Yale University

Yale IT Infrastructure Construction Standards
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IT INFRASTRUCTURE CONSTRUCTION STANDARDS

1.1. Introduction and Purpose

This document provides the Yale IT design guidelines to ICT Design professionals for use in preparation of construction documents for new construction and renovation projects. The scope of this document includes requirements for IT project processes, structured cabling systems, security systems, audiovisual systems, and distributed antenna systems. This document is subject to change in form and technical content as warranted by advancements in building construction techniques and IT systems technology. As such, Yale University specifically reserves the right to add to and revise, the information contained herein.

These design guidelines shall not be used as the final specification or bid document for any specific new or renovation project. Detailed and specific requirements for a project shall depend on the programmatic use of the space(s) and shall be confirmed during the project formulation and design phases of the project. The ICT Designer shall incorporate existing systems to ensure a seamless co-existence of newly provided infrastructure.

The project ICT Designer shall be a BICSI Registered Communications Distribution Consultant (RCDD) and/ or an AVIXA Certified Technology Specialist (CTS). The ICT Designer shall consult with the Yale Facilities Project Manager; Yale IT and project end users to ensure all IT requirements for the project are met.

Variances and exceptions are to be presented to Yale IT for approval in writing and shall include a written explanation and drawings describing the proposal. The ICT Designer or Contractor submitting the exception request is responsible to ensure that the performance of the system and the requirements of this specification are met within the proposed changes.

1.2. Codes and Standards

The IT systems design shall adhere to Industry Standards, applicable building codes, and specific user requirements for the building. Relevant codes and standards to be followed are listed below. For a complete list of IT standards, refer to the BICSI *TDMM 14th Edition Appendix A: Codes, Standards, Regulations, and Organizations.*

TIA:

- TIA-526-7-A, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
- TIA-526-14-C, Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
- TIA-568.0-E, Generic Telecommunications Cabling for Customer Premises
- TIA-568.1-E, Commercial Building Telecommunications Cabling
- TIA-568.2-D, Balanced Twisted-Pair Telecommunications Cabling and Components
- TIA-568.3-D, Optical Fiber Cabling Components
- TIA-568.4-D, Broadband Coaxial Cabling and Components
- TIA-569-E, Telecommunications Pathways and Spaces
- TIA-606-C, Administration Standard for Telecommunications Infrastructure
- TIA-607-D, Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
- TIA-758-B, Customer-Owned Outside Plant Telecommunications Cabling Standard
- TIA-862-B, Structured Cabling Infrastructure Standard for Intelligent Building Systems
- TIA-942-B, Telecommunications Infrastructure Standard for Data Centers

- ANSI/TIA-1152-A: Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
- ANSI/TIA-1179-A, Healthcare Facility Telecommunications Infrastructure Standard
- TIA-TSB-162-A, Telecommunications Cabling Guidelines for Wireless Access Points
- TIA TSB-184-A Guidelines for Supporting Power Delivery over Balanced Twisted-Pair Cabling

BICSI:

- BICSI Telecommunications Distribution Methods Manual (TDMM), 14th Edition
- BICSI Telecommunications Project Management Manual (TPMM), 1st Edition
- BICSI Information Technology Systems Installation Methods Manual (ITSIMM), 7th Edition
- BICSI Outside Plant Design Reference Manual (OSPDRM), 6th Edition
- ANSI/BICSI 002-2019, Data Center Design and Implementation Best Practices
- ANSI/BICSI 004-2018, Information Communication Technology Systems Design and Implementation Best Practices for Healthcare Institutions and Facilities
- ANSI/BICSI 005-2016, Electronic Safety and Security (ESS) System Design and Implementation Best Practices
- ANSI/BICSI 006-2020, Distributed Antenna Systems (DAS) Implementation Best Practices
- ANSI/BICSI 007-2020, Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises
- ANSI/BICSI 008-2018, Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices
- ANSI/BICSI N2-17, Practices for the Installation of Telecommunications and ICT Cabling Intended to Support Remote Power Applications
- ANSI/BICSI N3-20, Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure

AVIXA:

- Audio Coverage Uniformity in Listener Areas
- Standard Guide for Audiovisual Systems Design and Coordination Processes
- Image System Contrast Ratio
- Audiovisual Systems Performance Verification
- Videoconferencing Lighting
- Rack Design for Audiovisual Systems

Codes:

- National Fire Protection Association (NFPA) 70, National Electrical Code
  - Article 110: Requirements for Electrical Installations
  - Chapter 3: Wiring Methods and Materials
  - Chapter 5: Special occupancies, including hazardous locations and health care facilities
  - Article 645: Information Technology Equipment
  - Article 770: Fiber Optics
  - Chapter 8: Communications Systems
- NFPA 72, National Fire Alarm and Signaling Code
- NFPA 75, Standard for the Fire Protection of Information Technology Equipment
- NFPA 1221, Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems
- Connecticut State Building Code
- International Fire Code, Section 510 Emergency Responder Radio Coverage in New Buildings
- ASME A17.1-2016, Safety Code for Elevators and Escalators
- Americans with Disabilities Act (ADA)

1.3. Terms and Abbreviations

For a complete list of relevant ICT industry acronyms, definitions, and abbreviations, refer to BICSI's *ICT Terminology Handbook, Version 3.0*. Yale IT specific acronyms, definitions, and abbreviations include, but are not limited to the following:

- **Core Network Room** – A dedicated room containing the Yale IT core network electronics - the public switched telephone network (PSTN) lines - health, life, and safety (HLS) electronics - and, central control equipment for alarms and notification systems, that provide data network and telecommunications services to campus buildings. The Core Network Room is the primary origination point of first-level copper and fiber backbone cables; a cable infrastructure configured in a physical star, that terminates in campus buildings. For the required building services, the core electronics and equipment are interconnected with the campus backbone cable system via main distribution terminal (MDT) cross-connections and/or fiber distribution panels (FDP) patch cord patching.
- **IDT** – Intermediate Distribution Terminal: Located within a floor Telecom Room, the IDT is defined as a group of connectors (e.g., patch panels, punch-down blocks) that allow horizontal cross-connect (HC) of horizontal, backbone, and equipment cabling to be cross-connected with patch cords or jumpers. Also commonly referred to as an intermediate distribution frame (IDF).
- **MDT** – Main Distribution Terminal: Located within the building main Telecom Room, the MDT is defined as the intermediate cross-connect (IC) connection point between a backbone cable that extends from the campus main connect (MC) and the backbone cable from the horizontal cross-connect (HC). Also commonly referred to as a main distribution frame (MDF).

1.4. References

Office of Facilities Yale University: Refer to the Office of Facilities Yale University Design Standards for Capital Projects for additional project requirement including, but not limited to:

- General Guidelines
- Division 00: Procurement & Contracting Documents
- Division 01: General Requirements
- CAD Standards
- CAD Titleblocks
- Yale University Contractor Health & Safety Guidelines
- Link: https://facilities.yale.edu/contractor-consultant-resources/design-guidelines/yale-university-design-standards-capital-project

Yale New Haven Health System: YNHHS ITS Standards Network Infrastructure – Data Closets and Cabling 2018.

- Link: https://yale.box.com/s/c9dq5cyrpworlidnkaohx559vgm2ta57

Yale IT: Minimum Physical Security Standards for Critical IT Spaces

- Link: https://cybersecurity.yale.edu/protectingcriticalitspaces

1.5. Project Contractor Requirements and Qualifications

The ICT Designer shall include within the project specifications that the Structured Cabling Contractor shall meet the following requirements and qualifications:

- Contractor Resume: a resume of qualifications shall be submitted with the Contractor's proposal indicating the following:
  - A list of recently completed projects of similar type and size with contact names and telephone numbers for each.
  - A list of test equipment proposed for use in verifying the installed integrity of copper and fiber optic cable systems on the project.
  - A technical resume of experience for the Contractor's project manager and on-site installation supervisor assigned to the project.
  - A list of technical product training and manufacturer certifications attained by the Contractor's personnel installing the system.
  - A list of subcontractors who will assist the Contractor in performance of the work. Subcontractors shall meet the same training and certification requirements as the prime Contractor.
- The Contractor shall provide documentation indicating proper licensing by the State of Connecticut to install structured cabling systems.
- The Contractor shall be manufacturer certified, such that the structured cabling plant system will be warranted by the specified manufacturer for parts, labor, and application assurance for a period of no less than 25 years. The Contractor shall submit copies of the manufacturer certifications.

The project security system scope of work, including building access control, security cameras, intrusion detection, and intercom/emergency communications, shall be provided by a prequalified Security Contractor. The List of Prequalified Bidders includes:

- Structure Works
  Walt Cropley
  (845) 877-1460
  walt.cropley@structureworksinc.com

- Tyco/JCI
  Jon Seldon
  (800) 289-2647

Contact Yale IT to confirm the current list of prequalified Security Contractors approved to perform projects at Yale. Incorporate the prequalified Security Contractor list into the project bidding requirements.

1.6. Demolition and Temporary Protection of Yale IT Systems

Campus renovation projects may involve work effecting telecommunications infrastructure that is existing to remain. Temporary protection and selective demolition shall be provided by the project or through an associated enabling project. The following provisions shall be included in projects in coordination with project and construction managers:

- Existing Telecom Rooms and infrastructure effected by project demolition and renovation shall remain in operation until successful cutover to replacement Telecom Rooms and infrastructure, or until temporary service is established.
- Prior to demolition of existing Telecom Room walls, ceilings or flooring, construct temporary barriers fully enclosing the existing room equipment. The barriers shall provide physical protection from demolition debris and environmentally seal off the equipment to prevent ingress from dust and contaminates.
- Provide temporary cooling within the barrier spaces to maintain a temperature range between 50-85 degrees Fahrenheit and 10%-90% relative humidity noncondensing. Provide positive pressure within the barrier for dust control. Cooling equipment shall be served by the campus alternate power source if available in the building, or by a standby generator.
- Provide temporary power for the room equipment to maintain operation throughout the duration of construction. Temporary power shall be on alternate power source.
- Yale IT shall have access to all equipment throughout the course of construction. Provide a barrier entrance with sticky clean walk-off floor mats.
- Provide an IP based environmental monitoring system which shall alert the Contractor upon loss of power and when temperature and humidity is outside the acceptable ranges.
- The Contractor shall be held responsible for replacement of Yale IT equipment damaged or for voiding equipment warranties during construction per the general conditions of the contract.
- Temporary short duration planned outages of room equipment shall be preapproved by Yale IT.
- Provide sealed cabling egress ports for existing and new cabling routing through the barriers to the equipment racks. Where existing cabling bundles route through walls scheduled for demolition, provide protection for cabling and re-support cabling from structure. Permanent sleeves shall be provided around existing cabling to be built into new walls.
- Provide selective demolition of cabling back to the patch panels in the equipment racks. Re-terminate and re-label existing to remain cabling infrastructure on patch panels such that gaps do not exist where cabling was demolished. Organize the existing and new patch panel termination per the final permanent renovation layout.
- Relocation of IT active equipment within the room shall be performed by Yale IT.
- The Contractor is responsible to maintain continuity of branch wiring, controls cabling, etc. of existing systems that may extend outside of the scope of the demolition work of the project.

1.7. Project Design and Construction Processes

Proper coordination of IT design and construction requirements are essential throughout the course of the project. Refer to Table 1 below for a summary of required tasks and deliverables organized by project phase. Note that some small projects of short duration shall have a combined Schematic Design and Design Development Phase, also referred to as an Enhanced Schematic Design (ESD).

Table 1 - Project Tasks and Deliverables

	Schematic Design	Design Development	Construction Documents	Bidding and Procurement	Construction	Close-Out
Project Design Kick-Off Meeting with Yale IT and Office of Facilities	X					
Site Survey with Yale IT Representative	X	X	X			

	Schematic Design	Design Development	Construction Documents	Bidding and Procurement	Construction	Close-Out
Forward Project Team Directory and Milestone Schedule to Yale IT representative	X					
Coordinate Project Telecom Rooms with Architect	X					
Coordinate with Utility Service Providers as Required	X		X			
Scope and Design Project Enabling Construction Packages	X	X	X			
Identify and issue written requests to Yale IT for variances from design requirements	X	X	X			
Provide Site OSP Plan, Building Riser, and Telecom Room Service Zone Diagrams	X	X	X			
Provide DAS Systems Site Assessment	X					
Determine DAS Systems Project Scope of Work	X					
Provide ICT Basis of Design Project Narrative	X	X	X			
Provide Technology Project Drawings	X	X	X			
Provide Division 27/28 3-Part CSI Specification		X	X			
Provide Telecommunications Key Connection Schedule		X	X			
Provide project Wi-Fi Predictive Wireless Study Report using Ekahua Pro Software		X				
Conduct Page Turn Review Meeting with Yale IT	X	X	X			
Provide and Reconcile Yale IT Project Construction Budget	X	X	X			
Provide BIM Design and Coordination to LD300 Requirements			X			
Confirm Prequalified Security Contractor List			X			
Confirm Project Registration with Approved Cabling Plant Manufacturer				X		
Review Schedule of Unit Prices and Schedule of Values				X		
Descope Bidders and Review Contractor Certifications and Credentials				X		
Contractor Shall Provide Project Schedule including Yale IT Milestone dates					X	
Contractor shall provide Yale IT with weekly construction progress reports					X	
Review and Approve Project Submittals (Copy and Discuss Approvals with Yale IT)					X	
Conduct Sitework and Underslab Site Field Report(s)					X	
Conduct Above Ceiling Pathways Field Report(s)					X	
Conduct Telecom Room and Structured Cabling Field Report(s)					X	

	Schematic Design	Design Development	Construction Documents	Bidding and Procurement	Construction	Close-Out
Sign-Off of Completed Turn Over and Acceptance Criteria					X	
Conduct Punch List(s) (Copy and Discuss Approvals with Yale IT)						X
Review and Approve Cabling Test Reports (Copy and Discuss Approvals with Yale IT)						X
Review and Approve Operations & Maintenance Manuals (Copy and Discuss Approvals with Yale IT)						X
Review and Approve Product Warranties (Copy and Discuss Approvals with Yale IT)						X
Review and Approve Record Drawings and BIM Model, Provided by the Contractor to LOD400 Level (Copy and Discuss Approvals with Yale IT)						X

1.8. Construction Drawings and Specifications

Provide a complete set of ICT construction documents detailing the project's scope of work. The organization and contents of the drawings shall follow the recommendations of the BICSI *Telecommunications Project Management Manual (TPMM)* and *ANSI/INFOCOMM 2M-2010 Standard Guide for Audiovisual Design and Coordination Processes*. Indicate ICT design work on T-series (Technology), SE-series (Security), or AV-series (Audiovisual) drawings as required for the project. Refer to Appendix B – Differential Scope of Work Matrix for a system level breakdown of the work included in capital construction projects.

In addition, provide full CSI 3-Part Specifications including Division 27 – Communications and Division 28 – Electronic Safety and Security for each project. Typical Specifications Sections to be included, depending upon specific project requirements, are listed below. Refer to "Appendix G – CSI Outline Specifications" for abbreviated outline sections for reference only. The ICT Designer shall incorporate the content of the outline sections into full length specification sections for inclusion in the project construction documents.

