tunnel section. It may be necessary to place a vault or extension on narrow sections of a tunnel to provide the clearance necessary to place new cables.
- Conduits leaving a utility tunnel to service a specific building must have the name of the building and the length of the conduit run stenciled onto the wall of the tunnel directly above or below the conduit. If the conduit feeds a vault or manhole, the number of the manhole and the distance must be stenciled on the wall.

3.3.1.2. Conduit and Utility Vault Systems

A conduit and utility vault system is the most common form of Inter-building pathway used throughout the CSU. They are frequently designed incorrectly as “signal” or “low voltage electrical” distribution systems. A good quality telecommunications design using materials and procedures designed specifically for the industry is required to support the long-term use of this infrastructure.

- Conduits should be Schedule 40 PVC or, if concrete encased, type C signal conduit with a four (4) inch internal diameter. Conduit runs should be made in large straight sections utilizing wide (40 foot or more) sweeps rather than ninety-degree bends. If ninety-degree bends cannot be avoided, they should be located at either end of the conduit run (not in the center of a long run) and must have not less than a 60-inch radius (it is recommended 12½ to 15 foot “street sweeps” be used as the minimum size whenever changes in direction are required).
- Buried conduits encased in concrete must be installed using fixed spacers between all conduits. The orientation of the conduits must be maintained from end-to-end, and the conduit support system should be secured within the trench to eliminate the potential of the conduit “floating” when the concrete is poured.

- All conduits must be buried a minimum of 24 inches below grade. The trench must be backfilled with materials that have been sifted and mechanically compacted. Locatable utility marking tape should be buried 12 inches below the surface, directly above the conduit.
- Conduits shall normally be concrete-encased end-to-end; however, small runs of two or less conduits in good soil may be direct-buried. Conduit runs of any size placed in poor soils, under parking lots or other roadways (not highways), in sections that might be stressed during the placement of cable (such as the low spot at the bottom of a hill), and all bends, must be encased in a concrete mix. The concrete must be a cement/sand mix with a minimum compressive strength of 2,500 lbs. per square inch after 28 days, or a Class 2B mix with a maximum aggregate size of three-eighths inch.
- Conduits under highways or railroad rights-of-way must be encased in steel casing pipe consistent with the appropriate AASHTO or the AREMA specifications. The thickness of the pipe is dependent upon a variety of factors and must be engineered for each specific instance.
- American Association of State Highway and Transportation Officials (AASHTO) <http://www.transportation.org/>
- American Railway Engineering and Maintenance-of-Way Association (AREMA) <http://www.arema.org/>
- The minimum separation between communications conduit and power cable conduits is 3 inches in concrete, 4 inches in masonry, or 12 inches in earth. The minimum separation from other utilities, such as gas, oil, steam, water, etc., is 6 inches when crossing and 12 inches when parallel.
- A nylon pull rope must be installed and all conduits plugged at both ends with a neoprene or rubber duct plug to prevent water and/or gas seepage into a building, tunnel, or vault.
- New conduits, existing conduits or repaired conduits are required to be proofed or mandrel tested prior to placement or replacement of OSP cabling.
- When placing conduits to a future site and conduits are stubbed and capped in the ground, location devices (buried mark ball and ground level marker, tracer wire/tape, or cable marker posts) should be placed at the point where the conduits end to facilitate ease of location in the future.
- Conduit entering a building must transition from PVC to galvanized rigid steel (GRC) or must be contained within a galvanized metal sleeve from a distance of 24 inches beyond the exterior of the foundation to six inches within the building.

Conduits entering buildings must slope downward away from the building to reduce the potential for water entry.

- The design of a conduit entry through a building’s foundation should be reviewed by a structural engineer. Some facilities will need the structural rebar to be located using x-rays, and others may require a significant space between any new openings to reduce the concerns of seismic weaknesses.

- The number of four-inch conduits entering a university building will vary depending upon building size, location, intended mission, and the size and type of cables expected to be used long-term. The design goal is to always have a conduit open to provide a pathway for cable reinforcement (growth or replacement). Even a small campus building of 2-4,000 square feet needs a minimum of two four-inch conduits. One conduit can contain a copper cable and three or four innerducts (one with a fiber optic cable), and the other conduit would be open to act as a reinforcement pathway.

Building Gross Floor Space	Minimum Number of 4 Inch Conduits
Minimum	2
10,000 – 30,000	4
30,000 – 50,000	6
50,000 – 75,000	8
75,000 – 125,000	12

- Additional conduits are required for buildings over 125,000 square feet, specialized communication facilities (computer center, library, media center, or telephone switch site), or buildings that may be difficult or impossible to reinforce at a later date.
- For the use of fiber optic cables, and smaller copper cables, the use of innerducts is recommended per BICSI and industry recommendations. Traditionally, this innerduct has been minimum 1” solid or corrugated PVC tubing installed 3 or 4 at a time within a single standard 4” conduit. With the availability of products like MaxCell campus should consider these as a viable alternative to traditional PVC innerducts. With some of the newer fiber innerduct products, it is possible to have up to 9 segmented pathways within the 4” conduit, instead of the traditional 3 or 4 pathways.

3.3.1.3. Vaults and Pull Boxes

The selection and placement of vaults and pull boxes must be made as part of an overall distribution plan that includes a complete understanding of the media to be served, the structures and locations to be linked, the systems and applications to be supported, and the forecasted growth pattern across the campus. This understanding allows the designer to approach the problem in a systematic manner, rather than simply adding capacity in all directions.

One of the major ways to address this process is to prepare the designs using telephone system design criteria and component designs. Electrical vaults and distribution systems are different from telecommunications, and the two systems must not be designed in the same manner. The following subsection provides a list of the major points to consider when identifying the pull boxes and utility vaults for the telecommunications infrastructure.

- Pull boxes rather than utility vaults are used only in situations in which the maximum number of conduits in that route is never expected to exceed two four-inch conduits. A small unit (16" wide by 26" long by 18" deep) is used exclusively for a single conduit not to exceed two inches in diameter, such as might serve an isolated public telephone or parking lot emergency phone. The standard size unit (3' wide by 5' long by 4' deep) should be fitted with a hinged, traffic-capable lid with a locking mechanism. In all cases, the conduit feeding pull boxes must enter and leave the pull box in-line parallel with the top of the box. A pull box should not be used as a location in which to make a turn in the conduit routing.

- Utility vaults must be located with both initial cable placement needs and future expansion requirements in mind. Telecommunications utility vaults should be pre-cast units designed for traffic loading and should be located in a major "trunk and feeder" design. Main runs of nine to eighteen conduits should form the backbone

Number of Conduits	Utility Vault Size
Less Than 6	5' x 7' x 7'
6-12	6' x 10' x 7'
13-18	6' x 12' x 7'
19-24	8' x 15' x 7'

- distribution system and should feed smaller runs of six to nine conduits. Any building not located within 200 feet of a main or feeder utility vault should have a separate vault installed to act as a cable pulling point between the building's service entrance facility and the main Inter-building distribution pathway system.
- The target spacing for the placement of utility vaults is 350 to 400 feet. Unlike the more normal utility company placement of 600 feet, the campus design requires closer spacing to more easily serve major buildings, provide flexibility for expansion, and make the placement of cables easier. Factors that would reduce the recommended distance include natural or manmade obstructions, extensive backfeed needs, or more than two ninety-degree bends in the serving conduit.
- All utility vaults must be equipped with a dry-sump, corrosion-resistant pulling irons (one at each end), cable racks on both long sides, standoff brackets at both ends, a grounding rod, and a ladder. Concrete used for vaults should be at least 4,500 lbs. per square inch in strength.

