

## Section D7070 Audiovisual System Standards

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### **D7070.0 - Introduction**

1. This section outlines standards and requirements for audiovisual (AV) systems projects.
2. All AV installations, materials, equipment, and workmanship conform to project specifications and drawings, as well as all applicable provisions of the most recent versions of the following regulations, codes, and standards including all applicable addenda. The following items are referenced throughout this section.
  - a. ANSI/INFOCOMM 2M-2010 Standard Guide for Audiovisual Design and Coordination Processes
  - b. ANSI/INFOCOMM 3M-2011 Projected Image System Contrast Ratio
  - c. ANSI/INFOCOMM 10:2013 Audiovisual Systems Performance Verification
  - d. AVIXA A102.01:2017 Audio Coverage Uniformity in Listener Areas
  - e. AVIXA F501.01:2015 Cable Labeling for Audiovisual Systems Rack Building for Audiovisual Systems
  - f. AVIXA F502.01:2018 Rack Building for Audiovisual Systems
  - g. AVIXA F502.02:2020 Rack Design for Audiovisual Systems
  - h. AVIXA V202.01:2016 Display Image Size for 2D Content in Audiovisual Systems
  - i. AVIXA RP-C303.01:2018 Recommended Practices for Security in Networked AV Systems
  - j. AVIXA AV Implementation Handbook, AV Design Reference Manual, LAN and Internetworking Design Manual.
  - k. Americans with Disabilities Act (ADA) 1990/2010 ADA Standards for Accessible Design
  - l. Section 508 of the Rehabilitation Act (29 U.S.C. § 794d), as amended by the Workforce Investment Act of 1998
  - m. State of Colorado Technical Standard TS-OEA-001, Technology Accessibility for Persons with Disabilities
  - n. National Fire Protection Agency (NFPA) 70, National Electrical Code (NEC) 2017
  - o. FIPS-197 Advanced Encryption Standards (AES) US Government National Institute of Standards and Technology (NIST) publication 2001

### **D7070.1 – Scope of Work**

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1. Provide all services, labor, materials, tools, and equipment required for complete and appropriate AV System installations within UCB spaces as called for in documented specifications and related drawings.
2. Work includes, but is not limited to, the following:
  - a. AV equipment housings with mounting accessories
  - b. Placement of and additions to interior cabling pathways including display devices, remote control panels, lighting integration, audio amplifiers, loudspeakers, lecterns, etc.
  - c. Installation and termination of audio, video, data, and control cabling to connect the various AV components
  - d. Programming of AV control systems
  - e. Testing, verification, and system administration of the AV systems in UCB spaces
  - f. Grounding and bonding for AV systems

The work covered by this section consists of furnishing all materials, accessories, connectors, mounts, electrical protection, equipment, tools, setup, preparation, labor, supervision, incidentals, transportation, storage, and necessary accessories. Perform all operations necessary to complete the AV system work as indicated in the project scope of work and drawings and as specified in this Standard. Upon completion of the project, the AV system will be provided that is designed, built, coordinated, and integrated as necessary with the existing infrastructure of the space (e.g., voice/data network, room layout). All systems will be thoroughly tested (verification) and ready for operation prior to hand off to the department user(s).

### **D7070.2 – AV Design Coordination**

1. Design specifications are generated and maintained by the UCB OIT Learning Spaces Technology (LST) Team.
2. All AV system designs for UCB spaces (to include classrooms, lecture halls, distance learning classrooms, and conference rooms, etc.) within UCB buildings (on and off campus), must be approved for standards and design by LST. Any design outside of these standards must be approved and include a written agreement for the design from LST.
3. All AV designs and equipment lists shall be submitted to LST for review and approval prior to commencement of work. Whenever possible, representative(s) from the UCB department/owner will also review and approve all proposed designs.
4. All questions or concerns regarding these specifications and design coordination shall be directed to the LST Design Team at: [oit-lst-d@lists.colorado.edu](mailto:oit-lst-d@lists.colorado.edu) and the LST Planning and Logistics team at [oit-lst-pl@lists.colorado.edu](mailto:oit-lst-pl@lists.colorado.edu).

