

# Audiovisual Information Technology (AV/IT) Infrastructure Guidelines for Higher Education



Copyright 2021 AVIXA®

All rights reserved.

Revised edition.

Printed in the United States of America.

Published by AVIXA, 11242 Waples Mill Road, Suite 200, Fairfax, VA 22030.

No part of this work may be used, reproduced, or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without prior agreement and written permission from AVIXA.

The contents of this work are subject to revision without notice due to continued progress in methodology, design, installation, and manufacturing in the audiovisual industry. This material is sold as-is, without warranty of any kind, respecting the contents of this work, including but not limited to implied warranties for this work's quality, performance, merchantability, or fitness for any particular purpose. AVIXA shall not be liable to the purchaser, user, or any other entity with respect to any liability, loss or damage caused directly or indirectly by this work.

# CONTENTS

1	Introduction .....	1
1.1	Who Will Benefit from this Guide? .....	1
2	Teaching Spaces and Technologies .....	4
2.1	What is a teaching or learning space and what does it look like? .....	4
2.2	Spaces by Size .....	5
2.3	Spaces by Pedagogy .....	6
3	Teaching Space Technologies .....	11
3.1	Learning First, Technology Second .....	11
3.2	Technologies for Presentation .....	11
3.3	Technologies for Collaboration .....	16
3.4	Asynchronous and Remote Teaching Technologies .....	19
3.5	Unified Communications and Collaboration .....	20
3.6	Key AV System Design Considerations .....	22
3.7	Higher Education Trends and Technologies .....	31
4	Building and IT Infrastructure Requirements for Technology .....	37
4.1	AV/IT Convergence .....	37
4.2	Infrastructure .....	38
4.3	Network and IT Infrastructure Requirements .....	42
4.4	Network Infrastructure Components .....	43
4.5	Network Design Considerations .....	45
4.6	Planning and Coordination .....	46
4.7	Power for Audiovisual Equipment .....	47
4.8	Lighting Design .....	47
4.9	Light Sources and Controls .....	49
4.10	Special Requirements for Videoconferencing Spaces .....	51
4.11	Daylighting .....	52
4.12	Paging and Emergency Communication .....	52
4.13	Video Display and Digital Signage .....	52
4.14	Building and Campus Control and Monitoring .....	52
4.15	Asset Security .....	53
4.16	Other Building Systems .....	53
5	Architectural Design to Support Technology Infrastructure .....	54
5.1	Programming (Concept Design Phase) Decisions .....	55
5.2	Planning Considerations .....	56
5.3	Furnishings .....	57
5.4	Architectural Acoustics .....	57
5.5	Acoustic Considerations in Technology-Enabled Learning Spaces .....	58
5.6	Designing Screen Sizes and Sightlines .....	59
5.7	Ceiling Heights .....	64
5.8	Flat and Tiered Floors .....	64
5.9	Impacts of Room Geometry and Orientation .....	64
5.10	Designing for Image Quality .....	65
5.11	Architectural Integration of Equipment .....	67

6	Sustainable and Smart Buildings .....	68
6.1	Sustainable Design and Construction .....	69
6.2	Rating Systems .....	70
6.3	Smart Buildings .....	71
7	Accessibility .....	73
7.1	Compliance .....	74
7.2	Assistive-Listening Devices and Captioning .....	74
7.3	Visually Impaired Assistance .....	76
7.4	Furniture to Support Accessibility .....	76
7.5	Touch Panel Heights .....	77
7.6	Emergency Notification .....	77
8	Processes .....	78
8.1	Project Planning and Coordination .....	78
8.2	Project Schedule .....	87
8.3	The Needs Assessment Process .....	89
8.4	Assess Existing Institutional Infrastructure .....	90
8.5	Needs Assessment for Renovations .....	91
8.6	Project Documentation .....	94
9	General Budgeting of Technology Systems .....	100
9.1	Base Building vs. Furnishing, Fixtures, and Equipment .....	101
9.2	Establishing a Budget .....	102
9.3	Managing the Budget .....	103
9.4	Project Closeout and Post-Occupancy .....	105
	Annex A Teaching Space Examples .....	109
	Annex B Relevant International and National Standards .....	113
	Annex C : Further Reading .....	115
	Annex D : Bibliography .....	119
	Annex E : Glossary .....	120

## Figures

Figure 1 – Audience cross-sections of knowledge in technology design, processes, and roles .....	2
Figure 2 – AV systems design project phases (top view) .....	3
Figure 3 – A didactic space example: Central Michigan University (courtesy of The Sextant Group) .....	7
Figure 4 – A whole-group collaborative space example: Northern Michigan University (courtesy of The Sextant Group) .....	7
Figure 5 – A small-group collaborative learning space example: University of Iowa (courtesy of The Sextant Group) .....	8
Figure 6 – A kinesthetic or physical-learning space example: Western Carolina University (courtesy of The Sextant Group) .....	8
Figure 7 – A distance-learning space example: University of Missouri Kansas City (courtesy of The Sextant Group) .....	9
Figure 8 – A presentation wall display (courtesy of The Sextant Group) .....	13

Figure 9 – Distributed displays (courtesy of The Sextant Group) .....	13
Figure 10 – An example of individual screens (courtesy of The Sextant Group) .....	14
Figure 11 – A control room (courtesy of Duke University) .....	25
Figure 12 – A touch panel.....	26
Figure 13 – Secure monitoring and management .....	26
Figure 14 – Blocking for a monitor in an open wall.....	41
Figure 15 – A patch panel .....	45
Figure 16 – Typical three-circuit lighting scheme consisting of separate lighting instruments and control circuits for board lights, presenter illumination, and audience (note taking) lights.....	48
Figure 17 – Oregon College and University active-learning classroom.....	56
Figure 18 – Area of Conformance for DISCAS BDM .....	60
Figure 19 – Area of Conformance for DISCAS ADM .....	62
Figure 20 – Vertical viewing Calculation for Closest Viewer.....	62
Figure 21 – Evolution of smart buildings .....	72
Figure 22 – Architecture of a smart university system (retrieved from the Smart IHU Project Website) .....	73
Figure 23 – AV systems design project phases by role .....	79
Figure 24 – Sample completed verification list (AVIXA 10:2013, <i>Audiovisual System Performance Verification Guide</i> ) .....	82
Figure 25 – The verification phase .....	100
Figure A.1 – Didactic of Lecture .....	109
Figure A.2 – Whole group collaborative or case study.....	109
Figure A.3 – Small group collaborative .....	110
Figure A.4 – Kinesthetic or physical learning classroom.....	111
Figure A.5 – Synchronous distance learning/asynchronous learning classroom .....	112

## 1 Introduction

The audiovisual (AV) field is an exciting industry combining several seemingly disparate technologies and products to create systems that enhance communication. It attracts professionals from a wide range of disciplines, many with eclectic backgrounds and varied educational areas of study.

Many long-term practitioners describe AV as both an art and a science. Certainly, the field is based on science and requires expertise in electronics, geometry, acoustics, light, optics, sound, and structural calculations, among others.

But ultimately, AV is evaluated based on human perception: Is the user experience seamless and of high quality? Does the audio system produce the intended impact? Is the equipment integrated into the building architecture in an aesthetically pleasing manner? Does the overall environment work to enhance the intended communication?

This combination of art and science sometimes creates tension — both creative and technical in designing, constructing, and operating AV systems. It also yields industry standards that may attract general, but not complete, agreement within the field — or even within a single organization.

Because AVIXA has developed a wealth of industry standards, this document will refer to them frequently. However, all readers would be wise to remember that these standards are for the general AV industry and may not specifically address the nuances, subtleties, and unique requirements of higher education institutions. Adapting and applying these ideas to account for the specific project needs will be the responsibility of various team members — who will be practicing both an art and a science.

The following are key terms used in this document:

**Audiovisual (AV) system** — All equipment integrated into the energy-consuming infrastructure necessary to fulfill the intent of communicating audio and/or video content to an audience. It is a set of specified, individual audio and video components designed and configured to operate as one comprehensive system.

**Information technology (IT)** — The study or use of systems (especially computers and telecommunications) for storing, retrieving, and sending information.

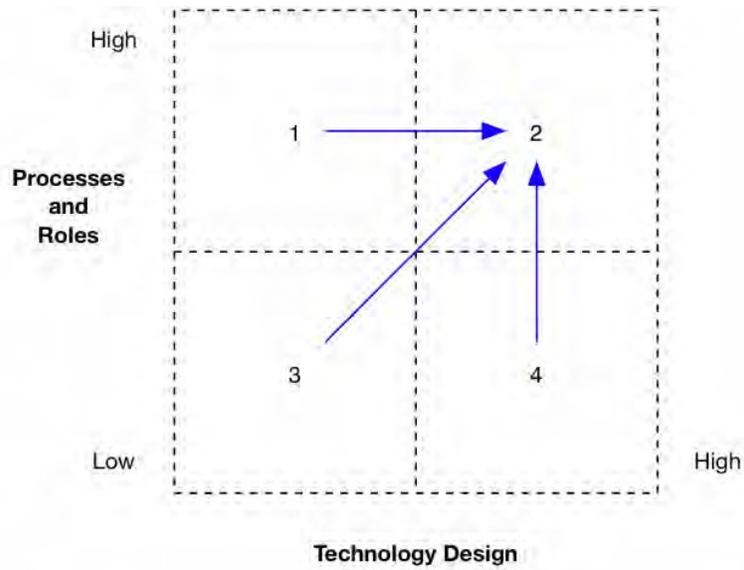
**Infrastructure** — The basic physical and organizational structures and facilities needed for the operation of an organization (for our purposes, a higher education institution).

**Information and communications technology (ICT)** — Any communication device, application, or service related to radio, television, cellular technology, computing, networking, and satellite systems, including services such as videoconferencing and distance learning.

### 1.1 Who Will Benefit from this Guide?

The following diagram represents the authors' attempt to categorize the various possible readership groups according to their current level of expertise and knowledge.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION



**Figure 1 – Audience cross-sections of knowledge in technology design, processes, and roles**

- Some readers may have a significant knowledge and understanding of how to administer an AV/IT-heavy project, so the process, roles of team members, scheduling, and the various tasks are well known but may not be as strong in the technical aspect of the project; this group is represented by **quadrant 1**.
- Other readers are strong in their knowledge of the technical aspects of an AV/IT-heavy project and, therefore, are comfortable with the various technology options, issues, and solutions but may not be as strong in project administration and management; this group is represented by **quadrant 4**.
- A third group of readers, while experts in their own field of study, are not experienced in either the process of administering an AV/IT-heavy project or the technical side; this group is represented by **quadrant 3**.
- Finally, a fourth group is already strong in both areas; this group is represented by **quadrant 2**.

The authors hope to fulfill the expectations and needs of readers in each quadrant. The central goal of this guide is to move each segment of the audience — architect/engineers/facilities professionals, campus technology staff, AV designers and other AV professionals, and end users (faculty members and others) — toward quadrant 2, which represents high knowledge in both the processes and technology design.

Architects may find themselves in quadrant 1, having high knowledge of processes but lower knowledge of technology design. System integrators with experience in out-of-the-box systems, rental, and staging would be in quadrant 4, as professionals who know a lot about technology design but do not necessarily understand the architects' and designers' roles and processes. Finally, faculty and other users are most likely to find themselves in quadrant 3, with low knowledge of both the processes and technology design.

### 1.1.1 Purpose and Scope

The purpose of this document is to address the architectural and infrastructural considerations that need to be made when designing and implementing AV/IT technologies in higher education learning spaces while preserving the pedagogical and functional needs of such spaces — both virtual and physical — throughout the project cycle.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

This document covers general learning spaces — collaborative spaces, didactic spaces, lecture halls, and so on — and does not intend to cover all types of spaces or scenarios in higher education. It does not specifically address purpose-designed spaces that require specialized hands-on instructional activities (e.g., medical simulation, academic recording studios, physical science labs, vocational training labs, maker spaces, or kinesthetic learning spaces). What it offers are contemporary, systems-oriented, guidelines that are grounded in:

- Best practices in AV systems design and installation
- User experience
- Planning for future technology
- Sustainability
- Industry standards
- Professional experience of the authors
- Coordination with other trades (e.g., IT, administration)
- Facility manager requirements
- Operations and maintenance

This guide will:

- Convey the knowledge of how spaces are designed/re-designed so the learning environment is optimized for learning and teaching.
- Show how, as technology needs and learning methods evolve, the AV/IT infrastructure can continue to support those changes.
- Explain to all stakeholders in a technology design and construction project for higher education spaces how the complete process — from planning to operations — ensures the needs of the end users are met.
- Help staff communicate/collaborate successfully with architects/engineers (A/E) and end users regarding wants and needs for AV systems.
- Raise the awareness of A/E and end users of how their project decisions or existing conditions affect AV systems implementation and user accessibility.
- Direct A/E, end users and tech staff to relevant technical resources.
- Prevent the most common mistakes in the AV/IT implementation process.

Though focused on higher education learning settings, these guidelines may also be helpful for others involved in infrastructure projects in schools, corporate training, virtual learning, or other highly specialized teaching/learning environments.

Throughout the document, we will use the term **AV designer** to indicate the person or entity responsible for the design and documentation of the AV systems and the infrastructure associated with the AV systems.

The figure below shows the AV systems design project processes. ([Chapter 8](#) provides a detailed discussion of these phases in the higher education context).



**Figure 2 – AV systems design project phases (top view)**

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

The AV designer helps to define the needs, establish a probable budget, coordinate requirements with other designers and contractors, create a schedule, and document the solutions.

The AV designer will often fall into one of these categories:

- **AV consultant** — A firm or individual who is responsible for the design of the AV systems and often the specification of the required AV systems. The consultant may facilitate competitive bidding or negotiation with AV systems integrators. To maintain a strict independence from particular solutions and to avoid any potential conflicts of interest, those marketing themselves as consultants do not typically sell equipment nor provide installation services, but this can vary.
- **AV systems integrator** — A firm or individual who in some cases is responsible for the AV design as well as the supply and installation of the equipment. This firm typically also provides software development, system training, warranty coverage, managed services, and ongoing service options. AV systems integrators are also sometimes referred to as AV contractors, AV dealers, AV value-added resellers (VARs) and so on.
- **Campus AV staff** — A group or individual on the campus technology staff that may perform the equipment installation, develop software, conduct user training, and other services or oversee the AV systems integrator performing such services. In some cases, this group may also document the systems for competitive bidding or negotiation with an AV systems integrator. Regardless of the involvement during systems design, this group is often responsible for ongoing system maintenance and training of users.

The AV designer and IT designer may work for the same outside firm or campus group, but is likely not the same individual, as each discipline has its own distinct knowledge base, set of skills and required expertise.

Of course, there are hybrid approaches to each of the above groups. A serious treatment of the advantages and disadvantages of each of these approaches is beyond the scope of this document, but AVIXA has additional resources on the work of AV designers.