- The configuration of the placement of conduit into a vault, either in the center or near the outer area of the end of the vault (splayed ducts), is subject to campus preference and requires an understanding of what systems are currently used. Conduits should never enter a vault from the long sides, the top, or the bottom. Vaults of standard size and configuration are not designed to support the placement of large copper cables with right angle bends.
- Conduits leaving utility vaults to service a specific building must have the name of the building and the length of the conduit run stenciled onto the wall of the vault directly above or below the conduits. If the conduit feeds another vault or manhole, the number of the manhole and the distance must be stenciled on the wall.
- The determination of the size of telecommunications utility vaults varies by the expected number of cables to be served and the types of support services or equipment that must be housed (such as splice cases and/or amplifiers). The minimum size utility vault recommended for CSU campuses is 5' wide by 7' long by 7' tall, which is generally sufficient to serve an individual building. If, however, the utility vault will be expected to serve as a pass-through point for other conduit or as a splice location for other buildings, the size must be increased. However, the final size and configuration of the vault will be driven by the number of conduits entering and leaving the vault, the number and type of splices, and the site in which the structure will be located.
- As physical security concerns increase, the use of locking utility vault lids is recommended. There are a variety of types and styles of lockable lids, and the individual Campus should make the selection based on their needs and environment.
- All telecommunications utility vaults must be rated at least HS-20 (vehicle traffic) per AASHTO standards (Standard Specifications for Highway Bridges, 24 CFR 200, Subpart S).
- American Association of State Highway and Transportation Officials (AASHTO) <http://www.transportation.org/>
- All telecommunications infrastructure should be clearly labeled with "COMMUNICATIONS", "TELECOM" or "SIGNAL" at the discretion of the campus.

3.3.2. Intra-building Backbones

The intra-building backbone pathways connect the service entrance facility and all the telecommunications rooms in a given structure. The backbone elements consist of conduits, sleeves, and trays. The designer should be aware that open cable trays are not an option for supporting large copper cables from the service entrance facility to the telecommunications room if the ceiling area can be considered a plenum-rated space. While many systems use fiber optic and/or coaxial cable that can be purchased with plenum-rated sheaths, the large copper cables used to support much of today's voice telephone service are generally limited in size to less than 100 pair in shielded, plenum-rated cable types.

3.3.2.1. Sizing

In determining the proper number of conduits or sleeves required to connect a service entrance facility to telecommunications rooms, it is important to understand how various types of cables will be utilized. The primary focus for cable within the building is the telecommunications rooms. Here, the electronic components serving users within the building will be interconnected with the cable feeding in from other parts of campus.

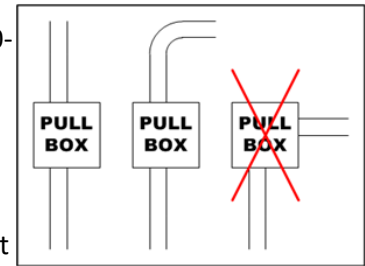
In initially sizing conduits between the service entrance facility and a telecommunications room, the designer should add two to the number of conduits entering the building. For backbone (riser) pathways, the starting point is three (3) four-inch conduits or sleeves, with one (1) additional conduit added for each 10,000 square feet of space above a base 10,000 assignable square feet (ASF). For example, a six-story building with 20,000 ASF per floor needs a minimum of three conduits serving each telecommunications room, plus two additional conduits for pass-through, and a dedicated conduit to serve future wireless or satellite systems on the roof. Due to the need to interconnect components on different floors, the number of conduits should remain constant from the top to the bottom of the building.

Additional conduit is required in situations that must be fed by offset conduit runs, such as non-stacked closets. Such conduit can only be utilized to less than half of its capacity, and this condition will restrict the number of cables that can be placed. The final quantity and placement of backbone conduit must be analyzed in light of the services to be installed, the route taken, and the potential for expansion of services; however, a minimum of one or two conduits should be added in these situations.

3.3.2.2. Design Details

- Sleeves should be used in backbone (riser) pathways. Sleeves should extend a minimum of two inches above the finished floor in the upper room and four inches below the true ceiling (or past any obstructions) in the lower room. All sleeves should be placed to provide short and straight pathways between floors.

- If conduit runs used to interconnect service entrance facilities and/or telecommunications rooms within the same building span areas with drop ceilings they should be placed above the false ceiling with no more than a total of two 90-degree bends. These conduits must not be angled down into the termination space. The conduit should be fixed four to six inches inside the room at a right angle to the wall. All metal conduits must be fitted with a collar or end bushing to eliminate damage to the cables during pulling.
- Pull boxes must be placed in conduit runs that exceed 100 feet or in situations that require more than two 90-degree bends. Such pull boxes must be located to provide free and easy access, in straight sections of conduit only (pull boxes should never be used for a right-angle bend), and must be installed to allow cable to pass through from one conduit to another in a direct line. Pull boxes must have a length at least eight (8) times the trade-size diameter of the largest conduit. Refer to EIA/TIA 758 OSP.



Pullboxes are not to be used in lieu of a proper 90°

Maximum Conduit Size	PullBox Width	PullBox Length	PullBox Depth	Add to Box Size for Each Additional Conduit
1.5"	8"	27"	4"	4"
2"	8"	36"	4"	5"
4"	15"	60"	8"	8"

- A marker dot shall be placed on the crossbar of a drop ceiling to indicate the location of all backbone pull boxes. Color of the marker is to be orange.
- Two four-inch conduits must be dedicated from a sealed junction box on the roof of the building in a direct line to a telecommunications room for use as an antenna access point. In addition, an earth ground must be provided at the roof junction box point, sized and designed in accordance with CEC requirements for its intended use. A one-inch conduit terminating in a weatherproof duplex box must be provided from the roof to the closest electrical panel for electrical power.
- All backbone (riser) sleeves must be fire-stopped with re-enterable fire-stopping and sealed following code and manufacturer’s instructions.
- All pathways are to be labeled on both ends as to the far end location.
- All pathways, regardless of fill percentage, are to include a pull cord.

- All pathways are to be continuously electrically or mechanically bonded for the entirety of their run.

3.3.3. Horizontal Pathways

Horizontal pathways are facilities that support the installation and maintenance of cables between the telecommunications room and the telecommunications outlet locations. In new construction, the designer should use plenum-rated telecommunications cable supported by a cable tray serving station conduit stubbed into the false ceiling space.

Telecommunications cables shall be independently supported and never be allowed to rest on ceiling tile or be attached to other service utilities or conduits. Whenever cable penetrates a smoke or fire-rated barrier, that barrier must be returned to its original rating through the use of one or more listed products. This subsection outlines the major methods recommended within the CSU for supporting cables in the horizontal pathways.

3.3.3.1. Cable Trays

A specified cable tray must be sufficient to hold the weight of all the cables likely to be supported over the life of the system, must be routed correctly, and must be installed to maximize usage.

- In most cases, minimum 12" cable tray will be the cable tray of choice. Other types and styles of cable tray are available to use as the specific needs of the Campus dictate. The trays must qualify under NEC Section 318-7(b) as equipment grounding conductors.
- Trays should be secured in the manner prescribed by the cable tray manufacturer and in accordance with all building and electrical codes. If both sides of the tray cannot be accessed or other limitations prohibit the placement of cable equally in both sides of the tray, a center trapeze or wall support system should be used.
- All tray installations must meet seismic bracing standards for Zone 4 and must be supported against horizontal, lateral, and vertical movement.
- If using painted cable tray, consider using powder-coated rather than spray painted.
- The cable tray should be routed in a manner that reduces the need for long unsupported cable runs. However, the tray need not be extended to cover all areas of a floor simply to transport cables to one or two locations. At the discretion of the campus, non-continuous supports ("J" hooks, bridal rings, or cable saddles (on 6' centers) on 3ft to 5ft centers may be used to support individual runs of cable. It is recommended to vary the distance between supports to maintain the minimum level of transmission performance. or a zoned conduit system may be used to supplement the cable tray.

