University of California, Santa Barbara

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COMMUNICATIONS

INFRASTRUCTURE STANDARDS

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1.0   Introduction and Background

Consistent with the types of issues encountered during the planning and implementation of Technology Infrastructure involving the higher education environment, the University of California Santa Barbara (hereafter "UCSB") has prepared the following planning document for the purpose of standardizing on a set of industry standard guidelines to be used by UCSB staff and design professionals in developing a standards-based approach for deployment of telecommunications cable infrastructure.

A. Introduction

This document has been prepared with input from UCSB staff, existing University Design Standards and Guidelines, the product vendor community and design consultants. The intent of this standard is to provide a standardized approach for the development of intra- and inter-building telecommunications infrastructure systems and is not intended to be the sole source of planning and design information but, rather a tool for defining specific telecommunications-related infrastructure requirements.

In general, this document provides direction for UCSB staff, facility planners, architects and other design professionals in the design and application of telecommunications media, pathways and spaces. Standards objectives are to:

- Provide for the consistent application of guidelines for inter- and intra-building infrastructure design and deployment;

- Define minimum standards for spaces, pathways, and telecommunicaions-related infrastructure for new building construction or remodeling projects;

- Outline specific media selection and design criteria;

- Highlight technical issues that must be incorporated into the design and procurement process;

- Define methods and procedures for installing, testing, and documenting cable and related infrastructure.

B. Architectural Implications

Although architectural and engineering (A&E) planning must be based on defined needs, the impact of changes in instructional technology and research and the increased use of telecommunications services must be viewed as a rapidly moving target. It is not reasonable 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 spaces for technology and pathways for telecommunications, the facility planner

– following accepted industry standards and best practices – can limit the cost of modifications that must be made during or shortly after construction by designing a space with maximum flexibility.

The following sub-sections identify some of the areas within the UCSB campus and administrative environment that will be impacted by the implementation and expansion of evolving telecommunication services**.**

1. Classrooms

All classrooms must be equipped with voice, data, and video services in a wide variety of structured cable configurations. Although not covered in this standards document, increased use of multimedia-generated displays require updated methods of providing support facilities (power and signal) from the instructor locations to room displays and beyond. Vastly improved methods of lighting, heating and cooling, and acoustical treatment, are needed to permit the successful integration of technology in the traditional classroom learning environment. For additional classroom design details, refer to the updated Classroom Standards Document.

2. Research Labs

In addition to "standard" classroom telecommunication services, research lab spaces require higher concentrations of communications services for student and faculty access. Adequately sized and re-configurable pathways must be provided for both communications and power during initial construction. Avoiding these pathway concerns would severely impact costs for mediations to existing facilities. Research labs must be designed to support the constant evolution of technology, equipment and student locations. In some cases these spaces must provide dedicated space to house standalone computing and network equipment, with an associated increase in electrical, cooling, and security services. These spaces may be heavily reliant on wireless networking in additional to standard wired connections.

3. Computer Labs

Similar to "Research Labs", these spaces require a higher concentration of both wired and wireless telecommunication services for student access. Adequate pathways must be provided for both communications and power during initial construction. Avoiding these pathway concerns would severely impact costs for mediations to existing facilities. Computer labs must be designed to support the constant evolution of technology, equipment and student locations. In some cases these spaces must provide dedicated space to house standalone computing and network equipment, with an associated increase in electrical, cooling, and security services. These spaces will be heavily reliant on wireless networking in additional to standard wired connections.

4. Libraries

Library facilities play a central role in the use and application of electronic information. Extensive support for both communication users and equipment is required at all levels, including public electronic access areas and other multimedia access points, and group research and study areas. In addition, library buildings frequently act as centers for:

- Instructional media production;

- Centralized and distributed computing;

- Specialized computing and/or training labs, and;

- Teleconferencing resources.

5. Common Areas

Common areas (i.e., cafeterias, lobbies, student bookstores, registration areas, etc.) must be equipped to provide expanded voice, data, and video services. Within these areas:

- Wall phones are as important as coin telephones and should be easily accessible. These phones can provide a variety of communications such as; links to voice mail systems, access to automated systems such as registration, and, campus security.

- Video monitors can be used to display the status of class registration, campus news or event announcements, or items of local or national interest.

- Information kiosks and electronic card access locations distributed throughout a campus can support on-going information, security, and purchase applications.

6. Conference Rooms

All conference rooms should 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 means all 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, acoustics, room design, and HVAC parameters, in order to establish an environment suitable for product life and effective use of the technology.

7. Machine Room

A machine room is defined as a communication space for separate business units to house network electronics and servers. These spaces must have dedicated power and cooling similar to a Telecommunications Room. Pathways into these spaces must be provided for both communications and power during initial construction. Avoiding these pathway concerns would severely impact costs for mediations to existing facilities. Machine rooms must be

designed to support the constant evolution of technology changes. Access to these spaces should be administered separately from typical Telecommunications Spaces. These spaces will have 24/7 HVAC requirements independent from standard building air.

8. Administrative and Faculty Office Space

Office spaces must be designed to support multiple technology configurations such as multi-media and communication outlets. 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 a faculty member to operate a new type of information device shortly after that infrastructure is installed, the design did not adequately support the concept of planning for the use of technology. At a minimum, there must be one voice and two data cables per workstation outlet.

C. Purpose of this Document

These UCSB Standards Documents have five main purposes:

- To inform the facility planner and other members of the design team of the types of technology that may be utilized in campus facilities;

- To identify the minimum infrastructure (i.e., pathways, spaces, and media) support required by each technology;

- To outline the standard media services that should be installed;

- To inform of other planning and technical design resources available to the design team; and

- To outline the broad range of faculty, staff, and students that will utilize the installed services.

This document is not intended to "provide all the answers" to telecommunications-related infrastructure design issues. The nature of this document is such that while providing certain specific solutions or design methods, the primary intent is to identify the range of components and issues covered by the telecommunications distribution requirements in an average building construction or renovation project. Most of the IT Standards are based upon various national standards, guidelines, and codes for telecommunications systems, such as those developed by the Telecommunications Industry Association (TIA), Institute of Electrical and Electronics Engineers (IEEE), National Electrical Code (NEC), and Building Industry Consulting Services International (BICSI). Utilizing information from these sources is generally more desirable than using specific manufacturer's proprietary designs that may quickly become outdated or may be incompatible with other needed equipment.

D. Glossary of Terms

The following information details common Telecommunications terms are standard language used in specifications and standards documents throughout the industry.

Adapter - A device enabling different sizes or types of plugs to fit with one another or into a telecommunications outlet.

Analog - A format that uses continuous physical variables such as voltage amplitude or frequency variations to transmit information.

ANSI - American National Standards Institute

APC Connector - Angled Polish Connector is polished on an 8 degree angle.

Armor - Additional protective element beneath outer jacket to provide protection against severe outdoor environments. Usually made of plastic-coated steel, it may be corrugated for flexibility.

Attenuation - The decrease in magnitude of power of a signal in transmission between points. A term used for expressing the total loss of an optical system. Attenuation is normally measured in decibels (dB) at a specific wavelength. Attenuation increases as frequency increases.

Attenuation Coefficient - The rate of optical power loss with respect to distance along the fiber, usually measured in decibels per kilometer (dB/km) at a specific wavelength. The lower the number, the better the fiber's attenuation. Multimode wavelengths are 850 and 1300 nanometers (nm); single-mode wavelengths are 1310 and 1550 nm. Note: When specifying attenuation, it is important to note whether the value is average or nominal.

Backbone Cabling - The portion of premises telecommunications cabling that provides connections between telecommunications rooms, equipment rooms and entrance facilities. The backbone cabling consists of the transmission media (optical fiber cable), main and intermediate cross-connects, and terminations for the horizontal cross-connect, equipment rooms and entrance facilities. The backbone cabling can further be classified as campus backbone (cabling between buildings) or building backbone (cabling between floors or closets within a building).

Bandwidth - Measure of the information-carrying capacity of an optical fiber. The greater the bandwidth, the greater the information carrying capacity in a given period of time. Frequency is measured in (Hertz) cycles per second.

Bandwidth-Distance Product - The information-carrying capacity of a transmission medium is normally referred to in units of MHz-km. This is called the bandwidth-distance product or, more commonly, bandwidth. The amount of information that can be transmitted over any medium changes according to distance. The relationship is not linear, however. A 500 MHz-km fiber does not translate to 250 MHz for a 2 kilometer length or 1000 MHz for a 0.5 kilometer length. It is important, therefore, when comparing media, to ensure that the same units of distance are being used.

Bend Radius - The smallest bend that may be put into a cable under a stated pulling force.

BICSI - Building Industry Consulting Service International

Building Backbone - The portion of the backbone cabling within a building (floor-to-floor or closet-to-closet). See Backbone Cabling.

Bundle - Many individual fibers contained within a single jacket or buffer tube. Also, a group of buffered fibers distinguished in some fashion from another group in the same cable core.

Cable - An assembly of one or more conductors (copper or optical) within a surrounding sheath used for transmission or information.

Cable Assembly - A collection of wires or cables banded into a single unit with connectors on at least one end. General use of these cable assemblies includes the interconnection of optical fiber cable systems and opto-electronic equipment. If connectors are attached to only one end of a cable, it is known as a pigtail. If connectors are attached to both ends, it is known as a jumper or patch cord.

Cable Bend Radius - The minimum recommended bending radius during installation or after installation where cable damage will not occur. Cable bend radius during installation infers that the cable is experiencing a tensile load. Free bend infers a smaller allowable bend radius since it is at a condition of minimal load.

Campus Backbone - The portion of the backbone cabling between buildings. *See Backbone Cabling.*

CATV - Originally an abbreviation for Community Antenna Television. The term now typically refers to cable television.

Centralized Cabling - A cabling topology used with centralized electronics connecting the optical horizontal cabling with the building backbone cabling passively in the telecommunications closet.

Composite Cable - A cable containing both fiber and copper media per article 770 of the National Electrical Code® (NEC®).

Connecting Hardware - A device used to terminate an optical fiber cable with connectors and adapters that provide an administration point for cross-connecting between cabling segments or interconnecting to electronic equipment.

Connector - A mechanical device used to align and join two fibers together to provide a means for attaching to and decoupling from a transmitter, receiver or another fiber (patch panel). Commonly used connectors include the Duplex SC, ST, LC, and MT-RJ.

Connector Panel - A panel designed for use with patch panels; it contains either 6, 8 or 12 adapters pre-installed for use when field connectorizing fibers.

Connector Module - A module designed for use with patch panels; it contains 6 to 24 connectorized fibers that have a pigtail or are connected to an MTP® Connector adapter for Plug & Play™ Systems.

Connector, Small Form Factor - Duplex optical fiber connector that takes up half the space of a duplex SC connector in hardware such as patch panels and wall outlets (e.g. MT-RJ, LC connectors).

Consolidation Point (CP) - Interconnect distribution point located within the horizontal pathway and space that links to the telecommunications outlet.

Core - The central region of an optical fiber through which light is transmitted.

Coupler - A device used to connect two similar connector types.

Cross Connect - The connection method used between permanent cabling (inside the walls) and equipment. A patch cord is often used as the connection means.

Decibel - Unit for measuring the relative strength of light signals. Normally expressed in dB, it is equal to one-tenth the common logarithm of the ratio of the two levels. Expressed in dBm when a power level is compared to a milliwatt. 1 mW (electrical) = 0 dBm (optical), dBm = 10 log mW.

Demarcation Point - The point at which operational control changes, (for example, where the phone company's responsibility ends and the building owner's begins.

Dielectric - Non-metallic and, therefore, non-conductive. Glass fibers are considered dielectric. A dielectric cable contains no metallic components.

Dispersion - The cause of bandwidth limitations in a fiber. Dispersion causes a broadening of input pulses along the length of the fiber. Three major types are: (1) modal dispersion caused by differential optical path lengths in a multimode fiber; (2) chromatic dispersion caused by a differential delay of various wavelengths of light in a waveguide material; and (3) waveguide dispersion caused by light traveling in both the core and cladding materials in single-mode fibers.

Duplex Cable - A duplex cable consists of two separately buffered fibers, joined together into one fiber optic cable.

TIA 568 - A standard for commercial building wiring. The purpose is to provide a generic telecommunications wiring system to support multi-product, multi vendor installations. Now referred to as TIA 568.

EMI - Electromagnetic Interference

Entrance Facility (EF) - An entrance to a building for both public and private network service cables including the entrance point at the building wall and continuing to the entrance room or space.

Equipment Room (ER) - A centralized space for telecommunications equipment that serves the occupants of a building. An equipment room is considered distinct from a telecommunications room because of the nature or complexity of the equipment.

FC Connector ('Fiber 'Connector) - A slotted screw-on type connector. This connector is popular in singlemode applications.

FCC - Federal Communication Commission

Fiber - Usually refers to a single filament made of a dielectric material such as glass or plastic, which is used to guide optical signals.

Fiber Bend Radius - Radius a fiber can bend before the risk of breakage or increase in attenuation.

Fiber Optics - Light transmission through optical fibers for communication or signaling.

FOTP - Fiber Optic Test Procedures. Defined in TIA Publication Series 455.

Frequency - The number of times a periodic action occurs in one second. Measured in Hertz.

Fresnel Reflection Losses - Reflection losses that occur whenever light passes between two materials with different refractive indexes, e.g., fiber core to air.

FTTD - Fiber to the Desk

Fusion Splice - A permanent joint produced by the application of localized heat sufficient to fuse or melt the ends of the optical fiber, forming a continuous single fiber.

GbE - Gigabit Ethernet

Gb/s - Gigabits per Second

Gigahertz (GHz) - A unit of frequency that is equal to one billion cycles per second, 10^9 Hertz.

Graded-Index - Fiber design which the refractive index of the core is lower toward the outside of the fiber core and increases toward the center of the core; thus, it bends the rays inward and allows them to travel faster in the lower index of refraction region. This fiber type has higher bandwidth capabilities for multimode fiber transmission.

HDA (Horizontal Distribution Area) - A space in a computer room where a horizontal cross-connect is located.

Horizontal Cabling (workstation wiring) - That portion of the telecommunications cabling that provides connectivity between the horizontal cross-connect and the work-area telecommunications outlet. The horizontal cabling (workstation wiring) consists of transmission media, the work-area outlet, the terminations of the horizontal (workstation) cables and horizontal cross-connect.

Horizontal Cross-Connect (HC) - A cross-connect of horizontal (workstation) cabling to other cabling, e.g., horizontal, backbone, equipment.

Hybrid Cable - A fiber optic cable containing two or more different types of fiber, such as 50 μm multimode and single-mode.

IDF – Intermediate Distribution Frame. *See Telecommunications Room for additional information.*

IEC - International Electrotechnical Commission

IEEE - Institute of Electrical and Electronics Engineers

Index of Refraction - The ratio of light velocity in a vacuum to its velocity in a given transmission medium.

Insertion Loss - The attenuation caused by the insertion of a device (such as a splice or connection point) to a cable.

Intermediate Cross-Connect (IC) - A secondary cross-connect in the backbone cabling used to mechanically terminate and administer backbone cabling between the main cross-connect and horizontal cross-connect.

Intra-building – Used to identify the interior systems or segments of a communications system.

Inter-building – Used to identify the exterior systems or segments of a communications system.

ISO - Abbreviation for International Standards Organization. Established in 1947, ISO is a worldwide federation of national standards committees from 140 countries. The organization promotes the development of standardization throughout the world with a focus on facilitating the international exchange of goods and services, and developing the cooperation of intellectual, scientific, technological, and economical activities.

Jumper - Optical fiber cable that has connectors installed on both ends. See Cable Assembly.

Kilometer (km) - One thousand meters, or approximately 3,281 feet. The kilometer is a standard unit of length measurement in fiber optics. Conversion is 1 ft = 0.3048 m.

Laser - Light Amplification by Stimulated Emission of Radiation. An electro-optic device that produces coherent light with a narrow range of wavelengths, typically centered around 850 nm, 1310 nm, or 1550 nm. Lasers with wavelengths centered around 850 nm are commonly referred to as VCSEL.

LC Connector - The LC connector holds a single fiber in a 1.25 mm ceramic ferrule, half the size of the standard SC ferrule. LC connectors are examples of small form factor connectors. Made of molded plastic, and features a square front profile. An RJ-style latch (like that on a phone jack) on the top of the connector provides easy, repeatable connections. Two LC connectors may be clipped together to form a duplex LC. The small size and push-in connections of LC connectors make them an excellent choice for high-density fiber applications, or for cross connects.

Link - A telecommunications circuit between any two telecommunications devices, excluding the equipment connectors.

Local Area Network (LAN) - A geographically limited communications network intended for the local transport of voice, data and video. Often referred to as a customer premises network.

LOMMF - Laser-optimized multimode fiber; a 50 μm optical fiber design optimized for use with VCSELs.

Loose Tube Cable - Type of cable design whereby coated fibers are encased in buffer tubes offering excellent fiber protection and segregation.

LSZH - Low Smoke Zero Halogen

Low Voltage Compatible Services (LVCS) - Low Voltage services with equipment and distribution requirements that are compatible with communications equipment and distribution requirements. Such services that are currently allowed include: Fire alarm systems, building monitoring and control systems, key access systems, video camera systems, and security alarm systems. Low Voltage Compatible Services must not exceed a nominal 50VDC or 30VAC RMS voltage, and must have 16 wiring gauge or smaller.

Main Cross-Connect (MC) - The centralized portion of the backbone cabling used to mechanically terminate and administer the backbone cabling, providing connectivity between equipment rooms, entrance facilities, horizontal cross-connects and intermediate cross connects.

Mb/s - Megabits per Second

Machine Room (MR) - generally the location in which individually owned and operated servers and some privately owned equipment is housed.

Mechanical Splicing - Joining two fibers together by permanent or temporary mechanical means (vs. fusion splicing or connectors) to enable a continuous signal.

Megahertz (MHz) - A unit of frequency that is equal to one million cycles per second, 10^6 Hertz.

Micrometer (μm) - One millionth of a meter; 10^{-6} meter. Typically used to express the geometric dimension of fibers, e.g., 50 μm.

MPO Connector - The MPO connector houses an MT ferrule, and so can provide for upwards of twelve fibers in a single connector.

MTP™ Connector - An MTP™ connector can house up to twelve and sometimes more optical fibers in a single, monolithic ferrule.

Multimode Fiber (MMF) - A type of fiber optic cable where the core diameter is much larger than the wavelength of light transmitted. Two common multimode fibers are 50/125 µm. and 62.5/125 µm.