### **D7070.3 – AV Configuration and Construction Guidelines**

These guidelines communicate fundamental AV configuration and construction guidelines for UCB spaces to be used by architects, engineers, and contractors as they pertain to AV Systems in UCB spaces. These design guidelines may include architectural and infrastructure considerations as well as technology requirements. Emphasis is placed on ease of use of the teaching space, including simple user interfaces for AV controls and effective sight lines between student seating areas and display devices. This section describes general AV

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guidelines to be applied to all UCB spaces; however, it should be noted that each space within the work scope will require individual interpretation.

1. **CLASSROOM ORIENTATION:** AV system designs must be functional in both long and narrow and wide and shallow room orientations. This is dependent upon ceiling height and furthest viewer from the display (see AVIXA V202.01:2016 Display Image Size for 2D Content in Audiovisual Systems).
2. **PRESENTATION SPACE:** Allow adequate space in the front of room for the presenter and so projected images can be clearly seen from any seating position including the nearest viewer. Flat panel displays may be preferred to ceiling projectors in certain environments. Wide aspect displays vary by system and display type based upon the size and orientation of the space (see AVIXA V202.01:2016 Display Image Size for 2D Content in Audiovisual Systems).
3. **LIGHTING ISSUES (ACTIVE AND PASSIVE):** It is critical to prevent ambient room light from washing out projected screen images. Light sources must be controlled to minimize washout of projected screen images and/or flat panel displays. If a room's lighting control will be integrated with the audiovisual controls in any way, consult with LST on this aspect of design.
4. **ENTRY DOORS:**  
Special notes for LARGE LECTURE HALLS: All entry and exit doors in the room should be designed so that no light from outside the room falls on the screen(s) when doors are opened.
5. **WALLS and CEILINGS:**  
Surface materials used in the construction of the space must maintain speech intelligibility of the presenter and must meet AVIXA standards for Audio Coverage Uniformity (see AVIXA A102.01:2017 Audio Coverage Uniformity in Listener Areas).

### **D7070.4 –Accessibility Guidelines and the Americans With Disabilities Act (ADA) in Learning Spaces**

1. **MOBILITY IMPAIRMENTS:**  
AV Controls for devices in classrooms cannot be higher than 54 inches (side approach) or 48 inches (front approach) or lower than 24 inches above the finished floor and must accommodate a parallel approach by a person in a wheelchair.
2. **HEARING IMPAIRMENTS:**  
ADA Section 219 requires that assistive listening systems (ALS) are provided in spaces where communication is integral to the space and where audio amplification is used. Section 706 ensures compliance with Section 219 in that the ALS provided must meet certain minimum specifications.
3. **VISUAL IMPAIRMENTS AND TECHNOLOGY ACCESSIBILITY:**  
Section 508 of the U.S. Rehabilitation Act of 1973 and the State of Colorado's Web Content Accessibility Guidelines describe the minimum requirements for designing, installing, securing, monitoring, maintaining, protecting, and decommissioning technologies which provide service to those with disabilities. If questions arise regarding Section 508 or WCAG 2.0 Compliance, contractor/consultant shall seek guidance from LST and/or the UCB Accessible Technology team at [digitalaccessibility@colorado.edu](mailto:digitalaccessibility@colorado.edu).
  - a. References Online:  
[http://www.ada.gov/2010ADASTandards\\_index.htm](http://www.ada.gov/2010ADASTandards_index.htm).

<https://www.section508.gov/>

<http://webaim.org/services/design/>

<https://www.colorado.gov/accessibility-standards>

## **D7070.5 – AV Connectivity and Power**

These design guidelines include minimum requirements for connectivity and optimal placement of electrical power outlets to support LST devices.

### 1. NETWORK CONNECTIVITY FOR AV SYSTEMS:

- a. Each space is to be equipped with the following network connectivity to support AV Systems:
  - 1) One (1) or more wired data connections for instructor use, located near the primary teaching location
  - 2) Two (2) or more wired data connections for the primary AV equipment housing (for larger and/or more complex spaces and designs, additional data jacks may necessary)
- b. All network cabling, connectors, and related infrastructure for data shall comply with UCB OIT construction standards. This section and the other IT standards are posted at <https://www.colorado.edu/facilities-standards/>.
- c. All such services/terminations must be located within appropriate proximity for their intended use.
- d. AVoIP – special consideration for AV system IP network switches within the AV system design will need to be coordinated with LST and Network Engineering prior to installation for proper configuration and integration with UCB networks.