- Cable trays must only be utilized over areas with ceiling access and should transition to a minimum of three four-inch conduits when routed over fixed ceiling spaces or containing any angle greater than 20 degrees.
- Trays should be electrically bonded end-to-end. All conductive trays shall be bonded together in the manner prescribed by the TIA-607-B and BICSI standards.
- The cable tray, the support method, the bracing system, and the anchoring components must work together to provide sufficient support for a wide variety of cable types and sizes. It is unlikely the ultimate capacity requirements of an individual cable pathway can be defined as part of a new construction or retrofit project. With the continuous changes in technology and the expanding role of telecommunications in the educational process, forecasting and designing to specific weight capacities is unreasonable.
- Trays should enter into telecommunications rooms and extend a minimum of six inches into the room, then utilize a drop out in a “waterfall” to provide cabling with a proper bend radius from the end of the tray.
- All penetrations through firewalls must be designed to allow cable installers to install re-enterable fire-seal around cables after they are installed. The use of tray-based mechanical firestop systems instead of a transition to conduit is encouraged when a tray must penetrate a fire barrier.
- Cabling exiting a cable tray should be supported if its vertical fall distance exceeds 12”.
- Changes in elevation or direction with a cable tray must utilize products manufactured specifically for that purpose. No field modified or improvised components are acceptable.
- Cable trays must not be placed closer than five inches to any light fixture and no closer than 12 inches to any electrical ballast. A minimum of ~~eight~~ ^{eight} ~~eight~~ ^{eight} ~~eight~~ ^{eight} inches twelve inches of clearance clear vertical space above the tray must be maintained at all times.
- All changes in elevation or direction in the tray, transitions from cable tray to conduit, or installations of fire stopping must remain fully accessible.
- Trays should be mounted no higher than 3 feet above the grid of an accessible ceiling.
- The ITS distribution designer should ensure that other building components (e.g., structural supports, air ducts) do not restrict access to cable trays.

3.3.3.2. Conduit Sleeves (J-Hooks)

A separate conduit sleeve (minimum of two conduits that are two inches in diameter) must be provided as a pathway through any wall with obstruction (such as a rated hallway which would require fire stopping) from the cable tray into any room having multiple telecommunications outlets. Such conduit runs must be continuous over fixed ceiling areas but may be sleeves between false ceiling spaces that have access. Refer to section 3.3.6 “Retrofit design issues”.

3.3.3.3. Conduits

- All conduits will be home run back to a cable tray or TR(.
- All conduits shall be continuously bonded back to the TGBB in the TR.
- All conduit terminations will be equipped with bushings.
- Conduit runs for horizontal cabling shall not be installed below a building’s slab; however they may be installed within the slab.
- All station conduits, except as otherwise specified, must be at least 1¼” diameter.
- All station conduits are to have no more than (2) 90° or 180° degrees of bend before the placement of a pull box.
- All conduits are to be continuously electrically or mechanically bonded for the entirety of their run.
- All conduits, regardless of fill percentage, are to include a pull cord.
- All conduits not terminating in a junction box or pull box shall have a plastic bushing installed.
- All station conduits terminating in a TR are to be labeled on that end as to the location of the far end.

3.3.3.4. Cable Runway (Ladder Rack)

- Cable Runway is to be used only within Telecommunications Rooms, Equipment Rooms or Service Entrance Facilities.
- Within each telecommunications room, cable runway should be bonded together, electrically continuous, and bonded to the TGB/TMGB.
- Use a radius drop to guide cables wherever cable exits overhead cable runway.
- Cable runway shall be secured to the structural ceiling, building truss system, wall, floor or the tops of equipment racks using the manufacturer’s recommended supports and appropriate installation hardware and methods.

- Where cable leaves a pathway to transition to a cable runway, and that transition spans more than 18", continuous support shall be required.
- Cable runway shall be supported every 5' or less in accordance with TIA-569-B. Where additional support is required for runs over 5', cable runway is to be supported from the ceiling.
- Cable runway shall be supported within 2' of every splice and within 2' on both/all sides of every intersection. Support cable runway within 2' on both sides of every change in elevation. Support cable runway every 2' when attached vertically to a wall.
- Cable runway installed parallel to the wall shall be placed with an 8" offset from the wall.
- Leave a minimum of 12" in between cable runway and mechanical systems, lighting fixtures, ceiling or any other obstructions. Multiple tiers of cable runway shall be installed with a minimum clearance of 12" in between each tier of ladder rack.
- All cable runways are to be continuously electrically or mechanically bonded for the entirety of their run to the TGB/TMGB and meet both TIA 607 and the manufacturer's installation recommendation.

3.3.3.5. Basket Tray

- The wire basket tray shall be U shaped and constructed of round wire mesh. The basket tray shall be installed trapeze-style or wall-mounted. It shall not be center hung.
- End-of-tray cable waterfalls shall be used where wire drops down top reserve bend radii and prevent abrasions and cuts from metal tray edges.
- The tray shall be no closer than 6 inches from the structural ceiling, ducts, pipes, or any other possible obstructions. A minimum separation of 5 inches from lighting, especially fluorescent lighting, is required.
- The tray shall maintain a minimum 18-inch clearance from sprinkler heads.
- All basket trays are to be continuously electrically or mechanically bonded for the entirety of their run.

3.3.4. Station Telecommunications Outlets (TO)

In current practice, a telecommunications outlet will often be configured to serve a variety of telecommunications needs. An outlet, which only a few years ago merely provided access to a voice connection, today typically supports connections to fax, multi-media data, and video

devices of various types by the time the building construction is complete. If all outlet locations are standardized, the university may gain flexibility through being able to determine the actual services placed in the outlet.

An important point to remember about telecommunications outlets is the need to design their locations for projected future needs, not just current applications. Outlets that are not initially activated can be ready for later use. By paying attention to potential locations for telecommunications devices and the routes by which they are served, the designer can save significant time and costs in responding to the changing requirements of the university community. This is particularly true of outlets intended to support emerging technologies, such as equipment required for wireless access implementation, LCD display monitors or security cameras.

3.3.4.1. Standard Wall Outlet (CAT 6)

The standard wall outlet shall be served by a 4-11/16" inch, by 3" deep, square outlet box. Each box shall be served by a dedicated 1¼-inch conduit stubbed-up a minimum of 6" above accessible ceiling space, nearest cable tray or main horizontal distribution pathway (with no more than a total of 180 degrees of bend end- to- end).

Telecommunication outlet boxes should never be daisy-chained or mounted back-to-back using a common feeder conduit. Outlet boxes are to be finished with a single or dual gang mud ring.

3.3.4.2. Remodel Wall Outlet

In remodeling locations without fire barriers or in filled walls where cable can be "fished," a faceplate support bracket may be used. Faceplates without the use of the support brackets is not allowed. The best design provides an EMT conduit from above the ceiling space to just above the point at which the faceplate is to be mounted.

3.3.4.3. Floor Box Outlet

If flush-mounted floor outlets are required, the designer should place a dual use (signal and power floor-box) preset outlet in the floor surface and feed the conduit (1¼" for signal only) through the floor slab to the nearest wall and up into accessible ceiling space.

In-floor systems shall support flexible solutions for providing power, communications, and the special space requirements of audio/visual type connectors to above grade floors, in open space areas, or directly to the workstation. Systems shall provide multiple trade size knockouts to support a minimum 1-1/4" conduit, allow for most conduit schemes and accommodate future moves, adds and changes. Preference shall be given to large capacity systems to reduce the need for multiple floor boxes for one location or user group and sufficient space, so minimum copper and fiber cable bend radius requirements are not exceeded. They shall support multiple connectivity options, accept a wide range of industry standard and proprietary interfaces for voice, data, audio, and

video applications. The Telecom outlets shall be recessed below the finished floor cover plate typically referred to as a sub-plate. Configurations shall allow for egress of multiple cables in a variety of sizes and provide tension reduction on cables and connections. Covers for these floor boxes shall incorporate protection to prevent water, dirt, and debris from entering the power and communication compartments. Covers shall support furniture feed applications in modular furniture environments. Audio/video, data and power shall be maintained in separate pathways. All power components shall conform to NEMA standards. Assemblies shall be UL Listed to U.S. safety standards for multiple floor-type applications and maintain the fire rating of the floor as required. In-floor systems shall not be obstructed by any means to remain accessible at all times.

3.3.4.4. Counter Serving Outlet

Custom counter or workstation installations requiring telecommunications services should be connected to a wall-mounted junction box fed by a two-inch conduit. In all cases designer shall review cable counts and upsize to a second conduit to ensure fill ratios are adhered to.

3.3.4.5. Raceway Served Outlets

In some laboratories, work areas, and/or counter spaces, wall-mounted surface raceway should be utilized to distribute power and signal to a variety of user locations. This raceway must be of a material that is suited for the specific location, maintains the bend radius of the cable to be used, and at a minimum be 1 ¾" x 4". Raceways shall use fiber radius fittings. All transitions in either the horizontal or vertical plane shall use products designed and manufactured for that purpose. The communications portion of the raceway should be fitted with standard single or dual gang ring for mounting the communications jacks. It is recommended that the designer consider providing for multiple access points into the raceway, and place a minimum of two 1¼" feeder conduits into every eight feet of raceway section.