DIVISION 27 – COMMUNICATIONS

270000 GENERAL COMMUNICATIONS PROVISIONS
270500 COMMON WORK RESULTS FOR COMMUNICATIONS
270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS
270528 PATHWAYS FOR COMMUNICATIONS SYSTEMS
270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS
270534 FLOOR BOXES FOR ELECTRICAL AND COMMUNICATION SYSTEMS
270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS
270543 UNDERGROUND PATHWAYS AND STRUCTURES FOR COMMUNICATION SYSTEMS
270544 SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING
270553 IDENTIFICATION FOR COMMUNICATIONS SYSTEMS
271100 COMMUNICATIONS EQUIPMENT ROOM FITTINGS
271116 COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES
271313 COMMUNICATIONS COPPER BACKBONE CABLING
271513 COMMUNICATIONS COPPER HORIZONTAL CABLING
271523 COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING
272000 TWO-WAY COMMUNICATION SYSTEMS

275119 SOUND MASKING SYSTEMS
275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY
281300 ACCESS CONTROL
281600 INTRUSION DETECTION
282300 VIDEO SURVEILLANCE
285100 SECURITY INTERCOMMUNICATIONS SYSTEM

1.9. Project Budgeting and Schedules

Yale IT participates in the budget development and reconciliation process with the Facilities Project Manager during each project enabling, design, and bidding phase. To facilitate this process and properly plan for active systems deployment, the ICT designer shall proactively initiate coordination through the Facilities project manager. The ICT designer shall submit the following Coordination of Service Documentation (COSD) to Yale IT at each phase:

- "Appendix B – Differential Scope of Work Matrix"; Review and edit on a project specific basis. Each ICT system within the scope of work shall be identified.
- Project Summary: project name, project number, location, departments and occupancies, building space program with SF, and 8-1/2" x 11" plan diagrams
- Description of proposed site work and potential for interruption of existing infrastructure, including campus utility service providers
- Demolition and new work floor plans, indicating existing, relocated, and proposed Telecom Rooms
- Project schedule including enabling phases, departmental relocation move dates, certificate of occupancy dates, final occupancy dates
- ICT Basis of Design (BoD) narrative. The BoD shall include security systems device layout plan sketches and audiovisual systems types designations and quantities.
- ICT project drawings and specifications
- Telecommunications Key Connection Schedule: Coordinate and provide a Telecommunications Key Connection Schedule for each project in Microsoft Excel format. This schedule shall provide port take-off information for Yale IT to plan and deploy the network electronics and devices for the project. Refer to Table 2 below for a sample schedule:

Table 2 – Sample Telecommunications Key Connection Schedule

ROOM#	ROOM NAME	LOC.#	C6-V	C6-D	TV	FIB.	ACTIVE-Y/N	STA.ID	PHONE#	LEN
X	X	X	X#	X#	X#	X#				
X - FILLED IN BY THE ICT DESIGNER										
# - NUMBER OF VOICE/DATA/CATV/FIBER AT EACH LOCATION										
ACTIVE - CONNECT TO DATA HUB										

The ICT designer shall review the Construction Manager's project schedule for inclusion of the following milestones critical to Yale IT project deployments:

- Contractor bid review and descoping

- Bid award and Contractor notice to proceed
- ICT submittals review
- Selective demolition of existing ICT systems
- Communications site utility construction
- ICT systems rough-in
- ICT cabling installation
- Subcontractor network access requests
- Telecom Room turn over and acceptance
- Yale IT systems cutover
- Network Go Live
- Certificate of Occupancy Inspections
- End User Building Occupancy

1.10. Telecom Room Turn Over and Acceptance Criteria

Prior to Yale IT acceptance of newly constructed or renovated Telecom Rooms, the project Contractors shall complete the following checklist and submit for ICT Designer/Yale IT approval. Incorporate the criteria below as contract requirements in project documentation:

- □ The Structured Cabling Plant is installed in a neat and workmanlike manner, meeting the recommendations of the BICSI *Information Technology Systems Installation Methods Manual (ITSIMM)*. All cabling is bundled and managed using required cable management and runways.
- □ The punch list walkthrough has been performed
- □ All construction is complete inside the MDT/IDT Telecom Rooms
- □ Wall and ceiling surfaces are clean with final paint. Plywood backboards are properly installed
- □ Flooring is deeply cleaned (and waxed if applicable)
- □ Equipment racks, components, and trays are free of dust
- □ Packaging, supplies, debris, and wire clippings are removed from the TR interior and exterior vicinity
- □ Ductwork and vents serving the Telecom Room are cleaned
- □ Cabling service loops are properly supported
- □ The Structured Cabling Plant is labeled with machine printed labels and tested
- □ TR patch cords have been furnished, ready for installation by the Cabling Contractor
- □ Telecom Room penetrations and openings are sealed and firestopped with room positive air pressure
- □ Environmental systems are commissioned and operating normally with new air filters or temporary HEPA filters
- □ Power outlets are operational with correct device types. Prior notifications of planned power outages are provided
- □ Lighting and controls are installed with fixtures positioned correctly
- □ Grounding and bonding are provided per *TIA-607-D, Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*
- □ Permanent door is locked with limited key availability and the card reader is activated
- □ Door dust stopper is installed
- □ Dirt trapper/sticky mats are placed inside entrance door

1.11. Approved Products and Substitutions

Refer to Appendix A – Approved Components and Manufacturers, for a detailed list of equipment to be specified in capital construction projects. Yale IT primarily utilizes the listed approved products and has adapted language, practices, expectations, and a maintenance inventory based on their use. All ICT

designs shall specify the features, quality, and performance of the products offered by these manufacturers. Where a specific manufacturer's product is specified, the Contract shall be based on that product only. Where several manufacturer's products are specified, the Contractor may select any of the listed products.

1.12. Cable Testing and Verification

Each copper horizontal permanent link shall be tested and verified per *ANSI/TIA-1152-A* and *ANSI/TIA-568.2-D* standards with Level III field test instruments for Category 6 (250 MHz) and Level IIIe field test instruments for Category 6A (500 MHz) cabling.

Each horizontal and backbone optical fiber permanent link shall be tested and verified per *ANSI/TIA 568.3-D*, *ANSI/TIA-526-7*, and *ANSI/TIA-526-14*. Test parameters shall include optical loss testing, magnified endface inspection, length measurement, and polarity testing. Outside plant interbuilding backbones shall also receive OTDR bidirectional testing at required multimode and Singlemode wavelengths.

Cable television coaxial cable plant shall be tested and verified per *TIA-568.4-D* with signal level and TDR testing performed to record insertion loss, slope testing, leakage testing. Provide amplifier configuration charts.

Copper multipair backbones shall be tested and verified for continuity, conductor shorts, polarity, effective ground test for shield, ground faults, power fault.

Air blown fiber tube cable testing: pressure and obstruction tests for all tubes and tube cables shall be conducted to manufacturer's recommended procedures. Test reports shall include tube cable ID, tube # (in), tube # (out), test pressure (P.S.I.), time held, and span length.

Test reports shall be generated and submitted to the ICT Designer, Yale IT and the cabling system manufacturer for review in electronic format with the appropriate reader software. All results shall include the cable identification numbers, test date and times, test operator, and the make/model of the testing equipment.

1.13. Record Documents

Upon completion and close out of the project, the ICT Designer shall review, approve, and forward a copy of the final project ICT record documents to Yale IT through the Facilities project manager. Yale IT will integrate the documentation into the cable plant and network system management databases. Electronic file naming shall follow Yale facilities standards requirements. Record documents provided shall consist of the following:

- Electronic drawing files in the following formats
  - Revit BIM Model, Level of Development 400 (LOD400)
  - CADD files in AutoCAD 2019 Format
  - PDF files
- Drawing files containing scale drawings of the complete ICT work set with all Yale IT disciplines. This will include site and building floor layouts depicting outlet locations, equipment plans, device locations, final labeling, telecom rooms, cable pathways, riser diagrams and all other information pertinent to the installation.
- Spreadsheet tables in Microsoft Excel format providing categorized workstation outlet room locations and labels as well as cross-connect field labeling diagrams for each patch panel and 110 block.
- Outside Plant Documentation – Submit the following for Yale IT to incorporate into the campus Langan GIS outside plant database:
  - Record photography of each telecom maintenance hole/handhole wall, as well as ductbank point

of entrance close-ups
    - Record photography of OSP excavation indicating uncovered site utilities prior to trench backfilling
    - Butterfly maintenance hole diagrams in Microsoft Excel format listing each backbone and ABF tube cable name, type, size, and conduit routing.
    - Communication site civil utility drawings with ductbank routes and depth profiles
    - ABF system distribution diagrams
- Test reports for various systems as required herein in PDF format and original test data files with reader software.
- Operation and Maintenance manuals in PDF format for each system as required herein.
- Product and systems warranties as required
- Audiovisual control systems source code files and configurations
- Wireless Access Point Installation Data including:
    - A floor plan identifying the exact location of each WAP
    - The identifier of the UTP permanent link supporting each WAP
    - The serial number and MAC address of each WAP in reference to its location
    - The mounting height above finished floor of each WAP
- User and system administrator training course materials and recordings

1.14. Interbuilding Backbone Pathways

Campus outside plant communications ductbanks and subbasement utility tunnels form the pathways for interbuilding backbone cabling serving each building. Yale IT must approve all pathways and building point of entrance designs in writing. Request existing outside plant record documentation from the Langan GIS system campus database for design reference. The recommendations of *ANSI-TIA-758-B-2012 - Customer Owner Outside Plant Telecommunications Infrastructure* and BICSI *Outside Plant Design Reference Manual, 6th Edition shall be followed for specific design and installation requirements*. In addition, observe the following design criteria:

- Interbuilding backbone pathways shall be provided in buried duct structures or building utility tunnels.
- Backbone pathways to each building point of entrance from the designated existing communications maintenance hole shall consist of four (4) 4” schedule 40 rigid nonmetallic conduit in concrete encased reinforced ductbank, unless directed otherwise by Yale IT. Confirm project specific requirements for redundant pathways for physical route diversity.
- Depth to top of ductbank shall be no less than 30” from grade. Follow NESC and NEC requirements for minimum utility line separations.
- Each duct conduit shall be mandrelled and have a pull rope with footage markers installed. Conduit ends shall be reamed and plugged to prevent ingress of water and debris. Ductbanks shall slope away from building point of entrances at 1/8” per foot minimum.
- Tracer wire caution tape shall be installed 12 in. above communications underground ductbanks.
- Ductbank lengths, routing, and bends shall comply with ABF tube cable system installation limits and requirements. In a campus environment, continuous straight ductbank lengths between maintenance holes shall be limited to 350 ft. Ducts shall have no more than 180 degrees of cumulative bends between maintenance holes/handholes. Curvatures shall be long and sweeping with a minimum bend radius of 15 ft.
- Joint Use Maintenance Holes (MHs) are not permitted for communications infrastructure.
- Communications maintenance holes (MH) may either be pre-cast or cast-in-place with at least 24,000 kPa (3500 psi) concrete, typically sized 7’L x 7’W x 6’H. Final size selection is project specific, to be governed by Yale IT.

- MH's shall have duct knockouts arranged for conduit entrances on all four walls. Conduits shall enter and exit the maintenance hole in a straight-line method. The remaining parallel walls are to remain free of conduit entrances for cable support and splicing operations unless otherwise permitted by Yale IT.
- MH appurtenances shall include ground rod, cable racks, pulling irons, 8" diameter sump hole, bolted entrance collar and frame, permanently installed ladder from top of collar to floor, and cover labeled "Telecommunications"
- MH covers shall be minimum 30" diameter round, cast iron, and centrally located on single-cover MH. Collar
- Handholes (HH's) may be used in backbone pathways serving small facilities where the communications infrastructure requirements are sparse. HH's shall be used as pull through points only and not splice points. HH's shall not be used in conduit runs that have more than three (3) 4" conduits. The maximum HH size shall not exceed 4'L x 4'W x 4'H.
- HH covers shall be 30" round minimum and centrally located for full access to the vault. Frames and covers used in roads or driveways shall be H-20 rated minimum to withstand vehicular traffic.

Utility Service Provider Coordination

Where the project scope of work involves moves, adds, changes, or disruption to existing utility service provider infrastructure, coordinate requirements through Yale IT. Existing campus service providers include:

- Frontier
- Comcast
- Crown Castle

Air Blown Fiber (ABF) Campus Distribution

The ABF system forms the optical fiber pathway infrastructure for distribution of air blown PEF (Polyethylene Extruded Foam) jacketed fiber bundles that contain 2 to 48 strands. The project may provide ABF tube cables through the campus ductbank system to buildings from a Core Network Room, an intermediate fiber distribution hub in another building, or from splices in nearby maintenance holes. Coordinate ABF system designs with Yale IT, beginning in the schematic design phase. The number of required tubes and fiber bundles shall be sized to accommodate the fiber configuration specified by Yale IT. The tube cable pathway may be segments of new tube cables, existing tube cables, or a combination of both. They shall be spliced together at various locations, to provide a continuous tube for air blown fiber bundles from the Core Network Room to the project building destination.

For each fiber span, indicate fiber types, strand counts, fiber distribution panels, tube cables, tube distribution units, and indoor and outdoor tube splices. Fibers may be OM4 50/125 um multimode (MM) and/or OS2 singlemode (SM) in bundles of 2 to 48 fiber. Confirm quantity and types of fiber strands required with Yale IT.

Provide for termination hardware of fiber bundles in building and core network rooms. Specify appropriately sized, high density, MM and SM, rack mounted, fiber distribution panels (FDP) with connector adapters as directed by Yale IT.

Tube cables include capacities of 2, 4, 7, and 19 tube cells. The cable tube capacity shall accommodate immediate fiber requirements plus future spares, as directed by Yale IT. The tube cable may be installed in conduit, exposed in tunnels or plenums, and routed through MH's. In all cases, the minimum bending radius of the tube cable, in conduit or not, shall be no less than 20 times the tube cable diameter.

Tube Distribution Units (TDU) are inside building enclosures used to transition or branch individual tube cells of tube cables. Tubes are joined together with manufacturer specified connector hardware, to provide the required, continuous, air blown pathways between building and core network rooms. At branch locations provide, unjacketed, black tubes to connect required tubes of one tube cable to another. At the network room locations, transition to unjacketed clear tubes for connection from the TDU to the rack mounted FDP's. Bending radius of tubes to be no less than 9" radius. All non-used tubes in the tube cables are to be sealed with tube end caps and stored in the TDU

Provide and locate, in the building and core network rooms, and any required intermediate building branch points, appropriately sized wall mounted tube distribution units (TDU) to terminate tube cables. Manage tube cables using Kellems Grips and bushings as recommended by the system manufacturer. Mount no more than three tube cables per TDU enclosure.

Tube cable splices not in TDU's may be required for long tube cable lengths (in-line) and/or branching in MH's. Provide appropriately sized, preformed, outdoor splice casings for maintenance hole or tunnel installation. Install tubes cables in conduit in such a manner that one (1) conduit is full prior to using the next conduit. Conduit fill shall not exceed 40% of conduit cross sectional area. A maximum of two (2) 19-tube tube cables may be installed in one (1) 4 in. conduit without exceeding 40% conduit fill limitations. A maximum of five (5) 7-tube tube cables may be installed in one (1) 4" conduit without exceeding 40% conduit fill limitations.

The ABF system Contractor shall be certified by the ABF system Manufacturer to provide a 25-year extended warranty for the installation. The system shall be labeled including all fiber bundles, fiber termination units, terminations, tube cables, tube cells, tube splices, and tube distribution units. The system shall be fully tested, and reports provided as required. Documentation preparation shall include but is not limited to submittals, record drawings, system O&M documents, extended warranty, and manufacturer's certification of systems.

1.15. Interbuilding Backbone Cabling

Project requirements for interbuilding multipair copper and hard sheath optical fiber backbones shall be provided to the ICT Designer by Yale IT. OSP multipair copper cable shall be gel filled with transition to non-gel filled riser cable or lightning entrance protector stubs prior to termination. OSP rated cabling may be routed exposed from the building point of entrance for no more than 50' when not routed in IMC or rigid metal conduit. Provide lightning entrance protection for all OSP copper interbuilding backbone pairs, using 5-pin 240v solid state modules with PTC (positive temperature coefficient). Rack mounted lightning entrance protectors are typically provided within core network rooms with wall mounted units provided in building Telecom Room MDT's. Typically, a 25 pair copper backbone or 25 existing pairs in an existing trunk bundle shall be provided to serve each building (to be confirmed by Yale IT). Copper multipair outside plant splices shall consist of preformed line product stainless steel fillable splice cases with re-enterable encapsulant and 710 modules.