### 1.1.2 Errata

As technology develops, some of the information defined in this document may change. It is expected that some aspects of work started here will be superseded by AVIXA standards and education products. All effort has been made to research the existing knowledge base to provide cohesive information and guidance. We look forward to industry feedback and a cycle of continual improvement. Please send your corrections to [membership@avixa.org](mailto:membership@avixa.org).

## 2 Teaching Spaces and Technologies

This section covers:

- Teaching or learning spaces
- Various examples of spaces by size (petite; small; medium; large; extra-large)
- The pedagogy behind different space designs

### 2.1 What is a teaching or learning space and what does it look like?

There are many ways to describe the various teaching and learning spaces on a typical college or university campus. They may be referred to as classrooms, laboratories, lecture halls, auditoriums, seminar rooms, studio classrooms, tutorial spaces, huddle and so on. We begin our discussion with learning spaces categorized by size and by the pedagogy or type of teaching and learning that is anticipated within the space.

The term **learning** can be defined as the acquisition of knowledge or skills through experience, study, or being taught. A learning space is the physical environment in which learning occurs. It needs to support the activity that occurs there, including a range of learning, teaching styles, and pedagogies. When we refer to learning spaces, we traditionally think of formal classrooms, but in

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

today's higher education, learning takes place virtually, and in non-traditional locations like hallways, cafes, and lounge areas.

Such learning spaces should be welcoming and designed to stimulate academic discussion throughout campus. Spaces and pedagogies should match, and their synergy should be evident to participants. A classroom with neat rows of desks facing the front of the room embodies the pedagogy of a traditional lecture, whereas flexible spaces with furniture on wheels reflect a pedagogy of self-discovery, collaboration, and experimentation.

If the goal is to develop students as collaborative members of a team, their learning space should contribute to that goal. A well-designed space will assist in creating possibilities that use technology to open, unending opportunities for learning.

For more information on human-centered guidelines, see the following Educause document:

<https://www.educause.edu/research-and-publications/books/learning-spaces/chapter-10-human-centered-design-guidelines>.

### 2.1.1 Common Goals of Learning Spaces

Goals for learning spaces should focus on the desired educational outcome of those spaces. The purpose of higher education is to create, advance, absorb, and disseminate knowledge through learning. Educators seek to motivate and inspire students, and they hope to have learning spaces that stimulate students, engage them in scholarly discussion, and promote inquiry and intellectual curiosity. Such spaces include well-designed AV/IT technologies and a solid supporting infrastructure.

### 2.2 Spaces by Size

The size of a space can be a contributing factor to the type of learning that takes place there. It would be difficult to expect that a large lecture hall space with fixed seating and tables would be a successful venue for a small, collaborative-learning activity. Conversely, a small, seminar-sized room would not help the institution fulfill the requirements of a large survey course with hundreds of students per section.

One way to categorize learning spaces is by the number of students supported by the space. Most college and university campuses have a mix of learning spaces to handle various class sizes. Although the following categories are not based on any specific industry standards, they may be helpful when considering possible learning spaces for the project.

- **Petite** — Accommodates one to 12 learners and may be called a **learning studio, huddle, or small group study space**. Small courses, such as seminars and upper-level or graduate courses may be taught in rooms this size. Students may also use these spaces for independent learning or as study rooms.
- **Small** — Accommodates 15 to 40 learners and may be called a **seminar room** or a **lab classroom**. It has been shown that small instructor-to-student ratios can enhance learning outcomes and promotes communication among students and faculty.
- **Medium** — Accommodates 40 to 75 learners, typically known as a **classroom** or a **learning studio**. On many campuses, this is the most prevalent learning space size. A classroom may be an ideal location for student scholar and club meetings, traditional lectures, case study debates, faculty meetings, collaborative-learning sessions, and more.
- **Large** — Accommodates 75 to 150 learners. Examples of these spaces are **lecture halls** and **large group team-based learning rooms**. As the shift to collaboration quickens, many of such existing rooms may need modifications or enhancements to remain effective.
- **Extra-large** — Accommodates groups larger than 150. These may be **lecture halls, conference halls, meeting halls, or convention venues**. Some of these spaces offer minimal flexibility in the teaching style because they are focused on maximizing the efficiency of delivering lectures to large groups of students. That said, some might be highly flexible, configured

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

with theater-style or banquet-style round tables or in combination with other rooms to accommodate even larger audiences.

### MODIFYING A LARGE LEARNING SPACE

In order to accommodate team-based exercises in a large lecture hall at Duke University School of Medicine, in Durham, NC, designers reduced the number of rows in the room and placed two rows of tables on the same level. This allows learners in the front row to simply turn around their chairs to work in teams and then rotate back to continue with a large group discussion.



Before



After

### SUPER LABS

In the United Kingdom and Australia, some universities are building **super labs**. These spaces are approximately 1,800 ft<sup>2</sup> (167.2 m<sup>2</sup>) and are fully interactive. Super labs use audiovisual technology to support 10 or more different teaching sessions within the space simultaneously. Classes can range from undergraduate labs to more advanced doctorate work.

Each workstation might receive live and pre-recorded sessions at their monitors, screens or headphones, allowing for maximum flexibility. This enables students to progress at their own pace and review information as needed for on-time learning. This system was introduced to manage the uncompromising demands of high-traffic areas within the institution.

### 2.3 Spaces by Pedagogy

Collaborative learning involves purpose-built spaces designed so large groups of students can work in teams. Spaces such as **student-centered active-learning environments with upside-down pedagogies (SCALE-UP)** or **active-learning classrooms (ALC)** deliver a wealth of information and research as part of the space design.

The term **pedagogy** has evolved from meaning the method or practice of teaching to bringing learning to life. Here are some basic forms of pedagogy and the types of learning spaces that fit their needs.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- **Didactic or lecture** — In this mode of instruction, knowledge travels from the presenter (teacher) to the learner, with little or no interaction. Learning spaces supporting this pedagogy typically include student chairs facing an attention wall, with a lectern or presentation station at the front, establishing a clear separation between the presenter and learners.



Figure 3 – A didactic space example: Central Michigan University (courtesy of The Sextant Group)

- **Whole-group collaborative or case study** — This pedagogy emphasizes a conversation among the whole group in a facilitated discussion. Students may interact only with the instructor, but more likely will be interacting with both the instructor and other students. The flipped classroom may be incorporated into this type of learning: Students do the fact-finding and watch pre-recorded lectures prior to coming to class. During class time, they discuss, demonstrate, and debate the knowledge that they have acquired.



Figure 4 – A whole-group collaborative space example: Northern Michigan University (courtesy of The Sextant Group)

- **Small-group collaborative** — In this pedagogical approach, learners work together in small groups of three to nine participants, solving problems and actively learning the required content. The concept of a flipped classroom also applies here. The lecture or direct-instruction mode is minimized or eliminated completely; in fact, some learning spaces supporting this activity do not even have technology or furnishings to support a short lecture. Other spaces have complete presentation systems and furnishings for a brief lecture or facilitated discussion with the class.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

This pedagogy aims to foster the growth of real-world team experiences. This type of space may also include systems for students to practice presentation skills.



**Figure 5 – A small-group collaborative learning space example: University of Iowa (courtesy of The Sextant Group)**

- **Kinesthetic or physical learning** — Such learning demands specific modifications to the learning space and may include traditional science lab rooms, simulation spaces for medical or engineering content, and gymnasiums. This type of pedagogy is directed to learners who learn by doing. It may also be referred to as *tactile or active learning*.



**Figure 6 – A kinesthetic or physical-learning space example: Western Carolina University (courtesy of The Sextant Group)**

- Spaces focused on **synchronous distance learning** or audio/video capture for **asynchronous learning** will have different needs altogether. This type of learning is sometimes called e-learning; spaces that allow development and delivery of massive open online courses (MOOCs) would also fall into this category. This pedagogy allows for the flexible use of time and space and may support building a global learning community.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION



**Figure 7 – A distance-learning space example: University of Missouri Kansas City (courtesy of The Sextant Group)**

See [Annex A](#) for additional classroom examples categorized by size.

Just as there is no perfect way that people learn, there is no perfect space to support learning. Most higher education institutions require a mix of spaces broken down by size and pedagogy. As we will discuss in subsequent chapters, there is also no perfect complement of AV/IT technologies for all learning spaces.

In planning spaces that are flexible, dynamic, and technology-rich, we give learners the best opportunity for success in the future. Doing so also enhances our ability to imagine and construct the classrooms of the future.

<b>CASE STUDY: WESTERN RESERVE UNIVERSITY</b>
In 2013, Case Western Reserve University (CWRU) implemented an active-learning initiative focused on environment, professional development (of faculty and staff) and assessment. The school created two new learning spaces, launched an extensive faculty development program, and formed a plan to assess the initiative.
<p><b>The Environment</b></p> <p>CWRU partnered with The Sextant Group, the Bostwick Design Partnership, and Dobil Laboratories to design and implement the two active-learning classrooms on campus for the fall 2013 semester. Each space was optimized for active learning including moveable furniture, various collaboration technologies and writing surfaces.</p>
<p><b>Professional Development</b></p> <p>The design team recognized that just providing new spaces might not lead to a transformation in teaching and learning unless the faculty was engaged in a sustained, meaningful manner. A year-long fellowship program was developed so faculty could design or redesign a course using active-learning pedagogies and explore how active-learning spaces could increase student engagement and success in the classroom.</p>
<p><b>Assessment</b></p> <p>The research conducted measured the effectiveness of the initiative and provided data for future improvements and expansion. Data was collected at the end of the semester via survey and focus groups.</p> <p>Initial findings suggest that active-learning techniques, especially when used in technology-enhanced classrooms, could help transform the educational landscape in a variety of exciting ways.</p>
The research has been used to communicate the success of the effort across the university community and proven to be a key driver in securing support for expansion of the initiative. The data has also become

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

### CASE STUDY: WESTERN RESERVE UNIVERSITY

a valuable resource for the development of new active-learning classrooms and refinement of the fellowship.



### 3 Teaching Space Technologies

This section covers:

- The most common choices of display technology for presentation and collaboration
- An overview of other technologies found in the classroom
- Higher education-specific considerations
- Emerging technologies in higher education AV

#### 3.1 Learning First, Technology Second

The starting point for AV design in higher education is not (or should not be) a shopping list of the latest technologies. A successful AV design starts with understanding the teaching style (or pedagogy) that will take place in a learning space. That requires the AV designer to spend time with users (instructors and students) to document the types of activities they will be undertaking in the space. Once designers understand the types of teaching and learning to be supported and are clear about the opportunities and limitations of the physical space, then the designers can select technology that best matches those activities.

University spaces feature AV technologies that in some ways differ from those commonly found in other applications. Technologies such as web conferencing, lecture recording, and webcasting have extended the learning experience well beyond the university grounds.

Specifically, integrated AV technology serves many roles in lecture halls, tutorial rooms, and learning spaces. These applications fall into two broad categories: technology for **presentation** (by the instructor) and technology for **collaboration** (among students). Approaching them this way can help clarify the design and make technology choices simpler.

#### 3.2 Technologies for Presentation

Didactic styles of teaching (e.g., lectures) often require material to be presented on a screen. An on-screen presentation is also useful in many other educational settings (e.g., to demonstrate an experimental technique for a chemistry class).

Content is presented in an AV form so that the students can hear, see, follow the discussion, and take notes. This section provides examples of educational settings and describes presentation technology choices for a desired teaching style.

##### 3.2.1 Source Equipment for Presentation

Source equipment sends various presentation media to the space's display system(s). A common example for teaching is often a personal computer or tablet because they can present text, images, video, and sound. Although, dedicated devices such as DVD players, document cameras, and video/web conference equipment may provide better and more flexible results.

The simplest teaching spaces may provide a single connection point for a faculty member to connect a source device (e.g., a laptop), and most spaces provide a switching and control system at the teaching position along with a selection of source devices for the instructor to use in presenting material.

The choice of source devices should be determined in conjunction with the user group and depends on the type of material to be presented in the space. The following table shows possible source equipment options, along with their characteristics and usage guidelines.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

**Table 1 – Source equipment for presentation and conferencing**

Source	Characteristics/guidelines
<b>Laptop/tablet</b>	Often, connectors and a variety of devices are provided for a laptop, tablet or other portable electronic personal devices. Typically, a digital connection (e.g., HDMI or USB-C) will be provided along with a network cable (for more information about support for user-supplied portable electronic devices, see section 2.3).
<b>Wireless</b>	In addition to wireless data network connectivity, a wireless presentation connection option would accommodate a “Bring your own Device” (BYOD) environment. Using wireless “point to point” receiver devices, additional wireless sharing, and collaboration tools can be added. Such systems have several custom configurations that typically need to be coordinated with IT/Security.
<b>Document camera Or Visualizers</b>	Document cameras are used to show prepared material or to allow the instructor to demonstrate and diagram processes and procedures by writing on a pad of paper placed under the camera. The advantage of using document cameras over whiteboards is that the content can be enlarged to fill the screens, giving everyone a clear view, and the instructor’s worked examples can also be recorded or transmitted to a remote location. They also allow small three-dimensional objects to be displayed.  Document cameras or specialized demonstration cameras can also be used to give students a clear view of science experiments and demonstrations (e.g., chemical reactions, dissection techniques). Sometimes, more specialized microscope cameras may be required.
<b>Video playback</b>	Some courses (e.g., media studies) may require a more competent device, such as a Blu-ray player with surround sound (and a matching sound system) to provide a theatrical presentation for films or video material. In isolated cases provision may be required for legacy format players such as VHS, potentially including support for multi-region playback compatibility.
<b>Video conferencing/Web conferencing</b>	Some institutions provide a video/web conference endpoint to allow a lecture or demonstration to be presented from a remote location which are forms of distance learning. Videoconferencing may use a dedicated piece of equipment called a CODEC or web conferencing may use a dedicated PC (or presenter laptop) with third party software like Zoom or Teams (depending on campus site licensing). There are multiple add-ons being used for videoconferencing and web conferencing; i.e.; webcams; specialty cameras including pan/tilt/zoom (PTZ), media players, microphones etc.
<b>Fixed/dedicated computer</b>	The trend is that fixed computer environments are being removed from spaces. There are institutions who do provide fixed (or dedicated “house”) computers, with a permanently installed range of software, depending on the requirements, used in teaching. The PC should be a standard type used by the institution and be connected to the local network and the internet, again depending on requirements. Ensure that the optical drive and at least one USB port are accessible to the support team and so that the instructor can bring discs or USB drives for use in teaching. These are often configured like open student computer labs where the software is maintained remotely, and desktop “refreshed” regularly.

Media playing from the network is generally handled by applications that are part of the standard operating environment on the PC or laptop, or standalone media players may be used. Fixed media players (like DVD or Blu-ray) may be required, especially to deal with library media collections, which are not allowed to be placed online due to copyright restrictions.

### 3.2.2 Display Choices

After presentation/conferencing media leaves its source, it must be displayed so students and teachers can see and interact with it. Three common technology choices to present teaching material in an educational setting are:

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Presentation to the full audience using a **presentation wall display** (most commonly at the front of lecture halls and classrooms).



**Figure 8 – A presentation wall display (courtesy of The Sextant Group)**

- Presentation to groups of the audience using **distributed displays** (often used in labs and collaboration spaces).