3.3.5. Fire-stopping

Fire-stopping is a critical issue on all projects (new construction and remodels) and must be specifically addressed by the telecommunications design team. It is important the design team communicate their expectations about fire-stopping to the Contractor before the project is started. All firestop systems employed shall meet or exceed national, state or local building and safety codes.

- Each type of penetration is different, and the fire-stopping materials and configuration must be selected specifically for the conditions in the field. Although the designer can define in general terms the expectations and overall methods to be employed, the Contractor must work with the installer, the designer, and the firestop

manufacturer to identify the correct products for the job. Special considerations shall be taken for both the annular and interstitial space for all firestop systems.

- All fire-stopping products shall be re-enterable and maintainable to allow the placement of additional cable.
- Each firestop must have a manufacturer's UL rating sheet outlining the products to be used, the construction materials to be penetrated, the penetrating items (cable, conduit, material type), the rating expectation, and the installation methods. No single firestop material will meet every situation in a building-wide cable installation project.
- The designer should identify general types of acceptable fire stopping materials and methods, including manufacturers, and identify the types of fire-rated structures within campus buildings. There are several steps to this process:

3.3.5.1. Define Construction Types

Campuses must provide the design team with adequate construction as-built documentation or must conduct existing site condition surveys of the areas impacted to determine which structures within the building are rated and to what level.

3.3.5.2. Identify General Fire-stopping Methods

The design team must identify the generally acceptable methods of penetration and fire-stopping based upon how the cable will be installed and the plans for its maintenance.

3.3.5.3. Identify Special or Unique Situations

Large openings, such as cable trays, must be specifically identified, and fire-stopping materials and methods defined as part of the design package.

3.3.6. Retrofit Design Issues

The single most difficult design issue in retrofit projects, beyond obtaining space, is identifying ways to distribute horizontal communications cable within an older building. Pathways not designed into the original facility now need to be carved out of spaces that, at times, simply do not exist. One of the most common methods is to extend a cable tray or support system down a hallway or through the rooms on one side of a hallway. Tray systems above the ceilings of an existing building are sometimes difficult to install due to the large amount of varied equipment already placed in that limited space. Existing ductwork, piping, lighting systems, and wiring can make it difficult or impossible to install large sections of cable tray without unintentionally demolishing the ceiling material. Given sufficient funding and support, the installation of a tray system in conjunction with a ceiling and lighting retrofit project is a very attractive way to resolve this problem. Without that level of support, the following methods may be employed to install a hallway distribution system:

- If the ceiling is fixed or has limited access, it may be possible to install a series of additional access hatches positioned to permit the installation of cable tray or other support structures and thus provide technicians access to install and support cable placement.
- A portion of the ceiling may be removed and replaced after installation of the tray system. This is useful if there is a physical division between ceiling sections that will permit such work without creating a visible division after installation is complete. It is important to provide sufficient clearance to allow technicians on-going access to the horizontal pathways in the future.
- A wire way may be installed down corridors and painted to match existing conditions. This alternative becomes a problem when attempting to transition into the space on the other side of a hallway. The wire way needs to be very thick in order to support the minimum bending radius of high-speed copper cables. Campus planners often eliminate this alternative based on aesthetics, but it is a viable option if needed.
- An alternative to the wire way approach is to utilize an extruded molding, generally aluminum, designed to look like an architectural cove molding. This material is available in a variety of sizes and styles and is left open for the placement of future cable. The downside is a lack of security for the cable and a limitation on the amount of cable that can be installed. However, it is reasonably easy to place additional cable over time.
- In cases where surface mounted cable raceway is necessary to provide a pathway, it is important to select a product which provides cable support and routing for CAT 6 or better cables (no sharp bends) and has adequate capacity for both the initial installation and future growth. Generally, metal conduit or non-metallic raceways should be used within labs and classrooms due to the need for additional protection and the ability to secure the product. Heavy duty non-metallic surface mounted raceway plastic is a good choice for general usage in staff offices and administration spaces.
- In fire rated corridors, the designer must develop a specific plan for penetrating and restoring the ratings of walls, floors, and ceiling spaces in those corridors. That includes a method to allow technicians to continue to adequately firestop these penetrations over the life of the facility.
- The use of individual independent non-continuous ceiling support systems (e.g. j-hooks) hangers to suspend multiple varieties of copper, fiber, and coaxial cables within the same hanger support is not acceptable. Individual non-continuous supports, hangers, or stacked systems hangers must be provided to support each type of media to be installed. With newer media, the weight of even a very few cables can, over time, cause kinks or bends resulting in performance problems. Currently available cable support products designed to be suspended from ceiling

hangers, threaded rods, beam clamps, or wall mounts should be specified. Such products must be rated by the manufacturer as to the number and type of cables they will support and the maximum allowable distance between supports. Generally, such supports should be placed no more than three to five feet apart, providing capacities of up to a few dozen cables. The distance between supports shall be varied to reduce harmonics and maintain the minimum level of structured cabling system transmission performance requirements.

3.4. Summary of Key Design Considerations and Requirements

- Providing dedicated electrical service for telecommunications spaces is specifically designed to reduce or eliminate power-related problems while providing clean power and capacity for current and future applications.
- The telecommunications grounding system must be designed and installed as defined in ANSI TIA/EIA-607 and all relevant electrical codes. The designer must use a common point of ground for all services (power and telecommunications) within the same building.
- Any telecommunications space designed to support electronic equipment requires a dedicated air handling system to maintain positive air pressure, and remove heat 24 hours a day/365 days a year.
- Telecommunications pathways must be designed as a specific part of an overall telecommunications plan for the building. Current use is not the only design requirement for pathways, ease of access to accommodate future growth and capacity should also be considered. The entire life cycle of the building shall be considered.
- All telecommunications related infrastructure design must be based upon published industry standards such as the TIA/EIA series or BICSI standards. Vendor-specific requirements must be analyzed in light of an overall “standards based” approach.

4.0 PART 4 – Media Systems Design

This section of the Standards outlines specific media (i.e., copper, fiber optic, and coaxial cable) configurations and systems required to support the distribution technology requirements of CSU facilities.

4.1. General Considerations

4.1.1. Introduction

The types and configurations of telecommunications cable vary among CSU campuses based on local conditions, installed technology or vendor-specific products, and personal experience. This section of TIP identifies a standard design approach centered on evolving industry standards for voice, data, and video communications transport media. Section 4 is not intended as a tool to preclude a campus from developing its own unique solutions to support specific requirements, but does establish baseline standards for the selection, design, and deployment of services universal to all CSU sites.

The components discussed in this section are divided into three major groups:

- Twisted pair copper cable, both indoor and outdoor
- Optical fiber cable, both indoor and outdoor
- Coaxial cable, indoor only

Any use of manufacturer brand names in this document does not suggest that these are the only providers of a particular component or that they are specifically recommended by the CSU. To the contrary, the TIP Standards' intent is to convey the CSU's strong expectation that designers will specify sound products meeting published standards rather than on solutions designed around a particular vendor product, technology, or proprietary standard.

4.1.2. Cable Components

The EIA/TIA standards place cables into two distinct categories: backbone, and horizontal. "Backbone cable," regardless of media type, is defined as the cable that connects telecommunications rooms, entrance facilities, and/or equipment rooms within or between buildings. This definition includes cable formally known as riser or tie cable, and outside plant cable.

"Horizontal cable" is the cable between the actual user outlet (known as the telecommunications outlet or work area outlet) and the cross-connect termination. As a practical matter, the term "horizontal cable" includes the outlet, connector, and cross-connect. The term "cross-connect" refers to the component(s) enabling cable to be terminated and interconnected or cross-connected to other cables.

In addition to backbone and horizontal cable, this section of the TIP Standards provides information on cross-connect components, distribution systems, outlet and modular jack hardware, and cable management and support systems.

4.2. Copper Cable Systems

This subsection defines the minimum acceptable configurations for copper cable on CSU campuses. It specifically identifies the acceptable intra- and Inter-building backbone cables and provides criteria for selecting the appropriate horizontal copper cable.