1.16. Telecom Room Requirements

Telecom Rooms (TR's) shall be designed as dedicated environmentally controlled rooms within buildings to serve as HC's (IDT's) or an IC (MDT) as well as contain active network electronics and building system head-end panels. Telecom room locations, sizes, and dimensions shall be designed in the schematic design phase and must be approved in writing by Yale IT.

Location and Adjacencies

- Telecom Rooms shall typically be located near the center of the area/floor served. The area served by the TR and the location of the TR shall be such that no permanent link exceeds 90 m (295 ft.) in total length.
- In a multi-story building, the TR's shall be located as to stack one directly above another in vertical congruence.
- Consideration shall be given such that the TR location selected may offer expansion into a larger room. Locations that are restricted by building components limiting future expansion shall be avoided (e.g., elevators, building structural elements, kitchens, outside walls, or other fixed building walls, etc.)
- TR's shall be accessible through common-use corridors that will allow the delivery of large cable reels and equipment, and access for repairs on a 24x7 basis.
- The main Telecom Room housing the building MDT shall be located as close as practical to the building entrance demarc point, and (if possible) to the electrical service room to reduce the length of OSP rated interbuilding backbones and bonding backbone grounding conductors.
- TR's may not be inside of or be part of a mechanical space, equipment room, washroom, storage area, or janitor closet.
- TR's shall be located in a dry area not subject to flooding. The TR shall not be located below water level unless preventive measures against water infiltration are employed. The room shall be free of water or drain lines not directly required in support of the equipment within the room. A floor drain shall be provided within the room if risk of water ingress exists.
- There shall be no obstructions in the room such as columns or building structure.
- Plumbing, piping, and fixtures are not permitted within a TR, except for a code required wet sprinkler line/head. The room shall not be located beneath toilets, showers, laboratories, kitchens, sinks, roof drain leaders, or other areas where water/liquid services are provided. No fire protection mains shall be routed through the room.
- The TR shall be located away from transformers, switchgear, motors, x-ray equipment, induction heaters, arc welders, radio and radar systems, or other sources of electromagnetic interference.
- Mechanical lines (e.g., ductwork, pneumatic tubing, electrical conduits), not related to the support of the TR, shall not be routed through it. In addition, the corridor plenum areas adjacent to the TR shall remain accessible and clear for cable pathways exiting the room.

Architectural Design Criteria

Room Sizes: Each building, regardless of size, shall have a minimum of one (1) full size MDT Telecom Room, unless otherwise approved by Yale IT. For renovations and adaptive reuse projects, a Shallow Telecom Room (STR) or Telecom Enclosure (TE) design may be submitted for final approval by Yale IT.

Telecom Room size shall be based on Table 3 below. Final sizes shall be reviewed on project specific basis. All dimensions indicated below are inside room dimensions.

Table 3 - Telecom Room Minimum Size Requirements

Building Area Served (GSF)	Room Size
Floor Area 25,000+	10'x14'
Floor Area 10,000-25,000	10'x11' *
Floor Area 5000-10000	10'x9' *
Floor Area 0-5000	10'x8' *
Building Smaller than 5000	4'x8'-6" (Shallow TR configuration)
Building Smaller than 1000	Telecom Enclosure (TE)

* *Where project programs require extensive audiovisual instruction and collaboration spaces, one or more TR's shall contain at least one additional equipment rack for network-based IP AV 1 Gbps and SDVoE 10 Gbps systems. To serve this capacity requirement, a 10'x14' TR room size will be required.*

Walls: All four (4) walls shall extend from the finished floor to the structural deck (e.g. the slab) and be fire rated if required by NFPA or the Connecticut State Building Code. This requirement is to provide environmental protection (dust) and climate control for electronic equipment. All four (4) walls shall be covered with ¾ in. void free grade A-C FRT plywood. Plywood shall be painted on all six sides with two coats of light gray fire-retardant paint, with FRT stamps left unpainted. Mount plywood 6" above finished floor to a height of 8'-6" on all walls. No windows or door sidelites shall be provided in the room.

Ceiling Height: No finished ceiling, open to building structure above, with minimum 10' clear above floor. Rooms shall not have a lay-in acoustical tile ceiling in order to not obstruct cable pathways. In such cases where fireproofing may be sprayed onto the exposed structural ceiling (deck), the fireproofing shall be treated to mitigate airborne dust.

Finishes: Floors, walls, and ceiling shall be treated to eliminate dust. Finishes shall be light in color to enhance room lighting in TR's. Floor covering shall be a vinyl anti-static material. Color shall be determined on a case-by-case basis. The flooring shall be prepped, leveled, sealed, and cleaned prior to installation of flooring materials.

Doors/Access Control: Doors shall be a minimum of 36" wide and 80" high, without doorsill, hinged to open outward (code permitting) and rated as required. Doors for shallow TRs shall be double doors that open out 180 degrees to corridor. Shallow TR doors shall have top and bottom flushbolts that secure the inactive leaf. Door(s) shall be fitted with the University standard wall mounted HID multiCLASS card reader with integral keypad for two-factor authentication. The lock shall be electrified with key override keyed for a Yale IT key code. Door position switch, latch bolt monitoring, and a request to exit switch shall be provided. A campus IP security camera shall be provided in the Telecom Rooms to monitor the room entrance.

Floor Loading: The TR shall be located on floor areas designed with a minimum floor loading of 2.4 kPa (50 lb./ft2). The project structural engineer shall verify that concentrations of proposed equipment do not exceed the floor-loading limit.

Signage: The TR room shall be identified in accordance with the campus and building signage system.

Table 4 - Telecom Room and AV Projection Room Finish Schedule

TR Surface	Telecom Rooms/ AV Projection Rooms	Comments
Floor	24" x 24" Electrically Conductive Rubber Tile	Provide product equal to Staticworx Eclipse EC; Static Generation: <20 volts when tested according to ESD STM 97.2.*
Base	6-Inch High Rubber Wall Base	ASTM F1861, Type TS (rubber, vulcanized thermoset), Group I (solid, homogeneous), Style B (cove)
Walls	¾ Inch Grade A-C FRT Plywood **	Install plywood 6 inches above finished floor to a height of 8'-6" on all walls. Paint plywood on all 6 sides with 2-coats of fire-retardant paint, (Light gray for Telecom Rooms, flat black for projection rooms). Do not paint over the Grade and FRT stamps.
Ceiling	Open to underside of deck above.	Where fire-resistive coatings are present on structural steel members, apply a compatible surface sealer to prevent dusting.***

* Prior to finish floor installation, confirm floor levelness meets the requirements for the function of the room. Provide floor leveling as required for room function and finishes. For projection rooms, the floor shall be level and not be sloped such as the audience area of the venue.

** Plywood backboard wall panels are installed on gypsum-board-clad steel stud or masonry walls. Within

*** Surface sealer shall be a UL classified surface sealer. Apply surface sealer at manufacturers recommended spreading rate.

Electrical Design Criteria

Power: Each Telecom Room shall contain a 120/208V, 100A Main Circuit Breaker, 42-circuit subpanel dedicated to serve the equipment within the room. The subpanel shall be served from the campus normal and alternative (if available) power source Main Distribution Panel in the building. The subpanel shall be protected from voltage transients and power fluctuations by a Surge Protective Device, IEEE category B3 rated, installed in the subpanel.

UPS Power: Based upon the building use and project design criteria, a building-wide UPS system may be provided. This shall be a project specific decision confirmed by the project management team. If a building-wide UPS system is provided, the Telecom Room electrical subpanel riser shall be served by the UPS. If no building-wide UPS system is provided, local Telecom Room UPS's may be provided (project specific). Local Telecom Room UPS systems shall only be sized to maintain network systems operation during the outage time before the alternate power source is transferred online. Yale IT may typically size UPS's at 3KVA or 6KVA, depending upon the load requirement within the Telecom Room. If the building does not have the campus alternate power source available, local UPS units *shall not* be provided in Telecom Rooms. Note that UPS units, if provided, shall be registered under a multiyear maintenance service agreement (not included in the capital construction project scope).

Electrical circuiting and wiring devices: Provide circuits and receptacles from the TR electrical subpanel.

- Provide one (1) 120V/20A branch circuit with two NEMA 5-20R duplex receptacles in a 4"x4" outlet box mounted on the cable runway above and behind the center equipment rack.
- Based on project specific requirements, provide two (2) 208V/30A or 20A, 1Ø branch circuits each supplying one NEMA L6-30R or NEMA L6-20R twist-lock receptacle, respectively, in 4"x4" outlet box mounted on the cable runway above and on each side of abovementioned outlet box.
- Provide a minimum of two (2) 120V/20A branch circuits to serve security access control system panels and associated power supplies.
- Coordinate with design disciplines to determine locations of additional building systems panels located in the TR. Provide circuits as required for the systems (e.g. BAS, Fire Alarm, DAS, MNS, FAVE)
- Provide two (2) 120V/20A branch circuits serving a minimum of six (6) NEMA 5-20R duplex receptacles spaced evenly along the room perimeter at 18" above the floor, with box extensions through the plywood backboard. Shallow TR's shall be provided with three (3) NEMA 5-20R duplex receptacles.
- All junction boxes and receptacles shall have laser printed circuit identifiers affixed indicating the panel ID and circuit number.

PDU Units: Two redundant PDU units shall be provided and mounted in the TR equipment racks. The redundant power supplies within the network electronics equipment shall be connected to each PDU. One PDU Unit shall connect directly to the twistlock receptacle (L6-30R or L6-20R) located on the cable runway above the equipment rack, that is circuited to the Telecom Room subpanel (building power). The second PDU shall connect to the local UPS in the room if provided (project specific). The local UPS shall connect to second twist-lock receptacle (L6-30R or L6-20R) located on the cable runway above the equipment rack. If no UPS is provided for the project, both PDU's shall connect directly to the twistlock receptacles (L6-30R or L6-20R) located on the cable runway above the equipment rack served by the Telecom Room Subpanel.

Lighting: Lighting levels shall be a minimum of 50 foot-candles horizontal and 20 foot-candles vertical measured 3'-0" above the finished floor in equipment rack aisles. Fixtures shall be pendant mounted from structure approximately 8'-6" above the finished floor, suspended between and not from cable runway sections. Light fixtures shall be LED with universal-voltage electronic drivers and protective wire guards. A wall control switch with digital timer control shall be located at the room entrance. Dimmer switches and occupancy sensors shall not be used. Lighting fixtures shall be powered on a dedicated circuit from the TR subpanel, powered from the building alternate source to provide stand-by lighting within the room.

Bonding and Grounding: A telecommunications grounding system shall be provided complying with *TIA-607-D* . The main TR housing the MDT shall have a Primary Bonding Busbar (PBB) provided to which all Secondary Bonding Busbars (SBB's) located in STR's/TR's/AV Projection Rooms are connected through the Telecommunications Bonding Backbone (TBB). TR equipment, equipment racks, conduits, cable shields, entrance protectors, cable runways, sleeves, structural steel, local electrical panels, etc. shall be bonded to the room PBB or SBB. In addition, provide grounding for roof mounted antennas and equipment. The PBB shall be connected to the normal main electrical service ground of the building with a Telecommunications Bonding Conductor (TBC). Note that Yale buildings may have the alternate service ground separated from the normal service ground, or the normal and alternate systems bonded together. Provide grounding system labeling and testing per standard recommendations.

Environmental Design Criteria

The rooms shall be protected from high temperature, contaminants, dust, moisture, and humidity that could affect operation and material integrity of active equipment within the TR.

HVAC Systems: HVAC shall be available on a 24 hours-per-day, 365 days-per-year basis. A stand-alone unit shall typically be provided for TR's when the building's HVAC system cannot ensure continuous operation. HVAC systems shall be powered by the campus alternate power source if available within the building. Provide a BMS system high temperature alarm point programmed to activate if the cooling setpoint temperature threshold is exceeded for more than 15 minutes.

Equipment Locations: HVAC equipment shall typically be wall mounted at a location that does not obstruct room cable pathways. Do not locate HVAC equipment above equipment racks or wall mounted systems panels. If this is unavoidable due to project circumstances, and a variance is granted by Yale IT, drip pans shall be located under the HVAC equipment. The pans shall be configured with drain lines and integral leak detection sensors that are configured as monitoring and alarm points in the building's BAS system. Equipment condensate drain lines shall immediately exit the room and not be routed along walls, cable runways, or over equipment racks. Condensate pumps shall not be provided within the TR unless approved by Yale IT.

Room Equipment Loads: Coordinate with Yale IT to develop load assumptions to be provided to the project HVAC Designer. The ICT Designer shall provide Yale IT with the required Coordination of Service Documentation including the Telecom Key Connection Schedule and Differential Scope of Work Matrix. This shall permit an estimate of network port counts and other system equipment to be created, confirming approximate heat rejection and cooling load requirements. Typical TR room loads shall be in the range of 1 to 2.5 tons of cooling; however, Designers shall complete equipment specific load calculations and/or study equivalent TR's on campus to determine necessary cooling approach. Note that the addition of audiovisual network gear into the TR, if required, shall increase load requirements.

Operational Parameters: The TR HVAC system shall support equipment classes A1-A4 per ASHRAE TC9.9 with the following criteria:

- Heating setpoint: 64.4°F

- Cooling setpoint: 80.6°F
- Humidity Range, Non-Condensing 16°F DP to 59°F DP and 60% RH
- Local room thermostat control with BMS high temperature alarm

Positive Pressure: Per BICSI *TDMM* recommendations, provide a room positive pressure differential with respect to surrounding areas, with a minimum of one air change per hour.

Vibration: Mechanical vibration coupled to equipment or the cabling infrastructure can lead to service failures over time. A common example of this type of failure would be loosened connections. If there is a potential for vibration within the building that will be conveyed to the TR via the building structure, the project structural engineer shall design safeguards mitigating excessive vibration.

Fire Protection: TR fire protection systems shall be provided as required by Code. Typical building TR's may be fitted with wet sprinklers utilizing wire guards over heads. In some cases, the TR may contain highly mission critical equipment or highly valuable assets that could mandate a dry pipe pre-action system. Campus Core Network Rooms shall require dry pipe pre-action or FM-200 clean agent fire suppression systems. Coordinate fire detection and extinguishing requirements with the Yale Fire Marshal.

Telecommunications Room Fit-Out Requirements

The TR's shall be fit out to meet the infrastructure requirements of Yale IT. Building end user equipment shall not be permitted in TR's. Fit-out components shall include:

- Wall plywood backboarding (refer to Architectural Design Criteria above)
- Overhead cable runway: Provide black color cable runway in 12", 18", and 24" widths around the TR perimeter and over each equipment rack line. Provide 6" of clearance from the wall to the edge of the cable tray for wall mounted electrical and systems panel clearances. Install the cable runway at 7'-9" above finished floor, leaving 9" clearance above equipment racks. Provide "waterfall" cable radius bend protection over each rack vertical cable manager. Ground each section of cable runway and bonding to the PBB/SBB.
- Sleeved penetrations: Provide a minimum of four (4) 4" re-enterable engineered firestop through penetration sleeves with integral intumescent material, installed through the wall into the corridor ceiling plenum above finished accessible ceiling. In addition, provide a minimum of four (4) 4" re-enterable engineered firestop through penetration sleeves in the floor below and deck above into corresponding stacked TR's. Final sleeve quantity required shall be based on cabling amounts, plus 50% spare capacity. Sleeve fill should not be less than the minimum, nor, more than the maximum, specified by the fire stopping material manufacturer. Provide additional vertical wall mounted cable runway sections to transition from floor and wall sleeves. All firestopped penetrations shall be labeled as required.
- Equipment rack line: Typically, provide three (3) two-post open 84"H equipment racks in a rack line, bolted to the floor, each bonded with a dedicated #6 AWG TEBC to the PBB/SBB.
    - Provide full height double-sided vertical cable management between each rack and at both ends of the rack line.
    - Upper transition trays shall be provided at the top of each rack, with horizontal cable managers required
    - Rack #1 (left) shall contain interbuilding backbone (MDT only) and riser cabling terminations at the top of rack. These shall consist of optical fiber termination cabinet(s) and 48 port RJ-45 Category 5e copper multipair voice riser cross-connect patch panel(s). Also, Yale IT provided active network electronics, gateways, and PDU's shall reside in the rack.