**Figure 9 – Distributed displays (courtesy of The Sextant Group)**

- Presentation to **individual screens**, often streaming over a network to student PCs (used in specialist teaching spaces including computer labs).



**Figure 10 – An example of individual screens (courtesy of The Sextant Group)**

The choice is often determined by local factors, such as the preferences of faculty and students and the technological infrastructure available.

### **3.2.2.1 Presentation Wall Displays**

One of the initial considerations for display and system design is whether to use single or multiple images. Rather than letting room size dictate using more displays, let the instructor(s) needs and teaching methods be the guide.

Larger spaces may utilize a large display located on the presentation wall, typically the front wall, combined with the needed ceiling height and unobstructed sightlines for the entire audience. The minimum requirement is a single widescreen projector and screen. If the space is very large or filled with light, sometimes a videowall or LED display is used instead to maintain an acceptable contrast ratio. Smaller spaces may simply require a single flat-screen monitor.

Some courses may benefit from two or more side-by-side displays, depending on spatial requirements or the teaching modes employed.

For example, an instructor may wish to display:

- " Two full-screen graphic images simultaneously to allow compare-and-contrast simultaneous content mode.
- " A graphic on one screen and an explanatory document on the other.
- " A web page on one screen and the supporting HTML code on a second screen.
- " A spreadsheet spread across two screens and the output of an electronic whiteboard on a third screen.
- " A detailed graphic, such as a CAD drawing or building information modeling (BIM) model, which requires additional screen space to display fully.
- " A supporting graphic on one screen and a close-up video camera view of the presenter on the two side screens (most often used in large spaces).
- " The presenter's graphics on one screen plus graphics and other contributions from select students on other screens.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

A frame image freeze capability can enhance dual-screen functionality by allowing images or live notation, such as math formulas, to be frozen on one display while the instructor continues to work on another. Ideally, the geometry of the space will allow adequate sightlines from all seats to all screens so independent images can be displayed. Alternatively, multiple images may be used to compensate for sightlines that would otherwise be problematic.

In mixed use scenario rooms, the AV might be designed to accommodate both dual screen and single screen projection with three projectors, allowing the user to decide which mode to use for their class session. Certain courses (e.g., cinema studies) may prefer to have students focus on a single screen. Room size should not dictate the need for more displays. Instead, the needs of visual examples in the subject's instruction

### 3.2.2.2 Distributed Group Displays

If a presentation wall display can't be seen properly by the entire audience due to a low ceiling, existing columns, blocked sightlines at some seats, problematic room geometry or other issue, placing the same content on several smaller screens close to each student group can be effective. This is also useful if students are working collaboratively at tables or laboratory benches rather than in a classroom setting (for more information about matching presentation options to suit collaborative learning.

With multiple displays, students may choose between watching a nearby screen and watching the talker. From an attention standpoint, this design may not be ideal. When placing a screen near the presenter, the presenter's gestures toward the screen are seen as an extension of the presenter. When a screen is placed farther from the presenter, the audience's eyes are drawn away from the person presenting and toward the screen. This situation can be less personal, and the human connection between the presenter and the participant is diminished.

Moreover, a monitor near the front of a space may be too small for students farther in the back. If a screen near the presenter is not large enough to be seen by the participant, moving the screen closer or adding additional screens can help the participant to see the image better.

### 3.2.2.3 Individual Displays

If the teaching mode requires students to work with computers or tablets, or if the class is widely spread out (or even remote from the instructor), each student's computer or tablet screen may display the presentation distributed over a network. Usually, that requires special classroom collaboration or screen-sharing software on both the instructor's and the students' computers.

Solutions of this kind are more complex than other presentation choices. Thorough testing of any proposed solution is recommended before making a final design choice.

### 3.2.3 Basic Classroom Equipment

Every classroom or lecture hall needs some basic equipment. Although whiteboards, lecterns, and workstations may not be the responsibility of the AV designer, these tools should be considered when planning any new teaching and learning space fit-out. Let's explore some of this equipment.

#### 3.2.3.1 Writing Surfaces

Despite inroads made by the various electronic options over the last few years, traditional, non-electronic writing surfaces are still the most used tools in many classrooms.

##### 1) Whiteboards

Traditional purpose-built, fixed, solid whiteboards are a common type of writing surface used in classrooms. Whiteboards should be high quality and intended to stand up to years of service. Enamel on steel (also referred to as porcelain) is usually considered the most robust whiteboard surface. A magnetized surface is also useful. Back-painted glass surfaces that can double as writable surfaces are increasingly common in study areas and tutorial spaces.

Although traditional whiteboards are decidedly low tech, they may be part of high-tech applications that should be taken, into account. Special applications, such as videoconferencing, in which the

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

boards may appear on camera, may dictate the use of a specific color shade. That said, white is generally the most common and most preferred.

In addition, some applications may require video projection onto the writing surface. In these cases, the selection of whiteboard material is critical.

### 2) Chalkboards

Despite the cleanliness issues as well as the health concerns, expect traditional chalkboards to be required in some situations. Mathematics, statistics, and physics are probably the most common departments to insist on these. If an institution or user group asks for chalkboards, it is often safe and wise to assume that significant internal debate had already occurred on the matter.

### 3) Movable Writing Surfaces

The amount of actual board space required or expected will be a local preference. In venues where significant board space is required, sliding board systems are often useful. Sliding board systems have multiple panels on tracks that allow boards to be slid up (or to the side) out of the way revealing another board. These are also useful when chalkboards are required, allowing a chalkboard to be added to the mix while maintaining whiteboards.

### 4) Interactive Whiteboards

Interactive whiteboards, where the instructor writes on a projected computer image using an electronic stylus, have become very popular in K-12 education systems. They are sometimes used in university spaces but are generally limited to small tutorial rooms or meeting rooms. Because the screen cannot be any larger than the instructor can physically reach across, interactive whiteboards used in large teaching spaces must be connected to a larger projection system. In larger spaces, document cameras or visualizers can perform much the same role and allow teaching without turning away from the students. Another option for projection is interactive flat screen monitors. Writeable surfaces, paintable and wall applied materials may affect room design. The software application that these run on are feature rich and should be carefully selected and trained on to ensure teaching faculty use.

### 3.2.3.2 Instructor Workstations and Lecterns

In many classrooms, the lectern is the hub of all AV systems. It can include sources, switching, inputs, cabling — literally an AV rack hidden within the furniture. The installation of an instructor workstation or lectern in higher education is common, but not universal. They are also the subject of widely varying design. If lecterns are in use, consider the history and usage of existing designs with an eye toward improvements that may be proposed.

Other local issues may affect the installation of workstations. Some institutions have restrictions against umbilical cables running across the floor and, in some cases, even the overfloor cable raceway. That often depends on the accessibility needed and on local laws and regulations (see chapter 7 for more information). As installed PCs in classrooms become less prevalent, the need for fixed workstations or lecterns becomes less necessary as well. The need for flexibility of the work area is becoming more important with portable lecterns becoming more popular at some institutions.

Sometimes the coring of floors for cable or conduit is not permitted. This is most common in older buildings or in seismically active areas.

## 3.3 Technologies for Collaboration

Collaborative or active learning, in which students work together, is important in higher education settings. For many projects, the technology design must provide for the instructor's presentation, videoconferencing, and enable group work.

This style of learning is not dependent on supplying technology to student groups. When properly executed, a team-based or problem-based learning pedagogy can be highly impactful without any campus-provided technology. However, technologies that are accessible by each student group can give them the ability to research, display and capture content, and collaborate digitally. This can energize and magnify study efforts.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Common technology choices for facilitating collaboration among students include:

- Support for user-supplied laptops/portable electronic devices (bring-your-own-device, or BYOD).
- Individual or group computer(s).
- Shared group displays, one or more for each student group.
- Traditional whiteboards, one or more for each student group.
- Collaboration hardware and software systems, and
- Wireless presenter systems.

As mentioned earlier in the chapter, the choice is often determined by local factors, such as the preferences of the faculty and the student cohort, and the level of student access to BYOD technologies. BYOD introduces two connectivity-related concerns:

- Connectivity for sound and video
- Connectivity for intranet/Internet

It is important that each student group be equipped identically so that learning experiences are equitable across all of them.

### **3.3.1 Support for User-Supplied Laptops/Portable Electronic Devices**

Even in cases where education institutions provide computers for students to use, the current trend is toward allowing students to bring their own devices into class. Therefore, all learning spaces should be equipped to cater to laptop use, with the institution providing wireless networking.

However, individual laptops present limitations when used for group, face-to-face collaboration. A single laptop screen can only be shared comfortably by two to three people. Use of screen-sharing software and multiple laptops may allow for larger groups, but functionality and ease of use may still not match that of a dedicated, shared display.

### **3.3.2 Individual or Group Computer(s)**

In some situations, such as when access to special software or databases is required, it might be essential for each student (or small group of students) to have access to their own computer and possibly a monitor. Individual computing is common for software instruction in computer labs, for example, where each participant requires one-to-one access to a computer. Other learning spaces, such as the Technology Enabled Active Learning (TEAL) model developed by the Massachusetts Institute of Technology, may require a group of up to three students per PC.

However, when all students are using their own screens, it is difficult for group members to physically see each other, even when seated at the same table. As a result, this form of collaboration may not allow for the same dynamics of face-to-face collaboration as when students share displays. If the educational brief requires it, effective face-to-face group collaboration is still possible through thoughtful architectural design, careful attention to the physical form of the furniture, and innovative integration of low-profile displays. Using sharply raked displays or monitors inset into the desktop can help.

### **3.3.3 Shared Group Displays**

Regardless of the computing devices provided by the institution or the student, each student group should ideally have a shared group display. This could be a large flat-panel display, a flat panel with a multitouch overlay for dynamic interaction, an electronic or traditional whiteboard with ultra-short throw projector, or other technology solution. Screen-sharing software or plug-in connections are also recommended to allow laptops to display on the shared screen.

### **3.3.4 Traditional Whiteboard**

Though not considered a technology by many, standard whiteboards are often an important tool for brainstorming, diagramming, documenting, and generally communicating among student

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

groups. Ideally, each student group will have convenient access to at least one large whiteboard surface.

Some institutions also utilize “personal” whiteboard surfaces, approximately 18 by 24 in (45.7 by 60.9 cm), which can hang on a wall-mounted track for group viewing, be moved to the group table, or carried to the instructor for further discussion. These boards may hang and/or be stored on the student group furniture.

### 3.3.5 Collaboration Hardware and Software Systems

The technology design should allow students to display output from their devices to their own group and to the whole cohort (through central or distributed screens). This will involve provisions for the students to connect their devices’ display outputs to local screens and the central display system. This may involve a hardware, software, or hybrid solution.

Some technology collaboration hardware/software solutions also allow the instructor to:

- Push their graphics to each student group display
- Distribute the output of any individual student group to all other student group displays
- Share the output of any individual student group with the central display system so the entire class can see it
- Establish clusters of student groups with whom to share displays (rather than the entire class)

### 3.3.6 Matching Presentation Options to Suit Collaborative Learning

In most cases where students are working collaboratively, it is necessary for the instructor to switch attention back to a central source, either to display their own material or to share work done by a selected student or group of students. Displaying a presentation from a central source alongside the student’s own work can be done using one of the three presentation options described earlier. Keep in mind:

- A **single screen** for presentation is the simplest and should be used if sightlines for each group allow.
- Sending the presentation to the **distributed group displays** is effective in situations where not all students have clear line of sight to the teaching position.
- Alternatively, consider sending the presentation to **individual displays** where each student is using a PC (such as in a computer lab).

### 3.3.7 Furnishings to Support Collaborative Learning

If group collaboration is one of the teaching modes expected, furniture should either be conducive to group collaboration or reconfigurable.

Some of the variables in planning such furnishings include the number of students per group, the level of flexibility desired, types of technology at each table, and the importance of convenient views of group displays. Insights into these issues will drive decisions related to the size, shape, flexibility, and technology integration of the furnishings.

Several furniture manufacturers have responded to the trend toward collaborative learning and offer a variety of interesting choices for this application. Of course, some institutions opt for custom furnishings to support their unique needs.

Consideration should be given to the provisioning of cabling to support AC power, data and/or AV cabling in a manner that avoids tripping hazards.

### 3.3.8 Other Considerations

Collaboration and interactive technology can take many forms and it is not possible to provide a recipe that will suit all situations. Before designing systems to suit a requirement for collaborative learning, it is vital to take a detailed brief of the teaching and learning requirements and work through possible solutions with the faculty.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Some important questions to ask during such discussions include:

- Will the whole group be involved in collaboration?
- Will accessibility be inclusive?
- Will the cohort be broken down into smaller groups? How many students in each group?
- Will each group require technology to be supplied by the institution?
- Will there be participation from distant or remote students or groups?
- Will microphones and loudspeakers be required so that groups may report back or present their work to the whole cohort?

### 3.4 Asynchronous and Remote Teaching Technologies

Many universities now provide the capability for classroom lectures to be broadcast to other locations or recorded and used later. Common applications for this include:

- **Flipping the classroom** — Supporting a pedagogy whereby students watch pre-recorded lectures prior to the material being covered in class, freeing class time for collaborative learning experiences
- **Overflow situations** — Sending material to other rooms on campus so that more students can be accommodated
- **Remote instruction** — Enabling courses to be viewed — typically in real time — by individuals at other campuses or even at home
- **Online courses** — Offering courses online so that students anywhere may participate
- **Revision and review** — Providing recordings of lectures so students can either catch up on material or review (also useful for non-native language students)

Wherever the recording or broadcast of material is required, it must be planned in close coordination with the institution. The system chosen must be fully compatible with any existing infrastructure and must conform to all policies the institution may have regarding IT security, copyright, and privacy.

#### 3.4.1 Distance Learning

Distance learning may involve relaying the lecture to another location on campus — as in an overflow situation — or it may include sending the lecture to students at another school or even at home.

Distance learning may use two-way video or web conferencing platforms, or it may be one way video (of the instructor). When students are viewing a lecture remotely, provisions should be made to allow students to ask questions of the lecturer. This may be done via interactive audio (audio on all ends — instructor, in-room students, and remote students — as opposed to audio return channel and microphone) but could also be as simple as using a phone, online instant messaging or even texting.

#### 3.4.2 Lecture Capture

Any implementation of lecture-capture systems must be in conformance with existing institutional systems. Any installed systems should be fully compatible with existing content management systems and with other back-end systems, such as identity management. This is another area where significant consultation with campus IT personnel is required.

Careful consideration must also be given to any recurring annual licensing fees to ensure that the proposed systems will fit in the department's funding model.

#### 3.4.3 Web Streaming

Web streaming of lecture content can provide students an opportunity to participate in courses that they cannot physically attend. It is also a popular way of broadcasting events or ceremonies

to the rest of campus, or even the community at large. For Web Streaming to occur, there may be a need for accessibility accommodations (i.e., captions and screen reading) for students.