4.2.1. Inter-building Backbone Copper Cable

Inter-building backbone copper cable (most commonly OSP cable) must support a variety of voice-grade applications, as well as a range of signal and other low-speed data services. In addition to stand-alone voice systems, CSU campuses use this cable to support point-to-point circuits for signal and control systems, radio and alarm connections, dedicated communication links, and emergency telephone and reporting systems.

4.2.1.1. General Design Requirements

With the continuing implementation of VoIP systems, the trend toward combining multiple applications into a single high-bandwidth network, and the increased use of optical fiber, it is no longer a given that large copper cable plants are considered a base requirement. Campus planners and design consultants must carefully analyze both existing and projected applications and technology to develop an adequate mix of Inter-building copper and optical fiber cables.

In addition to standard phone lines, these copper cables also carry circuits for services such as emergency telephones, non-campus telephone services, alarm and control circuits, radio system uplinks and other telephone utility lines that may not be directly managed or supported by the campus telecommunications services.

Even though many new distributed systems use primarily optical fiber to interconnect nodes, Inter-building copper cable is still a viable method of providing services from the node to the buildings and on to individual users. This cable is generally available in a variety of configurations from several sources. The CSU TIP standards for Inter-building backbone copper cable are as follows:

- 24 AWG should be used for cable runs up to 2,500 feet, and 22 AWG for longer distances.
- Cables of different wire gauges should not be spliced into multiple sections of a single run. A single gauge cable should be maintained for each cable end to end.

- Plastic-Insulated Conductor (PIC) cable with color-coded 25-pair binder groups protected by a shield and heavy outer cover should be used in all outdoor locations.
- Cables of 900 pair and larger must have the sheath bonded to the wrap to reduce the potential for kinking and damage to the cable during placement.
- All cables placed in an outdoor environment must be constructed with water-exclusion gel, even if only a portion of the cable may be exposed to moisture.
- As per NEC Article 800, OSP cable entering a building cannot extend more than 50' into a building and then must terminate in an enclosure or a primary protector.
- The use of aerial cable is not recommended under this document. Use of aerial cable is at the discretion and sole responsibility of the local campus.

The selection of cable construction and sheath type are driven by the environment in which the cable will be installed. Generally, outdoor backbone cable used on a CSU campus is not to be placed in a hazardous environment; it is contained within conduit or a combination of tunnel and conduit.

The greatest threats to the long-term life of outdoor cables are damage caused during cable placement, theft, accidental physical damage during building construction or during the placement of other utilities, and exposure to moisture. CSU designs should employ water-exclusion gel-filled cable, which will significantly reduce problems with moisture over the life of the cable.

Designers are expected to select the appropriate cable sheath and specify construction techniques limiting the possibility of damage during placement or ongoing use. Pathway design strategies should also address potential future physical damage concerns.

Backbone copper cables are available in a variety of configurations in sizes from 12 to 4,200 pairs. The largest size cable generally utilized in a four-inch conduit (within the CSU) is 1,200 pair (assuming a standard bonded sheath, 24-gauge, ASP cable). There are cables on the market that allow 1,800 or more pairs to be installed in a four-inch conduit, but CSU telecommunications planners and designers should assume a maximum of 1,200 pairs per four-inch conduit.

Large cables are generally available only in relatively short lengths (500 to 750 feet). These short lengths must be taken into consideration when planning new infrastructure facilities, to ensure that pathway distances do not exceed the available products.

4.2.1.2. Cable Sizing

Determining the number of pairs required to serve a new building is a rather straightforward process, but one which must be based on a solid understanding of the current and future load (number of users) in the facility. Assuming the greatest use of copper cable into a building will be to support voice telephone service, it is reasonable to use one-and-one-half to two pairs per work area outlet (or telephone) as the maximum number of pairs required to support the majority of telephone systems on the market today. The designer is responsible for determining the projected number of users (and potential user areas) and the number of miscellaneous pairs needed for “special” circuits to determine a starting point for the sizing process.

If the number of current and potential users is not known, cables should be sized to provide 1.5 or 2 pair for every 125 assignable square feet in a building as a starting point. From there, the designer should add pairs for known applications, such as monitoring and control equipment, security systems, and electronic key access. Once a total number of pairs has been determined, the designer should assume no more than 85% of the pairs will be usable over the life of the cable and round up to be the nearest generally available cable size; 100, 200, 300, 400, 600, 900, 1,200, 1,500, or 1,800 pairs.

The designer must focus on developing a reasonable forecast for each building and each

Backbone Copper Cable Sizing Example

50,000 ASF building

$50,000 \div 125 = 400$ work areas – *ASF divided by work area size*

$400 \times 1.5 = 600$ pairs – *Work areas times average pair usage*

100 pairs for miscellaneous services – *Known or assumed figure*

$600 + 100 = 700$ pairs – *Subtotal of actual pairs required*

$700 \div .85 = 823$ pairs – *Cable life allowance for problem pairs*

floor of each building. Obviously, the best manner in which to develop a cable design is to fully understand the needs of the users and the potential applications to be supported. While installing sufficient cable to meet only an initially defined application will result in too few pairs for the long-term use of most facilities, installing the maximum pair count into every building is expensive and unnecessary; neither strategy is acceptable to the CSU. The designer must factor in the range of applications and needs that are likely to require support over the useful life of the installed cable, not the building.

Installation of new cable, perhaps even a new medium, can reasonably be expected over the building’s useful life span.

If the designer focuses only on an assignable square foot algorithm, specialty facilities, such as libraries, sports complexes, and performance centers, would end up with backbone copper cables of enormous size with very little actual requirement. Conversely, a small building may house a help desk application or a call center that requires a significantly higher work area density than the assumed 125 square feet. The CSU's expectation is that the designer will obtain or develop information that will result in the most accurate forecast reasonably possible for each facility being considered.

For campuses that have or will be migrating to a VoIP system, the OSP copper cable requirements are significantly reduced. Traditional analog voice services may be limited to fire and/or burglar alarm, fax machine, or other legacy voice-based systems. With these uses, it is reasonable to expect that even the largest facilities would be well served with as little as a 100 pair cable. However, the design team is expected to examine each project based on the local campuses needs and expectations as well as the extent of the campus VoIP deployment.

4.2.1.3. Cable Protection

Cable protectors are used in conjunction with proper bonding and grounding to provide electrical hazard protection to personnel and to sensitive electronic equipment.

All copper cables running between buildings and/or cables terminated outside must be equipped with an entrance protector on each end.

There are two primary types of protector panels. The first consists of the protector field and an integrated cross-connect terminal. This product is most often used on smaller pair count cables, such as in installations of less than 900 pair. This type of product allows cross connect wires to be interconnected with backbone (riser) or station cable without other components.

Any location with 900 or more pair should be served by wall or rack mounted protectors that are separate from the cross connect terminals. These large pair count configurations provide connection points for multi-pair testing, and the separate cross-connect fields can be incorporated into high density double-sided systems serving up to 7,200 pairs per group.

Any facility that requires termination of more than 3,600 pairs must be specifically designed using methods applicable to main distribution frames and central offices.

Both types of protector panels use the same type of protectors. The TIPS recommendation is to use fast-acting, 3 element (5 pin) gas-tube units with sneak current (low voltages) protection. All copper cable pairs placed into a facility must be equipped with protectors, not simply the ones expected to be activated in the near term.

As “special” voice application circuits become the bulk of the use on UTP cable, careful attention needs to be paid to the voltage rating of the fuses compared to the service being used on the given circuit.

4.2.1.4. Splice Cases

New cables should be designed to run point to point with no splices placed outside or underground. In the occasion where an outside splice cannot be avoided, such as repair to an existing cable, all splices must be contained within a splice case. All outdoor (vault and tunnel) splice cases should be encapsulated or pressurized, re-enterable units fully dressed and enclosed to fit the number and type of cables terminated. All end plates must be designed for the number and size of cables served by the splice case and designed to seal around each cable individually. The designer must select and specify an appropriate splice case when installing copper cable systems. Individual splice cases are designed for specific environments, including use in vaults, underground direct-burial, above-ground pedestals, use within a building, or mounted on a pole. Inferior products, inadequate installation techniques, or incorrect use of a particular product can lead to moisture leaks and ultimately cable troubles and are unacceptable.

All filled cable must be connected to air core cable within a sealed splice case prior to termination of the entry pairs. In no case shall a filled cable be directly terminated on a backboard. All entrance cables must utilize a splice case rated (by the NEC) for use in those situations.