- Rack #2 (center) moving left to right, shall contain horizontal cabling cross-connects consisting of angled 48 port RJ-45 Category 6 and Category 6A (for wireless access points) patch panels.
- Rack #3 (right) shall contain systems including:
  - DAS system singlemode optical fiber system hub(s) and horizontal optical fiber cross-connect serving remote units
  - ScienceNet FTTD 50-micron laser optimized OM4 multimode horizontal optical fiber cross-connect termination cabinet(s), and corresponding fiber network switches, if required
  - Audiovisual systems network infrastructure, including IP AV 1 Gbps and SDVoE 10 Gbps architectures. Based upon the extent of these systems, additional dedicated equipment rack(s) (Rack #4, etc.) may be required in the rack line. SDVoE 10 Gbps systems operate on 50-micron laser optimized OM4 multimode optical fiber horizontal connections and additional fiber termination cross-connect cabinets shall be provided to support them.
  - IP sound masking and paging systems if required
  - Miscellaneous building systems

- Cable management: Cabling within the TR shall be expertly installed and managed in equipment racks and cable runways per the BICSI *ITSIMM*.
  - Category 6/6A cabling shall be organized in neat bundles of 24 cables, trained together from the rear patch panel terminations and routed into the rear section of the rack vertical managers and up to the overhead cable runway.
  - Strain relief bars shall be provided behind each patch panel where cabling will be supported and converge into a bundle.
  - Bundles shall neatly lay adjacent to and in parallel with one another within the cable runways.
  - Each bundle shall be secured with re-enterable hook and loop strap fasteners at the same 2' intervals. Aligned strap positioning shall be used to create air flow gaps between bundles.
  - Follow the recommendations of the NEC and *TIA TSB-184-A Guidelines for Supporting Power Delivery over Balanced Twisted-Pair Cabling* for design of cable bundles and pathways supporting the *IEEE 802.3bt* standard to source up to 90 watts at the PSE.
  - Machine printed cable labels shall be affixed within 2" of the cable termination at the patch panel.
  - Service loops shall be configured in figure 8 arrangements and fully supported on wall plywood backboard or empty cable runway.
- Building Systems Headend Collocation: Yale IT shall permit the TR to be used by designers to collocate low voltage systems equipment panels and headends. This strategy permits shared use of the secure conditioned environment, cabling plant, building pathways (maintain separations), and IP networking. These low voltage systems shall include:
  - Security Systems
    - Access control panel headends shall be wall mounted in building TR's.
    - Network connectivity for access control panels, security cameras, intercom systems, and emergency phones shall be provided by the campus network. A dedicated security system IP network shall not be provided.
    - Category 6 cabling serving security devices shall be purple color. The cabling shall be fully integrated into the cable plant and not broken out into a separate patch panel.
    - Access control system composite cabling (non-IP) shall be physically separated from Category 6/6A cable bundles within pathways by no less than 6".
  - Audiovisual Systems
    - Each AV device in IP AV systems operating at 1 Gbps (such as the QSC Q-SYS Ecosystem) shall be served with Category 6 cabling plant from the TR with no physical layer distinctions in the cable plant.
    - Dedicated AV LAN network switches shall be provided in the TR by the AV Contractor, and the IP AV devices shall be patched into the AV LAN network switches.
    - Optical fiber riser backbone strands shall uplink the AV LAN network switches.

        - IP AV system Core Processor(s) shall be provided the MDT TR to serve the building-wide system.
        - Each AV device in SDVoE systems operating at 10 Gbps (such as the IDK 4K@60 AV over IP) shall be served with a dedicated 50-micron laser optimized OM4 multimode optical fiber horizontal cable plant.
        - 10 Gbps AV devices shall be connected to dedicated 10 Gbps per port, 100 Gbps or better AV LAN network switches that shall be provided in the TR by the AV Contractor, and patched into the AV LAN network switches.
        - Optical fiber riser backbone strands shall uplink the 10 Gbps per port, 100 Gbps or better AV LAN network switches.
    - DAS Systems
        - DAS system secondary hubs in TR's shall provide 48V power (2C-14AWG) and communications (2 strand OS2 singlemode on LC duplex connectors) to remote units/antenna located throughout the building, using building pathways and open top J-hooks.
        - The DAS system primary hub shall be located in the building main TR MDT.
        - Singlemode OS2 backbone riser strands shall be designated for DAS and cross-connected into the hubs within TR's.
    - Building Automation Systems (BAS)
        - The ICT Designer shall coordinate with the project mechanical engineer for final locations of BAS system panels. The BAS systems shall utilize an independent dedicated control system network provided by the BAS system vendor. Campus network connections shall be provided at main BAS control panel locations, with no distinction in the physical layer cable plant.
    - Fire Alarm Voice Evacuation (FAVE) System
    - Mass Notification Systems (MNS)
    - ScienceNet FTTD

1.17. Backbone Riser Cabling

Backbone riser cabling shall be provided for interconnections between the building MDT (IC) and IDT's (HC's) in a logical star topology. Backbone riser cabling requirements include the following (to be confirmed by Yale IT for each project).

- Optical Fiber Backbone Riser Cabling
    - Twenty-four (24) strand OS2 singlemode optical fiber, OFCP rated with interlocking armor and tightbuffered construction, terminated in rack mounted fiber termination cabinet with duplex LC splice on connectors. The fiber shall be ITU-T G.652.D compliant Full Spectrum.
        - Six (6) strands are reserved for DAS systems
        - Six (6) strands are reserved for AV LANs
    - Twenty-four (24) strand 50 Micron Laser Optimized OM4 multimode optical fiber, OFCP rated with interlocking armor and tightbuffered construction, terminated in rack mounted fiber termination cabinet with duplex LC splice on connectors.
    - Provide 50% spare capacity in fiber termination cabinets
- Copper Multipair Voice Backbone Riser Cabling
    - One (1) 25 pair, CMP rated 100 Ohm multipair balanced twisted pair, 24 AWG solid conductor Category 3
    - In the MDT, terminate all risers on wall mounted 110 cross-connect blocks with C5 clips and cross-connect into the building entrance cable 110 block.
    - In the IDT's, terminate on a rack mounted 24 port Category 5e RJ-45 patch panel, with one pair terminated per RJ-45 port. The pair shall terminate on pins 4,5 in AT&T T568A connection.
    - Within the MDT, one (1) 25 pair shall be provided from the 110 wallfield cross-connect block, terminated wit C5 clips, to the rack. On the rack, terminate on a 24 port Category 5e RJ-45 patch

panel, with one pair terminated per RJ-45 port. The pair shall terminate on pins 4,5 in AT&T T568A connection.
    - This topology shall permit an analog voice line to be cross-connected to any building workstation outlet using an RJ-45 patch cord.
- Broadband Coax Cable Television Distribution Backbone Riser
    - Provide this backbone to support legacy broadband cable television systems only if requested by the project stakeholders and approved by Yale IT
    - The local CATV provider (Comcast) shall design and install the CATV system. This includes backbone coaxial cables and terminals. Designate space for this service in the TR's. Yale IT shall coordinate design requirements with the service provider.
    - Provide a coaxial riser backbone from the plywood backboard in each TR IDT to the plywood backboard in the TR MDT. The cable shall be a .500" Parameter III coax distribution cable and UL listed to be installed in an environmental return-air plenum space (CATVP).
    - Terminate each cable end with a F81 bulkhead connector. All connectors shall be terminated with OEM specified tools. Provide and neatly store 10 feet of additional cable at each location.

1.18. Backbone Riser Pathways

- Backbone cabling pathways shall be clearly designated and designed to provide routing and protection for backbone riser cables, with 50% future capacity growth.
- Provide a minimum of four (4) 4" EMT from the main TR MDT to the IDT TR stack of rooms, or to each TR where they do not stack. In lieu of EMT conduit stubs, re-enterable engineered firestop through penetration sleeves shall be used where TR's directly stack.
- Backbone Pathways routed through the building shall be either cable tray or conduit. The installation of a physical separation for the protection of the backbone cables from horizontal cable installation is required. Backbone cables installed in cables trays shall be rated for appropriate use. Yale IT must approve use of cable tray as a backbone distribution system.
- Where backbone cables pass through stacked TR's, provide a cable runway vertically mounted from floor to ceiling for cable support.
- The conduit pathway shall extend to the roof to accommodate current or future cabling needs. Roof penetrations and seals shall be provided by the roofing contractor and not violate the roof warranty. Extend the building TBB to the roof to permit bonding of equipment.
- All pathway through penetrations shall be sealed or firestopped.

1.19. Horizontal Pathways

Horizontal cabling shall be supported from the TR's to the workstation outlets with an organized system of cable trays, J-hooks, and conduits. Pathways shall be sized to permit 50% spare capacity. According to the TIA Category 6/6A standard cabling distance limitation, the maximum run distance of horizontal pathways, including to floors above or below, shall be less than 295'. All pathway through penetrations shall be sealed or firestopped.

Typical outlet pathway installation shall consist of the following:

- One (1) 1 in. EMT from 4-11/16"x4-11/16"x2-1/8" telecom outlet box with single gang trim ring stubbed above nearest accessible ceiling within the same room
- J-hook open top cable supports above accessible ceilings to main cable tray runs
- Cable tray runs in corridors and densely populated areas, consolidating at the local TR

Cable trays: Single tier overhead wire mesh basket style tray

- Provide 8" clear above tray for cable access
- Utilize ninety-degree sweeps when change in direction is required
- Bond to telecommunications grounding system
- Cable trays shall be continuous with no breaks or sharp cuts
- Methods of support: cantilever, trapeze brackets, or center hanging

J-hooks: J-hooks or equivalent open top cable supports are permitted for use above accessible finished ceilings.

- Supported from building structure
- Spacing shall be three to five ft. apart, with an average separation of four ft.
- Use is permitted from main cable tray runs to workstation outlet conduit stubbed out above accessible finished ceilings
- Provide 50% spare cabling capacity

Conduit: EMT conduit shall be provided for horizontal cable distribution where required. If the conduit route may be subjected to physical damage, provide RMC threaded conduit.

- Conduit runs shall have pull boxes every 80 ft. maximum and/or every two 90-degree bends
- Conduit bends shall sweep, LB fittings are not permitted
- Conduits shall be provided with pull strings
- Conduit shall be provided in the following areas:
  - Areas exposed without finished ceilings
  - Inaccessible ceilings
  - Tightly congested areas
  - Transition between floors
  - Serving floor mounted outlets

1.20. Horizontal Cabling

Horizontal network cabling for data, voice, and IP based video shall conform to the *ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components for Category 6 and Category 6A Cable*. Cabling shall be NEC CMP plenum rated. Cable jacket color shall be blue per Yale IT standard unless otherwise noted. Terminate using T568B style terminations on rack mounted angled Category 6/6A RJ-45 48 port patch panels. Do not paint installed cabling as it will void the manufacturer warranty.

Broadband television system cabling (legacy system) shall conform to *ANSI/TIA-568.4-D, Broadband Coaxial Cabling and Components*. For cable TV connections, RG-6 Quad shield coaxial cable shall be provided. Coaxial cabling shall be NEC CATVP plenum rated with 18 AWG solid copper covered steel conductor with FEP insulation, foam dielectric, aluminum foil - 60% braid – foil – 40% braid shield, terminated with compression F-connectors.

Optical fiber horizontal and FTTD cabling shall be of a fan-out type construction with a minimum 2.0mm outer jacket and high-strength reinforcing fibers protecting each fiber. The cables shall contain singlemode (OS2) fibers or 50-micron OM4 multimode fibers which meet or exceed the mechanical and transmission performance specifications in *ANSI/TIA-568-C.3*. The color of the cable's outer jacket shall be yellow for singlemode and Aqua for OM4 multimode. Cables shall be plenum rated OFNP. The fibers shall be terminated with splice-on LC connectors meeting *ANSI/TIA-568-C.3*. Adaptor modules shall be flush mount duplex LC. The color of the modules shall match the color of the mounting frame.

Wall mounted workstation outlets shall typically consist of a single gang four-port faceplate, color and material as selected by Architect. The faceplate shall be filled with the quantity of Category 6 or 6A jack modules required at each location with spare positions blanked off, with machine printed labels installed in label windows. Terminations shall be T568B style.

Additional outlet configurations include:

- Security Cameras: Provide one (1) Category 6 cable terminated in a biscuit style surface box.
- Elevator Travelling Cable: Include three (3) Category 6 cables to the elevator machine room for cab devices such as phones, security cameras, or wireless access points. Provide ethernet over coax extenders and include coaxial cabling in the travelling cable connecting the machine room and the cab.
- Building Equipment Panels: Provide two (2) Category 6 cables terminated in a biscuit style surface box at each building systems equipment panel including:
  - Main Building Automation System Panel
  - Security Access Control Panel
  - Fire Alarm Control Panel
  - Elevator Control Panel
  - Lighting Control Gateway Panel
  - Audiovisual Control System Panels
  - Power metering
  - Irrigation Control Panels
  - Timeclocks
  - Electronic Key boxes
  - Chair Lift Telephone
- Floor Boxes and Poke throughs: Provide decora style or 106 adapter plates as required to mount devices where full gang plates do not fit.
- Flat Panel Displays: Provide decora style or 106 adapter plates as required to mount devices in flat panel backbox located behind the display.
- Surface Raceways: Provide decora style or 106 adapter plates as required to mount devices.
- Wall Mounted Telephones: Provide one single jack wall plate.
- Elevator telephones: Generally provided under Division 14. Elevator phones are considered emergency telephones, battery operated automatic dialers are not acceptable. These circuits require dedicated conduit point to point. A ¾” conduit will be required for each elevator. This conduit shall be provided from the nearest TR to the box on the elevator controller cabinet where the elevator traveling cable’s telephone pairs are terminated in the elevator machine room. Coordinate the installation and termination with Elevator Vendor and Yale IT.
- Emergency Telephones: The installation and location of emergency telephones must be coordinated with the Yale University Public Safety. Outdoor emergency telephones are hands-free weatherproof and require a 1” rigid conduit. A standard blue light that is illuminated 24 hours per day, 7 days per week shall identify each emergency telephone. Emergency telephones are to be cabled using cable for the intended use (indoor, buried service, aerial). The cable is to be terminated in the appropriate TR on a dedicated voice block as directed in the Telecommunications Key Connection Schedule. These circuits may require dedicated conduit point to point.
- Exterior pole mounted emergency phone requirements:
  - Concrete foundation no smaller than 24” diameter and 42” deep. Anchor bolts and template for same will be provided by Yale IT.
  - One (1) 1” minimum telecom conduit terminating in the TR of the building from where the voice circuit is provided. Provide a pull string, tied off at both ends. Telecom cabling shall be provided in

liquid tight flexible steel conduit inside the pole. In addition, provide cabling to serve mass notification speakers where identified.

- One (1) minimum size 1" power conduit to the building from where the voice circuit is provided and one 120VAC 15-amp branch circuit with emergency backup power
- One 5/8" x 8' copper-clad steel ground rod with a #6 AWG copper wire to the base of the phone
- The units shall be located adjacent to walkways, not in travel areas where they might interfere with pedestrians or service vehicles. Locate the code blue emergency phone so as to be wheelchair accessible from the sidewalk. Install a concrete pad to extend to the sidewalk if necessary. Access to the phone shall not be impaired by landscaping or curbs. For ease of mowing in grass areas, the telephone shall be located on an 8" wide concrete mowing strip flush with the surrounding lawn.