Attention must be paid to accessibility as a critical design factor and is important to help eliminate any burdens placed on the student or viewer when accessing the stream. The bandwidth necessary to access the stream must be adequate for an uninterrupted experience. Again, it is crucial to coordinate with any efforts the college or university already has in place.

### 3.4.4 Video/Web conferencing

The field of video/web conferencing has been changing quickly. IP-based codecs (video conferencing) are often being replaced by software solutions running on a computer or laptop (web conferencing). Expect that what an end user considers an appropriate video/web conferencing experience may vary from one application to the next.

Incorporating this capability into a teaching space has become common – even critical during the pandemic. This usually requires multiple cameras/monitors for the various video signals involved, as well as specialized audio processing to eliminate echoes from interfering with the sound at one or both ends.

The key advantage of this technology is that it provides a return audio (and usually) video link from the students back to the instructor, allowing two-way interaction with echo cancellation.

### 3.5 Unified Communications and Collaboration

Unified communications and collaboration (UCC) in higher education is the integration of communication methods and technologies across a building or a campus. As legacy telephony infrastructure reaches effective end of serviceable life, there is a trend toward IP-based networked communication services. The traditional phone features are enhanced with video, screen sharing, chat and other collaboration through a single number (or email/name) reach. Campuses are finding that UCC provides increased productivity, improved collaboration, and cost savings.

According to a recent Gartner Group study (<https://www.gartner.com/doc/2705918/unified-communications-collaboration->), organizations worldwide are finding they can improve productivity by implementing and integrating a suite of unified communications applications throughout their facilities. That same trend can be found on many higher education campuses. As campuses plan new and renovation projects, it is not uncommon to find they are implementing VoIP, which incorporates many features of UCC, to replace older PBX systems.

With an appropriate IP-network infrastructure and implementation of cloud-based software services or Software-as-a-Service (SaaS), UCC can be extended to include the integration of real-time communication services beyond just fixed and mobile telephony to include instant messaging, location-specific presence information, videoconferencing and telepresence, electronic whiteboards and flat-panel video displays, desktop sharing, and data sharing, with traditional communication services such as unified messaging (directory services, integrated voicemail, email, SMS, and fax) across a new BYOD environment.

#### 3.5.1 Benefits

In its broadest sense, UCC encompasses all forms of communications that are exchanged via the network including telephony, conferencing, and digital signage. With a UCC network deployment, all communications can be directed as either one-to-one communications or broadcast communications from one to many.

The concept of **presence** — the ability to identify, locate, and engage with anyone in the network — is a key component of UCC. For example, using UCC technology a student seamlessly collaborates with another student on a project, even if the two are in separate locations. The student can quickly locate the necessary cohort by accessing an interactive directory, engage in a text messaging session, and then escalate the session to a voice call, or a video call.

Similarly, in a UCC environment, a member of the faculty can send a security alert to digital screens in classrooms, circulations spaces, and even mobile devices with the push of a single button.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

While such benefits are important, institutions are finding even greater impact by using UCC capabilities to transform collaborative processes. This is achieved by integrating UCC functionality directly into the application. As an example, to find an appropriate research resource, the process application can automatically identify a faculty or student resource at the point in the research activity where one is needed. When used in this manner, the concept of presence changes from simple text communication to one where what is important is finding someone with a certain expertise. In an optimized UCC environment, presence can identify available skills or capabilities.

### 3.5.2 Other Examples

UCC allows an individual to send a message on one medium and receive the same communication on another medium.

- Faculty can hold virtual office hours or conduct class with students face-to-face via web videoconferencing — even when the instructor is traveling.
- Instructors conference with colleagues or students located anywhere, expanding the traditional distance learning experience by seamlessly sharing white boards and other online collaboration tools during the session.
- Student teams create a study group on the fly, using the presence capability on their mobile devices to view each other's availability to meet via web conference
- Faculty members easily collaborate with colleagues to research or write documents using collaboration tools with group annotation applications in a web conference.
- Students and faculty can always be in contact on or off campus, anytime, from any device. All these scenarios are possible within a UCC environment.

### 3.5.3 Factors to Consider

The data network provides the foundation for all the communication services in a UCC plan. By using IP as the foundation, the campus can implement a range of communication options from voice, video, and collaboration. With unified communications, multiple modes of business communications are integrated. UCC integrates all systems a user might already use, and helps those systems work together in real time.

Design principles that should always be considered, include:

- **Define the case** — Identifying and prioritizing goals (“What’s important?”) allows for maximum value and cost-benefit.
- **Value drives investment, not technology** — A robust network infrastructure offers the potential to lower the costs of communicating while increasing flexibility.
- **Protect existing investments** — Determine the best way to implement new capabilities (“What is desired?”) without removing effective incumbent infrastructure (“What works now?”).
- **Take an integrated approach** — UCC integration extends across multiple vendors and platforms, and must incorporate interconnectivity across desktop virtualization, process applications (i.e., databases), the BYOD movement, social networking, and SaaS cloud computing services.
- **Think about future proofing** — What comes after what comes next? With the typical IT investment horizon at five years, think about emerging trends that may impact the UCC environment, and plan for flexibly adapting to change and unexpected opportunities.
- **Do not forget the end user** — A tool without a task serves no purpose. Engaging the user- group (administration, faculty, and students) in perception studies for issues of solution usability and complexity, change management, and implementing solutions that are focused on helping end users achieve desired results.

### 3.5.4 Impact on AV/IT Planning

Unified communications is an evolving set of technologies that automates and unifies human and device communications in a common context and experience. It optimizes education processes and

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

enhances communications by reducing latency, managing interactions, and eliminating device and media dependencies.

UCC may be found in a single product but can also be realized using a set of products that provides a consistent unified user interface and user experience across multiple devices and media types. It is imperative that UCC be considered as part of the overall AV/IT technology master plan and project plan on any campus today.

### 3.6 Key AV System Design Considerations

Higher education teaching and learning spaces make use of the same categories of technology as other projects, but because the activities in teaching and learning spaces are different from other projects, the design of basic subsystems, such as audio, control, and video, also needs to be different. There are some other factors that also need to be taken into consideration.

Standardization and coordination are vital. Universities often contain hundreds of teaching spaces, and users need to feel at ease and in control wherever they're teaching. Standard equipment types and uniform user experience (UX) are crucial to ensuring this.

Equipment in individual rooms must often interact with a wider technology infrastructure, such as recording and videoconferencing systems. Therefore, the correct operating protocols (and, in some cases, specific brands) must be listed.

Because many systems operate in proximity, everything from wireless microphone frequencies to IP address ranges must be coordinated with the university technical staff. Let's delve further into system design considerations.

#### 3.6.1 Audio Considerations

Most teaching spaces will require the ability to play back audio from a PC, laptop, DVD, or other source. Larger spaces will also require voice reinforcement. Large spaces such as auditoriums require specialist acoustic expertise as well as expert sound system designers to provide effective audio systems.

The first question that designers ask when planning a sound system is always, **"Do you need one?"** If the space is small, the acoustics are good and the background noise level is low enough, the room may not need a sound system. A bigger space that requires playback may need a sound system to get the message across.

If students cannot hear something at an adequate level without amplification, then microphones, audio mixers, signal processors, power amplifiers, and loudspeakers are used to electronically amplify the sound source so that they can hear it and the sound can be distributed to a larger or more distant audience.

The second question is, **"What level of privacy does the space require, both in terms of sound coming from outside a room and sound leaving a space?"** Infrastructure decisions will therefore play a pivotal role in how much sound enters or leaves a room.

To determine whether a space requires a sound system and how it should be set up, AV designers consider several factors, including:

- What is the level of ambient (background) noise?
- What is the target sound pressure level of the system given its application?
- How much reinforcement will the equipment provide?
- Is there a need for assistive listening or speech privacy?

Although the concepts and technologies behind proper sound systems can be complex, the basics of a classroom sound system are listed below.

### 3.6.1.1 Microphones

The use of microphones in higher education has grown considerably as AV systems have become more prevalent. It is not uncommon for microphones (and sound reinforcement) to be requested and provided in rooms as small as 30 people. Additionally, microphones and sound reinforcement systems have become simple ways to feed webcasting, distance learning, and lecture-capture systems. They also often provide the voice input to assistive-listening systems. It is critical to understand how microphones are being used at any institution where the installation of additional systems is planned.

- 1) **Wired Microphones** – Some universities still prefer a wired microphone as standard at the lectern or instructor’s workstation. It is a fast way to get a class going if the wireless system fails, and an easy way to add a second microphone. A wired microphone input can also be used to plug in a small mixer for an impromptu event that requires more microphones.
- 2) **Wireless** – Most microphones used in higher education today are wireless. However, wireless microphones present several factors that must be considered before they can be used successfully around other wireless systems. Installation is not usually as simple as putting a new wireless microphone system on an open frequency and turning the system over to the user.

Ideally, a wireless spectrum survey should be conducted to ensure non-interference with other signals. However, very few systems integrators can perform such a survey.

Unless the survey is repeated over time, some sources may be missed. It is crucial that the institution’s AV staff coordinates channels so that provision can be made for expansion across campus.

Regardless of frequency, wireless systems from different manufacturers do not generally work with one another. Even different models of wireless systems manufactured by the same company may not work together.

If the owners of a space are responsible for other wireless microphones and they already have an installed base of equipment, they will most likely want a compatible system so that they can maintain commonality and use the same equipment in any room. On the other hand, giving a department a wireless system identical to that of a different-but-nearby department may set them up for a lifetime of frequency conflicts.

Planning and consultation are essential before deciding on any wireless equipment and all Universities should have a campus wireless management plan that sets out where each service is located and allocates frequencies to avoid interference. If no plan is yet in place, users currently operating multiple wireless microphone systems on a campus can be an excellent source of information on which frequencies work and which to avoid at a specific location.

In most cases, nothing less than a good-quality, diversity (multi-antenna), frequency-agile system should be specified to local FCC rules and regulations.

### 3.6.1.2 Loudspeakers

Most teaching spaces in higher education will have two separate loudspeaker systems. The **front-of-house system** — will provide the audio for projected sources and any other high-fidelity multichannel reproduction. The other system — often referred to as public address (PA) — will provide the voice reinforcement.

The vast, majority of program audio systems in higher education are stereo, although some special applications involving theatrical or media studies may require 5.1 systems, 7.1 surround-sound systems, or other specialty treatment. Program audio systems will most typically be full-range loudspeaker boxes located on either side of the screen.

PA loudspeaker systems for speech reinforcement typically follow one of two design philosophies. Larger spaces with adequate ceiling height will benefit from a single large loudspeaker or loudspeaker cluster. In smaller spaces, multiple loudspeakers may be recessed into the ceiling. Recessed loudspeakers work best with lower ceiling heights, particularly when users want the audio directed more toward the audience and away from any microphones in use.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

In smaller spaces, PA and program audio may often be combined into a single system. These systems usually employ ceiling loudspeakers, particularly when a suspended ceiling has been provided.

Designing a sound system, particularly for a large lecture hall or auditorium, is a complicated process and often requires the design team to include an acoustic consultant. Such consultants can create acoustic simulations of the space in advance to help match the loudspeakers to the space. See AVIXA standard, A102.01:2017, *Audio Coverage Uniformity* for guidance on ensuring that the level of sound each user experiences is the same throughout the space.

### 3.6.1.3 DSP Systems

The use of digital signal processing (DSP) in higher education audio systems is becoming more common as DSP costs have fallen. In conjunction with the AV control system, a digital signal processor can handle all audio switching, processing, and level control, thereby simplifying system design and increasing reliability. DSP function may be part of the audio system hardware and/or part of software handling the audio signal flow (including within conferencing software). It's important to coordinate which DSP hardware/software processes happen in the various stages of signal flow to optimize performance and prevent over processing.

In larger spaces, DSPs provide cost-effective feedback suppression, room equalization, and delay that dramatically improve audio performance, even with difficult acoustics. Although DSPs are useful, they are limited in ability to address the impact of poor acoustics on in-room communication.

### 3.6.1.4 Audioconferencing

Audioconferencing, or teleconferencing, allows groups to communicate by voice only. Audioconferencing systems can be very simple; there are manufactured units that users place on a table. More sophisticated systems may include a dialing console, distributed loudspeakers, and surface microphones. Audio-bridging companies, an allied trade, host audioconferences when more than two parties are involved. All parties call the service provider, who in turn connects the multiple telephone lines.

Depending on the size of the conference, a central audioconferencing pod may fulfill audioconferencing needs. This portable tabletop pod typically contains a loudspeaker and several microphones. Larger conferences may require multiple individual microphones, installed as a part of a larger integrated AV system.

Part of the equipment included in audioconferencing will include either line or acoustic echo-cancellation technology. Larger systems may also include speech reinforcement and playback capabilities.

### 3.6.1.5 Accessibility Considerations

The audio system in a higher education teaching space often functions as an input to some type of assistive listening system.

## 3.6.2 AV Control Rooms

The requirement for an AV control room may be far more common in larger auditoriums, especially those used for conferences and public events.



**Figure 11 – A control room (courtesy of Duke University)**

As well as providing space for an operator to work, these spaces are often used to house noisy projection systems and ancillary equipment, such as amplifier racks. However, an institution that regularly provides an operator to assist instructors with AV technology may want control rooms to be included in some smaller teaching spaces, as well as auditoriums and lecture halls.

### **3.6.3 Control Systems**

Control systems are commonly specified in higher education teaching spaces because they simplify the operation of an AV system and allow remote monitoring of equipment status. They can range from simple button panels to network-enabled controllers with custom touch panel interfaces.

In their simplest form, control systems may merely eliminate the need for a collection of handheld remote controls. In their more complex form, they can be used to simplify the operation of a complicated system by activating such systems as projectors, lifts, screens, and lighting with the touch of a single button.

#### **3.6.3.1 Control System Brands**

The brand of control system that an education institution adopts may hinge on what it currently uses. Most control systems today are proprietary; thus, parts and programming are currently not compatible from one brand to another. Even when designing a system for a separate department on campus if most of that campus has a standard in place — particularly if that standard is programmed and supported by units on campus — an incompatible system should not be installed. The department will be unable to take advantage of resources and support that would otherwise be available.

#### **3.6.3.2 Control Panels and User Interfaces**

Wired panels are the most common user interfaces. Simple wired interfaces used to control devices within a typical space may include wall switches and doorbells. Complex wired control systems could be control rooms that operate systems to control lighting and other elements.

New technology merges the wired control with wireless computers that utilize GUIs, feedback displays, and push buttons.



Figure 12 – A touch panel

Control panels must be installed in appropriate locations within the room, ensuring the user can easily access the control system and the panels are viewable within the environment (e.g., out of direct sunlight, which can affect visibility).

**3.6.3.3 Remote Monitoring and Control**

The ability to remotely monitor and control a system is often just as important to the people supporting the equipment as the actual operational features are to the end user. As with control systems, there is currently no compatibility from brand to brand. The features are an integral part of the system programming and customized to each institution’s particular needs.

Secure remote management and monitoring (SRMM) is the process of managing a complex array of devices and systems without having to physically interact with any piece of inventory, while ensuring security and accountability.