Outdoor vault and tunnel splice cases should be stainless steel or heavy neoprene. Indoor cases used to terminate Inter-building cable filled with water- exclusion gel must also be capable of completely sealing around all cables at each end of the case and must be rated to contain a filled entrance splice. Splices of 25 pair or more must utilize 3M 710 splice modules for connecting cable pairs. Cable shields must be bonded through all splices and must be grounded as soon as possible upon entering a building or on any floor in which pairs leave the sheath on backbone (riser) cables.

4.2.2. Intra-building Backbone Copper Cable

The Intra-building backbone copper cable connecting a building’s service entrance to individual telecommunications rooms on various floors must be shielded copper sized to meet known or anticipated requirements and installed following BICSI installation guidelines. The general configuration of these cables should be as follows:

- CMR (riser) rated.
- 24 American Wire Gauge (AWG) with staggered twists and a mutual capacitance of not more than 19 nF per 1000 feet.
- The maximum length of the cable is defined by the application and technology to be supported (not subject to the 90-meter limitation).

Each telecommunications room will generally be connected to a building's service entrance facility with backbone cables sized to provide two twisted pair to each potential telecommunications outlet location, or three pair for every 125 assignable square feet if the number of outlets cannot be reasonably projected. These cables are extended from the service entrance facility directly to the telecommunications room on each floor either by placing dedicated cables or, in the case of larger multi-story buildings, placing large pair count cables to an upper floor, then splicing one or more smaller cables to serve floors above and/or below the splice point.

It is essential to use a properly grounded and shielded cable in the Intra-building backbone to lessen the impact of electrical and electronic interference. These backbone cables often carry both voice and special data circuits and require good installation techniques to reduce the potential for performance problems. Using a shielded cable that is improperly grounded or not grounded at all increases the potential for interference in the cable. Backbone cables should be grounded at the point of origination and at any floor in which pairs leave the cables sheath.

4.2.3. Intra-building Horizontal Copper Cable

The CSU network standard is 1 gigabits per second Ethernet Local Area Networks (LANs), and most campuses are moving to the implementation of 10 gigabit per second backbone network connections. To assure proper performance, system design and installation according to recognized industry standards are critical. With an eye to future growth and network performance, designers and engineers shall specify at a minimum Category 6 or higher cabling for new telecommunications installations. The CSU expects design consultants to be conversant with the underlying issues leading to such change and to employ their professional skills to minimize deleterious future impacts on the viability of University facilities.

The prevailing CSU standard for horizontal copper cable systems is as follows:

- Each user outlet will be served by three (3) twisted pair cables. For Campuses with an existing VoIP implementation of any scale, this requirement can be reduced to two (2) cables and utilize the “thru” port on most VoIP phones to make use of two devices on one cable/switch port.
- Typically, one of the terminated station cables will be used for telephone service and the two (2) remaining terminated station cables will be used for data services, although there may be other campus options. All station cables are terminated in the TR to modular patch panels or a wall field designed for the type of cable installed.
- All horizontal cable is to be plenum rated (CMP).
- All cable systems are to be installed following BICSI, EIA/TIA, and manufacturer guidelines with a special emphasis on bend radius, termination methods, and support and bending limitations.

- All horizontal copper cable is limited to lengths of not more than 90 meters (295 feet).
- All terminating components must meet or exceed industry standards for the type of cable installed, as appropriate.
- 8P8C modular jacks are to be wired using the EIA/TIA-568B configuration unless the campus standard stipulates otherwise.

4.2.3.1. Work Area Outlets

Work area outlets vary dramatically campus-to-campus in terms of size, configuration, placement, and layout. Other than making an effort to ensure these outlets are designed as integral parts of the overall high-speed link and provide the necessary transmission parameters, there is little reason to replace working equipment simply in an attempt at standardization throughout the system. There are, however, minimum standards that must be used for new construction and substantive remodels.

Standard work area outlets should include a multi-position jack faceplate and three (3) four-pair copper cables.

Special use outlets should be equipped with copper, fiber optic, and/or coaxial cable as defined by planning guidelines.

Outlet boxes should be 4 11/16 inches square by 3 inches deep, with a least one 1¼ inch knockout. The faceplate must provide a surface suitable for placing an identifying mark next to each jack or connector, not simply a single identifier for the faceplate.

Connectors for fiber and/or coaxial cable should be recessed or angled in the faceplate to reduce the potential for physical damage.

The CSU standard is for the termination of the four-pair station cables in separate 8-position 8-conductor modular jacks (i.e. 8P8C, RJ45). Station cable should not be split, i.e., terminated on two separate jacks, to routinely meet multiple service needs. Any design that requires the horizontal cable to be terminated more than once will lead to performance difficulties over time, and different configurations of this type are very difficult to maintain over the life of the system.

A significant issue with work area outlets and horizontal cable is the use of modular furniture. Much of the modular furniture available today is either designed to support, or has optional raceways to support, high-speed telecommunication cable.

Unfortunately, many installations do not take into consideration the need to link the modular furniture to the distribution system or to support ongoing moves, adds and changes (MACs). Due to this, modular furniture layouts that conflict with telecommunications outlets and furniture feeds shall include an access panel that

provides clear and unobstructed on-going access to the wall where the serving telecom facility is located.

Modular furniture must be designed with a specific telecommunications interconnection in mind rather than simply assuming that a connection method similar to the electrical service will be used. For example, a single floor outlet box will often be sufficient to serve only two user locations due to the size of the feeding conduit and the number and type of cables to be installed. Without proper planning, this situation may be overlooked, and modular furniture designed to seat four or even eight people will be linked to the horizontal distribution system by only a single poke-through floor appliance or a single ¾ inch flexible whip to a wall box.

Horizontal pathway and cabling must be specifically designed from the telecommunications room to the consolidation point or MUTOA (if used), through the furniture interconnection point and raceway system, to the user's work area outlet.

The transition from horizontal pathways to furniture shall not be obstructed by the furniture, unless an access panel in the furniture is provided.

4.2.3.2. Cross-Connect Equipment

Cross-connect equipment is the point at which horizontal cables link to backbone cables or network equipment. Typically, in a telecommunications room, voice circuits will be interconnected to backbone cables extending to a voice switching node or central switch site. Data circuits typically interconnect with network equipment within the telecommunications room.

While it is understood that many CSU campuses may still operate and maintain legacy infrastructure terminated on 66- and 110-style blocks, it is recommended all new infrastructure be installed and terminated on rack mounted 24 or 48 port patch panels inside Telecommunication spaces. In some cases, tie-cables may be installed between the wall field and Telecom racks when both systems are employed, or to make connections between analog services and the horizontal cable.

The preference to utilize wall/rack mounted 66- and 110-style blocks shall be at the discretion of the local campus' ICT design representative.

Cables designated to support only voice-grade services can be terminated on insulation displacement connector (IDC) terminals based upon the existing campus standard.

(Note: 66-style blocks should only be used for specific analog applications, and only at the campus discretion.)

4.2.3.3. General

Cable slack must be provided above the work area outlet and above the telecommunications room termination to allow rearrangement of cable within a five foot radius. All installed cables must have 3 feet or more of slack loop at each end to facilitate testing and long-term maintenance.

4.2.3.4. Patch Panels

When multiple patch panels of 24 or 48 ports are provided, each patch panel should be placed with a horizontal wire manager directly above and below the panel as outlined in the manufacturer's installation instructions. Additionally, when angled patch panels are used in conjunction with adequately sized vertical side wire management, horizontal management may be incorporated above the first patch panel and below the last patch panel in the termination field. This configuration may assist in maximizing vital rack space for future growth.

4.2.3.5. Wall Mount Terminations

Wall-mounted IDC terminations must be equipped with wire raceways specifically designed to support the placement and maintenance of cross-connect wire. Wall-mounted terminals should generally be placed from left-to-right on a wall, with station cable above the cross-connect wire holder and backbone (riser) cable below.

The RJ-45 patch cord typically employed for voice services is placed between the telephone patch panel and the station patch panel

A coloring method for providing visible identification cues for Patch cords, RJ-45 jacks and faceplates that identify the cables use or termination point in the cabling infrastructure is recommended.