MT-RJ Connector - The MTRJ connector holds a pair of fibers in a monolithic ferrule made of a plastic composite. The ferrule is held inside a plastic body that clips into a coupler with an intuitive push and click motion, much like the copper RJ-45 jack. The fibers are aligned by the pair of metal guide pins in the end of the ferrule of a male connector, which join into guide pinholes on the female connector inside the coupler. The MT-RJ connector is an example of a duplex small form factor connector. Having the pair of fibers held by a monolithic ferrule makes it easy to maintain the polarity of connections, and renders the MT-RJ ideal for applications such as horizontal fiber runs in facility cabling.

Multiplex - Combining two or more signals into a single bit stream that can be individually recovered.

Multi-user Telecommunications Outlet (MUTOA) - A telecommunications outlet used to serve more than one work area, typically in open-systems furniture applications.

Nanometer (nm) - A unit of measurement equal to one billionth of a meter; 10^{-9} meters. Typically used to express the wavelength of light, e.g., 1300 nm.

National Electrical Code® (NEC®) - Defines building flammability requirements for indoor cables. Note: Local codes take precedence but may refer to or require compliance to the NEC.

NEMA - National Electrical Manufacturers Association

NIST - National Institute of Standards and Technology

OM3 - laser-optimized 50/125um multi-mode fiber and used for systems with high bandwidth such as 10 Gigabit Ethernet.

OFCP - Optical Fiber Conductive Plenum

OFCR - Optical Fiber Conductive Riser

OFN-LS - Optical Fiber Nonconductive, Limited Smoke

OFNP - Optical Fiber Nonconductive Plenum

OFNR - Optical Fiber Nonconductive Riser

Optical Time Domain Reflectometer (OTDR) - An instrument that measures transmission characteristics by sending a series of short pulses of light down a fiber and providing a graphic representation of the backscattered light.

OSP - Outside Plant

Patch Cord - A cable assembly with modular plugs on each end. Used for patching equipment to the patch panel in the equipment room and also used to connect phones and computers at the drop.

Patch Panel - The common cross-connect method used inside an equipment or telecommunications room. A system that facilitates cable termination and cabling administration using patch cords.

PBX - Private Branch Exchange

PE - Polyethylene

Pigtail - A fiber optic cable with a connector at one end. Also known as Modular Cord, Single End.

Plenum - An air-handling space such as that found above drop-ceiling tiles or in raised floors. Also, a fire-code rating for indoor cable.

Point-to-Point - A connection established between two specific locations, as between two buildings.

Polyethylene (PE) - A type of plastic material used for outside plant cable jackets

Polyvinylchloride (PVC) - A type of plastic material used for cable jacketing. Typically used in flame-retardant cables.

Polyvinyldefluoride (PVDF) - A type of material used for cable jacketing. Often used in plenum-rated cables.

Receiver - An electronic package that converts optical signals to electrical signals.

Reflectance - Reflectance is the ratio of power reflected to the incident power at a connector junction or other component or device, usually measured in decibels or dB. Reflectance is stated as a negative value, e.g., -30 dB. A connector that has a better reflectance performance would be a -40 dB connector or a value less than - 30 dB. The terms return loss, back reflection and reflectivity are also used synonymously in the industry to describe device reflections, but stated as positive values.

Repeater - An active device used to regenerate an optical signal to allow an increase in the system length.

RF - Radio Frequency

RFI - Radio Frequency Interference

Riser - Pathways for indoor cables that pass between floors. It is normally a vertical shaft or space. Also a fire-code rating for indoor cable.

Rx - Receiver

SC Connector - SC is a snap-in connector that is widely used in singlemode systems for its excellent performance. It's a snap-in connector that latches with a simple push-pull motion. It is also available in a duplex configuration.

Simplex Cable - A simplex cable carries a single optical fiber within a buffer tube. Simplex cable is often used in jumper and pigtail assemblies.

Single-Mode Fiber (SMF) - An optical waveguide (or fiber) in which the signal travels in one mode. The fiber has a small core diameter, typically 8.3 to 9.5 μm.

Splice Closure - A container used to organize and protect splice trays and splices. Typically used in outside plant environments.

Splice Tray - A container used to secure, organize and protect spliced fibers.

Splicing - The permanent joining of bare fiber ends to another fiber. See Fusion Splice and Mechanical Splicing.

STP - Shielded Twisted Pair

ST Connector - (AT&T Trademark) - is the most popular connector for multimode networks, like most buildings and campuses. It has a bayonet mount and a long cylindrical ferrule to hold the fiber. Most ferrules are ceramic, but some are metal or plastic. And because they are spring-loaded, you have to make sure they are seated properly. If you have high loss, reconnect them to see if it makes a difference.

Telecommunications Enclosure (TE) - Enclosed space or housing for telecommunications intended to contain cable terminations, cross-connect cabling and electronic equipment located in the horizontal pathway and spaces that link to the telecommunications outlet.

Telecommunications Room (TR) - An enclosed space for housing telecommunications equipment, cable terminations and cross-connects. The room is the recognized cross-connect between the backbone and horizontal (workstation) cabling. Often referred to as an IDF.

Tight-Buffered Cable - Type of cable construction whereby each glass fiber is tightly buffered by a protective thermoplastic coating to a diameter of 900 micrometers. Increased buffering provides ease of handing and connectorization.

TR – *See Telecommunications Room*

Transmitter (Tx) - An electronic package used to convert an electrical information-carrying signal to a corresponding optical signal for transmission by fiber. The transmitter is usually a Light Emitting Diode (LED) or Laser Diode.

Tx – *See Transmitter*

UL - Underwriters Laboratory

UTP - Un-shielded Twisted Pair

VAC - Volts Alternating Current

VCSEL - Vertical Cavity Surface Emitting Laser

Wavelength - The distance between two successive points of an electromagnetic waveform, usually measured in nanometers (nm).

WCH - Wall-mountable Connector Housing

WMO - Workstation Multimedia Outlet

Work-Area Telecommunications Outlet - A connecting device located in a work area at which the horizontal (workstation) cabling terminates and provides connectivity for work-area patch cords.

ZDA (Zone Distribution Area) - A space in a computer room where a zone outlet or a consolidation point is located.

Zero-Dispersion Wavelength - Wavelength at which the chromatic dispersion of an optical fiber is zero.

E. Document Overview

1. Summary

Building/space planners can provide robust and flexible infrastructure designs, with minimized cost impacts, by keeping five things in mind:

- Planners should never underestimate the value of providing adequately sized telecommunications rooms. Following, as close as possible, industry standards and best practices will ensure appropriate environments and spaces for near and long-term technology needs.

- Telecommunications pathways and spaces are designed for the life of the building, not for a specific system or technology.

- Retrofitting a newly constructed building to provide service is expensive and time consuming. A few additional feet of conduit initially designed into a new building will be a minimal cost. During or after construction, that same conduit could cost several times as much to install.

- The telecommunications infrastructure should accommodate and reflect UCSB's need to install a significant number of new (and probably as yet undefined) services once construction of the building is complete. Changes in technology do not stop when the construction of the building is complete, and the design must take that into consideration.

- Space usage changes.

2. Remaining Sections

The remainder of this document is divided into sections consisting of related topics of interest.

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Section 2 - Construction Programming, defines the types of technology and information system-related spaces and distribution services that are in use or must be planned for in construction (new or remodel) projects. The focus of this section is on the information required by architects and space and facility planners.

Section 3 - Infrastructure & Pathways, identifies specific design and construction requirements that must be followed as the minimum acceptable level of building infrastructure support. It provides details on sizing of rooms and pathways, the electrical and mechanical services required, and other building construction (as opposed to telecommunications-specific) materials and considerations. Additionally, this section provides guidelines for cable support systems hardware typically needed for intra-building cable systems.

Section 4 – Media Systems, outlines specific "media" (i.e., copper, fiber optic, coaxial cable, and wireless) configurations and hardware support systems required to install, maintain, and expand the technology distribution needs of the University.

Appendix A – Reference Materials, identifies a range of source materials and documents which impact the design of telecommunication infrastructure either through the standards process or as a related industry publication.

2.0   Programming

A. Introduction

This section provides general guidelines for architects, engineers and facility planners for development of effective telecommunications infrastructure planning for new construction and remodeling projects. Focus is on space planning, needed building infrastructure, the identification of individual components required in a telecommunications distribution system, and other design considerations for serving campus and building environments. This section also provides a list of the commonly used industry standards and reference material.

Section 2 should always be used by the design team in conjunction with Section 3, Infrastructure & Pathways Details, to obtain a complete overview of both the space and pathway issues and the 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 with the appropriate direction in the preparation of actual working designs.

B. Design Concepts

A primary goal for telecommunications infrastructure design within a higher education campus and building environment is to plan today's facilities to meet future requirements without the need for costly future renovations. In recent years, the UCSB campus has undergone various upgrades to provide updated telecommunications and network services. These updates have usually included new media, pathways and spaces, and voice/data electronics. One of the more costly parts of the upgrade process is the renovation of pathways and spaces within buildings required before any new media can be installed.

The primary reason for the high costs of these renovations is typically due to the needed replacement and upgrade of undersized and inadequate supporting infrastructure (e.g., cabinets, rooms, pathways, power, grounding, etc.). However, when supporting infrastructure upgrades are properly planned, designed and implemented, future systems upgrades and related cabling can be deployed requiring minimal supporting infrastructure changes and at reasonable costs.

Two key planning components of properly deployed upgrades are the prudent application of recognized industry standards and industry best practices. When applied appropriately, these standards and practices can provide the quality and flexibility needed to successfully operate, maintain and, when necessary, upgrade with minimal difficulty over the life of a facility.

During the last two decades, standards have been developed that have lead to improved infrastructure   solutions.   The   American   National   Standards   Institute   (ANSI),   the

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Telecommunications Industry Association (TIA), and the Electronics Industry Association (EIA) are the major providers of published telecommunications-related standards.

A variety of standards and reference documents, which also serve as planning materials, are available to assist architects, engineers and facility designers with telecommunications infrastructure design. Some of the prime sources are:

- **TIA– 569-A** (and associated addenda) ***Commercial Building Standard for Telecommunications Pathways and Spaces.*** This standard provides specifications for the design and construction of the intra-building pathways and spaces required to support telecommunications equipment and media.

- **TIA– 568-B** (and associated addenda) ***Commercial Building Telecommunications Cabling Standard.*** This standard provides specifications for inter and intra-building cabling media and related installation and support hardware. Category 3, Category 5e, Category 6 and most currently Augmented Category 6 systems are approved and are currently the media of choice. This standard is divided into three parts:

  1) General Requirements

  2) Balanced Twisted Pair Cable Component Systems

  3) Optical Fiber Cable Component Systems

- **TIA -568-B.1, General Requirements:** provides specifications and testing requirements for installed intra-building copper and optical fiber cable systems.

- **TIA -568-B.2, Balanced Twisted Pair Cabling Components:** provides standards for the media and connectors used in copper cabling systems and specifies accuracy and reporting requirements for field testers.

- **TIA -568-B.3, Optical Fiber Cabling Components:** provides performance specifications for the cable, patch cords, and connectors used in optical fiber cabling systems.

- **TIA –758** ***Customer-Owned Outside Plant Telecommunications Cabling Standard,*** plus Addendum No. 1: Provides specifications for the minimum requirements for inter-building telecommunications facilities, including cabling, pathways, and spaces.

- **TIA –606A** ***Administration Standard for the Telecommunications Infrastructure of Commercial Buildings***. This standard identifies record-keeping requirements and information, including labeling, needed to effectively administer building telecommunications systems. All administration activities must be approved in writing from the University prior to installation.

- **J-STD- 607-A** *Commercial Building Grounding and Bonding Requirements.* This document identifies the need for, and composition of, a dedicated electrical grounding system for telecommunications.

- A variety of other TIA/EIA standards relating to the details of design, installation, testing, and documentation of telecommunications infrastructure are available and some are defined in Sections 3 and 4 of this document.

- **Rural Utility Services (RUS)** formally Rural Electrification Association (REA), bulletins (1700 series) define standards and methods for the construction of outside pathways and the installation of inter-building media.

  1) *Telecommunications Engineering & Construction Manual* (TE&CM) including all updates.

  2) *Bulletins 1735, 1715, 1753, 1755* Related to Telecommunications (cable and pathways) design, specifications, and construction.[1]

- **Building Industry Consulting Services International (BICSI)** *Telecommunications Distribution Methods Manual.* The manual describes intra- and inter-building infrastructure design guidelines and methods accepted by the telecommunications industry.

- **BICSI –** *Customer-Owned Outside Plant Design Manual.* This manual describes in-depth inter-building infrastructure design guidelines and methods accepted by the telecommunications industry.

BICSI, one of the leading telecommunications industry associations, is recognized as a key resource for both references to industry standards and best practices for training, testing, and certification in the design and installation of telecommunications distribution systems. A BICSI Registered Communications Distribution Designer (RCDD) is often employed by the architect or design engineer to prepare the detailed telecommunications infrastructure design and to assist with the initial program and space planning and the resulting construction documents.

An additional key and critical component to the development of construction documents that embody the Design Concepts referred to in this document, are written CSI Master Format bid specification. The Construction Specifications Institute (CSI) has recently completed a major revision to the organization of the Master Format construction specifications, which replaces the 1995 edition. This latest 2004 Master Format, also known as Division 50 due to the increase from the previous 16 divisions to 50 divisions, significantly expands the capabilities of the document and provides for a wider variety of disciplines and systems. It is anticipated that adoption of this latest format will be slow in coming, but no doubt will be the primary document used by

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[1] This series of RUS Bulletins replaces all former Rural Electrification Association (REA) materials such as PE-89 and PE-39.

professionals for recording project requirements and acquiring bids from contractors. The division associated with communications infrastructure has been identified as division 27.

C. Design Elements

The major elements of a telecommunications distribution design are spaces and pathways. Each of these elements consists of multiple components.

Spaces encompass the building service entrance, equipment, and telecommunications rooms, as defined below:

- *Building Service Entrance* - An independent room in which campus voice, data, and video distribution pathways and media systems enter the building.

- *Equipment Room* - The primary space allocated solely to housing (and supporting) telecommunications systems that will service the building, such as a voice switching node, backbone network equipment, and/or video transmission equipment.

- *Telecommunications Room* - 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. These spaces also house local electronic equipment and/or terminal resources not installed in the main equipment room. Electrical services must not share these spaces as EMI will interfere with data transmission signals.

Pathways encompass the inter-building (between buildings) distribution system, building backbone (riser) system, horizontal pathways, and station outlets, as follows:

- *Inter-building Distribution System* - The conduit, overhead, or buried media support structures for wire/cable between buildings.

- *Building Backbone (Riser)* - The vertical and horizontal pathways that connect all telecommunications rooms and spaces throughout an individual building.

- *Horizontal Pathways* - The conduit, sleeves, cable tray, non-continuous cable support, or other cable support system from the Telecommunications Room to the station (user) locations on a given floor.

- *Station Outlet* - The ultimate termination of a voice, data, video, or signal circuit.

Every building design must address each of these areas as both a standalone service and a component of an entire system. Problems occur when designs focus on only one or two of the components and do not consider how the entire building's distribution system will be utilized. For example, it is not enough to provide for cable tray in a building and cable runway in a Telecommunications Room; there must be pathway interconnection between these components;

such as riser/feeder conduits and non-continuous cable support hardware as well as fire and sound wall as well as ceiling and floor penetration sleeves.

Building designs that require the cable installer to drill holes in walls and place sleeves through fire partitions after construction should be avoided. While technology will change between the time of the initial architectural planning and building occupancy, the infrastructure (pathways and spaces) will be in place for the life of the building and must be capable of supporting multiple changes in technology.

D. Telecommunications Spaces

The term "telecommunications spaces" refers only to specific rooms or spaces dedicated to telecommunications services. It is important to identify the expected utilization of these spaces and to conduct planning sessions with the understanding that such spaces must be provided in any UCSB construction project.

There are three main categories of spaces, as previously defined: Service Entrances, Equipment Rooms, and Telecommunications Rooms. Each area has a distinct function, but all are inter-dependent. In rare cases, a single space may fulfill the function of all three spaces for a small building. However, it must be emphasized that the size and environmental support requirements are additive. If the size of a specific building calls for an equipment room of 150 square feet and that room is expected to serve as a service entrance room, the floor space must be increased 200 square feet to allow for the additional equipment and maintenance area.

1. Service Entrance Facility

The service entrance is a room in which inter-building Campus Network cable system are terminated and interconnected with the backbone cable used throughout a building. The University OIT owns and operates these rooms. Each new building must house two separate rooms servicing as the Entrance Facility to accommodate redundant connections to the campus fiber ring. It provides facilities and supporting hardware for large splice containers, cable termination mountings, and possibly copper cable electrical protectors. If this is a standalone space, it is not expected to house any network or telecommunications equipment.

This space should be 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 equipment room or backbone (riser) distribution spaces.

This space shall have key access independent of the master key to secure the space to restricted OIT personnel.

If used only as a service entrance room, no special air handling is required beyond that provided in a standard office of equivalent size. This space should not be located in or directly adjacent to the building's electrical service entrance, transformer room, or mechanical room. The minimum floor space requirement for a standalone service entrance room is five (5) feet by eight (8) feet in buildings under 10,000 gross square feet. See Section 3 of these Standards for additional detailed information.

2. Equipment Room

The equipment room is the central space used to house telecommunications network equipment intended to service users throughout a building. This type of room commonly contains telecommunications digital switching equipment, wide and local area network routers and switches, video distribution equipment, and cable inter-connect and cross-connect hardware. Past terminology for this space has included "Building Distribution Frame" (BDF) and/or Main Distribution Frame (MDF); however, the most recent concept encompasses additional functions and the installation of more types of equipment than that previously installed in these spaces.

In some situations, voice-switching equipment in one building will serve users in other nearby facilities, generally over copper cable. In these cases, the equipment room must support the termination of additional copper cables that are extended between buildings.

This room will house sensitive electronic components that will often be connected to a backup power source and will generate heat 24 hours per day, 365 days per year. It is important this space be designed with separate environmental controls and backup systems to maintain the environment necessary to support to critical telecommunications systems in the event of power failure or disaster situations.

The air handling system for equipment rooms must be designed to provide positive filtered airflow and cooling even during times when the main building systems are shut down. This requires separate air handlers and/or standalone cooling systems that are thermostatically controlled. If the equipment room is to be used as a campus communications hub and the equipment is served by an auxiliary power supply, the air handling system for this space should also be connected to the building's backup power generation system**.**

The equipment room should be located near the service entrance room and must have adequate access from outside the building to allow for the installation of large equipment cabinets (36" wide by 96" tall). The minimum size of this room is ten (10) feet by fifteen (15) feet. However, campus-specific requirements may easily increase its size.

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This space shall have key access independent of the master key to secure the space to restricted OIT personnel or other designated staff.