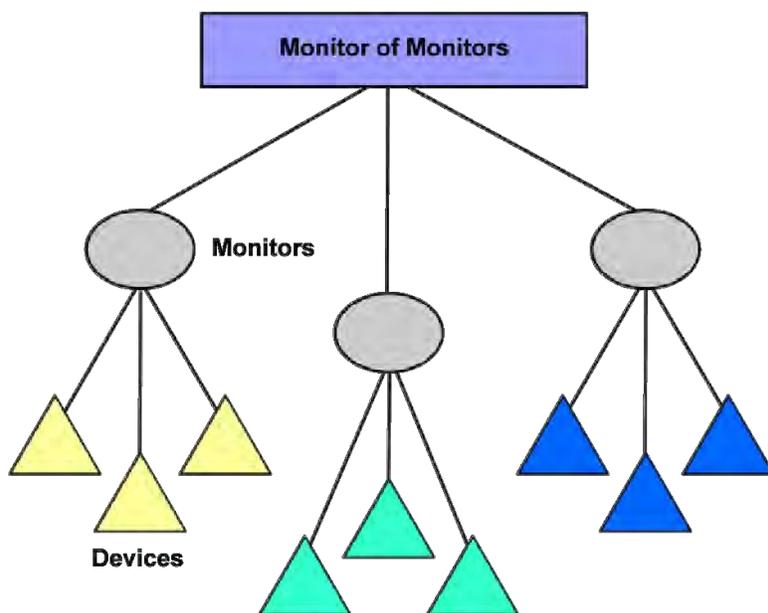


Figure 13 – Secure monitoring and management

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

SRMM architectures typically include Device Management Systems (DMSs) and Manager of Managers (MoMs). They rely heavily on IP networks.

A DMS is a network server that manages a particular type of device or devices by collecting status information and alarms.

A MoM has an interface that allows the user to configure the system and add subsystems and devices. By managing this information centrally, a MoM can make connections and retrieve relevant information. Advanced MoMs also have an auto-discovery process that can search a network, find subsystems and devices, and add them to its system configuration, without any user input.

There are two types of configurations to consider when discussing secure remote management and monitoring: internal and external configuration. Internal configuration refers to the setup and customization of management or control device. External configuration refers to the ability of one device to configure other devices and subsystems.

In the case of a Manager of Managers (MoM) software solution, this includes setting up user accounts and defining roles and privileges; discovering the subsystems and the devices on the network and putting them into inventory; applying profiles and classifications for each item in inventory; and configuring any of the advanced tools available through the MoM such as maps, topology, event rules, and alarms.

Managed items have several elements that require configuration, such as firmware updates, device settings, threshold and trigger profiles, network addresses, and user control.

Because MoMs are generally aimed at integrating with an unlimited number of devices and subsystems, they typically do not provide a mechanism for automating the configuration of each item in inventory. However, most MoMs do provide links and portals to the management interface of the devices and subsystems they are connected to. Once the system is connected to the DMS or the device in question, AV designers can usually directly configure its settings.

MoMs can communicate with devices and subsystems in a variety of ways, but nearly all of them originate in IP networking. The most common means of communication in SRMM systems is the simple network management protocol (SNMP). While originally used for routers and switches, SNMP has grown to encompass any device that connects to a network.

### **3.6.3.4 Network Issues**

Operation of a control system often involves working with the network and IT personnel responsible for its maintenance. In the case of pre-existing control systems on campus, many decisions may have already been made. In most cases, however, it is best to have IT staff involved early to avoid any issues. For example, plugging AV control system hardware into a network indiscriminately may trigger common IT security safeguards and cause data ports to be shut down.

### **3.6.3.5 Intellectual Property and Copyright**

If an AV control system is being considered, AV designers should discuss code ownership with the system owner. If an institution owns the uncompiled code for a system, it will be able to go to any programmer for future upgrades and changes to the system. If it does not, it will have to refer to the original programmer or vendor for all future work. A license agreement should be signed between the programming company and the user of the software which delineates ownership of the programming code in a clearly defined manner. An agreement should be included in the scope of work regarding ownership of the programming and AV code, architectural designs, system drawings, etc.

### **3.6.4 Video Considerations**

Video is a crucial component in all education spaces. Elements such as video projection systems and screens must be carefully planned to ensure the best possible teaching and learning experience.

### 3.6.4.1 Projection Systems and Displays

Despite the rise in the use of monitors, video projection remains the most frequently used method for displaying video information in classrooms. Projectors provide large images at relatively low cost and have an ease of serviceability that direct-view displays do not. This may change over time.

Although some new technologies can reduce heat output considerably, video projectors are often one of the biggest heat generators in an AV system. If they are mounted in any sort of enclosed space, their heat must be removed. Consider proper ventilation and adding an air handler unit to dissipate heat.

### 3.6.4.2 Aspect Ratio

Aspect ratio has been the subject of much debate in higher education. An aspect ratio of 16:10 was a strong contender for years and many monitors, laptops, and video projectors supported this aspect ratio. Today, most monitors and laptops are manufactured with a 16:9 aspect ratio. Unless the institution has a firm policy, 16:9 screens should be considered where there is a mix of monitors and projectors in the installation.

The 16:10 aspect ratio still has many proponents in higher education, many of whom continue to deal with legacy 4:3 equipment (4:3 works better on 16:10 screens). Additionally, a large 16:10 electric screen can be converted to 16:9 by merely adjusting how far it rolls down.

### 3.6.4.3 Display Image Size

Early in planning for the AV system and room layout, the design team needs to determine the size and placement of all displays (whether projection or direct view). See the (ANSI/AVIXA V202.01, *Display Image Size for 2D Content in Audiovisual Systems* standard) for guidance on both science and human factors. The standard starts (requires) with defining the end user content to be displayed and considers the resolution of the displayed image. Given lines of sight to the display, room elements (like height of ceiling) and the seating plan its imperative proper image size is considered early in the design.

### 3.6.4.4 Screens — Fixed vs. Retractable

Fixed-frame screens or specially prepared painted walls are sometimes used as projection surfaces, especially in larger spaces. However, roll-up or retractable screens are more common in learning areas with tight wall space, since retractable screens free up space for other uses (e.g., whiteboards) when projection is not required.

### 3.6.4.5 Screens — Manual vs. Electric

Whether a retractable screen is best operated manually or electrically will depend on the application. Manual screens do not last as long — sometimes only a few years of heavy classroom use. The screen housings are typically metal boxes hung on a wall and are often unattractive. Wider than about 10 ft (3 m), they become difficult to operate manually, but manual screens are relatively inexpensive and easy to replace.

Electric screens typically last longer (if they are not abused) because of their controlled raising and lowering. They are often designed to be installed recessed in a ceiling, making them more aesthetically appealing. Electric screens are often connected to the AV control system and raised or lowered automatically as projection is required. Electric screens are significantly more expensive to buy, install, and replace.

Some designers prefer tab-tensioned screens, which can be useful in keeping the screen on a flat surface but can have a higher maintenance cost over time due to ripping of the screen or glue from the tabs which can cause sticking on the surface. Check with your university design guidelines and facilities regarding whether tab-tension screens should be used for a particular installation.

### 3.6.4.6 Screen Surfaces

The most used video-projection surface is matte white vinyl, which is generally considered to be the best all-around surface material. However, projection screen manufacturers offer numerous other screen surface options that are optimized for specific applications. As brighter projectors

(and alternative light sources) become more cost effective, “gray” screen surfaces can help improve the image contrast. See ANSI/AVIXA V201.01, *Projected Image System Contrast Ratio*.

### 3.6.4.6.1 Alternatives to Screen Surfaces

Sometimes, projection onto alternative surfaces may be desired. Such surfaces may include walls or whiteboards. These applications require careful selection of products; therefore, it is highly recommended that they be pre-evaluated.

Short throw projections recommended on painted surfaces may require careful surface preparation and an upgraded wall installation and finishing. Using paint not intended for projection can affect the color accuracy of the projected image.

Standard enamel on steel whiteboards is usually too reflective for projection, directing glare from the projector — or a “hot spot” — back to the viewer like a mirror. There are various boards and roll materials on the market designed to function acceptably as writing surfaces without creating glare or hot spots. Often, these products are not as durable or easy to clean as standard enamel surfaces. The frequency with which the surface will be written on and how well it will last must be considered.

Glass surfaces are not suitable for projection.

### 3.6.4.7 Projector Lifts

Video projector lifts are installed to raise or lower video projectors into position for use or out of sight. They are also used to bring projectors into a location where they can be more easily accessed for maintenance or replacement.

Lifts are commonly used where projectors are installed in high, inaccessible locations, such as the ceiling of an auditorium or other tiered space, or in aesthetically sensitive spaces, to hide the projector after use. Users concerned with the long-term reliability and simplicity of a projection system design often avoid using lifts in any space where the projector can be reached with a standard ladder.

Lifts are often integrated with the AV control system so they can be automatically raised and lowered when the projector is used.

### 3.6.4.8 Rear Projection

The use of rear projection in higher education is decreasing. Although rear-projection systems can deliver large images that rival the brightness and contrast of a monitor, the space required for a rear-projection room is not usually considered a good trade-off except in very high-end applications.

A close cousin of rear-projection installations is the videowall (see below) — arrays of direct-view monitors or fine pitched LED panels. They do not require the space of a typical rear-projection system, but are expensive and generally used only when the presentation area needs to be brightly lit.

### 3.6.4.9 Direct-View Displays

Large direct-view displays — or monitors — have become more common for classroom usage as they have become larger, lighter, and less expensive. They can still be expensive to repair or replace, so the likelihood of misuse or theft must be considered.

When using inexpensive or consumer-brand monitors, be aware of their (often) limited feature set. Some models do not have serial ports (communication ports that interact with the control interface) or have limited serial command sets and can't be controlled over a network port.

Infrared control, with its lack of feedback, is often unreliable. A single command that toggles power on and off is common, but often problematic when used with a control system.

Consumer-grade displays usually lack the warranty projection necessary for commercial use. Consumer monitors also are not generally designed for the 24/7 (or simply 16/7) operation that may be required in higher education settings.

### 3.6.4.9.1 Videowalls

Combining multiple displays in a videowall-type configuration offers an interesting option in some learning spaces. Although this approach is often more expensive than other options, it offers some capabilities that cannot be duplicated with projection systems.

The displays can be clustered together to offer superior resolution, support for unique aspect ratios and the ability to perform in high ambient-light conditions. Monitors with extremely thin bezels (or mullions) and other unique features are manufactured specifically for this purpose.

### 3.6.4.9.2 Interactive Displays

The addition of interactivity to displays has essentially created an updated version of the interactive whiteboard. Some recent applications of interactive displays (such as wayfinding or touch panels) used for annotation in classrooms. Based on capacitive or conductive touch (like on many smart phones) a display can take direct input from a participant just using a finger.

One disadvantage of interactive displays is that there are no user interface or functionality standards from brand to brand. Every manufacturer has their own interpretation; therefore, operation and features vary greatly across the field of products. It is extremely risky to specify or install an interactive display without buy-in on a particular unit by future users. Moreover, adopting an interactive display usually means adopting, installing, and maintaining the required software.

### 3.6.4.9.3 Other Display Modes

Instructor **preview monitors** are typically located at the instructor's station. They can also be built into the touch panel screen as a video window if the room has a touch panel at the lectern.

They allow instructors to see what they will project to students before doing so and allow instructors to watch the projected feed without having to turn around.

Some **interactive monitors** used at the lectern allow instructors to annotate and highlight material. Annotation is a frequent requirement for teaching using mobile and collaborative devices

**Confidence monitors** are common in videoconferencing and lecture-capture situations. They are typically in the back of the room (so that the instructor appears to be looking at the class) but display the outgoing or recorded image so that the instructor knows the correct picture is being sent. They may also be placed downstage on short carts in case a room is too large to place confidence monitors in the back and/or they could be built into the first row of student seating.

In videoconferencing situations, confidence monitors are often positioned with the primary camera and the monitor showing the remote audience.

Operator monitors are common in booths and control rooms where a third person may be coordinating the presentation for an instructor.

### 3.6.4.10 Simulation, VR, and AR

Simulation systems are designed to provide a lifelike experience to the user that represents something that may be difficult, dangerous, or expensive to otherwise experience. These simulations can be useful tools for training or research. Virtual Reality (VR) is a term that is often used to refer to computer-based simulation systems. Simulations can support up to all five senses: visual (sight), auditory (hearing), somatosensory/haptic (touch/grasp), olfactory (smell), and gustatory (taste). The easiest, of course are sight and hearing. Stereoscopic display technology, often referred to as 3D, is a technology that provides discrete images to the left and right eyes. The slight differences between these left and right eye images provides the sense of depth or stereoscopy. While they also have standalone functions, stereoscopic displays are often the basis of a simulation system.

A head mounted display (HMD) is a special set of "goggles" that a user wears on their head over their eyes to create a stereoscopic display. The HMD either has a single display that is separated by lenses into discrete left and right eye images, or two discrete displays, one for each eye. A form of an HMD

that is semi-transparent through the display can provide imagery superimposed on the view of actual objects in the environment. This form of HMD would be called an Augmented Reality (AR) display.

The area of 3D displays, and simulation systems is an area that continues to rapidly evolve. As one example, most consumer displays supported some form of 3D viewing around 2011 and then consumer 3D effectively disappeared by 2017. Likewise, there was a steady rise of consumer-priced head mounted displays (HMDs), including systems designed to allow a smart phone display to be mounted in special headgear to create a 3D display. This HMD trend, too, shows signs of decline.

It is also important to note the trend toward consumer-focused VR/AR solutions such as HMDs. The benefit is the ease of use and potential for wider adoption among faculty. They may no longer require as much outside consulting or development. At the same time, the use of consumer hardware in an enterprise environment can often lead to support challenges, including providing adequate IT security.

When choosing a simulation or 3D system, one key factor to consider is the number of simultaneous users and required level of interaction. Do multiple users need to see each other as well as the simulated environment? Or is a system that supports a single user acceptable?

For systems where multiple users need to interact with each other, a room sized 3D display can be created. Often special screens are required, perhaps curved, or made from a special material to maintain certain properties of light used to create 3D effects. Many systems require the users to wear special glasses. Depending upon the technology selected, viewing angles or the number of users who can view the image correctly at any one time may be restricted. Due to their unique and specialized technical aspects of these larger systems, their design and installation must be handled by specialists with appropriate skills. If these technologies are truly desired by the client, subcontracting a specialized company with a history of providing these dedicated simulation and VR spaces should be considered.

Also, in most cases choosing and acquiring the required hardware is the easiest aspect of a good VR/AR solution; the challenge is the right software and content to be presented on the hardware. Special attention should be paid to how the content will be delivered. Content development can often cost much more than even the best hardware. Regardless of the type of hardware and content being considered, requiring a hands-on demo with faculty representation before purchasing is encouraged. Proceeding without having end users fully agree on a particular hardware and content solution would be very risky in that some systems may quickly become obsolete.