It is recommended that Infrastructure used to service fire alarm panels should be distinctly colored with red Patch cords, RJ-45 jacks and faceplates.

In configurations above 3,200 pair (such as in the MDF or in an equipment room with a switching node), a detailed plan for patch cord placement must be developed, and consideration should be given to using frame-mounted double-sided racks.

For VoIP campuses, the station cable that is designated for "voice" use should be treated as a data cable and should be organized as such. Discretion is left to the individual campuses on how to differentiate the VoIP and workstation data cables. With the migration to larger diameter station and patch cables, consideration needs to be given to the use of larger wire managers within the equipment racks.

The recommendations for terminating horizontal data cable are as follows:

1. Where possible, patch panels should be mounted in a rack designed to support interconnection with active equipment.
2. Generally, multiple patch panels of 48 ports or less should be specified rather than single large units to provide greater options for placing and managing patch cords.
3. Each patch panel must be placed with a patch cord wire manager directly above and/or below it as outlined in the manufacturer's installation instructions.
4. Each group of patch panels must have additional wire management mounted vertically and horizontally to support the use of multiple patch cords.

4.2.4. Copper Patch Cables

Patch cables are generally defined as a specific length of cable terminated at each end with a plug or socket. For CSU purposes, they are typically employed at the extremities of fixed horizontal distribution cabling to connect either to end-user desktop equipment or to network devices in telecommunications spaces.

Since patch cables are considered part of the horizontal "link" in structured cabling and inadequate interoperability with other link components can adversely affect overall system performance, they must be specified to meet industry standards in all respects.

It is recommended that the standard deployment of patch cords be no more than 15 feet in length, and that any application that requires anything longer be a special situation that must be considered by IT personal and never expected as part of the planning process.

While campuses may realize significant cost savings with the use of non-listed or generic patch cords, they offer a significant amount of reduction in usability and performance constancy due to lower manufacturing standards and designs. Because of this, it is recommended that campuses use patch cords from the brand name manufactures.

When performing a channel test, it is required to utilize a jumper length of 3 feet. This ensures the manufactures warranty is covered from end to end.

It is further recommended that campuses purchase patch cables that are serialized, or that campuses add serialized labels during the installation process.

4.3. Fiber Optic Cable Systems

Fiber optic cable is used to support voice, data, and video systems in a wide range of installation configurations throughout the CSU. Costs for fiber optic-based systems continue to decrease, while the growing number of supported applications and the increase in available cable types make fiber an ever more reasonable media of choice for numerous campus applications.

4.3.1. Campus Specific Fiber Design Considerations

This section specifies basic requirements and guidelines, however the decision process around what type of fiber (SingleMode, Multimode or both) to specify depends greatly on local conditions and planned use.

4.3.2. Singlemode Fiber Cable Selection

Singlemode optical fiber cable is used to support bandwidth and distance requirements exceeding multimode's capabilities. Data rate transmission in excess of 10Gb/s range is common.

Minimum bandwidth of OS1 singlemode optical fiber cable is not characterized in the same manner as multimode. The bandwidth of OS1 optical fiber cable presents no practical limit. Loss characterization is 1.0 dB per km at 1310 and 1550 nm for indoor cable and 0.5 dB per km at 1310 and 1550 nm for outdoor.

Minimum bandwidth of OS2 singlemode optical fiber cable is not characterized in the same manner as multimode. The bandwidth of OS2 optical fiber cable presents no practical limit. OS2 optical fiber is characterized by a loss of not more than 0.4 dB over its operating range of 1310 and 1625 nm as defined in ITU-T G.652.D, for both indoor and outdoor, typically using low water peak SMF.

Designers should plan to install OS1/OS2 singlemode optical fiber cable for interbuilding and intrabuilding backbones on all new CSU Projects; however, the standard may be modified by local campus ICT representatives to meet existing conditions and future needs.

4.3.3. Multimode Fiber Cable Selection

50/125 μm multimode fiber optic cable is used to support 1000BASE-SX (Gigabit Ethernet using the less expensive LED transmitter) for distances up to 550 meters. 62.5/125 μm cable can only support 1000BASE-SX for 220 meters. There are two types of 50 μm multimode cable, Standard and Laser Optimized (LO), or OM2 and OM3 (62.5 being OM1). Industry wide, both OM1 and OM2 cable have become obsolete and should not be considered for new CSU installations. As performance parameters call for higher transmission speeds, the industry has differentiated further the LO 50 μm cable to OM3 and OM4.

If multimode fiber will be used in addition to singlemode, designers should plan to install Laser Optimized 50/125 μm multimode fiber within buildings on all new CSU projects. There is no reason to replace existing 62.5/125 cable with the 50 μm product.

4.3.4. Connectors and Couplers

There are two general groups of fiber optic connectors on the market today: traditional-sized connectors, and those with the small form factor (SFF). The traditional connector group includes devices such as the SC and ST. Both SC and ST connectors are commonly found in existing implementations on CSU campuses. There are few reasons to change an existing connector that is functioning correctly. Jumper cables can be fabricated with different

connectors on each end to allow linking dissimilar components, usually referred to as hybrid cables.

Small form factor connectors offer a greatly reduced footprint, similar in size to the RJ45 copper cable jack. There are several types of connectors within the SFF group, but by far the most commonly used is LC. New fiber installations, unless specifically indicated at a campus level, are to use the LC type connector.

4.3.5. Fiber Optic Patch Panels

With the growth expected in the use of optical fiber cable, good planning is essential to ensure a workable distribution and interconnection layout in all telecommunications spaces. The recommended approach is to use rack mounted patch panels capable of terminating 72 strands. By standardizing on a single size unit, it becomes easier to manage and maintain all aspects of the terminals and cross-connect hardware.

Small wall-mounted 12 to 24 strand optic panels should not be used except to terminate a very limited number of optics in locations where further growth is unlikely.

Multimode and single-mode optical fibers must be installed in bulkhead connectors, commonly referred to as adapter plates. Backbone cables and horizontal cables must be housed in separate panels or as specified in the campus standard.

Jumper cable management becomes a critical component on large fiber installations. All patch panel designs must include both vertical and horizontal wire managers designed specifically to route cables from panels, through the racks, to equipment or other panels. The design must also make allowances for storage of cable slack in such a manner as to protect the cable without restricting access to it for ongoing maintenance.

4.3.6. Inter-building Backbone Fiber Cable Topologies

Each building on campus should be connected to a main campus distribution point. There are two overall design concepts for a master fiber plan:

- Hierarchical Star and Multiple Hierarchical Star
- A hierarchical star topology approach in which all fiber radiates from one central space, such as the MDF, to each building on campus.
- A distributed node approach (multiple hierarchical star) in which fibers extend from individual buildings to a concentration point or node location. Each node is then connected to a central point, such as the MDF
- In both cases, the facilities must be designed to support both point-to-point systems and point-to- multipoint, or loop, systems. This is generally accomplished by installing cable and by providing adequate support hardware such as splice trays and patch panels. The node approach also allows specific systems to be installed in a “ring” manner, providing a fault-tolerant design and allowing a properly configured system to continue to function in the event of a break in the fiber ring.

- The fiber run size numbers shown here are minimum requirements, to be used whenever actual campus needs are not known or cannot be reasonably defined. Common sense must play a role in sizing these cables, and there will be cases in which other configurations should be used. For example, individual animal sheds without power probably don't need fiber optic cable.
- Conversely, animal sheds used to monitor livestock may very well need fiber optic cable to link automated systems. At the other end of the spectrum, a central computing resource and a video head-end retransmission facility will each require additional fiber to serve known and projected applications.
- Each building should contain an additional 40-foot section of optical fiber cable, neatly coiled in a maintenance loop and secured before reaching the final termination point, which can be utilized as splicing slack in the event of a cable break. When placed in a conduit or a vault, fiber optic cable should be installed within an orange, 1 in or 1.25in innerduct. In respect to air-blown systems color and design may be proprietary. Within a building, the use of innerduct is required only if there is a concern the cable is susceptible to damage or may be mistaken for another medium.
- There are different types of backbone cable construction suitable for use on campus. Generally, outdoor cables should be:
 - Water exclusion (gel-filled or other at campus discretion), dielectric, loose tube construction with a tensile strength of 600 lbs. (long term).
 - Hybrid single mode and multimode cables of a common size to reduce costs and improve duct utilization.
 - Specialized indoor-outdoor cables are available that are constructed of materials suitable for use both outdoors and are NEC rated for use as a backbone (riser) cable within a building. The use of these cables can eliminate a splice point in the cable and reduce the cost of installation.
 - Outdoor splices are not allowed in new installations. Splice locations should be kept within buildings, where they can be protected yet accessed by authorized staff; in this manner, the fiber design will provide a great deal of flexibility without the high cost of dedicated cable runs to every building. The distance limitation of 300 meters for 10Gig transmission on multimode fiber should be taken into consideration when planning new building backbone.
 - Final termination style may include direct termination or pre terminated fusion spliced pig tail kit.