The minimum design guidelines for an equipment room are as follows:

- To limit the possibility of flooding, water or drainage pipes should not be placed directly over or near the equipment room. The surrounding floor area should be configured to drain accidental leaks before the equipment room becomes involved, or a floor drain should be installed if the danger of water entrance cannot be overcome in any other way. Floor drains should only be used when a room is located well above grade as backups in storm or sewage drainage systems can result in a water backup in a below grade room.

- A dry (pre-action or gas) fire suppression system should be provided in this space. Activation of the suppression system should be linked to the equipment's serving electrical panel to disconnect power in the event of activation.

- Ceiling height should be minimum 8'-6"; ceiling protrusions (e.g., sprinkler heads) must be placed to assure a minimum clearance of 8'; and finish should be free from dust and be light colored to enhance room lighting.

- A minimum floor loading of 100 lbs. per square foot (distributed loading) should be the structural design standard for this space.

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

- In the event power generation equipment is not provided, only sealed batteries are to be used to provide power failure backup, unless a separate room, designed specifically to support lead-acid batteries, is constructed. Local codes must be referenced for specific dedicated room and location requirements, floor-loading limitations, splash walls and drain curbs, venting requirements, and other safety concerns.

- The size of the equipment 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 specific sizing criteria are as follows:

  a. If no specific requirements are known, the minimum equipment room size is 80 square feet.

  b. For buildings over 20,000 square feet, the minimum equipment room space is .75 square foot for every 100 assignable square feet.

c. Design situations that will increase the required size of the equipment room include the following:

1. The building under design will act as a serving point for other campus buildings.
2. The density of workstations within the building will exceed an average of one per every 75 assignable square feet.
3. The equipment room will also serve as an entrance room.
4. Additional service providers may house electronics in this space. Add an additional 16 square feet for each additional service provider.
5. It will be necessary to house computing equipment (as opposed to network-only equipment) within the space.
6. A computer/technology facility without a specific design requirement must meet the following equipment room space minimums:

Number of Work Areas	Equipment Room Area
10 to 99	80 sq. ft.
100 to 400	400 sq. ft.
401 to 800	800 sq. ft.
801 to 1,200	1,200 sq. ft.

Figure 2-1

Equipment Room Space Requirements

3. Telecommunications Room

The telecommunications room is the space that supports the cable and equipment necessary for transmission between the building's backbone system and user (station) locations. This space was identified in the past as a "telephone closet" or Intermediate Distribution Frame (IDF), terms that no longer define the activities this room must support; nonetheless are still used within the construction industry. In keeping with the changes within the industry, UCSB has adopted the more descriptive and internationally recognized term, "Telecommunications Room."

This space is used to terminate the media from station outlets and backbone (riser) systems and house and support local area network equipment, system interconnects, cable cross-connects, video distribution equipment, wireless resources, and system monitoring components.

It is important to give the design and location of these spaces high priority within a building plan. At a minimum, these spaces must meet the following design constraints:

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

- These spaces must be dedicated to the telecommunications function and must not be shared with electrical, janitorial, fire alarms, security systems, or storage functions.

- The Telecommunications Rooms must be located near the center of the building but no farther than 90 meters or approximately 295 feet (cable horizontal and vertical cable pathway distance) from the most distant user outlet. The average distance should be 150 feet or less. The 90 meter rule shall apply

- 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 drain pipes, electrical interference, dust or other airborne contaminants, and physical hazards.

- The environment of these rooms must be equal to or better than a normal office (positive filtered air flow/cooling, office-level lighting, sealed or static dissipative tiled floor - no carpet). These rooms are intended to house terminal resources (network electronics) and must be equipped with increased electrical service and additional cooling equipment to provide 24 hour a day, seven days a week support.

- Standby power must be provided where available.

- This space shall have key access independent of the master key to secure the space to restricted OIT personnel or designated staff.

- A Minimum of 4' X 8' of wall space shall be allocated for the installation of security panels and equipment

- The minimum room size is ten feet by eight feet. Additional square footage should be provided if the space would need to accommodate optical fiber cable to individual station outlets and/or to house significant network routing or computing server equipment. Required space will increase with additional occupants due to service provider equipment.

Serving Area	Telecommunications Room Area
Up to 5,000 sq. ft.	10' x 8'
Up to 8,000 sq. ft.	10' x 9'
Up to 10,000 sq. ft.	10' x 10'

Figure 2-2

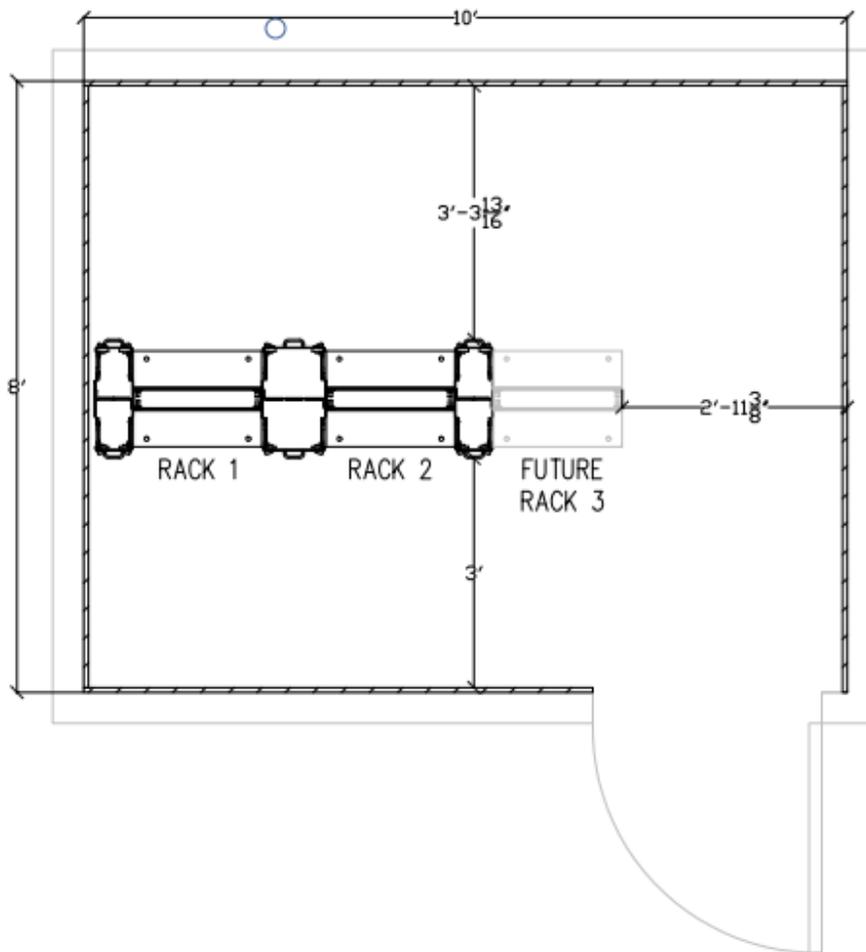**Telecommunications Room Size Requirements**

Figure 2-3

Typical Telecommunications Room Layout

E. Telecommunications Pathways

Pathways refer to the facilities and supporting structures used to transport telecommunications media (twisted copper cable, optical fiber, and coaxial cable) from one location to another. Most often, a telecommunications pathway consists of more than one physical structure, and it is important that the designer think in terms of the overall goal of these pathways rather than the individual components.

Pathways include inter-building backbone (outdoor) pathways and intra-building backbone and horizontal (indoor) pathways. The following subsections outline the general design concepts for each type. For more in-depth information, refer to the appropriate subsection of Section 3 of this document**.**

1. Inter-Building Distribution System

The inter-building distribution system is the conduit, utility vault, and/or tunnel system that supports the telecommunications media between buildings on a campus. A major design concern to the planner/designer of a new or remodeled structure is not simply the distance from the new facility to the closest telecommunications utility vault, but the condition of the overall distribution and feeder system back to the point of origin.

Although most design projects for new campus buildings address interconnection of telecommunications links from outside the building, there is frequently insufficient funding identified for the required renovation or expansion work on major inter-building pathways impacted by a new facility. In some cases, a separate construction project plan may be required to provide adequate pathways up to the point at which the building project can 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, it may be necessary to install new telecommunications services prior to removal of the old. In those cases, additional pathways are critical to meeting the needs of the students, faculty and staff for on-going service during an active cutover (conversion).

Should an existing underground cable be abandoned during the course of a project, this cable or cables must be removed as part of the new project.

In general, the following points should be observed when developing plans for communication feeder facilities:

- Every facility or building shall accommodate individual pathways for Voice, CATV/Security, Two (2) separate pathways for Data, and one spare.

- Anywhere from five (5) two-inch to six (6) four-inch, conduits are required to feed an average building. (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 in innerduct, and coaxial cables.

- Telecommunications utility vaults (manholes/pull boxes) must be situated to allow the conduit to enter the building with no more than two ninety-degree bends.

- The entrance conduits should enter the service entrance 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).

2. Intra-Building Backbone

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, this is the path used for placement of telecommunications media between the Service Entrance Room, Equipment Room, and individual Telecommunications Rooms. These pathways must typically support copper, optical fiber, and coaxial cables serving equipment and cross-connection hardware serving end-users located on each floor of a building.

- Backbone conduits and sleeves must be minimum two (2) inches to as large as 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.

- Conduit fill should not exceed 40%.

- The minimum number of vertical backbone (riser) conduits or floor sleeves is two (2).

- Plenum-rated pathways exist in many UCSB buildings and large pair count (300 and greater) copper cables are sometimes needed to distribute telecommunication services within a building. These pair counts may not be available with plenum-rated sheaths. Under these circumstances it may be necessary to either provide conduit for riser-rated 300-pairs and larger cables or multiples of 100-pair plenum-rated cable can be run without the need for conduit.

- All station conduits to outlets, except as otherwise specified, must be 1¼" diameter. Keep in mind that "special" 5S deep back boxes with 1¼" knockouts are required for these larger station conduits.

- The station outlets should be supported by a 5S deep backbox, with a single gang reducer ring,
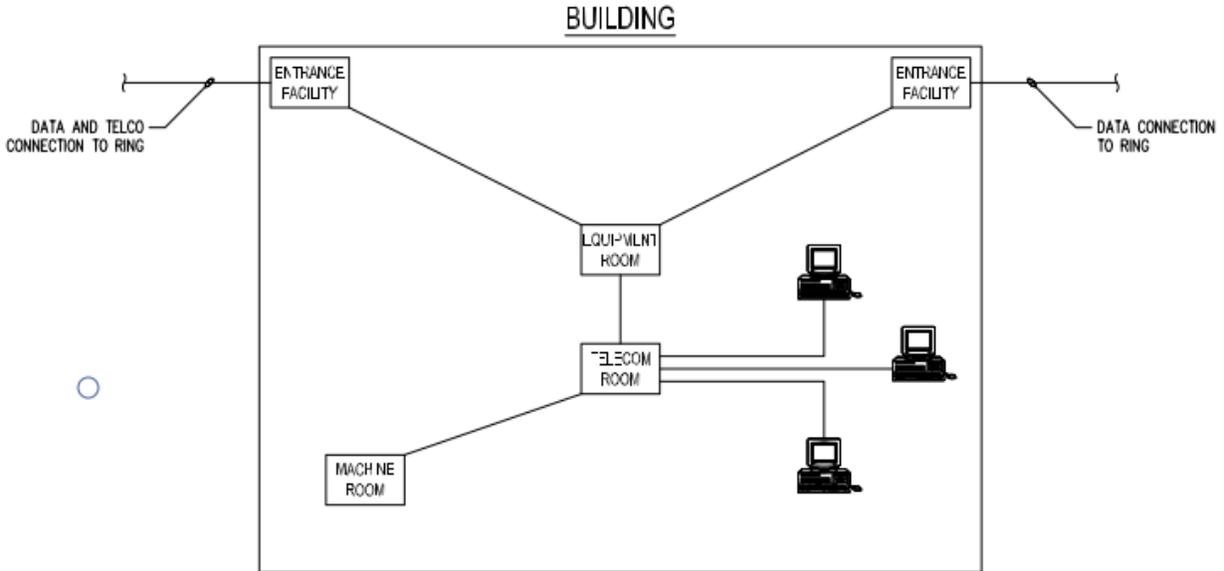

Figure 2-4

Intra-Building Backbone Connection Points

3. Horizontal Pathways

The horizontal pathways between the Telecommunications Room and the station outlet locations receive the heaviest usage and 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 providing the flexibility to meet future changes in technology.

There is almost no facility design that will allow for the use of a single telecommunications distribution method throughout the 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 the installation.

The telecommunications designer must coordinate the efforts of all members of the design team to define specific pathway configurations based on an understanding of the long-term use of a facility and affording 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 single correct approach to the design 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 a false ceiling.

- Every Telecommunications Room shall provide a minimum of 50% growth from the initial installation requirements.

- 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 conduit or sleeve that can be fire-stopped after cable is installed.

- Every room must be provided a specific pathway from a false ceiling area (used to access user jack locations) to the main horizontal distribution pathway (such as the cable tray).

4. Station Outlet

The station outlet will ultimately be configured to serve a variety of telecommunications needs. An outlet, which only a few years ago involved access to a voice connection, today typically supports connections to fax, multi-media data, and video devices of various types. If all outlet locations are standardized, the difference can ultimately be determined by UCSB in terms of the type of cable and terminations placed at the outlet.

The prime point to remember about station outlets is the need to design outlet locations for future needs, not just today's applications. Outlets that are not initially activated can be capped for later use. By paying attention to potential telecommunications locations and the routes by which they are served, the designer can save significant time and costs in meeting changing user needs.

At a minimum the university shall have three (3) cables at each outlet. One of these cables is typically used for voice services.

F. Design Issues

In addition to telecommunications space and pathway issues, a variety of environment-specific issues must be factored into the design of a new facility. This subsection provides an overview of the minimum telecommunications infrastructure requirements in specific areas of new construction and remodel projects. These requirements are intended to be used during program planning when specific local requirements are not identified.

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 with multiple voice and data outlets. Some locations will require CATV outlets as well. All outlet configurations should be situated to allow changes in furniture layouts. Other design considerations include:

- Typical offices and open suite areas should have multiple communication outlets (minimum of one per 75 square feet).

- All offices must be equipped with a minimum of one communications outlet, when two are required that should be located on opposite walls and adjacent to or near electrical outlets.

- Use of modular furniture requires significant coordination to define the methods to be used to connect the furniture systems to the distribution system. Each cubical must be designed with sufficient pathways to meet the needs of a single person office. Each pathway linking the furniture to the distribution system must be sized to support one outlet (3 cables) in each cubicle seating area plus 25% growth.

2. Conference Rooms

Conference rooms smaller than 12' by 12' should be equipped similarly to a standard office with a voice/data outlet on two walls. Larger conference rooms should be equipped, in addition to standard voice/data wall outlets with one or more floor outlet boxes that provide power and signal pathways. Large conference rooms should be provisioned with video distribution capabilities designed by the University or design engineer.

3. General Instructional Areas

This document is not intended to be a classroom design guide, nor is it intended to limit the application of technology within the educational environment. 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.

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

- Additional space is required to support even a limited number of workstations and printers. This equipment may also require secure storage facilities or simply additional floor space.

- Additional voice, data and video telecommunications outlets should be installed in every classroom facility.

- Additional electrical service must be provided to meet the loads 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.

a. Classrooms

The following types of media and equipment are typically scheduled for use in classrooms:

- Instructor: 1 port for voice and 2 ports for data at each workstation outlet

- Video CATV quality outlet

b. Computer Labs and Learning Resource Rooms

The definition of a "Computer Lab" is a room with a heavy concentration of workstations in which both the student and the instructor utilize computing equipment on a regular basis. The definition of a "Learning Resource Room" is a room with a heavy concentration of workstation for student use only. These spaces must be designed and configured to support 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 cable. If freestanding tables are used, a specific pathway design must be prepared for each room including one or more of the following:

- A wall-mounted raceway system at above tabletop height on all walls.

- A raised floor system with several pathways to the accessible ceiling space.

These rooms will require a significant amount of computing hardware that must be secured and connected to equipment within the room. The best design is to allocate space for a separate control or equipment room for every high tech space. In some cases, it may be possible to utilize a single control room for two or more high tech spaces.

Another alternative is to provide space in a portion of the room for an equipment cabinet or rack system. This arrangement will not provide the same level of physical security that can be provided by a separate room but may meet the needs of the campus staff.

The room or space used to house the equipment must be provided with additional cooling, electrical service, and telecommunications services regardless of the final configuration. Generally, this area will be the location in which all cable from a specific room is terminated and the hardware interconnected into the campus backbone network. As such, the distribution system, such as a floor trench system or dedicated conduit or raceway, must extend to this point, and a cable support system must be designed into the space.

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 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.

4. Libraries

Library facilities are often the focal point for instructional media (video) and a variety of instructional and academic computing systems. These facilities must be designed both to support specific systems and to provide various methodologies allowing access to information. This includes the use of "public" computing and information retrieval equipment with access to a wide range of services. These public access points will require a significant increase in the number of user-accessible communication services (both wired and wireless)

throughout the facility. Group study and meeting rooms must be designed to provide access facilities for voice, data, and video services from a variety of sources.

5. Research Lab

The definition of a "Research Lab" is a room similar to a Learning Resource Room with a heavy concentration of communications outlets including wireless access points in which students can access internal and external research material. These spaces must be designed and configured to support 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 cable. If freestanding tables are used, a specific pathway design must be prepared for each room including one or more of the following:

- A wall-mounted raceway system at above tabletop height on all walls.

- A raised floor system with several pathways to the accessible ceiling space.

These rooms will require a significant amount of computing hardware that must be secured and connected to equipment within the room. The best design is to allocate space for a separate control or equipment room for every high tech space. In some cases, it may be possible to utilize a single control room for two or more high tech spaces.

Another alternative is to provide space in a portion of the room for an equipment cabinet or rack system. This arrangement will not provide the same level of physical security that can be provided by a separate room.

The room or space used to house the equipment must be provided with additional cooling, electrical service, and telecommunications services regardless of the final configuration. Generally, this area will be the location in which all cable from a specific room is terminated and the hardware interconnected into the campus backbone network. As such, the distribution system, such as a floor trench system or dedicated conduit or raceway, must extend to this point, and a cable support system must be designed into the space.

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These floors are generally not suited for use in a computer room environment due 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.

6. Public Space

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 financial aid and registration offices, walkway or open entry areas, common meeting areas, or perhaps group study areas (Learning Resource Rooms). In keeping with the concept of improved access to information throughout the educational experience, public spaces need to be equipped with the necessary infrastructure to provide community announcement information, such as display monitors and interactive information kiosks, with public or semi-private network access points for high speed data communication.