1.21. Wireless Access Points

Wi-Fi shall be ubiquitous throughout the building. It is recommended that horizontal cabling serving wireless access points shall consist of two (2) Category 6A cables, in anticipation of the full future implementation of the IEEE 802.11ax standard supporting multi-Gigabit bandwidth rates. The outlets shall be mounted in a plenum rated biscuit style surface mount box with a 15' service loop to permit final field location adjustments. The ICT Designer shall plan Wireless access point (WAP) locations on floor plans using the recommendations of *TIA-TSB-162-A* in the Schematic Design and Design Development Phases. WAP's shall be a PoE PD. Yale IT shall provide Power-over-Ethernet IEEE *802.3at* Type 2 (PoE+) power sources.

In the Design Development phase, the ICT Designer shall conduct an RF predictive wireless study to confirm WAP locations. The study shall be performed by a certified wireless professional approved by Yale utilizing Ekahua Pro Software. Acceptable wireless certifications include but are not limited to ECSE, CWNA, CCNA Wireless, ACDA, or equivalent. The predictive study shall meet the following RF specifications as a minimum requirement for delivery of voice and video quality IEEE *802.11* services as defined by Cisco Systems:

- Radio shall be set on UNII2/3 frequencies at no more than 25mW power/14dBm
- Optimal Cell Boundary of the wireless access point shall be -67db measured by the client adapter in the 5Ghz band
- 20% cell overlap based on the optimal cell boundary to ensure smooth client roaming
- Latency shall be no less than 20 milliseconds
- Packet loss shall be no more than zero within the design coverage
- Packet jitter shall be less than 20ms

The ICT Designer shall review WAP mounting requirements with Yale IT to address various project conditions. A wireless access point enclosure may be recommended by Yale IT or the project Architect to provide physical protection or greater aesthetic appearance. In addition, high gain antennas, remote antennas, or high density WAP's may be recommended by Yale IT to provide appropriate coverage from acceptable mounting positions. Outdoor site coverage shall be reviewed for each project, served with remote outdoor antenna locations, RF transparent site bollards, or emergency telephone stanchions.

Wireless access points shall be furnished by Yale and installed by the Cabling Contractor. Some locations shall require the wireless access point to be configured for vertical wall mounting. One (1) ceiling grommet shall be provided for each ceiling access point outlet location, installed in the ceiling tile with a patch cable provided from the jack to the wireless access point.

Provide a post-installation study to verify coverage requirements are met. This study shall include allowances for the addition of or re-positioning of WAP as needed.

1.22. Patch Cords

Patch cords shall be furnished for each Category 6/6A link, with one workstation end patch cord, and one telecom room end patch cord. The lengths and colors of patch cords within the TR shall be coordinated to match telecommunications equipment rack layouts and Yale IT standards. Excessive lengths are unacceptable. Reduced diameter (or small diameter) 26 AWG and 28 AWG patch cords shall be provided in the TR. Final lengths and colors of patch cords furnished for workstations and devices shall be coordinated with Yale. The Cabling Contractor shall install patch cords within the TR and patch in network devices. The Cabling Contractor shall furnish patch cords to Yale IT and project subcontractors for installation at floor workstation and device locations.

1.23. Labeling and Administration

The structured cabling plant shall be fully labeled and documented. The recommendations of *TIA-606-C, Administration Standard Telecommunications Infrastructure* shall be used as a guideline with specific requirements dictated by Yale IT.

- Only machine printed laminated labels that are mechanically fastened are acceptable for equipment, panel, cabling, and outlet labeling. Handwritten markings on the cable will not be accepted.
- Uniquely identify and label each permanent link as to reference its source termination patch panel port or wiring block position. The labels shall be durable, machine generated, self-adhering, at least 3/8" wide; the font shall be a minimum of 3/16" high and contrasting the background in color. Affix labels at the end of each cable within 12 inches of termination and to the front of the faceplate near the connector module. All identifiers shall be clearly recorded on the as-built drawings.
- Backbone cables shall be labeled at each end, within 6" from each termination. Additional labeling shall be provided on cables that pass-through locations such as conduit ends, splices, MH's, and pull boxes.
- Fiber distribution units shall be clearly labeled on the front cover. Racks, patch panels, and interconnect blocks shall be labeled. Label pathways and grounding busbars and wires
- TR's shall be labeled WWW01 (for MDT's), WWW02, WWW03, and so forth (for IDT's), where "WWW" represents the Yale Building Number. However, in cases where there is a switch in the building, the MDT is designated as WWW00 and all consecutive numbers thereafter are IDTs. An example of this would be Green Hall, where the MDT is labeled 277000, and the IDT's are 277001, 277002, 277003, etc.
- Each Category 6 telecom outlet shall be labeled XXX-YY DZ, where "XXX" is the room number, "YY" is the outlet in sequential order starting from the door and moving left, and "Z" is the sequential number of the jack in the faceplate. For room scheduling signage, the room number is the corridor with "D" being replaced by "RS". For FTTD applications, "D" is replaced with "F".
- Individual patch panels are not labeled. Cables and patch panel port labels shall match the faceplate label.
- Fiber interbuilding backbones are labeled FYWWWXX-VVVV, where "FY" is "FM" for multimode fiber, or "FS" for singlemode, "WWWXX" is the label of the terminating MDT, and "VVVV" is the label for the originating Core Network Room or MDT.
- Wireless Access Points shall be labeled WAP-XX, where "XX" is the sequential number of the WAP in the building.
- Equipment Racks in a rack line shall be labeled sequentially starting at 01, moving from left to right.
- TR patch cords, furnished and installed by the Cabling Contractor, shall be labeled per Yale IT requirements

1.24. Area of Rescue Two-Way Communications Systems

The ICT Designer shall confirm whether projects require Area of Refuge and/or Area of Rescue two-way communications systems per Connecticut State Building Code. In addition, if not required by Code, the ICT Designer shall discuss with the Facilities Project Manager whether Yale wishes to implement the systems for improved building accessibility. Provide systems that meet code required functionality including call stations, signage, and a central command unit. The central command unit shall be programmed to dial out to the University's central station in the event there is no direct answer in the building fire command center, utilizing an analog POTS line.

1.25. Design Coordination for Joint Partnership Projects

Yale IT may deploy systems in facilities as a joint partnership with other entities where Yale IT does not directly control the infrastructure design. For these projects, the ICT Designer shall review the facility owner's standards and determine a methodology for adaptation to these standards. An example is joint projects with Yale New Haven Health System, where differing equipment manufacturers and healthcare standards are implemented.

1.26. Residential Colleges Requirements

The ICT Designer shall anticipate the following design requirements for projects at residential colleges.

- Wi-Fi shall be ubiquitous throughout the building and grounds. Pathways shall be planned for outdoor coverage. DAS coverage shall be provided for specific floors identified to have weak signal strength, in particular dining areas. Some vending and refrigerators utilize Wi-Fi and cellular communications for point of sale.
- Collaborate with the project Architect during end user interviews to uncover special case needs, activities, and events in the colleges that will rely on communications infrastructure.
- Various residential offices utilize service providers such as Comcast for cable television service, that is not billed through Yale IT. Anticipate service provider coordination required for moves, adds, changes to infrastructure in these cases.
- Cabling infrastructure shall be required for the following occupancies:
    - Suite Commons Rooms: two (2) Category 6 cables
    - Office spaces for Deans and Head of Colleges
    - Building common spaces used for guest speakers
    - Audiovisual Booths may require optical fiber connections
    - FAVE and MNS systems and speakers
    - Dining POS cashier stations – two (2) Category 6 cables
    - Laundry Rooms debit card system transaction panel – one (1) Category 6 cable
    - Public computer rooms – one (1) Category 6 cable and one (1) quad 120V/20A receptacle per workstation with two (2) Category 6 cables at multifunction printer stations for printer and card station. Students are now using Window Virtual Desktop more rather than going to the public computer rooms. These areas may be reprogrammed into E-Sports or Collaboration Rooms in the future. The ICT Designer shall assist Yale IT to develop the program for these spaces on a project specific basis.

- Vending machines – one (1) Category 6 per machine
- IP surveillance cameras, access control panels, intercom stations
- Chair lift telephone stations
- Dining services
  - kitchen timeclocks – one (1) Category 6 cable
  - kitchen wall mounted telephone – one (1) Category 6 cable
  - Employee kiosk– one (1) Category 6 cable
  - Manager's Office – three (3) Category 6 cables
  - Menu boards – two (2) Category 6 cables
  - Breakroom custodial timeclock - one (1) Category 6 cable
  - Digital signage flat panel displays – two (2) Category 6 cables

2.1. Security Baseline Requirements Summary

The following represents a general listing of security requirements for physical and electronic security system installations that typically applies to all projects:

1. All exterior perimeter gates and doors must be fitted with card access systems, to include card readers, exit devices, and door management alarms. Where perimeter gates are two sections, each section will have its own means of electronic locking controlled by a card reader. All exterior perimeter doors designated for exit only shall be fitted with alarm monitoring equipment (door contact, a door management alarm, and a request-to-exit motion detector), and there shall be no exterior hardware or keyway. Where doors are set for emergency exit only (to control egress), these shall be fitted with delay-to-egress hardware tied into the Security and Fire Alarm systems, where permitted by the building code.
2. The following locations shall be fitted with full card access packages:
    a. All rooms/closet entries that house student, staff, employee or patient personal information
    b. All major mechanical/electrical/telecom/server room/utility tunnel entry
    c. All rooms, suites, closets that house high value or high risk equipment
    d. Any room/closet housing an electronic key management system
3. CCTV camera and electronic access control systems are intended for deterrence and forensic purposes only, and not to provide real-time monitoring.
4. All loading docks shall be fitted with access control at the vehicle and perimeter entries to the dock; and every effort shall be made to build access-control separations between the dock interior and the rest of the facility. All perimeter entries shall be fitted with card access, a means of communication (intercom or phone), and a CCTV system for the dock exterior, the dock interior and vehicle entries shall be installed. If there is a local dock receiving office, communication, CCTV and gate/door control shall be wired through there as well (for local system control).
5. CCTV cameras shall be added to all entry/exit door(s) and to areas where high risk material is stored. All cameras shall be wired or networked to Yale Security main server via a secure network circuit on the Yale Public Safety Network. **Other locations for CCTV would include all exit/entry points, cash handling areas (tellers, cashiers, convenience store counters, tec.), parking lots….**
6. Emergency Blue Phones with blue lights shall be installed at key building perimeter and walkway locations, as designated by Yale Security. On a case-by case, consideration shall be made for phones/poles to be fitted both with digitally managed CCTV cameras to allow for the monitoring and automatic call-up of emergency use of phones and with public address speakers for broadcasting evacuation notification.
7. The buildings shall be fitted with a DMP alarm communicator, which will serve to centrally transmit all fire alarm signals and intrusion, panic and equipment alarms.
8. Any legacy burglar alarm equipment in the space, including keypads, door contacts, motion detectors and alarm horns shall be removed. Requests for new or reactivated burglar alarm systems will be reviewed on a case-by-case basis.
9. Reception areas shall be fitted with a duress button interfaced to the DMP alarm panel.
10. Where appropriate to the use and security needs of the facility, provisions for a Central Security-Manned Reception Desk at the visitor entrance shall be included, which would be fitted out for local annunciation of building alarms, as well as for local CCTV monitoring.

11. All facility perimeter windows within 10 feet off grade shall either be inoperable or, if operable, fitted with security screens or limiters.

12. Perimeter lighting, courtyard lighting and lighting on exterior perimeter walkways shall be enhanced to ensure clear visibility for after-hour use.

12. The building fire alarm system shall be equipped with voice evacuation capabilities for building-wide emergency broadcasting, as follows:

    a. University owned or leased space where the University operates and maintains the building's fire alarm system:

        1. All renovations shall include the installation of additional wiring and raceways capable of supporting future speaker/strobes. Any NAC circuit being added to or modified is required to be completely modified (rewired). Wiring shall be installed to support future voice evacuation activation. Initially, horn/strobes shall be installed and set at slow-whoop. All additional voice evacuation wiring shall be clearly marked for future use.
        2. When 20% or more of a building is renovated at one time, the Fire Alarm node covering that portion of the building shall be converted to voice evacuation using Yale Fire Code Compliance Unit and Yale Public Safety approved methods and shall follow all applicable NFPA, State, and Local codes as well as Yale Fire Code Compliance Unit and Yale Public Safety specifications. Voice evacuation coverage shall be throughout renovated area of the building. Equipment/wiring/data shall also be included and installed to communicate on Yale's network with either the Siemens or FCI/Gamewell Mass Evacuation panels at 57 Lock Street and 101 Ashmun Street.

    b. Commercially-leased space where the University does not operate or maintain the building's fire alarm system (including YNHH space):

        1. All renovations shall include the installation of additional wiring and raceways capable of supporting future speaker/strobes. Any NAC circuit being added to or modified is required to be completely modified (rewired). Wiring shall be installed to support future voice evacuation activation. Initially, horn/strobes shall be installed and set at slow-whoop. All additional voice evacuation wiring shall be clearly marked for future use.
        2. In those buildings supported by a Siemens or FCI/Gamewell fire alarm system, where 20% or more of the building is renovated at one time, the building's fire alarm system shall be converted to voice evacuation using Yale Fire Code Compliance Unit and Yale Public Safety approved methods and shall follow all applicable NFPA, State, and Local codes as well as Yale Fire Code Compliance Unit and Yale Security specifications. Voice evacuation coverage shall be throughout the building. Equipment/wiring/data shall also be included and installed to communicate on Yale's network with either the Siemens or FCI/Gamewell Mass Evacuation panels at 57 Lock Street and 101 Ashmun Street.
        3. In those buildings not supported by a Siemens or FCI/Gamewell fire alarm system, an audio interface from the building fire panel to Siemens or FCI/Gamewell headend Mass Evacuation panels at 57 Lock Street and 101 Ashmun Street shall be implemented. If the building's fire alarm panel does not support this feature, no additional work is required.

13. Each facility shall be fitted with a Morse-Watchman electronic key management system for use by local Facilities Operations personnel. Additionally, Residential facilities shall be fitted with separate Morse-Watchman systems for use by local residents and residential management personnel.

14. A broadcast speaker shall be installed centrally within the courtyard to facilitate emergency broadcast via the fire alarm voice evacuation system.

15. Where appropriate to the use and security needs of the facility, provisions for a Central Security-Manned Reception Desk at the visitor entrance shall be included, which would be fitted out for local annunciation of building alarms, as well as for local CCTV monitoring.