4.3.7. Intra-building Backbone Fiber Cable

SingleMode fiber optic cable should be installed in all building telecommunications (riser) rooms, with the option of also installing multimode fiber optic cabling. A typical minimum backbone optical fiber cable installation might normally consist of twelve (12) SingleMode fiber strands and Twelve (12) multimode fiber strands to each telecommunications room from the building's main TR or service entrance facility. As was mentioned at the beginning of this section, these requirements should be adjusted to meet local requirements and

needs. These cables should be "home-run" (a direct run with no splices) between telecom rooms. If any potential for physical damage exists, all fiber cables should be contained within innerduct, and all cable should be clearly marked as optical cables for additional physical protection.

Location Type	Fiber Strands
Remote Outdoor Location	12 Strands
Small Building	24 Strands
Typical Building	48 Strands
Large Building	96 Strands

All fiber backbone cables must be OFNR or OFNP rated, tight buffered, fan-out cables with a dielectric central member and must carry a crush resistance rating of at least 1100 lbs. per inch. Cables must have a 900 µm buffer and meet performance characteristics as defined in ANSI/ICEA S-83-596.

4.3.8. Intra-building Horizontal Fiber Cable

Horizontal optical fiber cable is regularly used in telecommunications outlets as a standard component in today's designs. It offers significant advantages over copper in terms of information-carrying capacity and is becoming easier to install with every new change in the industry.

For horizontal applications, the TIP standard is to use 50 µm multimode optical fiber cable optionally terminated in LC connector at the work area outlet end. The telecommunications room end should be terminated in frame-mounted panels with no more than 72 dual optical cables per panel, using the campus-defined duplex connectors installed with a common polarity. All installed cables must have 3 feet or more of slack loop at each end to facilitate testing and long-term maintenance.

4.4. Coaxial Cable Systems

Although not currently utilized as much as it was just a few years ago, coaxial cable still plays an important role in the distribution of multi-channel video programming within buildings on many CSU campuses.

General information regarding coaxial cable is included in this document; however, it is for information only, and is not a required part of the CSU TIP Standard. With many campuses

shifting to the use of digital imaging and alternative methods of transmitting video and audio signals, the decision to implement coaxial cable is now a matter for planning personnel at individual campuses.

This document assumes that the most frequent use of coaxial cable is the distribution of multi-channel video signals (using cable television technologies) within campus buildings. Coaxial cables are still used for a variety of services, such as radiation antennas for wireless systems, direct links to satellite antennas, cable TV, and radio transmissions. Each of these systems requires unique cabling engineered to meet the demands of a specific system, site, and application; and an analysis of that subject is beyond the scope of this Standard. Programming discussions with campus representative is encouraged to ensure that no design methods are missed.

4.4.1. General Design Considerations

Although TIP recognizes there are a variety of technical alternatives for distributing multichannel broadband television signals, the design concept assumed for discussion herein is as follows:

- Signal outputs from local service providers, campus programming, satellite feeds, and other sources are balanced and combined into a common feed for a fiber optic-based analog cable television transmission system consisting of one or more laser transmitters.
- The output of the transmitters is fed into optical splitters either at a single head end location or in a multiple node arrangement.
- Each optical splitter, such as an eight-port unit, is constructed to provide a specific level of signal loss and is connected to a backbone SingleMode fiber cable feeding an individual building.
- Each building is equipped with a fiber receiver that accepts the incoming fiber-based signal and converts it to a broadband radio frequency (RF) signal. The RF signal is fed into a standard coaxial cable-based RF distribution system consisting of amplifiers, splitters, couplers, and multiport taps.
- The RF system is distributed in most buildings by using a trunked distribution system with 75-ohm half-inch (.500) coaxial backbone cable and quad-shielded RG6, plenum rated if required, horizontal station cable.
- The actual design of the television distribution system is beyond the scope of this document and should be undertaken only by a qualified video design engineer. However, the campus CATV distribution system, including all active and passive devices, is considered a basic component of the campus telecommunications infrastructure and must be integrated into any infrastructure design. This includes all components from the work area outlet

- The distributing system must be designed to average 3 dB or more to every station location. The multiport taps should be designed with no more than half of the taps used in the initial design. Additional taps must be provided throughout each floor of each building to allow for growth without redesigning the distribution system.
- Video that originates in a classroom or other facility can be economically transmitted back to the campus head end for storage or retransmission by using low cost multimode fiber optic transmitters. There are several units on the market that include one or more quality audio channels and a “broadcast quality” video signal over the same fiber.

4.4.2. Summary of Key Design Considerations and Requirements

- Category 6 unshielded twisted copper cable is the CSU standard for horizontal copper cable systems within new construction or renovation projects. All cables must be installed as specified by the appropriate structured cabling system warranty.
- The CSU standard outlet configuration is for a minimum of three four-pair stations cables on individual modular jacks.
- The use of Singlemode and (optionally Laser Optimized 50/125 μm multimode) fiber within and between buildings is recommended on all construction projects. These Standards also recommend the use of LC connectors for the termination of all fiber optic cables.
- The Inter-building backbone fiber system must be designed to support both a point-to-point (star topology) system and point-to-multi-point (mesh topology) system.
- The Inter-building backbone copper media system must be designed to support a point-to-point (star topology) system
- Inter-building copper and fiber systems are to be installed point to point, contiguous from building to building, with no splice points.

5.0 TIPS Appendix A - Telecom Drawing Symbols

Standard Location Based Symbols for Outlets

	Standard Wall Outlet @ 18" AFF	3 cables by default, no specific use indicated
	Standard Wall Outlet @ 18" AFF	3 cables by default, specifically cabled for data use Standard
	Wall Outlet @ 18" AFF	3 cables by default, specifically cabled for voice use
	Ceiling Mount Outlet	2 cables by default, specifically for voice
	Ceiling Mount Outlet	1 cable by default, no specific use indicated
	Ceiling Mount Outlet	1 cable by default, specifically cabled for data use Ceiling
	Mount Outlet	1 cable by default, specifically cabled for voice use
	Floor Outlet	3 cables by default, no specific use indicated
	Floor Outlet	3 cables by default, specifically cabled for data use
	Floor Outlet	3 cables by default, specifically cabled for voice use

Additional Details For Outlets

	# and Type of Cables	A number indicates a specific number of cables different than the default number of cables (as defined above, and by the TIPS Documents). A number prefaced by C indicates a specific quantity of Coax Connections. A number prefaced by F indicates a specific quantity of Fiber Connections.
	Specific Install Detail	W Wall Phone Jack @ 42" AFF (ADA) H Wall Jack @ +84 AFF (Security Cameras, LCD TVs, Etc.) WP Weather Proof AV Audio Video Cables (Specific use, Installed Point To Point) X Empty (Outlet with no cable, for future use)

Other Telecommunications Symbols

	CT Cable Tray		PB Pull Box (Size to be indicated on plan)
	J J-Hooks**		CB Ceiling Box (Typically For A/V Components)
	T Telcom Conduit		MB Media Box (Typically For A/V Components)
	T_ Telcom Conduit (Underground)		FB Floor Box (Typically Shared w/ Electrical)
	V Wiremold w/ Devices as Indicated		
	Conduit Turning Up		
	Conduit Turning Down		
	Conduit with Capped End		

Additional Device, Safety & Security Symbols

** If approved for use by the local campus

	EP Emergency Phone		Security Camera (Box Style)
	AP Wireless Access Point		Security Camera (Dome Style)

6.0 Change Control Log

Date	Change Description	Editor
3/21/22	Change Summary added and Change Control Log added	Matt Hughes