3.0   Infrastructure & Pathway Details

A. Introduction

The intent of this section is to provide design details for communications pathways and spaces. These details will assist architects and their sub-consultants with specific design related requirements. This section will also serve as a guide for Budget & Planning and Campus Design and Construction to determine construction details required for renovation projects as well as new construction.

This section will provide details for the following items:

- Provide various sizing and selection criteria

- Provide sample designs and "typical" configurations documents

- Provide general construction-related specifications and highlights for improving the methods used to address communications issues.

B. Reference Material

The primary technical reference documents for this phase of communications design are the TIA Commercial Building Standards related to telecommunications pathways and spaces and the BICSI *Telecommunications Distribution Methods Manual* (TDMM).   These documents are routinely updated to resolve conflicts and address new concerns and design opportunities. As of the time this document was prepared, the following TIA standard materials were available:

- TIA– 569-A (and associated addenda) *Commercial Building Standard for Telecommunications Pathways and Spaces*. This standard provides specifications for the design and construction of the intra-building pathways and spaces required to support communications equipment and media.

- TIA– 568-B (and associated addenda) *Commercial Building Telecommunications Cabling Standard*. This standard provides specifications for inter- and intra-building cabling media and related installation and support hardware.

- TIA– 758 *Customer-Owned Outside Plant Telecommunications Cabling Standard*, plus Addendum No. 1. This standard provides specifications for the minimum requirements for inter-building communications facilities, including cabling, pathways, and spaces.

- TIA– 606A *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.* This standard identifies record-keeping requirements and information needed to effectively administer building communications systems.

- TIA J-STD – 607-A *Commercial Building Grounding and Bonding Requirement.* This document identifies the need for, and composition of, a dedicated electrical grounding system for communications.

- Rural Utilities Service (RUS) Bulletin 1751F-640 *Design of Buried Plant, Physical Considerations*

- Rural Utilities Service (RUS) Bulletin 1751F-643 *Underground Plant Design*

- Rural Utilities Service (RUS) Bulletin 1751F-644 *Underground Plant Construction*

C. Documentation Standards

These standards provide direction to be used in conjunction with recognized industry standards, methods, and products; as well as Project Management documents, and the designer's professional services contract scope of work in preparing formal design documents.

Communications infrastructure project documentation should provide for at least the following information:

- *Statement of Work specific to the facility* – A brief overview of the scope of work for each building, a detailed plan outlining the method of transition to the new media or methodology proposed for distributing new media, and any restrictions or limitations for working within the facility.

- *Building floor plans* – Floor plans should reflect the location of telecommunication spaces, all riser or backbone (Intra-Building) pathways, and any unique construction requirements. The end result is that the bidder must be aware of the designer's understanding for all intra-building pathways. There should be no question of how cables should be placed to any outlet location. All communications outlets must be identified, by type and location, prior to the start of construction. This can be accomplished either as part of the detailed design documents or just prior to the start of installation in a particular building.

- *Statement of work for inter-building pathways and media* – A brief synopsis of the scope of work, by pathway, with an indication of unique or particularly difficult building entrance conditions. Include restrictions or limitations of particular routes or building entrance points. All inter-building media must be documented following BICSI, TIA, 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.

▪ *Building construction and system plans* – Details regarding architectural, electrical, mechanical, or plumbing work must be documented as with any project. Such details should be separate from the communications design unless the work to be undertaken is very minor and will not cause confusion to bidders.

▪ *Construction Standards Institute (CSI) format specifications* – Until the construction industry has accepted the new CSI format (Division 27 00 00), the specifications must generally follow the existing CSI Master Format. Construction work such as building a wall or painting a room should be specified under separate sections, not as part of a communications specification section.

D. New Construction and Retrofit

Planning and implementing a complete and flexible communications infrastructure has become a crucial piece of new construction. Gross square foot costs must be revised to reflect recent revision to the ANSI/TIA standards (telecommunication room sizes need to be increased to accommodate PoE switches, monitoring equipment, and other new technologies) and expanded space planning assumptions must be accommodated. Retrofit projects, however, are not as simple to address. It can sometimes be difficult to identify and/or obtain the funds needed for communications infrastructure improvements in existing buildings because of the unforeseen conditions that can inhibit the placement of the required infrastructure.

These Standards provide a series of requirements for communications 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 be more costly per square foot to provide 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 communications 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 distribution methods, and hazardous materials.

The most frequent consideration in retrofit design, however, is the requirement to continue communications service while a new system is being installed. With few exceptions, campus buildings are occupied most of the year imposing additional planning and costs.

Questions the retrofit designer must be prepared to answer 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, and specialized systems?

- How will the current systems be kept running if new media is to be installed in existing communications pathways?

- How will a transition be made from old media to new (for data, voice and video), assuming a re-use of communications pathways and equipment? Which group (Communications Services or building occupant) and by what process will be responsible for making the transition, testing, troubleshooting, and documentation?

- Will the work need to be undertaken at night or on weekends? 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 telecom spaces are not sufficient for new infrastructure, can the needed space be re-allocated and how would this process work?

- 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?

- All abandoned cable within a retrofit project must be removed in accordance with the National Electric Code sections 800.2 and 770.2. The National Electric Code definition of abandon cables identifies Installed communications cable that is not terminated at both ends, at a connector, or other equipment and not identified "For Future Use" with a tag."

Obviously, a retrofit design is extremely complicated and involves significantly more people, concepts, alternatives, and decisions than new construction. This document cannot provide the "correct" answer to all of the questions listed. However, it does outline the target recommendation for each aspect of the infrastructure and provide some options for addressing the problems associated with retrofit projects under the subsections titled Communication Spaces and Communications Pathways.

E. Communication Spaces

Inter-building communications spaces include the rooms and facilities required to:

- House the media and related equipment entering a building

- House terminal resources and specialized equipment, and

- Terminate user-level facilities

The minimum configuration for spaces within a standard academic or administrative facility includes two service entrance rooms (Entrance Facilities), an equipment room, which may be separate or combined with one of the entrance rooms, and one or more separate telecommunications rooms.

In many existing buildings, communications equipment is found in unsuitable spaces. Such poor environments cause equipment failures, limit the ability of users to obtain the services they need, can cause security issues and be a hazard to the people who must maintain the equipment.

This subsection defines the minimum electrical and mechanical support system requirements for all new and remodeled spaces.

1. Electrical Services

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

Configuration or design of electrical services not directly in support of communications spaces is outside the scope of this document. Excluded services include the need to support specific applications and user equipment in classrooms, computer and research labs, and common spaces. This document addresses specifically the minimum requirements for services in communications spaces.

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

Points). At a minimum, the electrical service designs for telecommunication spaces must be as follows:

- Telecommunications Rooms expected to use over 7,500 watts should be equipped with an electrical panel dedicated strictly to communications in that space.

- Serving electrical panels should be equipped with power suppression shunts to protect equipment from overloads.

- Minimum panel sizing: 100 AMP for Telecommunication Rooms and 225 AMP for Equipment Rooms. Smaller equipment rooms, without a forecasted load, may initially be served with 100 to 150 AMP service, but the feeder cables and panel must be sized to eventually support 225 amps. The designer must be aware some telecommunication rooms may require special twist-lock plugs specific to the equipment being installed.

- Equipment Rooms used to house voice, data network, or video distribution nodes must be equipped with at least one 30 AMP, 208-volt circuit. At a minimum, this includes all PBX switching nodes and all data backbone network node sites.

- If the building does have a backup generator, then the Equipment Rooms must have standby power, and all telecommunication rooms must have electrical conduit installed to support future installation of standby power. If the building does not have a standby generator (i.e., beyond life safety), then the Equipment Room and Telecommunications Rooms should be provisioned for future connections to standby power.

- Standby power where available should be provided for the service providers. This power is to be used in lieu of large UPS systems which could affect the floor loading requirements of the space. A typical floor loading requirement for these rooms is 150 lbs per sq. ft.

2. Communications Grounding System

There are three major sources for details of the required grounding system design; J-STD-607A *Commercial Building Grounding and Bonding Requirements for Telecommunications,* the BICSI *TDMM guide, the National Electric Code (NEC-2008), and the International Electrical and Electronics Engineering (IEEE) Std 1100-1000 Recommended Practice for Powering and Grounding Electronic Equipment*.

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 communications 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 Inter-building backbone 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 communications cable, such as ladder racks, cable trays, racks, cabinets and conduits, must be grounded.

It is imperative to design and install the communications grounding system as defined in ANSI TIA-607 and to use only a common point of ground for all services (power and communications) within the same building.

The standard for communications grounding contains some key elements:

- The ground resistance value target is 5 ohms; however, it is understood this is not always possible. Therefore, the ultimate goal is to achieve the lowest ground resistance value possible.

- Telecommunication grounds are not to be served through an electrical panel grounding bus, but must be directly cabled to the building service entrance ground 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 communications spaces and be coupled 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.
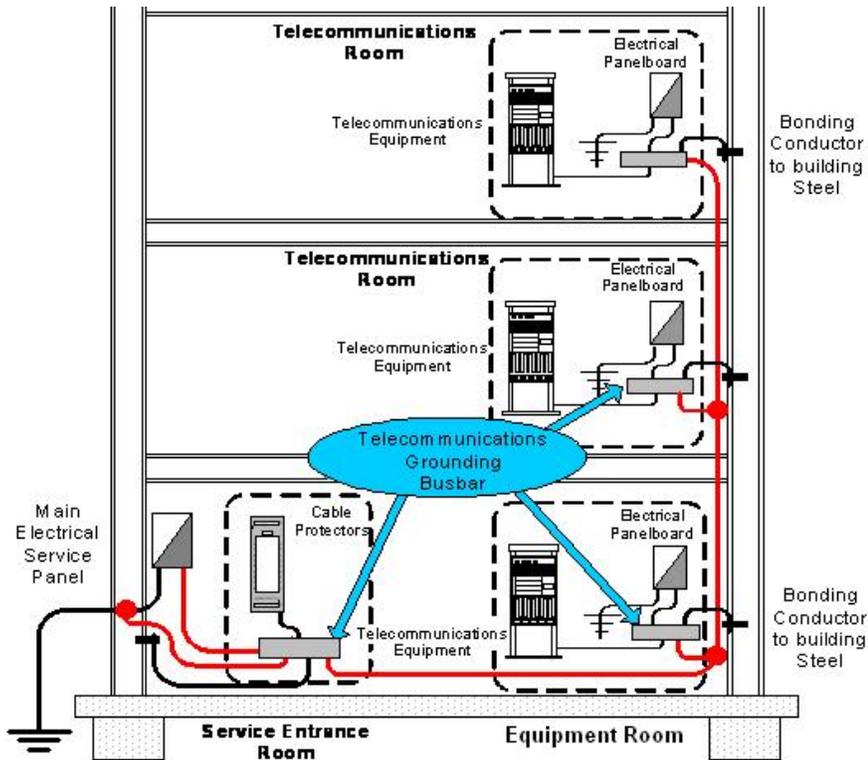
Figure 3-1

Communications Bonding Backbone

3. Entrance Facilities

Building entrance facilities (two required for UCSB services due to our ring architecture) 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. This room is also known as the MPOE, when the service entrance room serves at the Minimum Point Of Entry for service provider services to a building or campus. In either case, sufficient room and structural additions are required to support the installation of a variety of inter- and/or intra-building cables, as well as space for splice cases and electrical protectors.

a. Location

The entrance facilities must be located as close as possible to the point at which feeder conduits enter the building and to the vertical backbone (communications riser) pathway. The areas must be dry, not subject to flooding, and free of overhead water, steam, or drain pipes. Access to the room should be provided directly from a central hallway, not through another room. For buildings over 10,000 gross square feet (GSF), the building service entrance facilities must be dedicated to communications infrastructure and be enclosed rooms. For buildings less than 10,000 GSF, mixed-use rooms that meet all other requirements may be utilized as long as no cables entering, terminated in, or leaving the room come within ten feet of an electrical transformer or major switchboard.

Ideally, these rooms should be accessible from an exterior door. The interior environment of these rooms must be clean and dust free to accommodate terminations of optical fiber.

For mixed-use rooms, the cable terminations need to be in a protected space which could be accomplished via a separate space walled off from the rest of the room.

b. Size

In buildings smaller than 5,000 GSF, the communications entrance space should be a minimum of four (4) feet by five (5) feet. In buildings greater than 5,000 GSF, the entrance facilities must be a minimum of five (5) feet by eight (8) feet with usable wall space of 64 square feet. All space must be clear of other equipment, access points, or maintenance areas.
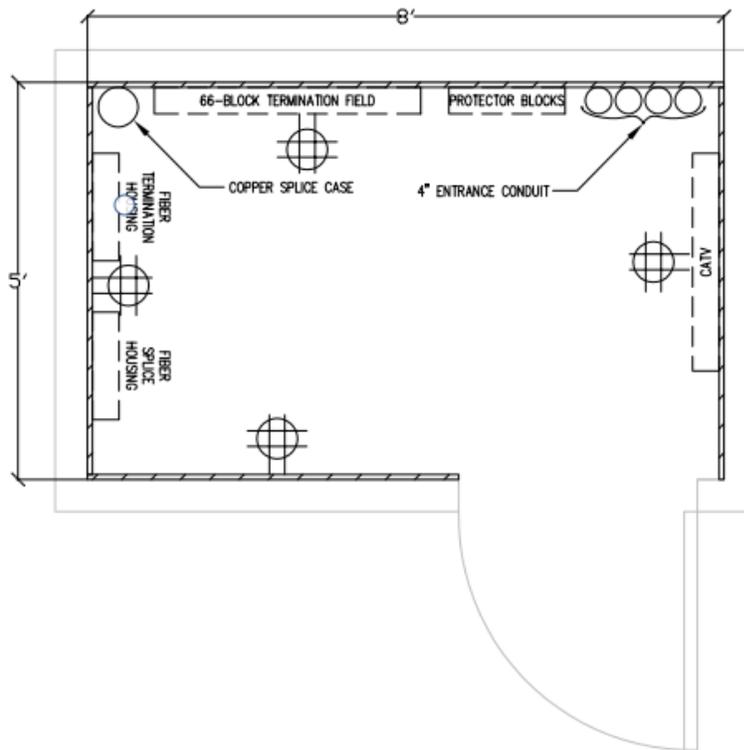
Figure 3-2

Entrance Room/Facility Space Requirements

c. Space Design

Standalone service entrance facilities are not designed to support the placement of electronic equipment. Electronic equipment must only be placed in properly equipped spaces, such as equipment rooms, machine rooms, or telecommunication rooms, or in combined service entrance / equipment rooms, in which case the requirements are additive. At a minimum, the service entrance facilities or spaces must contain the support items detailed in the following subsection "d".

d. Room Conditioning

▪ The walls must be covered with void-free 3/4 inch A-C plywood, sanded smooth and painted with fire-retardant paint (not fire-retardant plywood unless required by local fire codes), mounted vertically starting 6" above the finished floor, 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.

- 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. 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. At no time shall the ballasts be installed in close proximity to communications cabling. A minimum of 12" separation between cable racking and light fixtures must be adhered.

- The door to the room must be a minimum of 36" wide by 80" high and must be equipped with a separate locking system that has controlled and restricted access, and if this is a combined service entrance room / equipment room then there may be additional controls such as a locked cabinet for the different low voltage compatible services in the room.

- A telecommunications electrical ground (as defined by TIA standards) must be provided on a ten (10) inch (minimum length) busbar mounted 78" inches above the finished floor. This grounding bar must be connected to building steel, the main electrical service panel, and the central telecommunications ground cable.

- If the entrance facilities are stand-alone, meaning there are no active electronic components to be installed within the space, 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 entrance facility. In addition, the room shall be equipped with auxiliary duplex outlets placed 18" above the finished floor, at six-foot intervals around the perimeter walls. A maximum of four 110 volt auxiliary outlets may occupy a single 20 Amp branch circuit.

- 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 entrance room. All spaces around conduits, through a concrete wall or foundation, must be sealed using moisture barrier plastic expansion foam (not insulation) and the outer wall moisture barrier repaired and resealed. All conduits leaving the entrance facilities for other portions of the building must be fire-stopped whether or not they contain cable.

- The floor of the entrance facilities must be sealed concrete or must be tiled with static dissipative VCT to reduce airborne contaminates. The floor structure should provide a minimum of 150 lbs. per square foot loading capability.

- If additional equipment, such as fire alarm communication panels and/or building monitoring equipment, is housed in the entrance room, additional space and plywood backboards must be provided for such equipment with a minimum 16 square feet for each additional service. In no event should such equipment be mounted in the center of a wall or directly over entrance or riser conduits.

F. Equipment Room

The equipment room is the space used to house communications equipment intended to service users throughout the building. Typically, this equipment includes a PBX or other voice switching systems, campus data backbone equipment and local area network hubs, video distribution system components, or other communications equipment. In addition there may be other low voltage services with equipment and distribution requirements that are compatible with communications equipment and distribution requirements that may also be located in the communications equipment room. Such services that are currently allowed include: Fire alarm systems, building monitoring and control systems, key access systems, video camera systems, and security alarm systems. Low Voltage Compatible Services must not exceed a nominal 50VDC or 30VAC RMS, and must have 16 wiring gauge or smaller.

Due to the importance of this room to the varying types of campus networks, it is critical 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 facilities and must be the starting point for the building's backbone distribution system.

It is possible in some cases to combine one of the entrance facility spaces with the building equipment room into a single space. However, the requirements for this combined space are additive and will require the design of a space larger than outlined in this portion of the document.

1. Location

The equipment room should be located directly in-line with the entrance facilities and must form the basis for the rest of the building's backbone distribution system. The assigned space should be located where there is a possibility of future expansion and where access to the space from outside the building can be provided for large equipment (direct hallway access). The location of the telecommunications rooms on other floors will impact the site chosen for this space, because these rooms should be "stacked" one directly above the other.

Locations that might be subject to flooding (such as basements), electrical interference (such as adjacent to electrical equipment rooms), or hazardous situations should be avoided. Although few designers would make the error today of putting communications equipment in an electrical room, some designers still utilize common areas providing back-to-back rooms with electrical and communications. The impact of electrical interference from standard building systems on communications equipment and cable is not well defined. Layouts that can work in one situation will cause excessive failures on another.

The reasonable way to address this problem is to separate the electrical and communications equipment spaces so that they are not within ten feet of each other. Communications cables should never route through an electrical room to access the communications space.

If existing cable is currently using an electrical equipment room as a main pathway, a new pathway must be provided that does not pass through the electrical equipment room. If no such pathway is available due to distance limitations, 4" conduits can be installed for new cabling. This conduit must be grounded to the communications ground system.