### 2. AV POWER REQUIREMENTS IN LEARNING SPACES:

- a. Four (4) NEMA 5-20r outlets (in a single 2-gang mud ring) should be installed within five (5) feet of the primary AV component location. If a lectern is part of the design, two (2) NEMA 5-20r outlets should be provided at the lectern.
- b. For display or projector locations, at least two (2) NEMA 5-20r outlets should be provided in the ceiling or behind the display. Displays may also utilize AV back boxes with integrated power outlets.
- c. Special notes for Facilities Management with wall box or AV back box installations: Electrical fixtures and all related infrastructure must be flush mounted in the wall or behind the box and must not impede placement of the box or internal components. Consult with LST to ensure proper coordination.
- d. Media cabinet, lectern, and video projector power outlets must not be on the same circuit as room lights, printers, or any high-power devices. Ideally, all AV components within a space should be on the same phase.
- e. LST shall provide electrical load information for system. Coordination with Facilities Management is required.

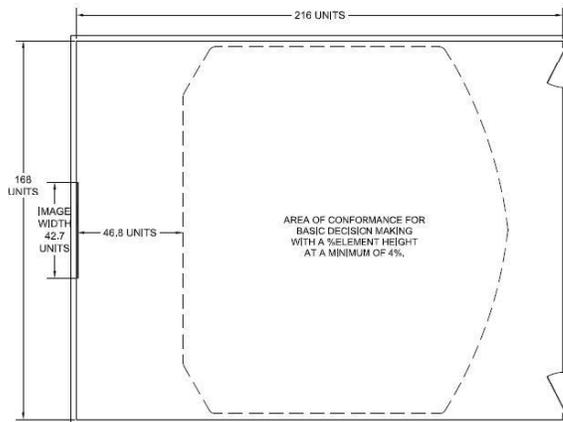
## **D7070.6 – AV System Components in Learning Spaces**

### 1. IMAGE DISPLAYS AND PROJECTION SCREENS:

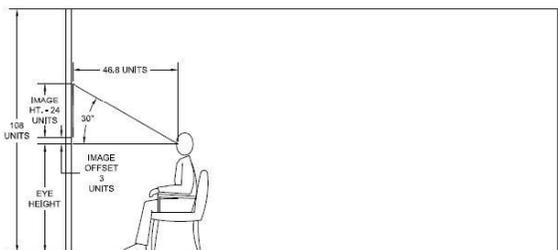
Room dimensions, ceiling height, and seating capacity determine the appropriate size, location, and type of the display(s) or screen(s) to be installed in each room. UCB follows AVIXA Standards which determine the required display image size and relative viewing positions according to the viewing detail required

and the teaching needs of the space. See AVIXA V202.01:2016 Display Image Size for 2D Content in Audiovisual Systems.

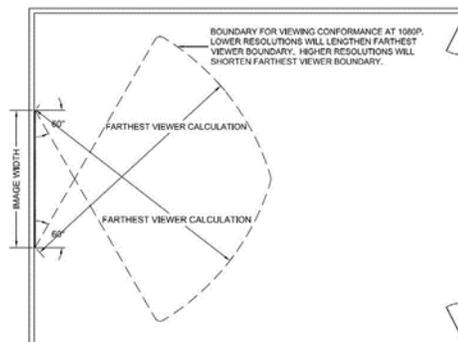
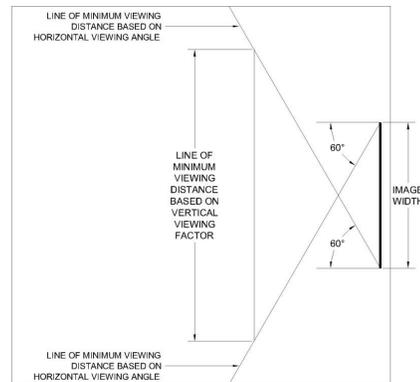
- a. For the percent element height, the minimum shall be no less than 3.0 percent element height.
- b. No viewer should be closer to the screen than 30 degrees from the top of the image. Additionally, no closer than 60 degrees to the furthest edge of the image.
- c. Mounting: Screens will be mounted high enough for the students in the back of the classroom to see the bottom of the image, typically 4 feet above the finished floor at the closest viewer.