2.2. Security Requirements Summary for Student Residential Facilities

1. The following additional physical and electronic systems shall be installed to secure Student Residential Facilities and environs:

2. All courtyard perimeter primary entry doors to Entryways and shared facilities shall be fitted with card access system packages, including remotely managed/controlled Door Management Alarms.
3. Card access shall be installed at the following locations:
    a. All interior public/residential separations
    b. Entries to Library facilities
    c. Entries to Secure Storage Rooms
    d. Entries to Gallery Areas
    e. Entries to Computer and Media Facilities
    f. Administrative Office Suite
    g. Guest Suites
    h. Any designated room off a common area where privileges are limited to residents of the college (Weight Room, Theatre, etc.)
4. The entries to the Dining Services' public and staff areas shall be fitted with card access; and when approved by the Associate VP of HR&A delivery entrances/exits shall be fitted with CCTV cameras for Dining Services admitting and event recording.
5. All College entryway card access entry doors shall be fitted with electric strikes or electrified hardware with monitoring capabilities. Gate mag locks will include bonding sensors.
6. The following areas will be fitted with burglar alarm systems: the Head of College's houses; the Head of College's/Dean's administrative offices, and any gallery/exhibit spaces.
7. The Head of College's Offices shall be fitted with Morse-Watchmans networked electronic key cabinets to house the respective College's keys for distribution. A Morse Watchmans key system shall be installed as well in the Custodial Manager's area and the Dining Hall secure staff area. To the greatest extent possible, these Morse-Watchman systems will be shared.
8. All second-means-of-egress pass-through doors—suite-to-suite; bathroom-to-suite/bedroom; bedroom-to-bedroom shall be fitted with remotely managed/controlled Door Management Alarms. The bedroom-to-bedroom pass-through arrangement shall be prevented, if possible.
9. A broadcast speaker shall be installed centrally within the courtyard to facilitate emergency broadcast via the fire alarm voice evacuation system.
10. Intercom systems shall be established for the following areas:
    a. At key entry doors to the Head of College's living space, wired to locations within the house and to the administrative office suite
    b. At a key delivery entry gate to the administrative office suite
    c. At dining hall delivery entries to within the Dining hall receiving area

2.3. Security Requirements Summary for Clinical Space

The following ***additional*** physical and electronic systems shall be installed to secure Clinical Facilities and environs:

1. All electronic systems shall be Yale University Security's standard security and access control system components and control panels, with all alarm signals transmitted to the Yale University Central Alarm Station.
2. All perimeter entry doors off public corridors shall be fitted with prox card access. Those designated to be able to be left unlocked during certain periods of time shall be fitted with a dedicated "control" card reader with LED mounted on the interior of the door. Those designated for exit only shall be fitted with an alarm contact and a request-to-exit motion detector, with no hardware or keyway on the corridor side of the door.
3. The following clinical spaces shall be fitted with card access:
    a. Medical Records File room
    b. Narcotics closets/rooms
    c. Dedicated staff entry to private/clinical areas not off the main public corridor
4. Clinic entry doors from public waiting areas shall be located at a point visible to the receptionist. This door shall be lockable.
5. Duress buttons shall be installed at any area where large amounts of cash are taken or stored.
6. All perimeter glass to the public corridor shall be fitted with acoustic glass break detectors.
7. Any cash storage safe shall be immovable. A holdup button shall be placed near the cash safe shall large amounts of cash be stored. The safe itself shall be invisible to passers-by.
8. If the clinic will be used for after-hours patients as well, the corridor entry door shall be fitted with a doorbell, and chime speakers shall be distributed throughout the suite.

2.4. Security Requirements Summary for Research Facilities

The following ***additional*** physical and electronic systems shall be installed to secure Research Facilities and environs:

1. Windows fronting the exterior in areas with high-value equipment shall be fitted with glass break alarms.
2. High Risk Research and Storage Area entry doors within the facility shall be fitted with card access. When appropriate, CCTV cameras may be installed at key doors.
3. Where appropriate to the use and security needs of the facility, provisions for a Central Security-Manned Reception Desk at the visitor entrance shall be included, which would be fitted out for local annunciation of building alarms, as well as for local CCTV monitoring.
4. There shall be two points of electronic access-control separation between the exterior of a facility and interior lab/lab support areas (including wet bench, dry bench and computer lab areas). This may require card access on some combination of corridors, stairwells, elevators, and/or individual room doors.

2.5. Security Requirements Summary for Child Day Care Space

The following ***additional*** physical and electronic systems shall be installed to secure Child Daycare Facilities and environs:

1. There shall be at least **two** points of electronic access-controlled separation at the public entrance separating the building perimeter envelope from an interior waiting area and that waiting area from the interior Child Care areas. If there is an intermediary vestibule, both the exterior and interior vestibule doors shall be fitted with card access, and the exterior vestibule may remain unlocked during regularly scheduled parent drop-off and pick-up times. To facilitate authorized access, parents may be issued access cards that will allow them no farther than the waiting area.
2. There shall be local intercom communications at all the public entrance doors to several select intercom stations within and around the facility. This shall be interfaced with CCTV cameras, so that visitors can be seen as well as heard. There shall be no remote door release from interior intercom stations.
3. A receptionist area within the public waiting area shall be established, with a desk having the ability to communicate with and identify visitors seeking admittance, and with door release from there only. The desk will be fitted with limited CCTV monitoring capability, and it shall be staffed during drop-off and pick-up times.
4. The interior Child Care Areas shall be restricted to staff access only. Any non-staff person authorized on a temporary basis to be there must be escorted in and out. All perimeter doors to the interior space shall be fitted with alarms that sound locally and throughout the facility when used without authorization. These shall have card access to control entry and a card reader to either allow controlled egress on non-exit doors, delayed egress, or a reader to shunt the alarm upon egress on required exit doors. In sum, there shall be a very limited number of such entry doors to interior space.
5. CCTV cameras may be installed at interior perimeter points of entry and exit; at exterior play areas; and pick-up and drop-off parking areas. CCTV monitors with pan-tilt-zoom camera control may be provided at key interior staff monitoring areas.
6. The building's environmental system shall be established so that no windows need to be operable. Fixed windows shall be fitted with shock sensors. Any accessible windows that are operable shall be fitted with fixed security screens. Shall any be required to be set for egress, these shall be fitted with safety locks and alarm contacts that sound locally and at key areas of the building.
7. It is recommended that the building be fitted with an interior PA system, with communications in each room. Ideally, the alarm system shall be interfaced with this, so that the exact location of an alarm breach will be broadcasted to staff through the facility's speakers.
8. All interior activity, classroom and sleep area room entry doors shall be fitted with large vision panels so that staff can assess the interior from the exterior corridors.
9. Any exterior play area shall be physically and visually separated from public pathways with a wall of a minimum of 8'. These shall be as close to the building as possible, separated from driveways or public parking areas. Access into the play area shall be via a gate or opening on card access, with card access to control egress as well. The play area shall be fitted with an emergency telephone with its camera and fixed cameras to cover general play areas.
10. Emergency duress buttons shall be installed in interior and exterior childcare areas. These shall be installed with protective covers and out of general child reach.

2.6. Security Requirements Summary for YARC Space

The following ***additional*** physical and electronic systems shall be installed to secure YARC Facilities and environs:

1. There shall be at least **three** points of electronic access-controlled separation between the building perimeter envelope and YARC Animal Holding rooms. All animal facility use rooms shall be equipped with prox card readers. This includes, but may not be limited to, animal, procedure, wash center, offices, break rooms, locker rooms, surgical suites, storage and waste containment.
2. Any mechanical, electrical, security or telecom rooms that house support infrastructure for this facility shall be fitted with prox card access. These shall be designed to reside within the secure suite.
3. All electric locking hardware on card reader doors shall be fitted with latch bolt monitoring to detect latch taping, and all such locking hardware and catches shall be installed with tamper-proof screws. Pinned hinges shall be used for doors that have exposed hinges on the corridor side.
4. Any access controlled portal or adjacent wall with glass shall be fitted with acoustic glass break detectors.
5. Emergency communications telephones (area of refuge phones), with automatic ring-down to Security, shall be installed in key interior areas, cage wash areas, and other perceived remote areas within the space. Where practical, emergency communication telephones shall be placed at intervals that allow line of sight to at least one emergency communication telephone from all interior corridor location. Each emergency communication telephone will be equipped with a blue lamp.
6. Cellular service shall be provided in all animal facilities.
7. Any exterior windows within YARC space shall be filled in and covered. Where BL3 research is done, these walls-if not 2” thick, shall be fitted with vibration sensors.
8. CCTV cameras shall be installed at each entry point to the YARC facility, and where practical at intervals to allow video monitoring of all interior corridor locations. The video from these cameras will be recorded at a digital video recorder and managed by Yale Public Safety.
9. Biometrics shall be considered for high containment (e.g. BL3) facilities, and other specialized or sensitive areas.

2.7. Security Requirements Summary for Garage Facilities

The following ***additional*** physical and electronic systems shall be installed to secure Parking Garage Facilities and environs:

1. All exterior perimeter pedestrian gates and doors must be tied into Yale Public Safety’s card access system only. All vehicle gates/barriers shall be wired primarily into the Yale Parking access system and secondarily into Yale Public Safety’s access control system. All perimeter overhead or other vehicle gates must have alarm contacts wired to Yale Public Safety CAS for status.
2. Card access shall be installed on any Garage offices and Cashier’s booths.
3. As much as is architecturally possible, all garage stairways and elevator backs shall be designed of heavy-duty glass or plexiglass to ensure clear interior visibility from the garage exterior. Doors into stairwells shall have large glass panels, and stairway landings shall be fitted with corner-mount mirrors for added security visibility.

4. The garage shall be designed to be fully enclosed/securable at all accessible points 12' from grade or below. Landscaping around the perimeter shall be arranged to reduce visual obstructions. Bushes or hedges, especially at entries and exits, shall be avoided.
5. In addition to key exterior perimeter pedestrian entries of the garage, Yale blue phone packages shall be installed at all elevator lobbies and stairwell entries on every floor, as well as on parking ramps and landings.
6. CCTV cameras may be installed at the following locations: at elevator lobbies and stairwells; at roof corners; at perimeter pedestrian entrances; at the interior and exterior of vehicle gates; at the Cashiers booth/office to monitor transactions; at blue phones. These cameras shall be wired back to the Yale Public Safety video servers. The garage office shall be fitted with a CCTV monitor and camera control for local viewing and assessment.
7. Garage Cashiers' booths and any office, in addition to card access, shall be fitted with glass break detection and emergency hold-up buttons.
8. Interior lighting must be widely distributed, and the lighting must compensate for any architectural obstructions, like closely spaced columns or beams.

2.8. Security Camera Installation Policies

This policy concerns the installation and use of equipment for video surveillance, monitoring, and recording on Yale University-owned, leased or controlled properties; this policy does not apply to the use of video applications for academic, research, or educational purposes of Yale University.

Security cameras are strategically placed throughout the Yale University community to meet the specific needs of departments and to assist the Yale University Department of Public Safety to deter crime, manage emergency response situations, and investigate suspected criminal behavior. No video surveillance cameras may be installed without authorization of the Department of Public Safety.

Video cameras to be used for safety, security or facilities management purposes may be installed in any location, on approval of the Video Review Committed (VRC), except for the following;

- Student dormitory rooms in the residence halls
- Living quarters of other residential facilities
- Bathrooms
- Locker rooms and other changing facilities
- Offices
- Classrooms not used as a lab

Storage and Retention of Recordings

All surveillance records shall be stored in a secure university centralized for a period of 45 days or, if required for specific purposes for certain locations, a set number of days. The video will then promptly be erased or written over, unless retained as part of a criminal investigation or court proceedings (criminal or civil), or other bona fide use as approved by the Director of Public Safety and Chief of Police or designee. Individual departments shall not store video surveillance recordings.

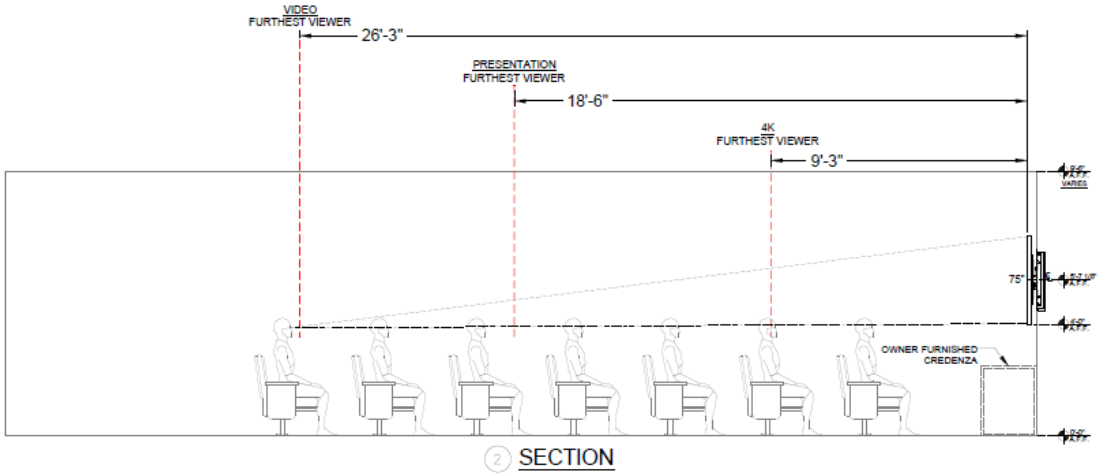
Exceptions

Uses of Public Safety Camera Systems beyond those described in this policy is prohibited. Persons having questions about the use of Public Safety Camera Systems not subject to this policy shall direct those questions to the VRC at VCR@yale.edu.

3.1. Audiovisual Guidelines and Best Practices

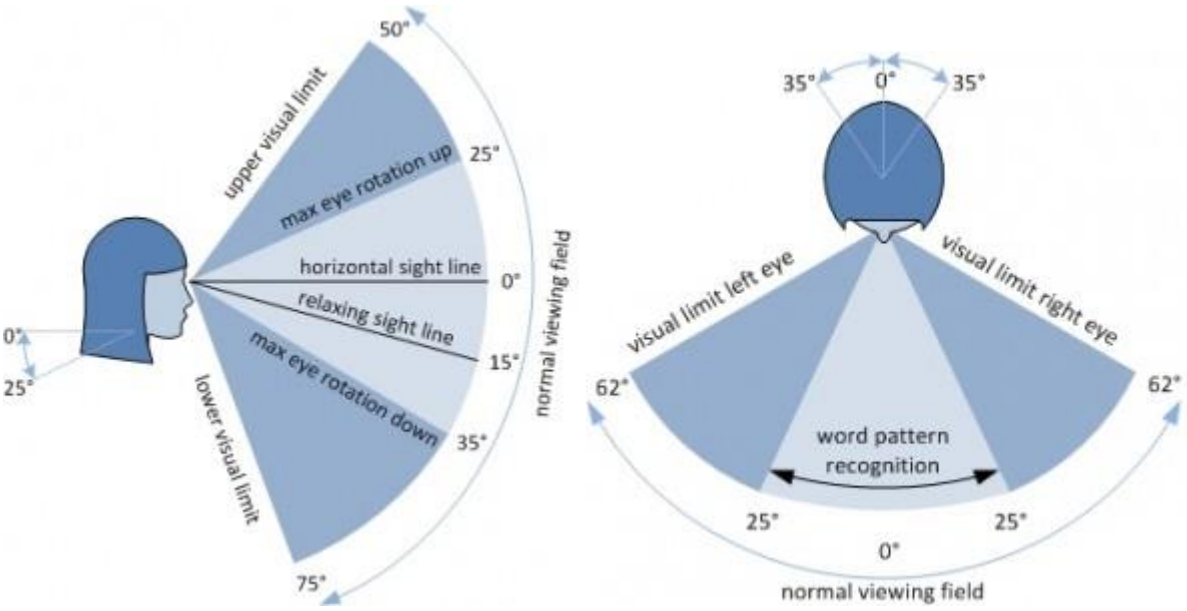
Recommended Display Size

Displays shall be sized to allow maximum viewability of content. Displays shall be 16:9 aspect ratio unless specified specifically for Cinema or non-traditional use. In a typical application displays shall be sized so that the Display Height (DH) multiplied by 6 is less than or equal to the Distance to the Farthest Viewer (DFV), DHx6≦DFV. In critical or fine detail viewing the DFV will be half or DHx3≦DFV. The maximum viewing angle cone shall be no more than 30 degrees from center. The closest viewer shall be no less than the height of the display away. In installations where recommended viewing distances and sizes cannot be met supplemental displays shall be included.