2. Size

If projected equipment layouts are unavailable, or if no special uses are defined for this space, the equipment room should be sized as follows: provide one (1) square foot of equipment room space for every 125 square feet of work station space (assignable space) served by that room. However, the minimum room size is 80 square feet. If the building is expected to support a large number of workstations (such as a computer or research lab), the room should be sized to provide enough rack space to accommodate the additional services. If other low voltage compatible services with equipment and distribution requirements that are compatible with communications equipment and distribution requirements will also be located in the communications equipment room, then there needs to be a minimum of an additional 16 square feet for each additional service.

Where it is known that a specific communications system will be utilized to service a building under design, a floor plan indicating equipment placement, including growth, should be prepared and compared with the projected room size. The final room sizing must also take into consideration issues such as the need for auxiliary power (UPS/batteries), the need for any of the systems to provide service to other buildings (e.g. a remote PBX node may be used to serve not only the building under design but other buildings nearby), local requirements for a separate battery room, and any known special needs.

3. Space Design

The specific features that should be designed into a typical equipment room are (these are also referenced for the telecommunications room – in Section Three, part G, subpart 3):

- An average floor loading of 150 lbs. per square foot. Specialized services, such as major UPS systems and batteries, may require floor design loadings exceeding 400 lbs. per square foot over a specified area and therefore, their design must be closely coordinated between the systems vendor, UCSB, and the design engineers. The floor must be sealed concrete or must be tiled with static dissipative tile to reduce airborne contaminates. 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.

- The equipment room 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 power supply transformers, motors and generators, x-ray equipment, or radio transmitters.

- Entrance doors should be minimum 36 inches wide by 7 feet tall. Additionally, consideration should be given to utilizing double (36" wide) doors opening out on larger-sized rooms.

- Sufficient heating, ventilating, and air conditioning (HVAC) sensors and control equipment must be installed to provide a consistent environment in this space. Unless specific requirements otherwise dictate, the room environment should approximate an office, and designers should assume a 12,000 to 20,000 BTU room load. The maximum change in temperature must not vary more than 15 degrees (F), and humidity should not vary more than 40 percent. The design target is a continuous operating temperature between 64 and 75 degrees with 20 to 60 percent (non-condensing) relative humidity. The recommended fire suppression system is a chemical discharge designed to work specifically within electronic equipment spaces. If that is not possible, a dry-pipe, pre-action system should be employed to reduce the potential of accidental discharge or leaks.

- If a wet-pipe system is used, a system control link should be provided to cut power to the equipment in the event water is discharged from the system, and drainage must be provided to limit the potential of flooding. At a minimum, this room must be equipped with a fire suppression system with high-temperature thermal links and cage-enclosed heads.

- If additional compatible low voltage service equipment, as defined above, is housed in the communications equipment room then cabinets or some other securing barrier needs to be provided to restrict and control access to different service's equipment.

- Lighting must be installed in the spaces to provide a minimum of 50 foot candles of illumination measured 3 feet above the finished floor. Light fixtures should be mounted a minimum of 8.5 feet above the floor and should be located in the middle of aisles between frames or cabinets. Equipment rooms should be equipped with emergency backup lighting sufficient to allow a technician to service any system operating on emergency power during a commercial power failure.

- A separate electrical service panel, sized to support 225 amps, must be installed in each equipment room supporting communications equipment. A <u>minimum</u> of two 30-amp (208

volt) AC simplex and four 20-amp, 110 volt, AC duplex isolated electrical outlets, each on a separate circuit, shall be installed in the equipment room. These outlets are to be located to support individual equipment racks and should be placed minimum six feet above the finished floor. In addition, the room should be equipped with auxiliary duplex outlets placed 18" 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. Additional low voltage services may require their own separate electrical panel.

- Electrical services must be identified for low voltage services. Some systems may require a separate service panel.

- Additional electrical needs exist for equipment specific to each building. Some PBX systems use 48 volts DC to power the equipment, therefore the equipment 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.

- Care must be taken to determine the long-term potential load (rather than the initial load) for electrical services in these spaces. Often only a few switches and routers will be installed in a new building, leaving the electrical engineer assuming a rather light load. However, the designer must keep in mind the need to look at future requirements to determine the need for expansion potential within such spaces. Additional outlets and circuits eventually will be required in almost every equipment room in most buildings.

- The load on the alternate power supply must be determined using the active communications equipment plus lighting, room air handlers, cooling units, and fan or blowers. An automatic transfer switch must be installed to link the various cooling components to the secondary power source when commercial power fails. The use of a standard uninterruptible power supply (UPS) designed to support only sensitive electronic network equipment is not generally the best solution for the primary power connection for extensive heating, ventilation, and air conditioning (HVAC) systems. Each UPS system needs to be designed to meet the specific requirements of the project.

- An isolated electrical ground (as defined by Article 250-74 of the NEC) must be provided on a copper bus bar mounted approximately 78" above the finished floor, unless otherwise specified. This grounding bar should be connected with minimum #4 copper wire to the building's main electrical grounding grid and may also require a separate concrete-encased electrode, or a buried ring ground.

- 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.

- Equipment rooms should be equipped with a finish ceiling with a minimum height of 8'-6".

- All walls must be covered with 3/4 inch A-C plywood, sanded smooth and painted with two coats of fire-retardant paint (not fire-retardant plywood unless required by local fire codes). The plywood should be mounted vertically starting 6" above the finished floor, and secured to the walls using flush-mounted fasteners designed and listed to secure wood to the specific wall/stud material. All plywood panels must be mounted in contact with one another, with no gaps between sheets. All fasteners must be flush with the surface of the plywood.
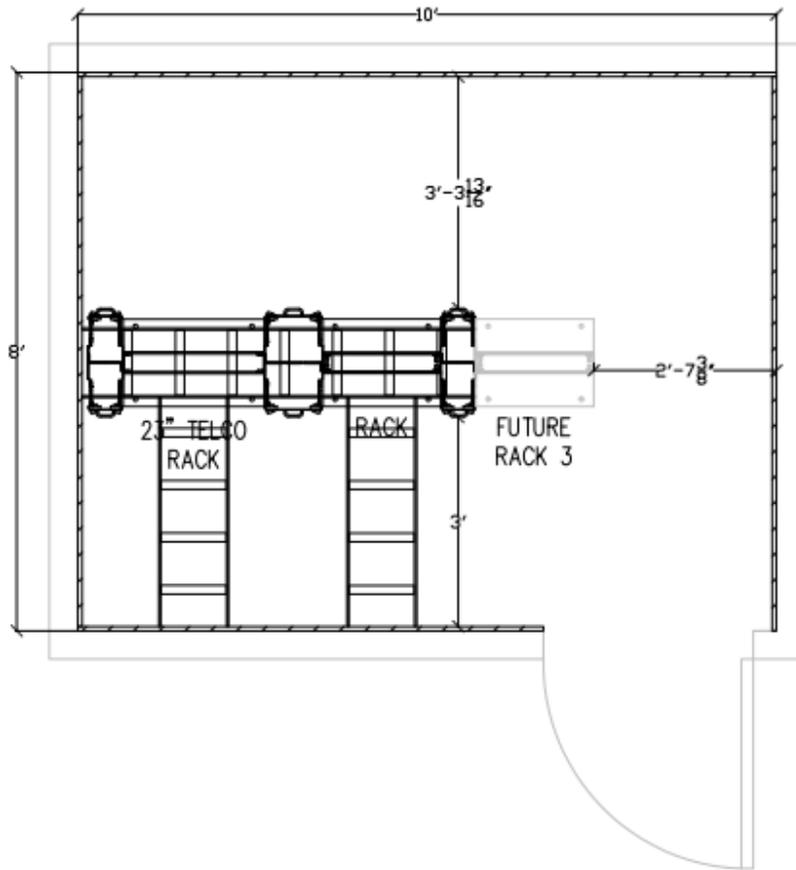

Figure 3-3

Typical Equipment Room Layout

G. Telecommunications Room

The telecommunications room typically supports all station cabling and cross-connects, network electronics, as well as other low voltage communications distribution equipment such as video,

wireless, security, etc. Additionally, in multi-story and large single floor buildings, these rooms serve as part of the horizontal and vertical pathway system. Always keep in mind, these rooms will require frequent access by technicians installing and maintaining various network services and must be sized and equipped to meet this demanding role.

1. Location

As one of the primary focal points for all communication services, 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. It must be identified as a fixed location similar to an elevator, mechanical shaft, or electrical room. These rooms must be located near the center of the area they will serve, must be stacked one above the other in multi-story buildings, and must be sized to accommodate UCSB's communications infrastructure needs. Whenever possible, access to these rooms should be directly from hallways, not through classrooms, offices, or mechanical spaces.

- The telecommunications room must be located within an absolute maximum cable pathway distance of 90 meters or approximately 295 cable feet to the most distant outlet location. Cable-feet distance is defined as the total distance of the route the actual station cable must follow between the telecommunications room and the outlet location. For planning purposes, the most distant outlet locations should be designed to be no more than 245 feet measuring parallel and at right angles to building structure. An additional Telecommunications room is likely needed if any horizontal segment exceeds a distance of 245 feet excluding vertical segments. This distance should be identified for the furthest communications outlet from the Telecommunications room.

- 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.

- These rooms must be dedicated to the exclusive use of communications and compatible low voltage service equipment to provide a proper environment and security. They cannot occupy partial spaces within mechanical or electrical rooms.

- Multiple rooms located on the same floor must be interconnected with conduits. The backbone pathway subsection identifies number and type.

2. Size

Telecommunications Room(s) serving an individual floor must be of sufficient size to support an extensive list of voice, data, video and compatible low voltage services equipment. Figure

3-4 identifies the required room size for various gross square footages. This design size criterion assumes average mixed-use utilization of space (between 60-100 square feet per person). In facilities with high-density seating such as a computer or research lab or a facility equipped with a machine room housing servers and/or fiber optics cabling to the workstation, additional space will be required to meet the increased load. In facilities with a high density of workstations and a number of different departments, additional space will be required to meet the increased load. The sizes provided reflect the minimum room size. If other low voltage services with equipment and distribution requirements that are compatible with communications equipment and distribution requirements will also be located in the communications equipment room, then there needs to be a minimum of an additional 16 square feet for each additional service. Rooms shall be square or rectangle with in shape with no curves or turns (L-shaped rooms are not acceptable).

Building Gross **Square Footage Served Up To**	**Total Room Square Footage**	**Room Floor Size**
2,000	40	5' x 8'
8,000	80	10' x 8'
12,000	100	10' x 10'
15,000	120	10' x 12'

Figure 3-4
Telecommunications Room Space Requirements

3. Space Design

The specific components that should be designed into an average telecommunications room are the same as defined for an equipment room (Section Three, part F, subpart 3) with the following modifications:

a. The Telecommunications Room must be provided a floor with a loading capacity of 150 lbs. per square foot, and the floor load capacity should be identified in the room with a metal plate on the wall.

b. Unless specific requirements dictate otherwise, the Telecommunications Room environment should approximate an office, and the designer should assume a 5,000-10,000 BTU load from installed equipment. Higher BTU loads should be assumed for Telecommunications Rooms larger than 10' x 8'. All Telecommunications Rooms should be positively cooled 7/24. In addition, a heat exchange system must be designed into the space to reduce overheating of equipment during times of building HVAC shutdown. Depending on climate conditions either a dedicated and separate

24/7 backup system or possibly a thermostatically controlled exhaust fan should be installed to augment the normal building cooling system.

c. If additional compatible low voltage service equipment, such as fire alarm panels and/or building monitoring hardware, is housed in the telecommunications room, secured access must be considered which may require additional power and cooling requirements.

d. A separate electrical service panel, sized to support, at minimum, 100 amps 24 breakers should be installed as necessary in each Telecommunications Room. A minimum of two 20 amp, 120 volt AC duplex isolated electrical outlets, each on a separate circuit, shall be installed for each anticipated service, where each service would have a dedicated circuit run from a panel in or near the Telecommunications Room. These outlets are to be located to support individual equipment racks (one circuit per rack) and should be placed six feet above the finished floor. In addition, the room shall be equipped with auxiliary duplex outlets placed approximately 18" 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.

H. Other Communications Spaces

There are other communications-specific or related spaces that may only occasionally need updating or modification. This includes the UCSB Machine Rooms (MR); generally the location in which individually owned and operated servers and some privately owned equipment is housed. These rooms must have direct access to the campus backbone network, network management and control centers, and in some cases the video distribution network.

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 communications infrastructure. Some of these considerations are:

- Each space should be connected to the closest telecommunications room via conduit.

- 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 communications grounding system for the building in which it is located.

- Each should be included in security and support systems such as basic power, accessible chilled water drain, auxiliary power generation, backup air handling, emergency lighting, special fire suppression, and physical security and monitoring.

- Campus Machine Rooms should be designed following guidelines similar to a data center in terms of structural systems, support requirements, security provisions, cable entrance support systems, and future growth capabilities.

1. Retrofit Space Issues

The primary concern of space design for retrofit projects is simply finding or creating a space that meets the physical design requirements of the infrastructure and is acceptable to facility planners and departmental heads. While the design target and support requirements for retrofit spaces are the same as those previously defined in this section, the real world will seldom provide perfectly shaped and sized open spaces stacked directly above one another in an existing building. It is up to the design team to determine the capabilities and limitations of the available space and to be creative in meeting the varying needs and restrictions.

If storeroom or office space is not available in a particular facility, perhaps well located instructional space can be traded with renovated non-instructional space in another portion of the building in an effort to maintain distance limitations and/or square foot usage. Sometimes common and/or hallway space can be used without affecting traffic flow or causing egress problems. Spaces within restrooms or with access through classrooms or offices are not acceptable locations for these rooms. A much less attractive alternative is creating a space on one floor to serve users on two floors. This alternative not only creates additional problems with pathways between floors, potential distance issues for the media, and ongoing maintenance concerns, but it also does not save actual floor space -- it simply shifts it to another location.

One way to resolve this issue is to install self-contained floor- or wall-mount cabinets. These types of units require a small foot print either anchored to the floor or to a wall in a potential joint use space such as a janitor closet, classroom or possibly an office. In addition to cabinets specifically designed to serve as communications distribution spaces, are similar infrastructure components, including: raceways, ventilation, power, grounding, cable management, etc.

2. Communications Pathways

Communications pathways include the inter-building conduit and utility vaults (also known as maintenance holes) used to transport cables between buildings and the conduit and raceways used to distribute cable within a building. Such pathways must be designed as an integral part of an overall communications infrastructure plan, not a technology component or vendor-specific system. 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 the initial requirements.

I. Inter-building Distribution System

An inter-building distribution system consists of conduit and utility vaults that interconnect campus buildings. The selection of routes and the sizing of an inter-building distribution system must be based upon existing conditions, known problem areas, and the growth associated with anticipated future plans.

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 off loading services from 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 communications distribution system undergo both a visual and physical 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 than the original.

This subsection provides some general guidelines for the design of inter-building communications 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 National Electrical Code (NEC), UCSB specific constraints, and project funding guidelines.

1. Conduit and Utility Vault System

A conduit and utility vault system is the most common form of inter-building pathway used throughout the UCSB campus. These systems are frequently designed incorrectly as "signal" or "low voltage electrical" distribution systems. A good quality communications 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 should be buried a minimum of 24 inches below grade. The trench must be back-filled with materials that have been sifted and mechanically compacted. Utility marking tape should be buried 12 inches below the surface, directly above the conduit.

- Generally, conduits should 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 concrete/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. Trenching is the preferred method for installation of underground facilities. If Boring is the only viable option, the following parameters must be met.

  o A Bore Path Survey including exit and entry stakes must be completed and documented.

  o Entire route and installation details must be documented and reviewed with University staff prior to installation.

  o HDPE conduits must be installed.

  o Copper trace wires must be installed within the pathway.

  o A guidance system must be used for all boring activities.

- o Pull-back pressure must be monitored and recorded during the installation of conduits.

- o After installation, hydro pressure testing must be completed with results documented and delivered to the University staff.

- Conduits under highways or railroad rights-of-way must be encased in steel casing pipe consistent with the American Association of State Highway and Transportation Officials or the American Railway Engineering Association specifications. The thickness of the pipe and depth of installation is dependent upon a variety of factors and must be engineered for each specific instance.

- 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.

- 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 structural weaknesses.

- The number of conduits entering a building will vary depending upon building size, location, intended mission, and the size and type of cables expected to be used long-term. At a minimum, however, three 3-inch (or larger) conduits per Entrance Facility are required to service most permanent buildings. The design goal is to always have a conduit open to provide a pathway for cable reinforcement (growth or replacement). Even a small building of 2-4,000 square feet needs a minimum of three 3-inch conduits per Entrance Facility. One conduit can contain a copper cable and three innerducts (one with a fiber optic cable), and the other conduit would be open to act as a reinforcement pathway.

- If no reasonable forecast can be agreed upon, or if it will be difficult or costly to trench to the building site in the future, Figure 3-5 can be used to determine the number of conduits.

Building Floor Space	4" Conduits	3" Conduit	2" Conduits
0 – 20,000	2 (one with three 1" innerducts)	2 (one with 1 1.25" innerduct and one 1" innerduct)	2
20,000 & larger	4 (one with three 1" innerducts)	4 (one with 1-1. 5" innerduct and one 1" innerduct)	2

Figure 3-5

Number of Serving Conduits per Entrance Facility

- In addition to the suggested number of communications related conduits, planners should consider requirements for other low voltage systems (e.g., fire alarm, clock, energy management, etc.) that may need to be differentiated and therefore require additional conduits.

- Additional conduits may be required for buildings over 125,000 square feet, specialized communication facilities (computer center, library, media center, research lab, machine room, or telephone switch site), or buildings that may be difficult or impossible to reinforce at a later date.

2. Utility Vaults & 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.

It is important to understand the capabilities and limitations of the components and the overall anticipated design. Too often, vaults or pull boxes of the wrong type or size are specified or

they have are situated or installed incorrectly, limiting the way cables can be placed within certain routes. This situation can lead to difficult or unsafe working conditions, inefficient use of conduit capacity, or damage to cables or conduits.

One of the major ways to resolve this difficulty is to prepare a design using telephone system criteria and component designs. Electrical vaults and distribution systems are different from communications, and the two systems must not be designed in the same manner. The following provides a list of the major points to consider when identifying the utility vaults for the communications 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 coin telephone or parking lot emergency phone. The standard size unit (3' wide by 5' long by depth as required) should be fitted with a traffic-capable lid (H-20 rating). 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. Communications 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 four to six conduits should form the ring backbone distribution system and should feed smaller runs of three conduits into the entrance facilities. Any building not located within 200 feet of a main or feeder utility vault should have a separate vault or pull box installed to act as a cable pulling point between the building's entrance facilities and the main inter-building distribution pathway system.

- The target spacing for the placement of utility holes may not exceed 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 and more efficient. Factors that would reduce the recommended distance include natural or manmade obstructions, extensive back feed needs, or more than two ninety-degree bends in the serving conduit.