**AREA OF CONFORMANCE FOR BDM**  
NO SCALE  
VIDEO IMAGE HAS 16:9 (1.78:1) ASPECT RATIO



**CLOSEST VIEWER CALCULATION FOR BDM**  
NO SCALE  
VIDEO IMAGE HAS 16:9 (1.78:1) ASPECT RATIO



**VIEWING PARAMETERS FOR ADM**  
NO SCALE  
IMAGE HEIGHT BASED ON 16:9 (1.78:1) ASPECT RATIO

## 2. PROJECTION SCREENS:

- a. Some environments may require powered screens due to size or specific screen materials based on required viewing angles and/or contrast. LST Designers will determine and/or approve the best possible solution for the space.
- b. For LST spaces, the contrast ratio for Passive Viewing shall be a minimum of 7:1. Basic Decision Making requires a minimum contrast ratio of 15:1 or better.
- c. Please see AVIXA V202.01:2016 Display Image Size for 2D Content in Audiovisual Systems for the mathematical formulae required for calculating Display Image Size.

## 3. VIDEO PROJECTORS:

- a. Video projectors are typically mounted to the room's ceiling structure. Locate the projector mount(s) according to industry standard calculations for viewing distance, screen size, minimum element height, and projector specifications (see AVIXA V202.01:2016 Display Image Size for 2D

- Content in Audiovisual Systems). Use of projector mounts that attach only to a drop ceiling grid is not permitted.
- b. Projectors should be mounted so that the lens is laterally centered on the target projection screen, and the mount height should follow manufacturer installation guidelines.
  - c. Potential sources of vibration in the building structure must be considered as it may affect the stability of the projected image. A vibration inhibitor will be installed if necessary.
  - d. Brightness is measured in ANSI lumens. 5,000 ANSI lumens is considered the minimum allowable output from a projector in any UCB space. The ideal brightness will vary based on the ambient lighting conditions in the space. All projectors must support a minimum of 1920 x 1200 native resolution and achieve a visible contrast ratio of at least 15:1 for basic decision-making (see ANSI/INFOCOMM 3M-2011 Projected Image System Contrast Ratio).
  - e. Required/desirable features for digital projectors include:
    - 1) Low ambient fan noise (<40dB)
    - 2) High-altitude fan mode (desirable)
    - 3) Filter must be accessible even while projector is mounted
    - 4) Horizontal and vertical electronically processed lens shift
    - 5) Digital input required.
    - 6) RS-232 DB9 control connectors
    - 7) Native support for 1920x1200 pixels or better
4. FLAT PANEL TELEVISIONS AND DISPLAYS:
- a. Flat panel displays and televisions are often used in UCB learning spaces, conferencing facilities, labs, and other collaboration spaces. Installations must comply with ADA Protrusion limits (see 2010 ADA Standards, Section 307.2 - Protrusion Limits).
  - b. General guidelines and desirable features for flat panel displays include:
    - 1) Native, non-interlaced high-definition resolution support, 1080p minimum
    - 2) 350nit minimum brightness
    - 3) Input support:
      - i. Audio: stereo-mini (1/8 inch)
      - ii. Video: HDMI
      - iii. RS-232 DB9 control connectors
    - 4) Built in capacity for wired or wireless network connections.
    - 5) Energy Star rated
5. WIRELESS AUDIOVISUAL DEVICES:
- a. AV systems are hard wired for stability and dependability. For display and presentation, LST recommends a physical (wired) connection to the AV System for instructors and presenters. For questions related to wireless presentation technology and AV learning space systems, please consult with LST.
  - b. Wireless microphones frequency use and signal strength must be coordinated with LST Design before installation.
  - c. Wireless microphone systems shall include the option of changing the operating frequency to avoid RF interference. Preconfigured group, channel and frequency setups shall be available to ensure that multiple systems in use do not interfere with one another. All transmitters shall be powered by either a Shure SB900 or SB900A Lithium-Ion Battery or 2 AA batteries and shall have a power on/off switch. When operated with the Shure SB900 or SB900A Battery the system shall