2 SECTION

IMAGE DIAGONAL	MAXIMUM VIEWING DISTANCE		
	VIDEO	PRESENTATION	4K
75"	26'-3"	18'-6"	9'-3"

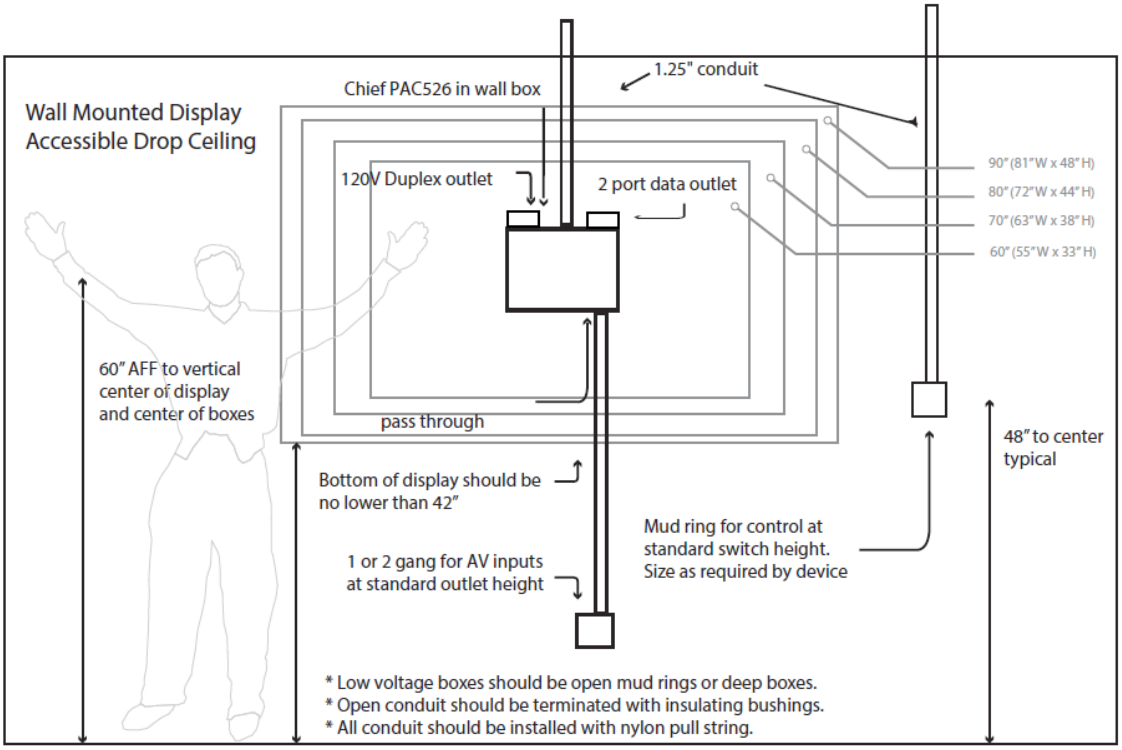


Recommended Display Type

Flat panel displays shall have 4K resolution. Projectors shall be LCD or LCOS based imaging and have a laser light source; 3-chip DLP projectors may be used in certain use cases. Projectors will be used in a 16:9 mode. Projection screens shall be tensioned and have a high contrast, 4K capable surface. Ambient light rejecting screen surfaces may be required in certain environments to provide adequate image brightness for the environment. Where architecturally appropriate the elimination of black drop on screens shall be considered. Projection screens shall be motorized with a physical up/down switch located in the room.

Display Installation

All displays must be installed in accordance with local codes and regulations. ADA clearances must be considered in all installations. It is recommended to install displays so the bottom of the image is no lower than 42" above finished floor (aff). Display height will depend on application. Displays shall be installed on articulating mounts to allow for easy access to the back of the display for service. For flat panel installation a Chief PAC526CF style back box is recommended with installed duplex power outlet and 2 Cat6 RJ45 data connections, additional conduit may be required per system design.



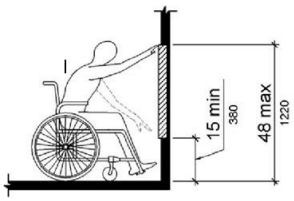


Figure 308.2.1
Unobstructed Forward Reach

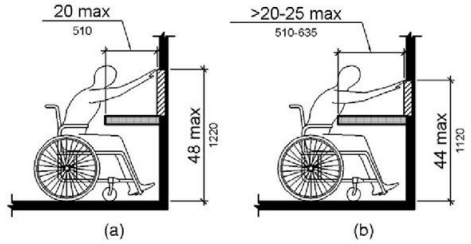


Figure 308.2.2
Obstructed High Forward Reach

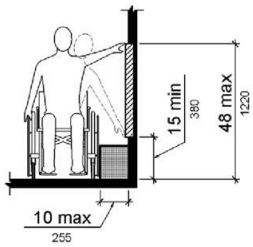


Figure 308.3.1
Unobstructed Side Reach

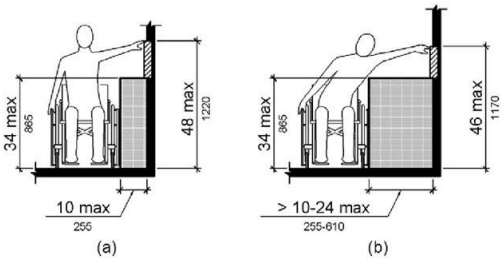


Figure 308.3.2
Obstructed High Side Reach

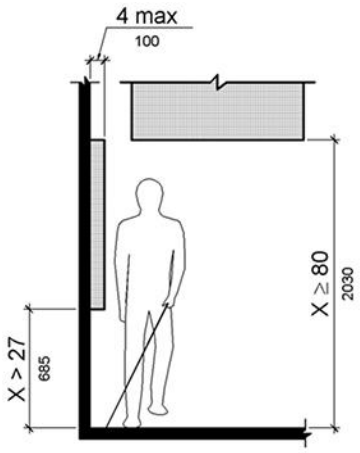


Figure 307.2
Limits of Protruding Objects

Audio Coverage and Uniformity

Program audio and music reinforcement shall reproduce a full range of frequencies while vocal reinforcement shall be tuned for speech intelligibility. Audio coverage shall vary by no more than 3dB across the listening area. Ambient Noise and Reverberation: Unoccupied classroom levels must not exceed 35 dBA; The signal-to-noise ratio (the difference between the teacher's voice and the background noise) shall be at least +15 dB at the listener's ears; Unoccupied classroom reverberation must not surpass 0.6 seconds in smaller classrooms or 0.7 seconds in larger rooms. ADA hearing assist capabilities shall be included in all implementations.

Stereo program audio and music speakers are recommended for the front of the room while ceiling or pendant speakers configured for 70V operation provide speech audio. If one or the other is not possible all audio will be handled by a single speaker type. Line array or specialty speakers may be required by application.

Provide a fire alarm system relay bypass relay connection to amplifiers where required for fire alarm system audibility.

Control Systems

AV control system can serve different purposes depending on application. Typical functions include display power on/off, source selection, audio volume control and can include additional functions as required by the system design. AV control systems and monitoring shall be used in every AV installation.

Extron or QSC's Q-sys shall be used as AV control systems. YALE IT can provide graphical user interface (GUI) templates for use with control systems to provide consistency with other installations across the University. Use of touchscreen AV controls is recommended.

Infrastructure Requirements

AV systems now follow traditional IT infrastructure architecture. Almost all devices connect over Cat6 cabling for audio, video, data and control, connect to network switches and need to be configured for specific applications and functions. An enterprise deployment of an AV system resembles a server farm or traditional network closet more than a traditional point to point system with AV devices transmitting information with traditional IP protocols and workflows, or AV over IP. As a rule of thumb each AV device requires a network connection. It is recommended centralized AV processing equipment reside in TR's as power and cooling requirements are the same for both systems. Additional AV infrastructure requirements include:

- AV equipment locations shall typically be served with a minimum 1-¼" conduit or as required by installation. Singular AV devices requiring only one (1) Category 6 cable, speaker wire, control cable, or microphone cable shall be served with a minimum ¾" conduit. Conduit shall terminate in an accessible location, AV equipment closet or TR. Conduit shall have nylon bushings installed on any exposed ends. Conduit shall be left with a nylon pull string for future use.
- Mounting heights for wall mounted control devices shall be mounted at ADA height.
- All physical device installation to be in compliance with local codes and industry best practices.
- Gang style boxes shall be open mud ring (old work) or deep boxes to accommodate AV connections.
- Cables and cords shall not be run across a floor without non-movable cord coverings.
- Large systems shall consider a Video over IP architecture which provides better value and control at scale than traditional systems.

Audiovisual Projection Rooms

Projection room infrastructure requirements shall conform to the architectural, electrical, and environmental design criteria in "Telecom Room Requirements" listed above. Power, cooling, and ventilation requirements demanded by large venue projection systems shall be carefully coordinated. The following design criteria shall be reviewed and coordinated for each project:

- Various sizes of projection rooms may be required for the following venues:
  - Single Projector Small Venue
  - Dual Projector Medium Venue
  - Multiple Projector Large Venue
- Based upon the room program and functional requirements, the ICT/AV Designer shall provide a Projection Room equipment layout plan and room section identifying the following:
  - Sight lines into the venue from operator workstations and projector light paths over the audience
  - Projection and view port glass windows and framing
  - Operator workstations
  - Equipment cart and trolley locations
  - Equipment racks and rack lines
  - Cable runways, room penetrations, and surface raceways
  - Grounding busbar
  - Lighting control panel
  - Electrical subpanel
  - Wall light switch(es), control panel(s), and AV panel(s) locations
  - Large venue projectors and infrastructure requirements
    - Mounts and structural tie points
    - Mirror systems for rear projection if used

        - Dedicated projection system ventilation or cooling apart from room HVAC system. Provide flexible ducts for final connections to equipment.
        - Power circuiting and device types
    - HVAC system loads, ductwork, and equipment locations
    - Room lighting
    - Wall sound transmission classes and room acoustical treatments
    - Door type and card reader access control
    - Rear projection screen installation details
    - Storage cabinet locations
    - Equipment working clearances and circulation paths
- The structured floor shall be 1" below finished floor within the projector room. Apply 1" self-leveling liquid flooring to ensure level floor across room with no more than 1/32" deviation from level. Coordinate final resilient flooring requirements with any trolley racks or rolling projector equipment sub-structure.
- Provide a dedicated electrical subpanel to serve the projection room.

3.2. AV Systems Types

Digital Signage

Digital Signage can range in size and type from a small table-top display up to a large video wall and can include interactivity or live triggering of content depending on programming. A typical digital signage deployment requires a display, duplex 120V power outlet, 2 Cat6 RJ45 network connections and a content player. Physical installation and content must meet accessibility guidelines and comply with ADA requirements. Digital Signage software or service subscription costs shall be budgeted as a recurring cost and is typically not included in the cost of installation. In addition, recurring service and maintenance costs may apply. System requirements include:

- Display, size and type as needed for the application and design intent
- Media Player, mounted behind the display
- Power: 120V/20A duplex receptacle behind display
- Network: two (2) Category 6 cables behind display
- Control (Power On/Off, Source Selection (if needed), Volume Control) via display or third-party control system
- Recommended: Chief PAC526CFW back box recessed in wall behind display containing the power and network outlets
- Optional enhancements:
    - Touch screen display
    - Supplemental audio reinforcement

Huddle Room

Huddle Rooms consist of small gathering spaces intended for less than 10 people and are intended as spaces for collaborative small group work. A typical huddle room requires a display, duplex 120V power outlet, two (2) Category 6 network connections, a laptop connection and optionally a dedicated source like a local computer. Wired HDMI input and wireless display video connection are highly recommended. Optional items include webcam/microphone. An interactive flat panel can be installed to provide additional use cases. Physical installation must meet accessibility guidelines and comply with ADA requirements.

Service costs may include periodic maintenance or troubleshooting and are typically not included in the cost of installation. System requirements include:

- Display, typically 55” - 65”
- Power: 120V/20A duplex receptacle behind display
- Network: two (2) Category 6 cables behind display
- Wired HDMI input
- Wireless display video connectivity, recommended
- Control (Power On/Off, Source Selection (if needed), Volume Control) via third party control system. Touchscreen controller recommended.
- Recommended: Chief PAC526CFW back recessed in wall behind display containing the power and network outlets
- Optional:
    - Touch screen display
    - Webcam/microphone, Logitech MeetUp typical
    - Dedicated local computer with wireless keyboard/mouse
    - External room schedule and booking displays
    - Meeting Room Digital Signage display

Small Conference Room

A Small Conference Room will have a viewing distance of no more than 18 feet to the farthest viewer and typically utilizes display sizes of 75” or less. A typical small conference room requires a display, duplex 120V power outlet, 2 Cat6 RJ45 network connections, a laptop connection and optionally a dedicated source like a local computer. Wired HDMI input and wireless display video connection are a minimum. Webcam/microphone are included but additional microphones may be required for audio coverage. An interactive flat panel can be installed to provide additional use cases. Physical installation must meet accessibility guidelines and comply with ADA requirements. Service costs may include periodic maintenance or troubleshooting and are typically not included in the cost of installation. System requirements include:

- 65” - 75” display
- 120V duplex power at display
- 2 data at display
- Wired HDMI input
- Wireless display video connectivity
- Control (Power On/Off, Source Selection (if needed), Volume Control) via third party control system and touchscreen controller. Table top control typical.
- Webcam/microphone, Logitech series typical
- Recommended: Chief PAC526CFW back box installed behind display with duplex outlet and 2 data
- Optional:
    - Touch screen display
    - Additional table microphones may be required.
    - Dedicated local computer with wireless keyboard/mouse
    - External room schedule and booking displays
    - Meeting Room Digital Signage display

Large Conference Room

A Large Conference Room will have a viewing distance greater than 18 feet to the farthest viewer and typically utilizes display sizes of 86” or above. For displays above 100” diagonal a projector/screen shall be used. A typical large conference room requires a display, duplex 120V power outlet, 2 Cat6 RJ45 network connections, a laptop connection and optionally a dedicated source like a local computer. Wired HDMI input and wireless display video connection are a minimum. Installed Pan-Tilt-Zoom (PTZ) camera and installed room microphones included. Interactive flat panels not typical to these installations due to room size. Physical installation must meet accessibility guidelines and comply with ADA requirements. Service costs may include periodic maintenance or troubleshooting and are typically not included in the cost of installation. System requirements include:

- 86” - above display, flat panel or screen/projector as required by application and intent
- 120V duplex power at display. Motorized screen will require power and low voltage relay connection with access that allows service of the power and low voltage connections.
- 2 data at display
- Wired HDMI input
- Wireless display video connectivity
- Control (Power On/Off, Source Selection (if needed), Volume Control) via third party control system and touchscreen controller. Table top control typical.
- PTZ camera and installed room microphones, QSC cameras and Shure microphones typical
- Recommended: Chief PAC526CFW back box installed behind display with duplex outlet and 2 data
- Optional:
    - Dedicated local computer with wireless keyboard/mouse
    - External room schedule and booking displays
    - Meeting Room Digital Signage display

Movable Display Cart

A Movable Display Cart is used in applications where a fixed installation is not possible or flexibility with display positioning is desired. A Movable Display Cart typically utilizes display sizes of 55” to 86”. A typical movable display cart requires a display, nearby duplex 120V power outlet, 2 Cat6 RJ45 network connections may be needed or the display may be able to operate on the wireless network, a laptop connection and optionally a dedicated source like a local computer mounted on a movable cart. Wired HDMI input and wireless display video connection are a minimum. Webcam/microphone are optional. An interactive flat panel can be installed to provide additional use cases. Physical installation must meet accessibility guidelines and comply with ADA requirements. Interactive displays require height adjustable carts. Service costs may include periodic maintenance or troubleshooting and are typically not included in the cost of installation. System requirements include:

- 55” - 75” Interactive Flat Panel with integrated Local PC and Wireless Display Gateway, wired HDMI input
    - Current model includes BenQ RP Series Interactive Displays, other models considered with YALE IT consultation
    - Power and 2 Cat6 to display by others
    - Yale network connection for each
- Wired HDMI input
- Wireless display video connectivity
- Control (Power On/Off, Source Selection (if needed), Volume Control) via the display onboard controls.
- Optional:
    - Touch screen display

  - Webcam/microphone
  - Dedicated local computer with wireless keyboard/mouse
  - Soundbar
- Mobile electric height adjust display cart.
  - Current model includes Salamander Designs XL Electric Lift Mobile Stand (FPS1XL/EL/GG), Electric Lift Mobile Stand (FPS1/EL/GG) and Fixed Height Display Stand (FPS1/FH/GG)
  - *Height adjustable stand required for interactive displays
  - Accessories included for mounting of webcam or other accessories, power and data connections, storage cover and laptop shelf

Seminar - Interactive Flat Panel:

- Interactive Flat Panel with integrated Local PC and Wireless Display Gateway, wired HDMI input
  - Current model includes BenQ RP Series Interactive Displays, other models considered with YALE IT consultation
  - Control directly via the BenQ display
  - Power and 2 Cat6 to display by others required
  - Yale network connection for each
  - Microphone and ALS added as requested

Seminar - Standard Flat Panel:

- Standard Flat Panel with integrated Local PC and Wireless Display Gateway, wired HDMI input
  - QSC:
    - QSC NV video encoder, local HDMI output to Primary Display
    - 8” wall or table mounted touch screen control
    - Current models include Samsung and LG Commercial displays, display to be controlled by QSC
  - Extron:
    - IN1084 DO four input DTP out switcher, local HDMI output to Primary Display
    - 7” wall or table mounted touch screen control
  - Power and 2 Cat6 to display by others required
  - Typical Chief PAC526CF series back box installed behind display with standard power/data/conduit
  - Microphone and ALS added as requested

Seminar - Projector and Screen:

- 16:9 aspect, 4K capable motorized screen
- 6000 lumen minimum laser projector
  - Current models include Epson (L610U) and Sony
- Local PC, Wireless Display Gateway, Wired HDMI input
  - QSC:
    - QSC NV video encoder, local HDMI to Preview Monitor
    - QSC NV video decoder, local HDMI to Primary Display
    - 8” wall or table mounted touch screen control
    - QSC Core processor, shared or standalone

- Extron:
  - IN1084 DO four input DTP out switcher, local HDMI to controlled 2 input Preview Monitor video switch. Note: Preview Monitor switch will receive content from the IN1804 or the secondary output of the local PC
  - HDBaseT output of IN1804 to Projector
  - 7” wall or table mounted touch screen control
  - Extron control
  - Audio Output in addition to ALS to include
- Stereo presentation speakers installed at the display location. Standard models include QSC AD-S8T surface mount speaker. Speakers and amplifiers as required by system design and requirements.
- ALS transmitter locations to be prewired. Single gang box with Cat6

Standard Presentation Classroom - Projector and Screen

Presentation Classroom: Fixed or flexible seating but primary use case is presentation of materials without recording capability. Traditional front of room teaching station with focus toward displays or large writing surfaces. Vocal reinforcement required. System requirements include:

- 16:9 aspect, 4K capable motorized screen
- 6000 lumen minimum laser projector
  - Current models include Epson (L610U) and Sony
- Local PC, Wireless Display Gateway, Wired HDMI input, Blu-ray Player
  - QSC:
    - QSC NV video encoder for local sources
    - QSC NV video decoder, local HDMI to Preview Monitor
    - QSC NV video decoder, local HDMI to Primary Display
    - 8” wall or table mounted touch screen control
    - QSC Core processor, shared or standalone
  - Extron:
    - IN1084 DO four input DTP out switcher, local HDMI to controlled 2 input Preview Monitor video switch. Note: Preview Monitor switch will receive content from the IN1804 or the secondary output of the local PC
    - HDBaseT output of IN1804 to Projector
    - 7” wall or table mounted touch screen control
    - Extron control
- AV Control located at teaching station
- Audio Inputs in addition to Source Audio to include:
  - 2, wireless microphones. Current models include Shure ULXD series.
- Audio Output in addition to ALS to include:
  - Stereo presentation speakers installed at the display location. Standard models include QSC AD-S8T surface mount speaker or as necessary for performance
  - Mono ceiling speakers recommended for vocal reinforcement. Standard models include QSC AD-C6T ceiling speaker
  - ALS transmitter preinstalled

Advanced Presentation Classroom - Projector and Screen

The advanced presentation classroom shall incorporate additional cameras and microphones for streaming and recording. System requirements include:

- 16:9 aspect, 4K capable motorized screen
- 6000 lumen minimum laser projector
  - Current models include Epson (L610U) and Sony
- Local PC, Wireless Display Gateway, Wired HDMI input, Blu-ray Player
  - QSC:
    - QSC NV video encoder for local sources
    - QSC NV video decoder, local HDMI to Preview Monitor
    - QSC NV video decoder, local HDMI to Primary Display. Additional display outputs may be incorporated.
    - 8” wall or table mounted touch screen control
    - QSC Core processor, shared or standalone
  - Extron:
    - Advanced switching or matrix system may be required to meet system functionality requirements. Large Extron systems shall be compared with SDVoE type solutions for cost and flexibility.
    - 7” wall or table mounted touch screen control
  - Software Defined Video over Ethernet (SDVoE):
    - A SDVoE, or Video over IP, system shall be considered for all large and advanced systems designs.
    - Inputs and outputs as required by system use and design
- AV Control located at teaching station
- Audio Inputs in addition to Source Audio to include:
  - 2, wireless microphones for teaching station. Current models include Shure ULXD series
  - 8 additional wireless microphone channels. Current models include Shure ULXD series
- Audio Output in addition to ALS to include:
  - Stereo presentation speakers installed at the display location. Standard models include QSC AD-S8T surface mount speaker. Upgraded audio may include Coda Audio.
  - Mono ceiling speakers recommended for vocal reinforcement. Standard models include QSC AD-C6T ceiling speaker
  - Dedicated Broadcast audio output
- Included:
  - Camera and microphones for Lecture Capture or Streaming. Standard models include QSC Cameras and Shure MXA910 microphones. Selection will vary by venue and application
  - Dedicated Broadcast video output of presentation content

Auditorium - Projector and Screen

Auditorium: Primary use case is presentation of materials to large audiences. Traditional front of room teaching station with focus toward displays or large writing surfaces. AV Booth typical. AV Booth shall be equipped with AV sources and displays to allow production of technician-controlled events. Vocal reinforcement required. Cameras and lecture capture capabilities included. Advanced AV system control and integration. System requirements include:

- 16:9 aspect, 4K capable motorized screen
- 12,000 lumen minimum laser projector

    - Current models include Epson and Sony
- Local PC, Wireless Display Gateway, Wired HDMI input, Blu-ray Player
    - QSC NV video encoder at teaching station
    - QSC NV video decoder, local HDMI to Preview Monitor
    - QSC NV video decoder, local HDMI to Primary Display
        - QSC NV video encoder for local sources
        - QSC NV video decoder, local HDMI to Preview Monitor
        - QSC NV video decoder, local HDMI to Primary Display. Additional display outputs may be incorporated.
        - 11” wall or table mounted touch screen control
        - QSC Core processor, shared or standalone
    - Extron:
        - Advanced switching or matrix system may be required to meet system functionality requirements. Large Extron systems shall be compared with SDVoE type solutions for cost and flexibility.
        - 10” wall or table mounted touchscreen control
    - Software Defined Video over Ethernet (SDVoE):
        - A SDVoE, or Video over IP, system shall be considered for all large and advanced systems designs.
        - Inputs and outputs as required by system use and design
- AV Control located at teaching station and Booth
- Booth AV Sources including Blu-ray and wired HDMI input
    - Integrated into AV system for control from the Booth
    - Video production mixer such as Rolland V-600UHD with appropriate inputs/outputs. Recommended for produced events to enable seamless video preview and switching
- Audio Inputs in addition to Source Audio to include:
    - 2, wireless microphones for teaching station. Current models include Shure ULXD series
    - 8 additional wireless microphone channels. Current models include Shure ULXD series
    - Microphones required for audience capture where necessary
    - Additional microphones as required by system design or functionality
- Audio Output in addition to ALS to include:
    - Stereo presentation speakers installed at the display location. Audio system specified and sized for venue. Coda Audio systems preferred where applicable
    - Mono ceiling speakers recommended for vocal reinforcement. Standard models include QSC AD-C6T ceiling speaker
    - Dedicated Broadcast audio output
- Included Options:
    - Camera and microphones for Lecture Capture or Streaming. Standard models include QSC Cameras and Shure MXA910 microphones
    - Manual audio mixing console enabling full manual control of all audio sources. Must interface digitally with Q-Sys for switching between manual and auto modes.
    - Lecture Capture recording system. Current standard is Panopto.

Active Learning Classroom

Active Learning Classroom: Instructor led, media rich, group collaboration. Typically, multiple displays allowing individual group collaboration and instructor directed media to be displayed and controlled in an interactive and dynamic manner.

- Wolfvision Cynap vSolution Matrix active learning platform shall be installed in all Active Learning spaces
- Teaching/Touchdown station providing dedicated control and local input sources such as Local PC, Wireless Display Gateway, Wired HDMI input
- Audio Inputs in addition to Source Audio to include:
  - 2, wireless microphones for teaching station. Current models include Shure ULXD series
  - Additional microphones as required for system functionality and performance
- Audio Output in addition to ALS to include sound reinforcement necessary for system functionality and performance
- Note: Due to the custom and complex nature of Active Learning classrooms YALE IT shall be consulted on and approve of all designs and implementations.

3.3. Yale Classroom Minimum Standards

Video Sources

- Local PC with extended display capability to Preview Monitor
  - Yale provided classroom managed workstation
  - Yale network connection
- Wireless Display Gateway
  - Crestron AM-200 (currently under evaluation, Dec 2019)
  - Wireless display network connection
- Wired HDMI input
  - Adapters provided for Mini DisplayPort and USB-C

Audio Sources

- Audio from input supporting allowable playback formats
- Microphone as needed for ALS
- Shure microphones, UXLD G50 or as needed by application to prevent interference. Frequency survey may be required.

Video Outputs

- Primary Display
  - Display shall be sized so that the height of display is equal to or less than the distance to the farthest viewer divided by 6
  - 16:9 aspect ratio
  - 4K capable projection surface or flat panel display
- Preview Monitor

- Touch monitor with USB connection to Local PC. Current model includes Planar PCT2265 installed on an Ergotron LX mount. Note: In single display systems the Preview Monitor may be omitted.

Audio Outputs

- Stereo program audio speakers, speaker level wiring as required by system, ceiling speakers as necessary
- ALS audio transmitter as needed, infrastructure preinstalled, Cat6 to ALS location
  - Listen Technologies IR Assisted Listening system or as required by venue
- Broadcast audio and video output as needed via IP
- No more than 3dB difference in audio level across the listening space

Control

- Acceptable systems include:
  - QSC Q-Sys Core, centralized audio, video and control processor
    - LAN A for AV, LAN B for Management
    - Located in MDF/IDF or locally as necessary
  - Extron IPCP Series Control Processor
    - LAN A for AV, LAN B for Management
    - Located locally to room
- Touch panel control in room of local AV system
  - Wall mounted, typical 1” conduit with 1, Cat6, POE+
  - Teaching station mounted in table top stand
- AV network connection
- Yale network connection allowing management, internet and remote access to the system

Video Distribution and Switching

- 4K infrastructure and compatibility must be provided
- Acceptable systems include:
  - QSC NV network based Video over IP
    - 1G Cat6 network devices installed locally in the room and in AV/IT MDF/IDF closets
    - AV network connection to each
  - Extron DTP point to point connection
    - Shielded Cat6 recommended
    - Direct wire devices to display
  - Software Defined Video over Ethernet (SDVoE):
    - A SDVoE, or Video over IP, system shall be considered for all large systems designs where a large number of inputs, outputs and signal routing flexibility is required. SDVoE systems support signal management and distribution in ways that make it a better value on large systems.
    - SDVoE systems are ideal for new construction and large renovations allowing enterprise management and scalability of deployments and full network integration of devices
    - 1G or 10G systems available, Cat6a or Fiber as required by the system, standard network infrastructure and topology, AV specific networking required. IDK is the preferred 10G solution.

Audio Distribution and Switching

- QSC Q-Sys Core audio processing, as part of Control
  - Q-LAN, AES-67 and Dante audio over IP
  - Mic/Line/Speaker level wiring as needed, IP distribution preferred
  - AV network connection
- Assisted listening:
  - Listen Technologies IR ALS preferred. Connection or conversion as required by the system.
- Additional audio outputs shall be considered for Broadcast use in each system and must be provided in Standard Presentation room and above.

Network

- AV device locations typically require 2 network connections: Yale data network and Yale AV network
  - Devices must be appropriately coordinated and configured with Yale ITS
  - Display locations shall receive 2, Cat6
  - AV Input locations shall receive 2, Cat6
  - Equipment rack locations shall receive 2, Cat6. Additional network switching may be required.
  - Touchscreen controllers receive 1, Cat6

Teaching Station

- ADA compliant teaching station, touchdown location or display cart. All devices must meet reach and usability standards.
  - Standard and custom furniture available
  - Custom millwork provided by Miller's Presentation Furniture
  - Power connection required
  - 2 Cat6 required or per system design

Wall Mounted Display

- ADA compliant mounting
- Articulating mount preferred for accessibility to connections behind the display
- Typical display to have Chief PAC526 mounted behind the display location.
  - Duplex 15A/120V outlet installed in box by others
  - 2, Cat6 installed by others
  - 1.25" conduit connected to lower wall boxes, floor boxes and/or extended to accessible ceiling
- Acceptable manufacturers include:
  - Samsung commercial
  - LG commercial
  - BenQ Interactive
  - Planar
  - Others as approved by YALE IT

Movable Display Cart

- ADA compliant, motorized height adjustable stand
  - Salamander Designs display carts with power, network, storage and accessory mounting options. Custom branding available

4.1. Radio Communication In-Building Coverage Specifications

Radio communication is the main mean of communications for Facilities Operations and Public Safety. Facilities Operations provides service and maintenance for the University and responds to emergencies that include building mechanical and structural failure. Facilities Operations may also be called upon to support other types of University events and emergences requiring support in areas of Physical Plant, Custodial, Grounds, and Fire Code Compliance, Power Plants, and Utilities. Additionally, when required, Facilities Operations can communicate with Yale Emergency Management, Yale Public Safety, Yale Hospitality, YARC, and host City/Town first responders.

Provide for inclusion of frequencies serving the municipalities' first responders in newly constructed buildings, additions to existing buildings, alterations to existing buildings where the geographic scope of work encompasses more than 50% of the building's gross area, including any additional floor area added and tie them into the fire system.

The ICT Designer shall consult with the Authority Having Jurisdiction (AHJ) of the municipality and the Yale IT. The radio system(s) shall be designed to provide a minimum of 90 - 95% campus coverage and 99% coverage in vital areas. Subterranean spaces present radio signal deficiencies resulting from signal loss due to building penetration. Radio signal in subterranean spaces shall be enhanced through a system design and engineering equipment which are linked to the radio systems through channel configuration (frequencies).

Code Requirements Summary: CT FLSC, NFPA 72, NFPA 1221, and IFC

- Minimum Signal Strength of -95 dBm is required for adequate coverage.
- Coverage testing per requirements
- Fire rated equipment and cabling

Systems and Equipment

- DAS
- Multi-band Bi-Directional Amplifiers (BDA)
- Digital signal booster
- RF in-building antennas
- Riser rated coaxial cable
- Riser and Plenum rated fiber
- IP Address
- Emergency backup power
- Backup batteries (24 hours)
- Alarm points
- Equipment Enclosures housed in NEMA-4 compliant spaces.