### **3.7 Higher Education Trends and Technologies**

Several trends and technologies have prompted higher education professionals to adapt to the changes they bring. Some of these technologies require new ways of management.

Others affect budgets or infrastructure — some simplifying, some complicating. The following are a few new technologies and trends that have begun affecting higher education.

#### **3.7.1 AV over IP for Higher ED**

The worlds of AV and IT have been slowly converging for years as more and more products are being developed to live on the enterprise network. When we say AV over IP, we are talking about distribution of audio and video inputs and outputs using the same network as computers, phones, and other network devices. It also means that control of AV systems can now be handled across network resources making remote support possible. Leveraging AV over IP products can help reduce costs and offer a tremendous amount of flexibility when designing an AV space. Below are some of the benefits to AV over IP.

##### **3.7.1.1 Audio Video Bridging**

Audio video bridging (AVB) is an Institute of Electrical and Electronics Engineers (IEEE) standard (802.1) that could eliminate the myriad audio, video, and control cables in an AV system and allow equipment to merely plug into a network. This could greatly simplify system planning and installation. AVB may require the added expense of upgrading network hardware, so it is capable of handling new signals but adds amazing system flexibility. Sending audio across a network using AVB is becoming commonplace. Video-capable AVB equipment has been slow to appear in the marketplace.

### 3.7.1.2 Networked Audio and Video Distribution

One of the most practical uses of AV over IP (AVoIP) is the distribution of the audio and video content over IP networks instead of traditional AV cabling such as HDMI or balanced analog audio. The use of networked AV distribution eliminates audio, video, and control cables in an AV system and allow equipment to merely plug into a network using category cable. This could greatly simplify system planning, installation, and flexibility. To take full advantage of networked AV distribution may require the added expense of upgrading network hardware so it is capable of handling new signals.

#### 3.7.1.2.1 AV over Category Cabling

##### HDBaseT

A recent trend in new AV systems is the expanded use of unshielded and shielded twisted pair (UTP and STP) Category class cabling delivering audio, video, bidirectional control, ethernet and even limited amounts of power to distribute to AV end points. This is a remarkable evolution in uncompressed signal delivery that can reduce the cabling cost and infrastructure size, ultimately reducing project infrastructure expenditures.

Using cables originally purposed for Ethernet, these UTP and STP cable structures can now be re-purposed for long distance AV distribution. Beginning with an HDBaseT technology for the point-to-point distribution of audio, video, IR and RS232 control, ethernet and power was made possible by a standard (IEEE P1911) and the Valens chip set enabled delivery of uncompressed audio and video and more.

HDBaseT can be designed in the more traditional way using AV switches that support the point-to-point distribution of HDMI and many manufacturers now have a wide variety of straightforward multi-input and matrix switches that are capable of transcoding HDMI to HDBaseT outputs to distribute these signals over CAT5e CAT6 and CAT6aA cable. On the receiving side, there are some displays and projectors with built in receivers that are capable of directly connecting the HDBaseT signals. Some of these built in HDBaseT receiver modules have a trade name, and/or may not support all aspects of the standard. When looking at all components in the system, the specifications need to be carefully reviewed for correct application.

For some models of HDMI switches, flat panel displays and projectors, there are individual HDBaseT transmitters and receivers that link the HDMI equipment with the HDBaseT signals. The transmitters will convert the HDMI input to an HDBaseT output, and the receivers convert the HDBaseT back to an HDMI output. In addition, there are breakout connections on the receivers for de-embedded audio, IR, RS232, Ethernet and lastly, the receiver can be powered by the power over ethernet (PoE) supplied (in most cases) by the HDBaseT transmitter.

Other advances in the HDBaseT technology have been 4K/60fps video with 4:4:4 color sub-sampling. Also, there have been recent changes to the High-Definition Content Protection (HDCP) upgraded to the 2.2 version. HDBaseT 3.0 over IP has also been announced by HDBaseT Alliance.

Lastly, when installing the Category cable for HDBaseT, stay with the either the TIA568A or TIA568B termination scheme. Nevertheless, be sure that the cable is terminated using the same termination scheme on both ends of the cable. Also, it's best practice to test the cable installation completely and consult with the equipment manufacturer or any accompanying documentation to determine which termination scheme and recommended Category cable type to use for the best performance and then stay with the chosen cable and termination scheme throughout the installation.

For more information about HDBaseT see: <https://hdbaset.org/>

### 3.7.1.2.2 AV over IP (Audio Visual over Internet Protocol)

The evolution of the use of category cabling in AV applications has inspired the development of AV over IP. Having the AV signals reside on a network infrastructure was the next logical step for this distribution after HDBaseT was successful. However, this concept changes the design of AV systems into a star-like distribution instead of a point-to-point design with the AV capable network switch as the central distribution point using IP addressing schemes to route AV and or multicast signals (single source to many) from an AV source device encoder to the desired end point decoders (displays, etc.).

There is still some debate over the amount of bandwidth desired to move AV over a network. Many believe that building a 10 Gbps network is the way to go to future proof a network guaranteeing delivery of 8K video. However, at the time of this writing, there are many that also believe 1 Gbps can deliver a quality video stream of 4K @ 30fps that may be the most cost-efficient way (with the proper compression techniques) to leverage existing cable deployments and mature network infrastructures. For example, a JPEG 2000 encoder/decoder can maintain the quality of an original 4K @ 30 fps signal ~ 12 Gbps with a compressed bit stream of ~ 500 Mbps to 800 Mbps, depending on the content.

The consideration of maximum bandwidth needed to move the specified AV signals is paramount in the planning stage. Bandwidth also weighs in when planning for when one switch is needed to be “trunked” into another switch to form a larger AV distribution system. For example, on some 1 Gbps switches there are trunk ports that are 10 Gbps fiber links (some are designed up to 40 Gbps). So, exceeding that 10 Gbps bandwidth on one switch could cause a signal delivery problem if, for example, (13) of the 1 Gbps streams are required for throughput to the second 10 Gbps trunked switch. The planned network architecture must be calculated to support the AV packet payload along with data that allows for the addressing of the signals.

Some signal compression is necessary for the deployment of the 1 Gbps design. In addition, equipment compatibility is essential for encoding and decoding. In other words, mixing 10 Gbps and 1 Gbps end points with differing codec schemes is not yet possible on a AVoIP design. The legacy JPEG2000 compression scheme can deliver 1080p, 4K@ 30fps, 4K @ 60fps, and 2160p. However, on the horizon there are other more efficient compression methods such as JPEG-XS, Tico, Crestron Pixel Perfect, DSC, (Display Stream Compression) Pure3® and VC-2/Dirac Pro.

Other considerations for evaluation of compression are linked to video and audio quality, latency, and bandwidth throughput. Some video compression methods are faster than others and it is worth testing equipment to ensure that the best encoding and decoding compression scheme that is selected for the new cabling infrastructure or, the re-use of cabling found in the institution that is intended for AVoIP use. A target latency for AVoIP within the same space should be ~10 ms. with a maximum of ~18 ms.

The network switch is a central point in the AVoIP design, and the selection of the switch needs to be coordinated with the Networking Staff to ensure compatibility with the institutional standards. However, there are some advantages to considering a network switch that is designed for AVoIP use.

In the marketplace, there are network switches now being designed to reduce the complexities of configuration. These newer switch management menus have preconfigured templates for the type of AV signals needed to pass through the switch and has simplified data inputs for VLAN set ups. If there are multiple switches in the AVoIP design, the network switches will most likely need a custom set up for compatible operation so the use of the AV menu can be helpful in this instance too.

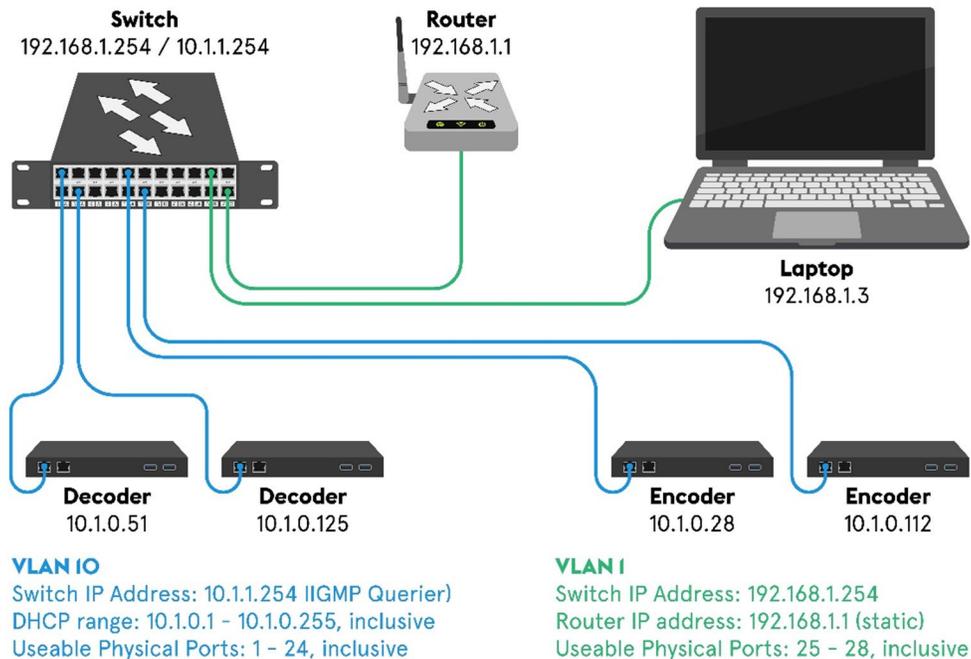
Basically, the network switch is a Layer 3 switch that will work with Multicast environments. Therefore, the selected switch needs to be capable of Internet Group Management Protocol (IGMP).

Some typical network switch requirements for AVoIP are:

- IGMP Support (Internet Group Management Protocol)
  - IGMP Snooping
  - IGMP Quierer
  - IGMP Immediate Leave

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Unrestricted Multicast Flooding aka Drop Unknown Multicast Packets
- Optional – Static Multicast Groups
- PoE (Power over Ethernet) Budget
  - This budget is determined by the total power that a switch can provide when PoE devices are connected to the switch. For example: a 24-port switch with a PoE of 370 Watts can supply up to 15.4 Watts of power on all 24 ports. ( $370 / 24 = 15.4$ )
  - If PoE is not available from the switch, then an external power supply would be required by the (encoder or decoder) end points.
- IP addressing for AV VLANS
  - For a basic single switch AVoIP deployment several VLANs may be needed. The AVoIP system design will be impacted by the product line(s) selected as well as the campus network topology. **It's best practice in all cases, to consult with the IT Network team before deploying any AVoIP solution so that IP addressing can be done correctly and is compliant with the institutional requirements.**



A word about control. At the time of this writing, many of the AVoIP manufacturers of encoders and decoders have proprietary control gateways and use a touch pad that could be more generic in design. Some touch panels have predesigned controls with routing matrixes. Others could be as basic as a button panel. The gateway component is used to communicate and navigate the routing of the AV signals from point to point.

Utilizing the IEEE 802.1x protocol on AVoIP networks enables the provision (e.g., assigning IP address, sending configuration) to take place only to authenticated devices and prevents rogue elements from disguising themselves as an encoder or decoder to gain access.

Also, applying switch security best practice including adding a layer of encryption to the content protects the service from being hacked and ensures that only devices able to decipher the content can decode and

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

display the content. One leading technology that is used for this is the advanced encryption standard (AES), and it is advised to use AVoIP devices that support at least 128-bit AES.

For more information about network security see: AVIXA RP-C303.01:2018 *Recommended Practices for Security in Networked AV*.

The advances in video compression, inclusion of HDCP, network switch development and the next generation of 10 Gbps network infrastructure makes the deployment of AVoIP more likely and its adoption on networks more bandwidth friendly. The advantages of scalability where a system can be expanded by additional switches, encoders and decoders makes the flexibility of the design very appealing in many instances.

There are an ever-changing set of competing protocols that support networked AV distribution. On the audio side, the leading protocols are Dante, AES67, and Audio video bridging (AVB). On the video side protocols such as JPEG2000, H.265, SDVoE (Software Defined Video over Ethernet), AVB (Audio Video Bridging), and HDBaseT-IP are often referenced. The protocol du jour is likely to change the day after this document is published, so users should educate themselves on the process of how the content is prepared and transmitted over the network. These steps include encoding, compression, encapsulation, and transmission. These steps are then reversed on the receiving side. As you consider the protocol buzzwords, you need to understand which of these steps the protocol is designed for to adequately assess their scope. Also note that some protocols are more open protocols, and some are proprietary; just be aware that choosing certain systems may lock you into a certain vendor or industry alliance.

### **3.7.1.3 Bring Your Own Device**

BYOD continues to grow and become a force in education. With students bringing in more devices, the challenge is how to manage them and integrate BYOD resources into the learning process, as well as how to tie them into existing AV systems. Working with your networking team you can leverage these student- and faculty-owned devices to enhance the learning space and utilize new learning tools.

### **3.7.1.4 Building Management Systems**

Building management systems (BMS) continue to grow in popularity and sophistication, driven by energy-management efforts (both saving energy and monitoring its use) and the growing concerns over safety and security. In the process, AV control systems will grow more sophisticated and increasingly offer a link between building systems and room devices. The days of simple, non-networked AV systems are numbered.

### **3.7.1.5 Collaboration**

Collaboration in all forms will be a growth area for many years. All the tools (both hardware boxes and software solutions) that facilitate collaboration (both in a single location and remotely across the network) will see increasing demand. Collaborating and conferencing online from a classroom or AV space has expanded what we think of as classroom space. Leveraging collaboration platforms, we can now have teachers and students from anywhere there is internet. Making sure the video and audio content is clear and understandable is the challenge. Audio and video feeds now must be sent to the conference device whether it is a laptop, PC, or hardware codec.

### **3.7.1.6 Displays and the Rise of 4k Video**

Displayed images will continue to be common in higher education. Laser projectors, with their promises of low (or no) maintenance and ecological benefits, will continue to get brighter and replace conventional lamped projectors. Meanwhile, monitors will continue to replace projectors, as the price and weight of large panels continues to fall. This may be a relief to some budgets, although if source material begins to take advantage of higher resolutions as they become available, there may be pressure to upgrade to more expensive, higher-resolution hardware. There has been a steady rise in Ultra-High Definition (UHD) displays and content. UHD displays have a resolution of 3840x2160, and thus are often referred to as 4K displays or content. 4K video and related equipment are gaining a foothold in the general AV market, and the transition largely depends on the adoption of the appropriate infrastructure to support the necessary bandwidth for the content. 4K streaming and 4K projectors are

already available, as are the software systems used to drive ultra-high-resolution, scalable display walls.

### **3.7.1.7 Flexible Teaching Spaces**

As collaboration grows so does the need for flexible teaching spaces. Flexible teaching spaces and spaces that can be reconfigured quickly will grow in popularity, as more faculty come to understand and adapt to their utility, not unlike the way AV-equipped rooms went from luxury to requirement over the last few years. Teaching styles like Team Based Learning (the ability to break up students into small groups) or Flipped classroom (lectures are pre-recorded and released online, then discussed in class) may drive a classroom refresh cycle that some groups (and their budgets) are not prepared for. The edge will go to the campuses that set up cross-departmental groups to develop room designs that work for their entire faculty, or to outside interests that can facilitate the process for their higher education customers. Additional information and examples are available at <https://flexspace.org/>.