display remaining run time in hours and minutes (accurate to within 15 minutes). The bodypack will have an LED indicating that power is on. Available transmitters shall include: a body pack for use with lapel or headset microphones, guitars, basses, and other electric instruments, and a handheld microphone for vocals. The transmitter front end shall optimize itself for standard inputs without requiring transmitter gain adjustments thus allowing all gain changes to be made at the receiver, which provides a 60dB range of system gain. Overall system signal to noise ratio shall be >120dB. The system shall be capable of AES-256 encryption to conform with the US Government National Institute of Standards and Technology (NIST) publication FIPS-197. The system shall use technology such as Shure's advanced digital predictive diversity to optimize RF stability. The receiver shall include an RF level meter, an audio level meter, and a Networking Interface connector for computer control and monitoring. The system shall be the Shure QLX-D Wireless.

#### 6. AUDIO SYSTEMS:

- a. Program audio in large spaces, such as DVD/Blu-ray sources, computer sources, etc., should be separated from voice reinforcement sources such as microphones. A typical example would have voice reinforcement from ceiling speakers and program audio from front-mounted left/right speakers.
- b. Speaker distribution should be determined via potential acoustic gain/needed acoustical gain (PAG-NAG) calculations.
- c. Audio calculations and effective practices such as Critical Distance and Audio Coverage Uniformity shall be utilized and submitted to LST for review (see ANSI/INFOCOMM A102.01:2017 Audio Coverage Uniformity in Listener Areas).
- d. Audio systems installed and/or commissioned by AV Contractors will be tested and balanced by said AV Contractors prior to evaluation, commissioning, and/or acceptance by LST.
- e. Microphones:
  - 1) Microphones for voice reinforcement are generally not installed in spaces with less than 50 student seats. Consult with LST for any exceptions to this standard.
  - 2) A balanced audio output of mixed voice and program audio will be available in a location away from the presenter/lectern, ideally at the back of the space. UCB AV Systems in large lecture halls are equipped with a port for the addition of an audio mixer.
- f. Digital Signal Processors (DSPs)
  - 1) In designs that have multiple potential audio sources and destinations, whether voice reinforcement or program audio, DSPs can be used to provide automatic gain control, leveling and more. If DSPs are proposed for a given system, as of July 2021, LST uses QSC audio DSP processors and I/O devices.

#### 7. AUDIOVISUAL CONTROL SYSTEMS:

- a. Standard control system configurations are designed and integrated into UCB spaces to assist the users of the technology. Standardizing the interfaces for these systems ensures consistent user experiences across different teaching and learning environments.
- b. Single display systems (i.e. one projector or flat screen) require a control system that provides end-users with the following minimum capabilities:
  - 1) turn system on/off
  - 2) provide source selection to the display
  - 3) program audio control and mute

- c. Systems with multiple sources and/or destinations (including lecture capture solutions) will require control systems that have more complex capabilities. The control systems for these more complex spaces need to be designed with a simple, uniform experience for the end user as a priority.
  - 1) LST has a standard Crestron configuration for touch panel control. Contact LST personnel for guidance and use of approved touch panel designs.
8. AV RACKS:
  - a. There are two standard types of LST rack installations in UCB spaces:
    - 1) Lectern rack - These are typically placed adjacent to the lectern on the presenter's right side if the lectern is on the presenter-right side of the room (audience-left).
    - 2) Freestanding rack - free standing racks are typically located in AV closets for larger amounts of gear or in control rooms adjacent to the operator space. For rack design and rack building, see AVIXA F502.02:2020 Rack Design for Audiovisual Systems and AVIXA F502.01:2018 Rack Building for Audiovisual Systems, respectively.
  - b. In other non-traditional classroom spaces, the use of credenzas or cabinets will require the installation of a sliding/rotating rack for ease of use and servicing.
  - c. LST must approve all rack types/solutions proposed for UCB AV systems.
9. LECTERNS:
  - a. Height-adjustable lecterns are generally expected to be semi-permanent/non-mobile. A lectern will typically include audio/video inputs, controls for the AV system, a wired network connection, and at least one duplex electrical outlet available to the user/instructor. The "Bring Your Own Device (BYOD)" input is connected to the AV system via current industry standard interfaces.
  - b. Mobile lecterns are typically furniture-only items on casters, with no wired infrastructure. In such designs, placement of AV controls and interfaces needs to be considered relative to the expected typical placement of the lectern/instructor, ideally within 6 to 8 feet to minimize trip hazards from cabling. Mobile lecterns such as these are often placed at the left front of the room, from a student's perspective.
  - c. To be ADA compliant, the work surface of a lectern must be height adjustable. Electric controls for height adjustment must be within ADA reach ranges. The work surface should be at least 30 inches wide, by 24 inches deep for lecterns.
  - d. Wired/fixed lecterns should be positioned such that the presenter will face the center of the back of the room. Typically, the lectern is placed to the audience left of the primary display from a student's perspective.
10. COMBINABLE SPACES:

Ease of use and system reliability are paramount in combinable spaces. LST strongly prefers a dedicated touch panel button for toggling between room modes (e.g., combined vs. separate), vs. magnetic sensors, relays, or software-based switching solutions. Consult with LST on any design concepts for combinable spaces.
11. VIDEO CONFERENCING SYSTEMS:

Video conferencing solutions have been evolving rapidly, and the most common uses today are often software-based. Traditional hardware solutions may still be needed. For software solutions, dedicated

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camera and/or microphone infrastructure may still be needed. Consult with LST for all designs requiring video conferencing functionality.

### 12. LECTURE CAPTURE / CLASSROOM RECORDING SYSTEMS:

LST uses a campus-wide standard for lecture capture solutions. Consult with LST in advance of designing any lecture capture or classroom recording systems. All capture systems shall be designed to support the current LST standard as well as the Family Educational Rights and Privacy Act (FERPA) requirements.

### **D7071 – Audiovisual System Materials**

#### 1. AV SYSTEM CABLING:

- a. All field cabling (not within the rack) for AV systems shall be plenum rated regardless of whether it passes through environmental air handling plenum spaces.
- b. Shielded cabling should be used in any environment where components are exposed to or in proximity to power supplies, electrical panels, or other potential sources of signal interference. Systems installed by contractors that fail to provide the required functionality due to signal or electromagnetic interference that can be traced to unshielded cabling shall be replaced at no cost to UCB.
- c. Cable labeling shall conform to AVIXA Cable Labeling for Audiovisual Systems AVIXAF501.01:2015

#### 2. AV NETWORK SWITCHES:

Current and future AV systems will rely on robust networks. Any use of network equipment needs to conform to UCB OIT and OIT-LST standards. The standard for network equipment is Cisco Catalyst series (see AVIXA Recommended Practices for Security in Networked AV Systems RP-C303.01:2018).

### **D7072 – AV System Execution**

#### 1. DESIGN AND COORDINATION:

See AVIXA Standard Guide for Audiovisual Systems Design and Coordination Processes ANSI/AVIXA D401.01:201X

#### 2. VALIDATION AND VERIFICATION:

See AVIXA Audiovisual Systems Performance Verification 10:2013

#### 3. AUDIOVISUAL CABLING INSTALLATION:

AV cable pathways are dedicated for use with AV cabling only. Cables for other low voltage systems (intercom, data, voice, security, fire, etc.) may share the AV technology pathways only if specified in the design documents, and only with prior written approval from LST.

#### 4. AS BUILT/RECORD DRAWINGS:

Final project drawings will reflect actual AV equipment placement and any variations from base specifications and drawings.

#### 5. WORKMANSHIP:

- a. Materials and workmanship shall meet or exceed industry standards and be fully warrantied in writing for one full year from final acceptance of the project.



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- b. Cable integrity and associated terminations shall be thoroughly inspected, fully tested, and guaranteed free from defects, transpositions, opens/shorts, tight kinks, damaged jacket insulation, etc.
- c. AV Contractor shall be responsible for and make good, without expense to UCB, any/all defects arising during the warranty period that are due to imperfect materials, appliances, improper installation, or poor workmanship.