- All utility vaults must be equipped with dry-sump, corrosion-resistant pulling irons (one at each end), cable racks on both long sides, standoff brackets at both ends, a grounding rod, a ladder. Concrete used for vaults should be at least 4,500 lbs. per square inch in strength and the structure must be rated for at least HS-20 (vehicle traffic) for A.A.S.H.T.O.

- The configuration of the placement of conduit into a vault, either in the center or near the outer area of the vault, is subject to individual campus requirements and requires an understanding of what systems are currently installed. Vaults of standard size and configuration are not designed to support the placement of large copper cables with right angle bends. For this reason, conduits should never enter a vault from the long sides, the top, or the bottom.

- The determination of the size of communications 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. The minimum size utility vault is 4' wide by 6' long by 7' tall, which is generally sufficient to serve an individual building. If 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 need to be:

- Driven by the number of conduits entering and leaving the vault, the number and type of splices

- The site in which the structure will be located, and

- Use Figure 3-6 to size communications utility vaults if no other forecasting or existing configuration information is available.

Number of Conduits	Utility Vault Size
Less than 6	4' x 6'
6 – 12	5' x 7'
13 -18	6' x 10' x 7'

Figure 3-6
Recommended Communications Vault Size Requirements

J. Intra-building Backbone

The intra-building backbone pathways connect the entrance facilities, equipment rooms, and all telecommunications rooms in a given structure. Backbone communications pathways consist of conduit, sleeves, and trays. The designer should be aware that open cable trays are not an option for supporting large copper cables from the entrance room to the equipment room or 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 300 pair in shielded, plenum-rated cable types.

1. Sizing

In determining the proper number of conduits or sleeves required to connect the entrance facilities to the equipment room or 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 equipment room. Here the electronic components serving users within the building will be interconnected with the cable feeding from other parts of campus.

In initially sizing conduits between the entrance and an equipment room, the designer should add two to the number of conduits entering the building.

The standard communications cabling package supporting each telecommunications room is:

- 6 x Cat 6A cables

- 12 single mode / 12 multimode fiber strands (=6 pairs each) in one 3/4" innerduct, and an additional spare 3/4" innerduct.

- 50 or 100 pair Cat 3 copper cables for telephone service

- (1) .500 PIII Coax (continuous between floors) for cable television service

- A minimum of three 4-inch conduits between telecommunication rooms, plus any additional conduits (or risers) needed to satisfy the following three requirements:

  o If the GSF of the floor to be served by the telecommunication room is greater than 10,000 then our practice is to build a second riser and set of telecommunication rooms because horizontal (workstation) cabling distribution would approach the max 5e and 6A performance distances.

  o The number of conduits needs to support the installation of the originally specified riser packages (where 2 packages fill a 4" conduit at 40% fill ratio).

  o There needs to be at least one empty conduit available between each telecommunication room.

  If 4" conduits cannot be used, then a minimum needed is the inside volume equivalent of four 4" conduits delivered via 3" conduits.

Separate conduits should be provided for compatible low voltage services that require their own cable runs between telecommunications rooms and the equipment room.

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.

2. Design

- For telecommunications rooms that stack, 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.

- Conduits used to interconnect entrance facilities and/or equipment rooms 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. Figure 3-7 provides a pull box sizing reference.

  All riser sleeves must be firestopped and sealed following code and manufacturer's instructions.

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

Figure 3-7
Pull Box Size

K. Horizontal Pathways

Horizontal communications pathways are facilities that support the installation and maintenance of cables between the telecommunications rooms and the station outlet locations. The recommended use of plenum-rated communications cable supported by a cable tray serving station conduits extending through the false ceiling space to the work station outlet is the general distribution method for all new construction. Communications cables must never be allowed to rest on ceiling tile or be taped or tie wrapped 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 rated products. This subsection outlines the major methods recommended within for supporting cables in the horizontal communications pathways.

1. Cable Tray

Cable tray should be provided. The designer must be certain the unit specified is sufficient to hold the weight of all the cables likely to be supported over the life of the system, is routed correctly, and is installed to maximize usage. This cable tray shall be used for all compatible low voltage systems.

- Unless otherwise specified, the cable tray should be wire mesh or basket type (e.g., Cabolfil, Inc. EZTray or equivalent product.)

- Shall be installed above the ceiling accessible ceiling space. If there is no access available then conduit must be provided.

- Should access to the ceiling space be unavailable and the pathway is required below a ceiling, installation of ladder tray is preferred.

- Minimum tray sizes for .310 diameter cables are as follows:

a. 4" x 12" less than 128 cables

b. 4" x 18" 129 to 192 cables

c. 4" x 24" 193 to 256 cables.

- Trays should be secured on five- foot centers using a double-sided channel, angled wall supports, or a trapeze support. 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 trapeze or wall support system should be used. <u>All tray installations must meet seismic bracing standards for Zone 4 and must be supported against horizontal, lateral, and vertical movement</u>.

- 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.

- Trays must only be utilized over areas with ceiling access and should transition to a minimum of two four-inch conduits when routed over fixed ceiling space distances greater than 30 feet or containing any angle greater than 20 degrees with total less than 180 degree bends.

- Trays shall be electrically bonded end-to-end.

- Trays should enter telecommunications rooms six inches into the room, then utilize a radius bend in a "waterfall" to protect station cables from potential damage from the end of the tray. All penetrations through firewalls must be designed to allow cable installers to 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.

- Trays must not be placed closer than five inches to any overhead light fixture and no closer than 12 inches to any electrical ballast. A minimum of eight inches of clearance above the tray must be maintained at all times to allow placement and management of the installed cables. All bends and T-joints in the tray must be fully accessible from above (within one foot). Trays should be mounted no higher than 12 feet above the finished floor and must not extend more than eight feet over a fixed ceiling area.

- Cable trays shall be accessible to the installation and maintenance of communications cables. Access panels shall be designed where required to accommodate this requirements. Access panels shall be a minimum of 2' X 2' and located at all pathway corners and elevation changes.

- All compatible low voltage system cabling shall be installed separately to avoid intermingling.

2. Conduit Cable Fill

Figure 3-8, assumes an average cable size of .31" (*Industry standard and NEC code is to design for a maximum of 40% fill), and this Figure only represents estimates and is based upon a number of variables. The actual number of cables which can be installed in a particular conduit can be slightly more or significantly less depending upon such factors as:*

- *All cables must be pulled at the same time to achieve the greater fill levels;*

- *Conduit runs should be less than 50 feet in length (reduce the number of cables by 15% for conduit runs between 50 and 100 feet;*

- *Pull boxes should be placed every 100 feet or if more than 180 degrees of bends are installed in the conduit; and*

- *Conduits shall enter and exit pull boxes in a continuous direction. Pull boxes are not to be used for 90 degree bends.*

Conduit Trade Size	Conduit Area (sq in)	40% Fill # of Cables	50% Fill # of Cables	60% Fill # of Cables
¾"	.44	2	3	4
1"	.79	4	5	6
1 – ¼"	1.23	7	9	11
2"	3.14	17	22	26
3"	7.07	46	60	70
4"	12.56	78	102	117

Cable Tray Size	Usable Area (sq in)	40% Fill # of Cables	50% Fill # of Cables	60% Fill # of Cables
12" X 4"	48	128	160	192
18" X 4"	72	192	240	288
24" X 4"	96	256	320	384

Figure 3-8

Typical Conduit Cable Fill (cable OD of .31")

3. Station Outlets

The "standard" wall outlet must be a 5S deep square outlet box, served by a 1¼-inch conduit (with no more than a total of 180 degrees of bend). Outlets must be mounted as defined by

code. Communications outlet boxes should never be daisy-chained or mounted back-to-back using a common feeder conduit.

Flush floor mounted location may require additional conduit bends to accommodate the installation of communications cabling. For these locations specifically, an additional 90 degree bend may be required. At no time may a communications conduit pathway exceed 270 degrees of total bends without the installation of a junction box.

Faceplates without the use of the support brackets are not recommended. The best design provides an EMT conduit from within 6" of the tray to above the ceiling space to just above the point at which the faceplate is to be mounted. All conduits need bushings and must have pull lines.

Some installations may require the following configurations:

- If flush-mounted floor outlets are required, the designer should place a dual use (signal & power) 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. Ideally, each box should be supported by a dedicated conduit. Flush-mount units must provide a space for communications comparable to the standard NEMA outlet box.

- Custom counter or workstation installations requiring communications services should be connected to a wall-mounted junction box fed by a two-inch conduit. A maximum of four workstations can be jointly served in this manner.

L. Horizontal Retrofit Pathways

The single most difficult design issue in retrofit projects, beyond obtaining space, is identifying ways to distribute station cable within an older building. Communications 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 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 mechanical, electrical and plumbing equipment already placed in that limited space. In these situations, it can be very difficult or impossible to install large sections of cable tray without actually 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 a new conveyance system 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 maintenance technicians on-going access to the horizontal communications 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. Architects and campus planners often eliminate this alternative based on aesthetics.

- Surface mounted cable raceway is another recommended pathway within classrooms and offices. It is important to select a product which provides cable support and routing for Cat 5E or better cables (no sharp bends) and has adequate capacity for both the initial installation and future growth. Generally, metal raceways should be used within research labs and classrooms (which require extremely high quantities of data connections) due to the need for additional protection and the ability to secure the product. Heavy duty plastic is a good choice for general usage in staff offices and administration spaces. If surface raceways are utilized, power must be installed a completely separate or at a minimum a segregated channel.

- Most hallways are constructed as fire and smoke barriers designed to provide a safe exit corridor in the event of an emergency. It is extremely important the designer develop a specific plan for penetrating and restoring the ratings of walls, floors, and ceiling spaces in these hallways. That includes a method to allow technicians to continue to adequately firestop these penetrations over the life of the facility.

- One of the most common forms of cable support, which is no longer recommended, is the use of individual ceiling hangers to support multiple copper, fiber, and coaxial cables. Due to the construction and performance needs of newer cables, the weight of even a very few cables can, over time, cause kinks or bends resulting in performance problems.

  The recommended solution is to use a conduit from the cable tray to the work station outlet. If this method is not available for any reason, one of several new cable support products available on the market will suffice. These are designed to be supported by ceiling hangers, threaded rods, beam clamps, or wall mounts. Each is rated by the manufacturer as to the number and type of cables it will support and the required distance between supports.

Generally, these supports are placed no more than five feet apart and hold up to a few dozen cables.

1. Firestopping

Firestopping is a critical component on retrofit projects and must be specifically addressed by the communications design team. In new construction projects, firestopping is generally addressed by each member of the construction team as they complete their portion of the project. The nature of a communications cable installation retrofit project is such that the contractor has a significant amount of leeway in determining where and how cable is to be installed. It is important the design team communicate their expectations about firestopping to the Contractor before the project is started.

- Each type of penetration is different, and the firestopping 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.

- Each firestop system must have a manufacturer's rating sheet outlining the products to be used, the construction materials to be penetrated, the penetrating items (cable, conduit, material type, annular spacing within conduits), the rating expectation, and the installation methods.

NO SINGLE FIRE STOP MATERIAL WILL MEET EVERY SITUATION IN A BUILDING-WIDE CABLE INSTALLATION PROJECT.

- It is the designer's responsibility to identify general types of acceptable and approved fire stopping materials and methods, including manufacturers, and to identify the types of fire-rated structures within buildings. There are several steps to this process:

  1. Define construction types – the design team must have 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.

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

  3. Identify special or unique situations - Large openings, such as cable trays, must be specifically identified, and firestopping materials and methods defined as part of the design package.

  4. During installation, the Contractor/installer must contact their supplier or firestop manufacturer to obtain UL-approved drawings outlining the existing field conditions,

the products they are installing, and the use of the firestop manufacturer's product. Each approved firestop drawing will include a unique identifier code that must be placed on an identifying tag at each penetration using that specific product and configuration. Drawings should be maintained by UCSB in order to easily determine the specific firestop material to be used at each location when additional cable in placed in the future.

5. Where possible use systems that allow installation or replacement of cables, such as mechanical fire stopping systems.

6. All fire stop systems must be pre-approved by the campus Fire Marshall.

4.0   Media Systems

A. Introduction

This standards section identifies a suggested design approach based on evolving industry standards for voice, data, and video communications as well as wireless transport media, the intention of which is to establish a baseline set of standards for the selection, design, and deployment of common services.

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

  a. Twisted copper cable, both indoor and outdoor

  b. Optical fiber cable, both indoor and outdoor

  c. Coaxial cable, indoor with only limited references to outdoor cable, and

  d. Cable distribution, support, and deployment components

Reference to brand names and product types are made in this section and, although identified by manufacturer name and/or description, specific product part or model numbers are not provided due to the evolving and ever changing nature of manufacturer's product lines and, more specifically, part numbers. In general, the purpose of the herein made recommendations is to ensure consistent deployment of product type as well as installation methods.

B. Cable Components

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

 "Horizontal cable" also referred to as "workstation wiring" is the cable between the actual user outlet (known as the 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 provides information on cross-connect components, distribution systems, outlet and modular jack hardware, and cable management and support systems.

C. Copper Cable Systems

Copper cable systems, specifically twisted copper cables, have been in use on the UCSB campus for many years. Recent changes in the industry, however, have given new life to this medium as a means to meet high-performance telecommunications transmission requirements. The majority of these performance improvements, including both the development of new products and the adoption of higher performance standards, focus on the horizontal cable also known as "station cable or workstation wiring" connecting user equipment and network transmission equipment.

This subsection defines the minimum recommended configuration for copper cable. Specifically, it identifies the recommended intra- and inter-building backbone cables and provides criteria for selecting the appropriate horizontal copper cable type.

1. Intra-building Backbone Copper Cable

Intra-building backbone copper cable is typically used for two functions. First, it is used as a home-run connection path from remote building locations into the entrance facility or equipment room. This is normally in support of traditional, analog, telephones, as well as other low-voltage applications that need to provide signals to a single, common building location. The second type of intra-building backbone copper cable is used for higher speed networking, and specifies a cabling system the same as intra-building horizontal copper cabling. In many cases, terminal rooms are "stacked" and the distance from terminal rooms to the equipment room exceeds the length specifications of the cabling system. In this case, the cable specifications are specified to allow interconnections between terminal rooms, to allow a "daisy chained' communication path between remote rooms.

    a.   The intra-building backbone copper cable connecting a building's entrance facility or equipment room to individual telecommunications rooms for purposes of home-run communications must be shielded copper sized to meet known or anticipated requirements and installed following BICSI installation guidelines.

    b.   The general configuration of these cables should be as follows:

        1)   CMR (riser) rated.

        2)   Bonded, shielded, and air-core style, also known as ARMM type.

3) 24 American Wire Gauge (AWG) with staggered twists and a mutual capacitance of not more than 19 nF per 1000 feet.

4) The maximum length of the cable is defined by the application and technology to be supported (not subject to the 90 meter limitation).

In buildings that have telecommunications rooms in addition to building equipment/entrance rooms that may also serve as telecommunications rooms, backbone cables must be provided for connection to these additional telecommunications rooms. These cables should be sized to provide two twisted pair to each potential station outlet location or three pair for every 125 assignable square feet if the number of outlets cannot be reasonably projected. These dedicated cables are extended from the entrance room directly to telecommunications room on the same floor or additional floors as may be needed.

It is important 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 actually increases the potential for interference in the cable. Backbone cables should be grounded at the point of origination and destination in which pairs leave the cable sheath.

The intra-building backbone copper cable connecting terminal rooms to each other, or the equipment room, in support of higher speed networking must meet the following specifications:

- For new buildings and building renovation projects that will be completed on or after January 1, 2015, all installed cable and components must be at least Category 6A.

- For the purpose of identifying an acceptable and cost-effective basic link (i.e., cable, termination hardware, and patch cords) solution that is eligible for an extended manufacturer's warranty, all components in the horizontal system must be from the same manufacturer.

- All cables will terminate as data cables. Cables shall terminate on rack-mounted modular patch panels identified with the destination terminal or equipment room, as specified in section E4, below.

- All cable jacketing shall be rated for building ceiling conditions; e.g., cable installed in a supply or return air plenum must be plenum rated (CMP).

- All cable systems are to be installed following BICSI, TIA, and manufacturer guidelines with a special emphasis on bend radius, termination methods, and support and bending limitations.

- All copper cable is limited to lengths of not more than 90 meters (295 feet).

- Data jacks are to be RJ-45s wired using the TIA-568B configuration.

- All installed cabling systems must be 100% tested. The permanent link components of the horizontal cabling system must be tested and meet the standards specified.

- Cabling test results should be downloaded directly from the test device to a computer designated by the University representative.

- Where possible, patch panels should be mounted in frames designed to support interconnection with active equipment.

- 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.

- 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.

2. Inter-building Backbone Copper Cable

This subsection has been included in these standards documents to provide requirements in the event copper cabling is the preferred method of distribution for a specific application or service. It should be understood that most UCSB services are extended via optical fiber.

Inter-building backbone copper cable (also known as outside plant [OSP]), like intra-building backbone copper cable is expected to 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, this cable may also need to support point-to-point circuits for signal and control systems, radio and alarm connections, dedicated communication links such as ISDN and T-1 circuits, elevator and emergency telephone, and reporting systems.

With the implementation of Voice over IP (VoIP) systems which combine multiple applications into a single high-bandwidth network and the increased use of optical fiber for monitoring and security systems, very large copper cable plants are no longer considered a base requirement in today's environments. Systems which use fiber as a backbone media may need fewer copper pairs than traditional large centralized systems. It is necessary to carefully analyze both existing and projected applications and technology to develop an adequate mix of inter-building copper and optical fiber cables. While many applications can now be supported over optical fiber cable, numerous systems designed specifically around twisted copper cable are expected to remain in place, making it necessary to continue to support this medium for a variety of applications. These copper cables also carry circuits for services such as elevator phones, non-campus telephone services, and other telephone

utility lines that may not be directly managed or supported by the campus telecommunications services and therefore may not be included in local documentation.

As suggested most distributed systems use optical fiber to interconnect nodes; however, inter-building copper cable is still the used as 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. 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.
- 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.
- 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.
- The use of aerial cable is not recommended nor supported under these Standards**.**

The selection of cable construction and sheath type is driven by the environment in which the cable will be installed. Generally, outdoor backbone cable is not placed in a hazardous environment; it is contained within conduit.

The greatest threats to the long-term life of outdoor cables are damage caused during its placement, accidental physical damage during building construction or during the placement of other utilities, and moisture. Using a water-exclusion gel-filled cable will significantly reduce problems with moisture during the life of the cable. Selecting the appropriate cable sheath and overall construction can limit damage during placement, while proper pathway design and cable installation can address ongoing physical damage concerns.