### **3.7.1.8 Internet of Things**

Online everything will be the norm. As the devices students, faculty, and staff carry — and as everything they will interact with in the classroom becomes not only connected but also interconnected — expect that all content and media will move online. Wireless control will allow users to interface with systems from their own handheld devices as solutions that work in enterprise IT environments will appear on campuses. Wireless connectivity between AV components will allow system changes without infrastructure changes. The technology is already popular in the residential world, where it saves considerable time and money. As with wireless control, access, security, and networking issues must be dealt with. Building management systems (BMS) continue to grow in popularity and sophistication, driven by energy-management efforts (both saving energy and monitoring its use) and the growing concerns over safety and security. In the process, AV control systems will grow more sophisticated and increasingly offer a link between building systems and room devices. The days of simple, non-networked AV systems are numbered. Becoming familiar with your networking team and well as general networking terminology will help manage and deploy AV classrooms and spaces.

### **3.7.1.9 Learning Analytics**

The monitoring and analysis of students' progress throughout the learning process will become much more prominent. With all students' devices online, measurement and assessment will become simple and commonplace. The desire for this capability may grow to be a strong force accelerating classroom technology adoption and greater connectedness.

### **3.7.1.10 Lecture Capture**

Lecture capture continues to grow into an even greater force, helped along by more sophisticated learning management systems and a blurring of the synchronous/asynchronous learning lines as content moves online. All this flexibility and availability will help to drive increased demand. The recordings themselves will become more useful as search, indexing, and cross-referencing functions become more powerful. Features such as tracking and facial recognition will migrate in from the security world.

### **3.7.1.11 Standards**

Industry-recognized measurements and procedures will become more common, recognized, and frequently required by clients and end users to enforce a level of accountability for the systems and designs that education institutions pay for. Additional information about AVIXA's Standards program is available at <https://www.avixa.org/standards>

### **3.7.1.12 Wireless**

Wireless control will allow users to interface with systems from their own handheld devices (although it is unlikely to avoid the cost of some type of control panel). Right now, the device-configuration process often involves a bit of work to preserve network security because the wireless handheld devices are usually consumer products. But solutions that work in enterprise IT environments will appear on campuses.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Wireless connectivity between AV components will allow system changes without infrastructure changes. The technology is already popular in the residential world, where it saves considerable time and money. As with wireless control, access, security, and networking issues must be dealt with.

### 3.7.1.13 Other Examples

Other technological developments that will affect higher education are virtual reality, gesture-based control, visualization, cloud-based AV systems, network delivery of content, “broadcast light” systems that simplify content creation, “gamification” of content, 3D printing, and improvements to online learning.

Furthermore, wireless connection to displays through mirroring technology is maturing, the use of 3D displays is on the rise, and campuses are beginning to use massive open online courses (MOOC) to supplement the on-campus experience.

## 4 Building and IT Infrastructure Requirements for Technology

---

This section covers:

- Coordination between the AV designers and the institution’s IT service departments.
- Building infrastructure systems that interact with the AV technology.
- Specific tips to avoid common difficulties where existing or planned building infrastructure can adversely affect AV systems performance (and vice versa).

All the AV and IT technologies going into new or renovated teaching spaces must be planned for, but as AV and IT technology converge, this planning should happen collaboratively, between disciplines. It cannot happen in traditional silos.

AV systems now rely on the data network. Indeed, many have essentially become part of the IT infrastructure, a trend that is accelerating. However, as we will see, AV technology depends on — and interacts with — much of the traditional building infrastructure, such as the electrical, mechanical and HVAC systems, and safety needs to be a consideration. Without advance recognition and planning, there is potential for AV and other infrastructure systems to interfere with each in the way they interact. These can be difficult and expensive issues to fix after the fact.

Effective coordination and integration among various infrastructure subsystems can be tricky to orchestrate. Chains of command are shifting because both AV/IT and traditional infrastructure systems are changing rapidly, particularly with respect to energy management and building automation.

### 4.1 AV/IT Convergence

In the past, AV wiring and systems were separate from computer networks. Now, with digital processing and IP technology ubiquitous in AV devices, many AV installations depend on the local area network (LAN) for control and monitoring and on the wide area network (WAN) for emerging fields of online and distance education. New project planning should anticipate all AV content will reside either on LAN storage or in the cloud and will travel between AV components following IP protocols. When that occurs, although there will continue to be specialists in each discipline, we will have a single, completely integrated AV/IT system. AV professionals will require some knowledge around current IT systems and practices for their campus environment. AVIXA offers classes that cover this convergence and AV/IP networking.

With the proliferation of IT connectivity in traditional AV devices, many classroom equipment installations have become very IT intensive. It is not uncommon for the average classroom equipment rack to be tied to multiple IT subnets — for instance it may connect to the local user (classroom) network, an external network for system communication back to a central location, and an “equipment” network for the various local devices to connect to and communicate across. As a result, the installation of managed switches inside individual AV systems is becoming common.

This often requires reworking and/or redefining traditional roles and responsibilities.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

### What do you need to ask?

A lecture hall AV system may require a dozen or more separate network connections: house, laptop, control system master and touch panel(s), lecture-recording appliance, projector, videoconferencing, IP cameras, and more.

Providing these network drops for an AV system leads to several questions:

- Who installs the network cabling: AV contractor, communications contractor, or the client's in-house staff?
- What wiring specifications must be followed?
- Will separate drops be provided or must a switch be used?
- If a switch, who will provide it? Where will the switch reside? In the AV rack or the IT closet? What are the specs? Who will program it?
- What are the best practices for a particular network that must be considered? You may want to consult with your local IT Dept for integration purposes
- How will the connected equipment be authenticated on the network and how will IP addresses be obtained?
- Will VLANs or subnets be required for certain categories of equipment? What are the existing VLANs?
- Is firewall traversal needed? Who can arrange that? What are the security policies?

Each of these issues needs to be planned and resolved well in advance of the installation.

### 4.1.1 Having the Right Conversations

In the world of higher education, the AV and IT fields are not only areas where technology change is accelerating, they have also been subject to great organizational changes. As traditional AV technologies have become more sophisticated and migrated onto the network, the lines between AV and IT blurred. Many higher education AV departments are now merged into the campus IT department. The exact organizational setup, however, may be completely different at every institution and convergence does not necessarily imply unity.

Today, involving campus IT personnel early in the design of any teaching space is imperative. If a building houses multiple departments, AV designers should anticipate the possibility of having to work with multiple IT groups. Additionally, IT departments may have different security policies, as well as different standards for handling all aspects of network configuration. AV designers should be familiar with the AV/IT organization that you will be working with before getting too far along in the planning process.

### 4.2 Infrastructure

One key element of classroom projects is largely behind the scenes, and yet the success of the project can hinge on its design — the infrastructure. These foundational, physical components need to be coordinated early in the project.

The elements discussed here are AV and IT focused, but their coordination crosses many areas of responsibility, potentially involving all building systems. Adding infrastructure components after the fact could prove difficult — perhaps impossible — and at best may involve redoing previously completed work. Coordinating infrastructure in advance will save time and money.

The standards or regulations to be followed regarding infrastructure can sometimes be difficult to determine. There are national standards. Regional variations, however, are also common. All involved in the infrastructure design must determine the authority having jurisdiction (AHJ) well in advance. When a regulatory issue arises regarding infrastructure, refer to the AHJ.

#### 4.2.1 Cable Pathways

Wireless propagation of AV and IT signals is a useful tool in some situations, however given the crowded RF spectrum that exists in institutions of higher learning, and fast-moving technology trends, wireless signal transmission should only be used when essential. Cable remains the most consistent and reliable method of getting signals to their destination. And with the AV and IT penchant for ever-increasing speeds and frequencies, it is a good bet that the cable would serve us well for a number of years. In addition, high quality audio and video signals require high bandwidth and low latency

connections so the performance specifications of the cable (copper or fiber) should be carefully selected and not a wise place to “value engineer”.

Running cables from point A to B requires need pathways. Having these cable pathways planned and installed in advance will greatly simplify and speed installation. Requests should be made in advance to ensure correct size of path is installed for adequate cable runs. Discussion with the architect on new cable pathway construction needs to occur early in the design process.

Check with your local organization about using IT raceways for AV cabling. Most IT departments will require a separate path for AV cabling to keep it separate from the IT network cabling. Do not assume that the same raceways or paths can be used.

Additionally, cable pathways provide not only a means by which to get a cable from A to B, they also serve to conceal and protect cables.

### 4.2.1.1 Pathway Examples

Cable pathways vary greatly depending on where they are located, as well as on the type and quantity of cables they are carrying. Where large numbers of cables are heading in a common direction, such as above a hallway or in a data closet, cable trays are common. Above ceilings, smaller bundles are often hung from J-hooks.

- **Cable ducts** may be designed passageways through the building structure, or purpose-built metal channel installed in a floor before concrete is poured on top.
- **Raceways** are metal or plastic tracks typically run on the surface of a wall or floor — typically when retrofitting an existing space and access is limited.
- **Conduit** is metallic or non-metallic tubing that may be found in any of these applications.

Building codes typically recommend the type of pathway based on various situations. The actual sizes of the required conveyance will depend on the number and diameters of cables carried and be determined by the AV/IT designers working on the project.

#### 4.2.1.1.1 Conduit

Metal conduit is probably the most common cable pathway found in classroom construction. It provides an easy way to quickly pull (install) the necessary cables across long distances.

Additionally, the metal is physically robust (one reason power is almost always found in metallic conduit) and shields the cables from electromagnetic interference (EMI) and radio frequency interference (RFI).

There are, however, recommended standards to follow regarding the distances and number of bends that a cable run can handle before an additional pull box must be added along the path. The number of cables it needs to carry, along with their respective diameters, determines the required size of the conduit. Most cables will also have a minimum bend radius, and conduit — with its smooth bends — can ensure those are not exceeded.

Best practice for conduit requires pull strings to be installed to facilitate the pulling of cables as well as the installation of plastic bushings on the ends of conduit to help prevent damage to the cables.

### 4.2.1.2 Pathway Considerations

Regardless of what a pathway is made of, there are other considerations. For example, some cables can't be run together — and there are areas of a space that may be off-limits to them.

#### 4.2.1.2.1 Cable Separation

Codes and recommended practices specify what types of cables can run together or even in close, proximity to each other. Such guidelines are a function of the electrical potential (the voltage) of the signal in the cables. Cables with high voltages or very strong signals can interfere electrically with cables carrying low-level signals.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Some signals need to be given their own conduit as a function of their purpose. Fire-alarm signals, for example, need to run in dedicated conduit in many jurisdictions. Microphone lines should be kept a certain distance apart from other cables (or isolated in conduit by themselves) because they carry very low-level signals that can easily pick up unwanted noise.

Most AV and IT cables should be kept some distance away from power cables, or even from common electrical loads, such as motors or lighting fixtures.

### 4.2.1.2.2 Plenums

A plenum is any space that is also part of the air-distribution system. Plenum spaces are significant to AV and IT work because they present an area for pulling cables, but codes restrict how cables can pass through these spaces.

In higher education construction, it is common for the space above classrooms to be a plenum — often part of the return air system for the room. Plenums can frequently be identified by an air grill that does not transition to duct work but is instead open to the space above the ceiling grid.

Plenum spaces can also be found under rooms. The space under many auditoriums, for example, is often considered an air plenum. The space under a raised floor in a server room or computer lab may also be a plenum. Vents in the floor will often be an indication. When in doubt, consult an HVAC professional.

In these spaces, cables (open to the air in the plenum) must meet special regulations. Many common cables, with their rubber or PVC jackets, cannot legally be installed in a plenum.

Special, plenum-rated versions of cable need to be used. Plenum-rated cables meet special requirements limiting flammability, as well as the production of smoke and toxic fumes.

Plenum-rated cable is generally more expensive than other cable and often has a thick jacket that makes it more difficult to pull and terminate. AV designers should check the local codes during the planning stages. In some locations, all cables passing through plenum space are required to be in conduit.

### 4.2.1.3 Other Pathway Considerations

Wherever cable pathways pass through floors, walls or ceilings, fire safety requirements need to be addressed. While drilling through a firewall is sometimes unavoidable, there are ways to do so safely. For instance, firestop should always be used when penetrating through a firewall. Firestop comes in many forms (e.g., foam, blocks, or plugs), but it all has the same basic function. It acts as an impenetrable insulator against flames.

When designing cable pathways, consideration should also be given to developments and upgrades. For example, some universities, anticipating future adoption of optical fiber cabling, have begun to specify a greater bend radius for their conduit to help protect the optical fibers from breaking. For optical fiber cabling, a minimum bend radius of 20 times the cable diameter may be required.

## 4.2.2 Equipment Mounting

The AV/IT world deals with more than its share of heavy equipment. Items such as equipment racks, projectors, monitors, loudspeakers, and projection screens are common, often heavy and can easily cause serious injury or death if they come loose and fall on someone.

Mounting these items often requires more than just attaching the object to the standard structure of the building. Surfaces often require some sort of backing or reinforcement to strengthen the intended mounting location and to help distribute the additional load across a greater area (see figure 3.1). These locations need to be planned with the architect and engineers, with an eye toward what additional structure may be needed during construction.



**Figure 14 – Blocking for a monitor in an open wall**

The passage of other building systems through these locations may affect planning. A large duct or fan coil unit above a ceiling may make creating a mounting location for a suspended object extremely difficult.

When hanging or suspending any equipment, a safety factor of five times the weight of the object being installed is typically required (i.e., a 100-lb [45.36-kg] loudspeaker should be installed on a mounting system capable of holding 500 lb [226.8 kg]). The rating applies to all parts of the mounting system that bear the load of the object. Even the nuts and bolts used for mounting applications require special ratings, indicated by SAE or ISO grade markings on the hardware. Please verify with local regulations regarding mounting.

The safety factor takes, into account, wear and aging that may affect the installation. It compensates for future additional loading. It also accommodates unplanned events that may stress the mounts, such as a projection screen rolling up suddenly and striking the case in which it is mounted.

Mounting AV/IT equipment brings into play issues of liability. When mounting anything that could injure someone should it fall, consult a structural engineer. Also refer to chapter 6 for additional safety information.

#### **4.2.2.1 Other Mounting Considerations**

Any equipment suspended by iron pipe (commonly video projectors, monitors, and loudspeakers) needs some type of hardware in place to keep the pipe or mounts from being unscrewed.

Even lighter objects, such as loudspeaker cans or small cameras, can pose a danger if they fall. Although they are often attached to the suspended ceiling grid (when in compliance with the ceiling manufacturer specifications and/or structural engineer), best practice is to also attach them to the grid deck with a safety chain or wire.