Figure 4-1 outlines the major recommended cable types following the nomenclature generally accepted within the industry. In addition, the Rural Utility Service (RUS), formally the Rural Electrification Authority (REA), is referenced as a standard, and an acceptable product is identified.

BACKBONE COPPER CABLE CONSTRUCTION		
Sheath Type	**Major Components**	**Primary Uses w/Comments**
Filled ASP	Aluminum, steel & polyethylene	Direct buried & conduit *(Offers greater mechanical protection)*
Filled Alpeth	Aluminum & polyethylene	Conduit & tunnel *(Good general use cable design)*
RUS PE 39	Aluminum & polyethylene	Conduit & tunnel *(Good general use cable design)*

Figure 4-1
Copper Cable Sheaths

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 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 for planning purposes, it is best to assume a maximum of 1,200 pairs per four-inch conduit. Large cables are generally available 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

a. Cable Sizing

Determining the number of pairs required to serve a building is a straightforward process if there is supported data for current and future load (number of users) in the facility. When assuming the greatest use of copper cable in a building will be used 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 must determine 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 to 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 have 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 nearest generally recommended and available cable size; 100, 200, 300, 400, 600, 900 or 1,200 pairs.

It is important that the designer focus on developing a reasonable forecast for each building and, as needed, each 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. 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 be expected over the building's useful life span.

BACKBONE COPPER CABLE SIZING EXAMPLE
20,000 Assigned Square Feet (ASF)
20,000 / 125 = 160 work areas (ASF divided by work area size)
160 x 1.5 = 240 pairs (Work area times average pair usage)
40 pairs for miscellaneous services (Known or assumed figure)
240 + 40 = 280 pairs (Subtotal of actual pairs required)
280 / .85 = 329 pairs (Cable life allowance for problem pairs)
Increase to the next highest cable pair size - **Install a 400 pair cable**

Figure 4-2
Copper Cable Sizing

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 registration call center that requires a significantly higher work area density than the assumed 75 square feet. It is up to the designer to obtain or develop the information that will result in an accurate, or at least a reasonable, forecast.

b. Copper Cable Protection

Cable protectors are used in conjunction with proper bonding and grounding to provide electrical hazard protection to human life and sensitive electronic equipment. The decision of where and how to use protectors is not clear-cut and must be viewed as part of an overall cable design process. Generally, copper cables serving on-campus switching systems should be protected at least at the switch end. The decision to protect

the station end (other buildings) is based on campus layout, potential for lightning strikes or power faults, and historical electrical fault problems.

In general, small buildings that are very close to one another and are grouped around a larger one are protected from lightning strikes because of the umbrella effect of the large, closely placed buildings. In such a case, only selected buildings need protectors. However, if there is a history of electrical problems, all buildings should be protected.

Conversely, a campus that has buildings widely spaced and a history of lightning-related problems must protect all buildings. The "rules-of-thumb" for protecting copper cables entering a building are as follows:

If a building is located on the other side of a roadway and/or is remote from the main part of campus, it must be protected.

If any part of the serving copper cable is above ground (on poles), it must be protected.

If any part of the serving cable is exposed (placed near) high voltage power cables, it must be protected.

If there is a history of power fault problems and/or lightning strikes, the cable must be protected.

There are two primary types of protector panels. The first consists of the protector field and an integrated cross-connect terminal. This product, such as the 188 unit, 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 riser or station cable without other components.

The Main Cross-connect (MC) cable terminations and any building with 25 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 systems.

Any facility that requires termination of more than 900 pairs must be specifically designed using methods applicable to main distribution frames and central offices. Many of the equipment manufacturers have expertise available in-house to assist in developing a

detailed and long-term plan for meeting the needs of large copper cable protection and termination installations.

Both types of protector panels use the same type of protectors (1 protector unit per cable pair). The recommended unit is a fast-acting, 3 element (5 pin) gas-tube unit 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.

c. Splice Cases

All splices must be contained within a splice case. All outdoor (vault) splice cases should be encapsulated, 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 burial, 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 failures.

All filled cable must be connected to air core cable within a sealed splice case prior to termination of 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 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 or more pairs must utilize 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 riser cables.

3. Intra-building Horizontal Copper Cable (Workstation Wiring)

Intra-building horizontal unshielded twisted pair (UTP) copper cable, also known as station cable or workstation cable, is the portion of the infrastructure that is changing the most rapidly. In an effort to keep up with the transmission performance requirements of high-speed data and image applications, this medium and its associated components continue to undergo significant changes.

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Although this standards document's main focus deals with infrastructure that supports traditional desktop voice dial tone, data networking and some video, it nonetheless has been positioned to support a variety of other emerging technologies. Some of these technologies include:

- Voice over Internet Protocol (VoIP), which is anticipated to replace traditional digital telephone (PBX) systems, thus rendering legacy voice cabling systems virtually useless other than support of analog services.

- Internet Protocol (IP) based video, which will support closed circuit television (CCTV) security cameras traditionally wired with coaxial cable.

- Broadband CATV video distribution over short distances, again replacing coaxial cable.

- IP-based Building Automation System (BAS) devices supporting secured access, heating, lighting, ventilation and other automated environmental systems, eliminating expensive and non-standard proprietary cable systems.

Currently, the UCSB data network desktop throughput standard is 10/100 Mbps with backbone throughput of 1 Gbps. Desktop throughputs of 10/100 Mbps - at a distance of up to 100 meters - are currently supported by horizontal Cat 5e and Cat 6 cable. Nonetheless, with either Cat 5e or Cat 6 cable, UCSB will be well positioned to increase desktop throughput to 1 Gbps and likewise herein identified singlemode fiber optic cable will be capable of supporting minimum 10 Gbps in the backbone.

Additionally, it is not the intent of these standards to direct the replacement of the installed base of properly installed data category 5e or even cat 5 cables with new Cat 6 or higher grade cable types. These standards identify Cat 6A cables, as well as associated components to be installed in retrofit projects for data purposes when authorized UCSB Planning, Communications Services, and IT staff determine it will be necessary.

The recommended standard for horizontal (workstation wiring) copper cable systems is as follows:

- For new buildings and building renovation projects that will be completed prior to January 1, 2015, all installed horizontal (workstation) cable and components **should** be at least Category 5e.

- For new buildings and building renovation projects that will be completed on or after January 1, 2015, all installed horizontal (workstation) cable and components **must** be at least Category 6A.

- For the purpose of identifying an acceptable and cost-effective basic link (i.e., cable, termination hardware, and patch cords) solution that is eligible for an extended

manufacturer's warranty, all components in the horizontal system must be from the same manufacturer.

- Standard communications outlets will be served by three (3) high speed, four-pair, 100 ohm, twisted pair copper cables.

- One (1) cable will terminate as a voice cable and two (2) cables will terminate as data cables. Voice cable terminations shall terminate on rack mounted patch panels identified with a "V" and Data cable terminations shall terminate on rack-mounted modular patch panels identified with a "D1" or "D2".

- All horizontal (workstation) cable jacketing shall be rated for building ceiling conditions; e.g., cable installed in a supply or return air plenum must be plenum rated (CMP).

- All cable systems are to be installed following BICSI, TIA, and manufacturer guidelines with a special emphasis on bend radius, termination methods, and support and bending limitations.

- All horizontal (workstation) copper cable is limited to lengths of not more than 90 meters (295 feet).

- All installed cabling systems must be 100% tested for Permanent Link. The permanent link components of the horizontal cabling system must be tested and meet the approved performance specifications for the system being installed.

- Cabling test results should be downloaded directly from the test device to a computer designated by the University representative.

- Voice and data jacks are to be RJ-45s wired using the TIA-568B configuration.

a. Work Area Outlet

Minimum standards for work area outlets are as follows:

- Standard work area outlets should include a multi-position jack faceplate and three (3) 4-pair copper cables.

- Outlet boxes should be 4 11/16 inches square by 2 1/8 inches deep (5S deep square outlet box), with a 1 ¼" inch knockout.

- Outlet boxes should be fitted with 1 1/4" conduit stubbed into the nearest open ceiling area, nearest cable tray or routed back to the closest Telecommunications Room.

- Outlet boxes that support single-gang faceplates shall typically be fitted with single-gang rings.

- Outlet boxes that will support double-gang faceplates shall be fitted with double-gang rings.

- Faceplates shall provide a surface suitable for placing an identifying mark next to each jack or connector, not simply a single identifier for the faceplate. These labels

shall be placed in the provided faceplate label holders and on the top edge of the faceplate so as to allow for direct above viewing.

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

A significant issue with work area outlets and horizontal (workstation) cable within administration buildings 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.

Modular furniture needs to 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 and through the furniture interconnection point and raceway system to the user's work area outlet. Typical pathway solutions for modular furniture include: floor boxes, wall feeds and/or communications poles.

In general, wiring a room specifically for modular furniture is to be discouraged. If done, there should NOT be a conduit stub-out, but rather a dual-gang box where the furniture will connect. This allows the box to be used as a wall plate by some future occupant. In consideration of the higher densities needed for modular furniture, the design should try to distribute the wiring to multiple locations, not centralize the connections. The drop length might be longer when using modular furniture, so the 10m patch cord allowance needs to be adjusted. Don't measure the 90m from patch panel to outlet box, but rather, include the length planned inside the furniture as part of the total distance drop length. For planning purposes, the following table identifies minimum pathway requirements for modular furniture installations:

	Floor Poke Through	Wall Feed	Communications Pole Feed	Poured in Place
Two Modular Workstations	Single 1 ½" Conduit	Single 1 ½" Conduit	2" X 2" dedicated channel	Two 1 ½" Conduits
Four Modular Workstations	Single 2" Conduit	One 2" Conduits	2" X 4" dedicated channel	Single 2" Conduit
Six Modular Workstations	Two 1 ½" Conduits, One for every (3) Workstations	Two 1 ½" Conduits	4" X 4" dedicated channel	Two 2" Conduits
Eight Modular Workstations	Do not use	Two 2" Conduits	Two 4" X 4" dedicated channel	Two 2" Conduits

Figure 4-3

Minimum Conduit requirements for Modular Furniture configurations

b. Cross-Connect Hardware

The cross-connect is the point at which horizontal (workstation) cables link to backbone cables or network equipment. Typically in a telecommunications room, voice circuits will be interconnected with cross-connect or hook-up wire to backbone cables extending to a voice switching node or central switch site. Data circuits typically interconnect with patch cords to network equipment within the telecommunications room.

Recommendations for terminating voice-grade services are as follows:

▪ On insulation displacement connector (IDC) terminal such as 110 type wiring blocks or panels.

▪ 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.

▪ IDC terminals may be wall or frame-mounted and must be equipped with wire raceways designed to support the placement and maintenance of cross-connect or hook-up wire.

▪ In configurations above 3,600 pair (such as in the MC or in an equipment room with a switching node), a detailed plan for jumper placement must be developed.

- Wall-mounted terminals should generally be placed from left-to-right on a wall, with station cable above the cross-connect wire holder and riser cable below.

Recommendations for terminating horizontal data cable are as follows:

- All voice and data station cable should be terminated to separately identified modular patch panels consistent with the grade of cable being installed.

- Where possible, patch panels should be mounted in frames designed to support interconnection with active equipment.

- 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.

- The accepted patch panel layout shall be as follows:

  o The first patch panel mounted in the rack shall be designated as a Voice panel.

  o The second patch panel shall be designated as Data – 1.

  o The third patch panel shall be designated as Data – 2.

- If additional workstation cabling is required, three additional patch panels must be installed with the same designations.

- 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.
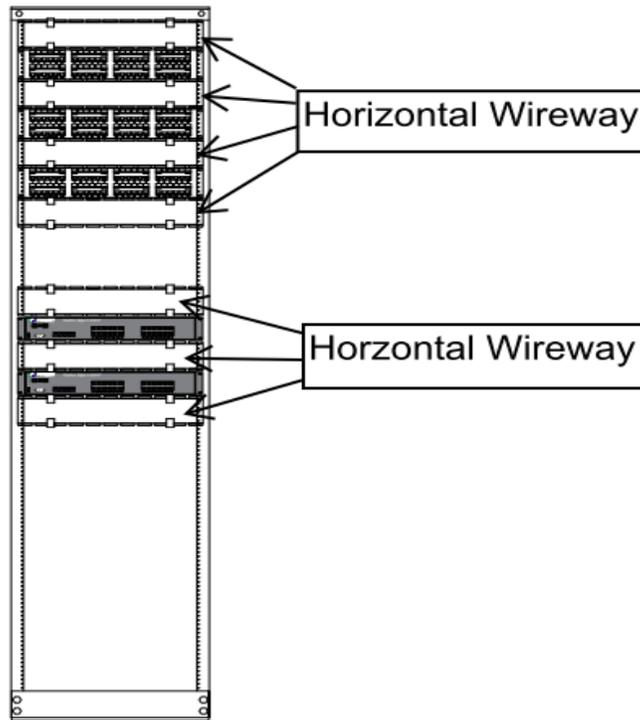
Figure 4-4

Typical Wireways (Horizontal Wire Management)

4. Work Area Termination

The UCSB standard is for the termination of the four-pair station cables in separate 8-position modular jacks (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 (workstation) 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. If two jacks are required and it is not possible to install a separate cable, an external splitter consisting of a single male jack and two or more female units should be installed.

D. Fiber Optic Cable Systems

Optical fiber cable is classified into two major categories: singlemode, and multimode. These designations refer to the number of paths light can take in each type of fiber. A smaller number of paths assures lower modal dispersion, and greater effective bandwidth. The number of modes is determined by several factors, including the physical size of the fiber. While many of the fibers have a 125 µm overall size, the inner core within which the light travels varies in size. The major fiber core sizes are identified below:

- 7 to 10 µm core diameter singlemode fiber is used for broadband (e.g., CATV) and long distance systems. Singlemode fibers use laser light sources, and the cable has a wide bandwidth that supports high-quality connections at high data rates.

- 62.5 µm core diameter multimode fiber was the standard core size previously installed within the UCSB campus. UCSB will continue to install 62.5 µm only where it must interface directly with installed legacy systems.

- 50 µm core diameter OM3 multimode fiber is the standard core size to be used for all new installations on the UCSB campus.

- If a required connection, supporting 1000BASE SX, has a distance greater than 220 meters, a single mode fiber optic cable is recommended.

- Terminated fiber optic cabling systems require testing to be accepted. Table 4-4 shows typical cable types, uses, and allowable lengths and attenuation. All cables should be tested at the wavelengths used on those cables (i.e. 850nm and 1300nm for multimode cables). The testing should include the maximum date rate standard for that cable (i.e. 10Gbps for 50 µm multimode, 1Gbps for 62.5 µm multimode, etc.)

1. Multimode Fiber Cable

One factor that must be considered is the length of the average transmission link factored into the equation of signal requirements. Most UCSB buildings have cable lengths within a building of less than 220 meters, even assuming each cable is home run from the work area outlet to a central equipment room. 50/125 µm OM3 cable is used to support 1000BASE-SX (Gigabit Ethernet using the less expensive LED transmitter) for distances up to 1000 meters.

The recommendation of these Standards is to install 50/125 µm OM3 multimode fiber within buildings on all new projects. At this time, there is no reason to replace existing 62.5/125 µm cable with the 50 µm product.

	Parameter	62.5/125 µm TIA 492AAAA (OM1)		850 nm laser-optimized 50/125 µm TIA 492AAAC (OM3)	
Application	Nominal wavelength (nm)	850	1300	850	1300
Ethernet 10/100BASE-SX	Channel attenuation (dB)	4.0	-	4.0	-
	Supportable distance m (ft)	300 (984)	-	300 (984)	-
Ethernet 100BASE-FX	Channel attenuation (dB)	-	11.0	-	6.0
	Supportable distance m (ft)	-	2000 (6560)	-	2000 (6560)
Ethernet 1000BASE-SX	Channel attenuation (dB)	2.6	-	4.5	-
	Supportable distance m (ft)	275 (900)	-	800 (2625)	-
Ethernet 1000BASE-LX	Channel attenuation (dB)	-	2.3	-	2.3
	Supportable distance m (ft)	-	550 (1804)	-	550 (1804)
Ethernet 10GBASE-S	Channel attenuation (dB)	2.4	-	2.6	-
	Supportable distance m (ft)	33 (108)	-	300 (984)	-
Ethernet 10GBASE-LX4	Channel attenuation (dB)	-	2.5	-	2.0
	Supportable distance m (ft)	-	300 (984)	-	300 (984)
Ethernet 10GBASE-LRM	Channel attenuation (dB)	-	1.9	-	1.9
	Supportable distance m (ft)	-	220 (720)	-	220 (720)
Fibre Channel 100-MX-SN-I (1062 Mbaud)	Channel attenuation (dB)	3.0	-	4.6	-
	Supportable distance m (ft)	300 (984)	-	860 (2822)	-
Fibre Channel 200-MX-SN-I (2125 Mbaud)	Channel attenuation (dB)	2.1	-	3.3	-
	Supportable distance m (ft)	150 (492)	-	500 (1640)	-
Fibre Channel 400-MX-SN-I (4250 Mbaud)	Channel attenuation (dB)	1.8	-	2.5	-
	Supportable distance m (ft)	70 (230)	-	270 (886)	-
Fibre Channel 1200-MX-SN-I (10512 Mbaud)	Channel attenuation (dB)	2.4	-	2.6	-
	Supportable distance m (ft)	33 (108)	-	300 (984)	-
FDDI PMD ANSI X3.166	Channel attenuation (dB)	-	11.0	-	6.0
	Supportable distance m (ft)	-	2000 (6560)	-	2000 (6560)

Figure 4-5

Multimode Fiber Optic Cable Performance Criteria

2. Connectors & Couplers

There are two general groups of fiber optic connectors on the market today: traditional-sized and small form factor (SFF) connectors. Some traditional fiber optic connectors include the SC, ST, FC, Biconic and SMA. Of these, SC and ST connectors are most commonly found on the UCSB campus. 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.

Small form factor connectors offer a greatly reduced footprint, similar in size to the RJ45 copper cable jack. Various types of SFF connectors, e.g., MT-RJ, LC, VF45, and the Opti-jack have been developed. Each is supported by one or more manufacturers. Although the revised TIA specification included support of SFF connectors, it stopped short of endorsing one type of connector over the others. The standard provides several performance characteristics that a connector must meet, allowing users to choose an individual product. At this time, the most often used SFF connector is the LC.

The prime benefits of the SFF connectors are that it allows the installation of twice the number of connections within the same space as traditional connectors, and it can be terminated for less cost. The downsides are questions regarding reliability, performance, and durability. These issues are in addition to the basic question of whether the fiber terminal panels should be twice as densely populated as they are currently causing even more congestion for patch cord management.

The fiber optic connector type recommended for use on all 62.5 um multimode backbone cabling shall be "ST" type as defined in the TIA-568 standards. This conforms to the legacy connector type used throughout campus for this cable type. This connector should be used for all 62.5 μm multimode cable strands. The fiber optic connector type recommended for use on all 50 μm OM3 multimode backbone cabling shall be "LC" type as defined in the TIA-568 standards. This connector should be used for all 50 μm OM3 multimode cable strands. This gives network personnel the ability to determine fiber type based on its termination. The fiber optic connector type recommended for use on all singlemode backbone cabling shall be "SC" type as defined in TIA-568 standards. This connector should be used for all singlemode cable strands. It is important that all fiber optic cables use an ultra polished connector (UPC) with factory-made pigtails fusion-spliced to the backbone cable to reduce signal reflectance. This requirement is extremely important to maintain adequate signal levels when extending the network fiber ring to a new building.

The most significant problem with wideband optical fiber (especially video) systems on campuses is not loss, but too much reflected signal. Normal connectors provide a return loss

measurement or reflectance in the area of -26 dB for singlemode fiber. The target for broadband video and some proposed multi-gigabit data systems is -55 dB. Experience with a variety of CATV system on various campuses indicates that poor return loss is the central problem with most newly installed systems. Fiber that does not meet the return loss measurements generally degrades the video signal or in some cases makes it completely unusable. By routinely installing factory-made APC connectors on all singlemode backbone cable, and specifically to use "FC" style pigtail assemblies for AM video systems, the designer has a greater chance of meeting both today's and tomorrow's transmission requirements.

3. Fiber Optic Patch Panels

For fiber hubs or distribution locations supporting multiple fiber optic cables that distribute to smaller buildings, 72-port, rack-mounted, fiber optic patch panels should be used. For those smaller buildings where fiber counts typically range from 12 to 24 optical cable strands, 24-port, rack-mounted, fiber optic patch panels should be used. Patch panels shall include appropriate connector panels that support anywhere from 6 to as many as 24 connectors.

Small wall-mounted 12- to 24-port fiber optic panels should not be used except to terminate a very limited number of fiber optic strands in locations where space is limited or further growth is unlikely. Whenever possible, existing small wall-mount units should be removed and the fibers consolidated into 24-port rack-mount patch panels. If a room does not offer sufficient space for a floor-mounted rack, wall-mounted racks can be installed. In problem locations where there is no room for wall-mount racks, wall-mount fiber optic panels, as previously stated, should remain or be installed.

50 um multimode fiber optic strands shall be fusion spliced with LC pigtails, and singlemode strands spliced with SC pigtails. Backbone cables and horizontal (workstation) cables should be housed in separate patch panels, or at minimum, separate connector panels.

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 frames, 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. Inter-building Backbone Fiber Cable

Each campus building should be connected to the main campus network ring at two locations with both multimode and singlemode optical fibers. There are three overall design concepts for fiber distribution:

- A distribution ring (used on the main campus) approach in which fibers extend out in two directions from each building to the network.

- A central hub approach in which all fibers radiate from one central space, such as the MC, to each building on campus.

- A distributed node approach 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 all cases, the facilities must be designed to support both point-to-point systems and point-to-multipoint, or loop or "ring", systems. This is generally accomplished by installing sufficient 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 run size figures shown in Figure 4-5 are minimum recommendations to be used whenever actual campus requirements 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 buildings or facilities without networking requirements typically do not need fiber optic cable. On the other hand, a central computing resource or a video headend re-transmission facility will likely require strand counts in excess of those recommended in this standards document. An additional multimode cable may be required to support buildings isolated due to presence of the new building. Insertions must be compatible with the existing cable plant, and sized at least as large as the existing cable count to adjacent buildings.

Building Type	Singlemode
Small – less than 10,000 sq. ft.	24
Large – greater than 10,000 sq. ft.	60

Figure 4-6
Minimum Fiber Cable Strand Counts

Each building should contain an additional 40-foot section of each optical fiber cable, neatly coiled in a maintenance loop (figure eight) and secured before reaching the final termination point, which can be utilized as splicing slack in the event of a cable break. When placed within a conduit, fiber optic cable should be installed within an orange, one-inch innerduct. 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. When innerduct is installed within a building, like cable, it must be properly rated for building interior conditions.

There are different types of backbone cable construction suitable for use on campus. Generally, outdoor cables should be:

▪   Water exclusion gel-filled, dielectric, loose tube construction with a tensile strength of 600 lbs. (long term).

Specialized indoor-outdoor backbone (riser) cables, that are NEC rated, are available and are constructed of materials suitable for use both inter- (between) and intra- (within) building applications. The use of these cables can eliminate a splice point in the cable and reduce the cost of installation.

An important point to remember when planning an inter-building fiber optic backbone system is to limit the number of splices, especially outdoor splices. By keeping splice locations within buildings, where they can be protected and, as necessary, accessed by authorized personnel, the fiber design will provide a great deal of flexibility without the high cost of dedicated cable runs to every building.

5. Intra-building Backbone Fiber Cable

Both multimode and singlemode fiber optic cable should be installed in between building entrance/equipment rooms and telecommunications (riser) rooms.   At a minimum, the backbone optical fiber cables should consist of (12) multimode and twelve (12) singlemode fibers to each telecommunications room from a fiber hub location in a building's equipment or entrance facilities.   These cables should be "home-run" directly from the equipment rooms into the individual telecommunications rooms on one or more floors. All fiber cables should be contained within innerduct if any potential for physical damage exists. All cable should be clearly marked as optical cables for additional physical protection.

Fiber Cable Type	Wavelength (nm)	Maximum Attenuation (dB/km)
50/125 µm OM3 Multimode	850	3.5
	1300	1.5
9/125 µm Singlemode	1310	1.0
	1550	1.0

Figure 4-7
Optical Fiber Performance Parameters

All intra-building fiber backbone cables must be properly rated for building conditions (e.g., OFNR, OFNP) 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 must meet the performance characteristics as defined in ANSI/ICEA S-83-596:

E. Coaxial Cable Systems

Coaxial cable systems are increasingly less deployed as part of today's video distribution systems in a campus environment; nonetheless, these systems still play an important role in the distribution of multi-channel video programming. General information regarding coaxial cable is included in this Standard; however, it is for general information purposes only. With the shift of digital imaging and alternative methods of transmitting video and audio signals, the decision on how or when to implement coaxial cable or an alternative is up to individual campus planners.

Coaxial cables are still used for a variety of services (e.g., terrestrial cable TV, satellite TV, closed circuit television TV, security, etc.). Each of these systems requires unique cable systems and equipment engineered to meet specific requirements and more in-depth information regarding these systems is beyond the scope of this Standard. 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.

Although these standards recognize there are a variety of technical alternatives for distributing multi-channel broadband television signals, the design concept of these Standards focuses on a hybrid fiber/coax solution, which, in general terms, 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 headend location or in a multiple node arrangement;

- Each optical splitter, such as a two, four or eight-port unit, is constructed to provide a specific level of signal loss and is connected to a backbone singlemode fiber optic 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 active and passive components (e.g., amplifiers, splitters, couplers, multiport taps, etc.); and

- The RF system is distributed in most buildings by using singlemode or multimode distribution systems or with 75 ohm half-inch (.500) and/or RG11 coaxial backbone cable and RG6 horizontal (workstation) station cable.

The actual design of any television distribution system is beyond the scope of this document and should be undertaken only by a qualified video design engineer. However, the CATV distribution system, including all active and passive devices, is considered a basic component of a campus telecommunications infrastructure and must be strategically engineered into any infrastructure design. This includes all components from the work area outlet (not television sets) back to the headend transmission system.

The primary components of the system are:

- Headend signal processing equipment necessary to bring all signals to a common level;

- Combiners, splitters, and couplers necessary to present the signal to the distribution system;

- 860 MHz (minimum 103 channels) analog DBF laser transmission system;

- Optical receivers;

- Angled Physical Contact (APC) optical fiber connectors on all serving, distribution, and jumper cables;

- 1 GHz active RF components such as amplifiers and equalizers;

- 1 GHz passive RF components such as splitters, directional couplers, multiport taps, terminators, attenuators, etc.;

- Backbone .500 coaxial cable extended floor-to-floor

- Horizontal RG6 (drop) cable; and

- Work area faceplates and connectors.

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 headend 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.

F. Labeling

The purpose of this section is to establish generic guidelines for uniform labeling of telecommunications cable systems in a Class 3 campus environment (many buildings, including

outside plant wiring). It is anticipated that these guidelines will be used by the architect, designer, consultants, contractors, installers, and facility administrators involved with the administration of the telecommunications infrastructure. Physical labeling of telecommunications cable systems and related components shall be, whenever practical, in conformance with this document and TIA-606 Administration Standards. Components shall include, but are not limited to, the following:

- Buildings

- Telecommunications Spaces

- Cables (both ends)

- Faceplates

- Wiring blocks

- Patch panels

- Miscellaneous other components

All cables and related components shall be permanently marked with machine-generated insert, adhesive, and wrap around (self-laminating) labels.

1. Label Format

Both ends of all cables shall be uniquely and permanently marked with machine-generated or stenciled (not handwritten) labels, according to current practice and as approved by UCSB before installation.

Label faceplates with adhesive machine generated labels.

All labels shall be computer or machine generated, no hand written labeling unless otherwise noted.

All label fields shall be separated by a hyphen.

Label type size shall be 12 point, unless space is not available.

2. Building

A unique identifier is assigned by UCSB for each building using numeric identifiers.

- Example: 614, 572, 384, etc.

3. Telecommunications Spaces

Telecommunications spaces (e.g., EF, MC, Equipment Rooms, Server Rooms, Telecommunications Rooms, etc.) shall be assigned unique identifiers based on room

number and location. This is important where two telecommunication spaces may share the same campus room designation but be physically separated by a large distance.

- Example for a 1st floor EF/MC might be: 112. A set of second floor telecommunications rooms sharing a common room number might be designated 2020W and 2020E for the west and east locations, respectively.

4. Campus Backbone

A unique backbone cable identifier shall be assigned to each inter-building backbone cable connecting building telecommunications spaces in different buildings.

- The first field shall identify originating building, e.g., "51". (Backbone cable will always terminate in the EF so this space is not identified.)
- The second field shall identify destination building, e.g. "23".
- The third field shall identify the cable using a one or two character numeric identifier, e.g., "1" (Keep in mind there can be more than one of the same type and size of cable therefore each cable needs an individual number.)
- The fourth field shall identify copper C or fiber F.
- The fifth field shall identify copper pair count (e.g., 900 pairs) or fiber strand count (e.g., 144 strands).
- Each label shall start with the originating building and fields shall be separated by a hyphen.
    - o Copper cable example: 51-23-1-C-900 and 23-51-1-C-900
    - o Fiber cable example: 51-23-1-F-144 and 23-51-1-F-144

5. Building Backbone

A unique backbone cable identifier shall be assigned to each intra-building backbone cable connecting building telecommunications spaces in the same building. The first and second fields should explicitly call out the type of space, based on the letter designations of "EF" for entrance facility, "ER" for equipment room, "TR" for telecommunications room, or "MR" for machine room.

- The first field shall identify originating telecommunications space: e.g., TR112
- The second field shall identify destination telecommunications space, e.g. MR212
- The third field shall identify the cable using a character numeric identifier, e.g., 1
- The fourth field shall identify copper C or fiber F.
- The fifth field shall identify copper pair (e.g., 100-pairs) or fiber strand count (e.g., 24 stands).
- Each label shall start with the originating building and fields shall be separated by a hyphen.

o   Copper cable example: TR112-TR212-1-C-100 and TR212-TR112-C-100

o   Fiber cable example: TR112-TR212-1-F-24 and TR212-TR112-F-24

6. Horizontal Station Cables

- The first field shall identify the service type, V for voice, D1 or D2 for data.

- The second field shall identify three numbers for each station cable, e.g., 011

    o   Example for a voice cable: V-011

    o   Example for a data cable: D1-011

7. Faceplates

- The first field shall identify the building number for this location. Example: 672

- The second field shall identify the location of the telecommunication space where this wiring terminates. Example: TR2020E

- The third field will be the three numbers for each work area outlet, e.g., 011

- There shall be a series of letters and numbers representing the individual ports for each faceplate.

    o   Example for a three cable faceplate: 011, V, D1, & D2
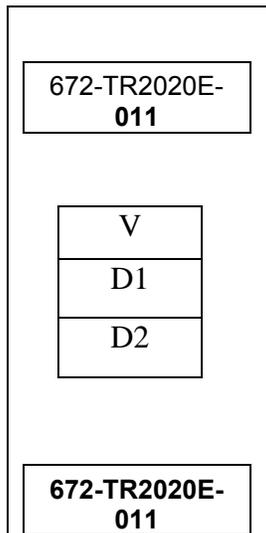
Figure 4-8

Faceplate Labeling

- Note that port density issues may require creative modifications from the example shown. For instance, the building and telecommunications room information may be marked on the outside of a grouping of wall plates, with each jack labeled with the station ID and "V", "D1" or "D2" to identify them. It is important that the entire identifier can be clearly understood for each termination.

8. Patch Panels

- Within each group of three patch panels, the panel itself will be clearly labeled with a "V", "D1" or "D2" to identify which jack in the wall plates are associated with this panel.

- The patch panel ports will be numbered sequentially with the station ID over all the panels present (i.e. don't start over every time you have a new 24-port panel)

- Each patch panel port will be labeled with a destination room number allocation

  - o Example: 2312-011

9. Wiring Blocks

- All wiring block designation strips shall be labeled and color-coded with their appropriate field colors according to TIA - 606 8.3.2, Color Coding Rules.

- Backbone Cable Wiring Blocks

  - o Cable pairs shall be identified in 25-pair increments or binder groups. Each designation strip shall start with the beginning pair at the far left and ending pair at the far right.

  - o   Example for a 100-pair cable:

0	25
26	50
51	75
76	100

Figure 4-9

110 Backbone Cable Wiring Blocks Labeling

- Station Cable Wiring Blocks

  - o The first field shall identify the room number, e.g., 134

  - o Each designation strip shall be labeled with as many as six station cables.

o   Example for six 4-pair:

134	136	145	146	147	151

Figure 4-10

Station Cable Wiring Blocks Labeling

G. Wireless Systems

Wireless technology has simplified networking by enabling multiple computer users to simultaneously share resources in an environment without the cumbersome and expensive process of deploying high-bandwidth wiring. This technology supports end user roaming access to network facilities at comparable speeds of a conventional 10BaseT Ethernet network without the need to be tethered to a wall outlet. Wireless networking has proven to be an easy way to deploy Ethernet connectivity in an un-cabled environment and with varying degrees of end user success.   Nonetheless, due to a variety of issues (e.g., poor performance, reliability, manageability, security, etc.), Architects should not arbitrarily assume wireless networking is a suitable replacement or substitute for high-bandwidth cabled connections. Wireless shall be deployed only in those areas specifically designated by authorized UCSB IT, Planning, and Communications Services staff.

Furthermore, security in a wireless environment is a constant and evolving problem and therefore associated costs can be significant. It is commonly understood that wireless networks are easier and cheaper to install than hard-wired networks, but when you factor in additionally needed and expensive wireless security applications and the personnel needed to manage them as well as the previously mentioned performance issues, wireless can - over time - cost more and underperform hard-wired networks.

Wireless networking standards or specifications were developed by the IEEE (Institute of Electrical and Electronic Engineers), which released the 802.11 specifications standard in 1999. All wireless networking products have been developed to comply with 802.11 specifications. Current IEEE standards support four subsets of the 802.11 standard. These subsets operate at different frequencies and data rate or throughput speeds, which are as follows:

- 802.11 – 2.4 GHz frequency with throughput of 1 to 2 Mbps

- 802.11b – 2.4 GHz frequency with throughput up to 11 Mbps

- 802.11a – 5 GHz frequency with throughput up to 54 Mbps

- 802.11g – 2.4 GHz frequency with throughput up to 54 Mbps (this standard offers faster data rates similar to 802.11a while maintaining compatibility with 802.11b.)

- 802.11n - 2.4 and 5 GHz frequency with throughput up to 150 Mbps

Wireless data rates or throughput are typically much less than standards stated rates and they tend to vary due to coverage distances a well as several other causes such as surrounding structures and RF interference, number of simultaneous users, and types (e.g., email vs. video streaming) of user sessions.

Examples of different standards and distance related data rates are as follows:

LOCATION	STANDARD	FREQUENCY	DISTANCE	DATA RATE
Indoor	802.11b	2.4 GHz	150 Ft.	11 Mbps
Indoor	802.11b	2.4 GHz	350 Ft.	1 Mbps
Outdoor	802.11b	2.4 GHz	800 Ft.	11 Mbps
Outdoor	802.11b	2.4 GHz	2000 Ft.	1 Mbps
Indoor	802.11a/g	5 GHz	170 Ft.	6 Mbps
Indoor	802.11a/g	5 GHz	130 Ft.	18 Mbps
Indoor	802.11a/g	5 GHz	60 Ft.	54 Mbps
Outdoor	802.11a/g	5 GHz	1000 Ft.	6 Mbps
Outdoor	802.11a/g	5 GHz	100 Ft.	54 Mbps
Indoor	802.11n	2.4/5 GHz	300 Ft	54-150Mbps
Outdoor	802.11n	2.4 GHz	600 Ft	54-150Mbps

Figure 4-11

Wireless Networking Standards

1. Standards and Distance Related Data Rates

The 802.11 standard defines two operational modes, ad-hoc mode and infrastructure mode. The ad-hoc mode is peer-to-peer, which involves two network devices (e.g., PC to PC, PC to Laptop, PC to printer, etc.) communicating with wireless network interface cards (NICs). The infrastructure mode involves multiple networked devices communicating with each other via an Access Point (AP). In this scenario one or more APs act as base stations supporting multiple 802.11 enabled network devices with NICs in a defined geographic area. The AP is typically hardwired for data connectivity via Category 5E/6 cable and requires electrical power from conventional 110V or PoE (Power over Ethernet). PoE utilizes pairs in Category 5E/6 cable to conduct low voltage power inserted at the cable origination point. When designing spaces where wireless networking might be desired in the future, it is best to plan the AP densities and provide power and data drops near appropriate locations.

Infrastructure mode wireless networking, as described above, is a viable solution in an office or educational environment where fixed cabling to each network device is not practical or desired. When wireless network access is needed in public areas (indoors as well as

outdoors), similar configurations using APs or Nodes, can support roaming internet, email and limited video streaming access. This type of infrastructure situation is better known as a "Hotspot". A "Hotspot" requires additional software for provisioning/configuration, web-based management, security, billing, etc. This software typically resides on a dedicated device called a gateway or controller.