<b>What do you need to ask?</b>
Designing networked AV systems leads to several questions about the network infrastructure: <ul style="list-style-type: none"><li>• Is the network for audio, video, and control of a suitable topology to support the services to be delivered?</li><li>• Where is the nearest IT closet? Is there room in the existing conduit/raceways from the classroom to the IT closet to accommodate additional cabling? Will the installed hardware (switches) support the additional load of an AV system? Who has access to these spaces?</li><li>• Are the network switches managed?</li></ul>

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

### What do you need to ask?

- Is there a VLAN, or can one be created to support the AV network?
- Are there bandwidth requirements for audio or video streaming?
- How are IP addresses for AV hardware assigned? Can IP addresses be used, or will hardware need to conform to DNS naming conventions for communication? Is there a form that needs to be completed to request IP address?
- Are there any network settings that need to be modified to allow audio or video streaming? CAN network settings be modified? Will that be allowed by the IT department?
- Are necessary ports open to allow off-net access ( videoconferencing)?
- What is the campus cabling standard?
- Would it be useful to employ power over Ethernet (PoE) so that both network connectivity and power can be delivered over the same cable for items like remote networked AV touch panels or room scheduling panels at room entrances?

### 4.3 Network and IT Infrastructure Requirements

The convergence of AV and IT has matured to a level that makes a basic understanding of IT infrastructure important when considering AV design requirements. It is now common for AV equipment to require a data connection for routine operation and monitoring. This section is not intended to be a comprehensive guide to networking. Rather, it is a quick reference to support AV systems design.

Examples of IT-enabled AV systems include:

- Control systems,
- Videoconferencing and remote teaching,
- Video, audio, overflow, and IPTV,
- Wireless collaboration systems, and
- Cloud applications, computing, and storage.

#### 4.3.1 Control Systems

Many AV control systems use IP communication between the control panel and the master control unit. Usually, these signals are low bandwidth and pass over the LAN between devices in the same room.

However, it is also common to need wider communication so systems can pass instructions to lighting dimmers, HVAC, and building automation controllers. Sometimes control systems may reside on separate subnets or virtual LANs (VLANs). Careful planning is needed to ensure appropriate access and (if the control system is placed on a VLAN) that management software suites can communicate with these systems. In addition, control systems offer reporting and monitoring functions to a central room management server and these functions may require wide area network (WAN) or even Internet access. The institution's AV, IT, and networking staffs should be consulted to determine the appropriate server addressing and subnet configuration.

##### 4.3.1.1 VLAN Reasons

There are several good reasons to have your AV equipment in a network VLAN. One reason is security. Having a dedicated AV VLAN allows you restrict access to av controls and configurations to only those who need it. Keeping it separated or guarantying bandwidth from regular web network traffic is also a good reason. If you are running an enterprise control system or a campus wide monitoring system, having an AV VLAN ensures all the connected gear can talk to one another. Talk this over with your network team to work out the best deployment on the network.

#### 4.3.2 Videoconferencing and Remote Teaching

Videoconferencing or remote-teaching systems, whether codec-based or software systems running on PCs, require WAN or Internet access to transmit and receive to and from remote student

locations. Seek advice from the in-house AV specialists about special VLANS or subnet arrangements for handling videoconference traffic.

### 4.3.3 Video, Audio, Overflow, and IPTV

An increasing number of devices utilize IT infrastructure to transmit audio and video signals over the network. Such devices enable wide distribution of content throughout campus and facilitate overflow or remote-viewing capabilities. An understanding of bandwidth requirements is important when including these device types (for more information, see “Network Design Considerations” in this section).

### 4.3.4 Wireless Collaboration Systems

Several systems now exist to allow students to participate in classes using their own devices (BYOD). This usually requires the display device to access the wireless network, which may require special planning and coordination.

The area of wireless collaboration is evolving and bears watching. WiFi standards such as Miracast® are making the wireless collaboration systems more agnostic allowing more devices to be connected to the wireless systems. This technology is still evolving and will still have to be coordinated with the IT staff because some of the more advanced collaboration systems may have videoconferencing capability and the needed connections for this ability would have to be configured properly by the IT technical staff.

### 4.3.5 Cloud Applications, Computing, and Storage

Many AV services, particularly videoconferencing, lecture capture, IPTV, digital signage, and AV control and monitoring systems have significant infrastructure that is network-based with servers and services that exist in the cloud.

Where new AV services will require network-based infrastructure such as servers, virtual servers, or access to remote services across a WAN or the internet, it is essential that planning start early and involve the institution’s IT department very closely.

AV designers, campus AV staff, and campus IT professionals will need to work closely to properly implement cloud-based services, considering factors as diverse as existing IT standards, security, network capacity, licensing costs and ongoing budgets for IT maintenance.

## 4.4 Network Infrastructure Components

A basic understanding of network design and components will be valuable for the design of systems that will utilize existing (or new) IT infrastructure. This overview is in no way comprehensive but will enable AV designers to capture essential networking requirements as they design systems. Coordinate with your IT Dept. about limitations and what products can be supported for your network configuration.

### 4.4.1 Switches

A network switch provides a physical connection between multiple devices. Every device has a globally unique media access control (MAC) address that identifies its connection on the network. As each device is connected, the switch collects and stores its MAC address. This allows devices connected to the same switch to communicate directly with each other via Ethernet, using only MAC addresses to locate each other.

- **Unmanaged switches** have no configuration options. Devices are just plugged in and they connect. However, with this simplicity comes the inability to properly optimize and secure the network.
- **Managed switches** allow the network technician to adjust port speeds, set up VLANs, configure quality of service, monitor traffic, etc. Managed switches are more common than unmanaged switches in modern campus environments.

Consideration must be made in terms of switch mounting location. Some facilities require that switches be installed in data rooms, while other facilities may allow switches to be installed in the same

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

equipment racks as AV equipment such as in a deployment of AVoIP. Cabling and distance are affected by switch location. Another consideration of switch location is the accessibility of support staff to allow physical access to the switch at the same time as keeping it secured away from unauthorized access.

### 4.4.2 Gateways/Routers

A **gateway** connects a private network to outside networks. All data that travels to the Internet must pass through a gateway. **Routers** will forward to the gateway packets destined for any device that can't be found on the private network.

When traffic arrives from outside the private network, the gateway forwards it to the correct router. Gateways also translate data from one protocol to another. For example, when data leaves a private network to travel across the Internet, a gateway translates it from a baseband to a broadband protocol. When designing AV systems that must access the “outside world” (distance learning, videoconferencing, remote management), it is important to ensure that the appropriate gateway ports are open.

### 4.4.3 Wireless Access Points

An increasing amount of network data is wireless. This enables users to connect to the public Internet, as well as the campus network, without a wired connection. Additionally, many control systems touch panels connect to their controllers via Wi-Fi.

Wireless access points (WAPs) are installed to facilitate this communication. Although they communicate with devices wirelessly, the WAPs are wired to the network. Deciding where to install WAPs to maximize coverage, bandwidth and security usually requires planning and an understanding of the chosen wireless technology's capabilities. If you are installing a wireless access point for a wireless device or touch panel, coordinate with your IT department to avoid conflicts or being considered a rogue network by the IT group.

### 4.4.4 Network Cabling

As AV systems are designed and planned, it is important to ensure that the correct network cabling is installed. Distance, bandwidth, fire rating and campus standards will all play a critical role in cabling selection. Category cabling (5e, 6, 6a, and 7) are the most widely used standards today. Each type has specific bandwidth limits that are important to capture during systems design. Optical fiber cabling is also widely deployed and can be used for extended lengths, highest bandwidth, improved security, or where total electrical isolation is required.

### 4.4.5 Patch Panels

Patch panels (see figure 3.2) are used for connecting and interconnecting devices on a network in an organized, flexible manner. Network connections from switches, routers, servers, and AV equipment are brought to patch panels, where patch cables are used for interconnection.



Figure 15 – A patch panel

## 4.5 Network Design Considerations

In designing AV systems that utilize network infrastructure, there are several other items to consider.

### 4.5.1 Bandwidth

Bandwidth requirements are an important consideration when designing AV systems. Minimally compressed High-definition video (720p), whether for IPTV, digital signage, or video/web conferencing, may require up around 3 to 4 megabits per second (Mbps) per connection. Immersive telepresence rooms and higher quality (1080p) increased resolution and/or color and contrast) requires 6 to 8 Mbps and higher per connection. As such, a discussion about bandwidth with the IT department should happen early in the design phase to avoid issues later in the deployment. Part of this planning should also review latency and prioritization – which is generally handled by QoS (Quality of Service).

### 4.5.2 Virtual Local Area Networks

As more and more AV devices make their way to the network, their management is enhanced by creating virtual networks within the larger network. This helps, to isolate certain devices and manage network traffic. As implied by the “virtual” part of the name, a VLAN can group various devices even though they are not all physically co-located or connected to the same switch. VLANs can be created to allow only certain types of devices to communicate with each other. Increasingly, AV systems are migrating to dedicated VLANs. This has the added benefit of greater security, isolating critical AV components and restricting access to them by other users and nodes on the network.

One example of a VLAN application is digital signage. If the signs that draw their content from a centrally located digital signage server will be deployed campus wide, those devices probably belong on a VLAN. Access to other systems, such as file or mail servers, from the signage player or displays will probably not be needed. Still, if information must be sent from a database or directory to the signs, they could still be allowed accessed via the router.

If the system should be segregated on a VLAN, either for its own benefit or that of the network, the AV designer will need to provide the network manager with the following information:

- What VLAN needs to be created and why (e.g., an IPTV VLAN so that the network isn't flooded with streaming video traffic).
- Which devices should be included in the VLAN.

Whether any routing between the VLAN and other network locations is required or allowed (ex: This may be important for emergency notification system which might need to display information on the

digital signage VLAN). This information should all be documented as part of the system device inventory.

### 4.5.3 IP Address Assignment: Static vs. Dynamic

Every device that communicates across a TCP/IP network must have an IP address. There are two ways for a device to get an IP address.

- The device can be manually assigned a permanent address. This is known as static addressing.
- The device can be automatically loaned an address on an as-needed basis. This is known as dynamic addressing.

Though it does require thoughtful management, dynamic addressing is less work in general. Instead of having to manually configure an IP address on every connected device, nodes obtain addresses on their own. Because all the addressing is handled by computers, dynamic addressing avoids the risk of human error. The system will not fail to connect because of an incorrectly entered IP address.

Because it is easier to maintain, especially on larger networks, dynamic addressing is used whenever possible. Not all devices support or should use dynamic addressing, though.

Dynamic addresses can change. If, for instance, the AV designer needs a control system to be able to locate a device by its IP address, the device should be assigned a static address.

A discussion with the campus IT department in the planning stages of a project will help direct the use of static or dynamic IP address assignment. IT will need all AV devices to be registered and likely has ways to work with the AV team to streamline registrations and IP assignments.

To register a device on most networks, usually the following information is needed, at a minimum:

- Network ID (needed to identify the responsible party)
- The device's hostname (usually must be a unique name)
- Device MAC address (unique to each device)

### 4.5.4 Security

When designing AV systems that interact with a network, security concerns must be considered. Unauthorized access to AV devices, whether for malicious intent or otherwise, can potentially wreak havoc on a system, expose user content and cause unnecessary interruptions in campus operations.

Not unlike other IT device security, AV security is gaining increased attention to prevent unauthorized access. AVIXA RP-C303.01, *Recommended Practices for Security in Networked AV Systems*, covers the range of issues around AV systems that need to be considered. These include strong passwords on both AV components and networking devices (including WAPs), employing VLANs, disabling unneeded services, set identification (SSID) broadcasts on AV-specific WAPs, and ensuring AV devices are installed in secure environments.

## 4.6 Planning and Coordination

AV designers and contractors should expect that all data networks must follow the standards and specifications of the institution and must be planned and approved in conjunction with the institution's own IT department.

During the programming phase of any AV project, the designer should discuss and document broad requirements for network connectivity to the AV system. This includes documenting whether real-time video and audio needs to be carried across the network and whether firewall traversal and access to WANs or the Internet is needed. The location and capacity of any existing or planned network should be determined.

During the design phase, the AV designer and installer must coordinate with the institution's IT department as well as any communications consultant or contractor to specify exactly where network

ports need to be provided for AV use and whether AV will require space for servers or switches in data closets or communications rooms.

The detailed design or contract documentation stage should include documenting not just the location and number of outlets, but also the back box type and size, required bandwidth, protocols, and access details such as VLANs, subnets, and firewall traversal. In addition, network security needs to be considered in all points of the design process. Please refer to AVIXA RP-C303.01, *Recommended Practices for Security in Networked AV Systems*.

### **4.7 Power for Audiovisual Equipment**

All installed AV equipment will require dedicated circuits and receptacles to be incorporated into the electrical design. Health and safety are taken extremely seriously in the education sector, and it is not acceptable for electrical cables to be strung along walls or across the floor where students or instructors must walk. AV equipment, therefore, needs dedicated outlets in close proximity — inside cabinetry, high on walls for monitors or loudspeakers, and in the ceiling for projectors. Like other allied trades, the AV designer will need to provide AC power requirements including the power consumption and location for all equipment. These are then provided to electrical engineer, electrician, and local authorities for coordination of electrical requirements.

#### **4.7.1 Source Equipment and Instructor Workstations**

The AV designer should provide estimates of the number of electrical circuits required and the total equipment load early in the design phase so that the electrical layout may be properly planned. By the contract documentation phase, the AV designer should have specified the number of outlets required within the workstation (for rack-mounted equipment) and the number of external outlets required for portable equipment (e.g., laptops).

It is best practice to put all equipment in a single space on the same electrical phase. This helps to eliminate electrical differences that can produce noise in audio or video systems. All equipment needs to be properly connected to safety ground.

A sufficient number of convenience outlets should be installed, particularly in the front and back of teaching spaces. Bringing portable equipment of various types into teaching spaces is a common occurrence in higher education.

#### **4.7.2 Wall- and Ceiling-Mounted Equipment**

Outlets should be provided adjacent to projector mounts, monitor mounts, and any other powered equipment, such as amplified loudspeakers or infrared, assistive-listening emitters. Where possible, these should be mounted flush with the ceiling tile or below the ceiling, per local code. Best practice for monitors and projectors is to provide dual outlets for ancillary equipment, such as receivers used to extend digital video signals. Electric screens, and some other specialty equipment may need direct connection to the power source (consult manufacturer and local AHJ).

### **4.8 Lighting Design**

After power and network requirements, nothing is more crucial to effective AV display than room lighting. Close coordination between AV and lighting designers is important to ensuring a proper outcome.

Achieving the proper contrast ratio is key to providing viewable images in an educational setting. Poor lighting design can ruin the effectiveness of projected presentations, making them look washed out and difficult to read.

In cinemas, contrast ratio is usually high, as people generally view the projected picture in near darkness. However, students need sufficient light for notetaking, known as task lighting, and most classrooms and learning spaces have a significant amount of ambient light. Overcoming this in all presentation and teaching spaces requires careful planning.

See later section on “Designing for Image Quality” for more detail on image contrast ratios.

#### 4.8.1 Lighting Zones and Circuits

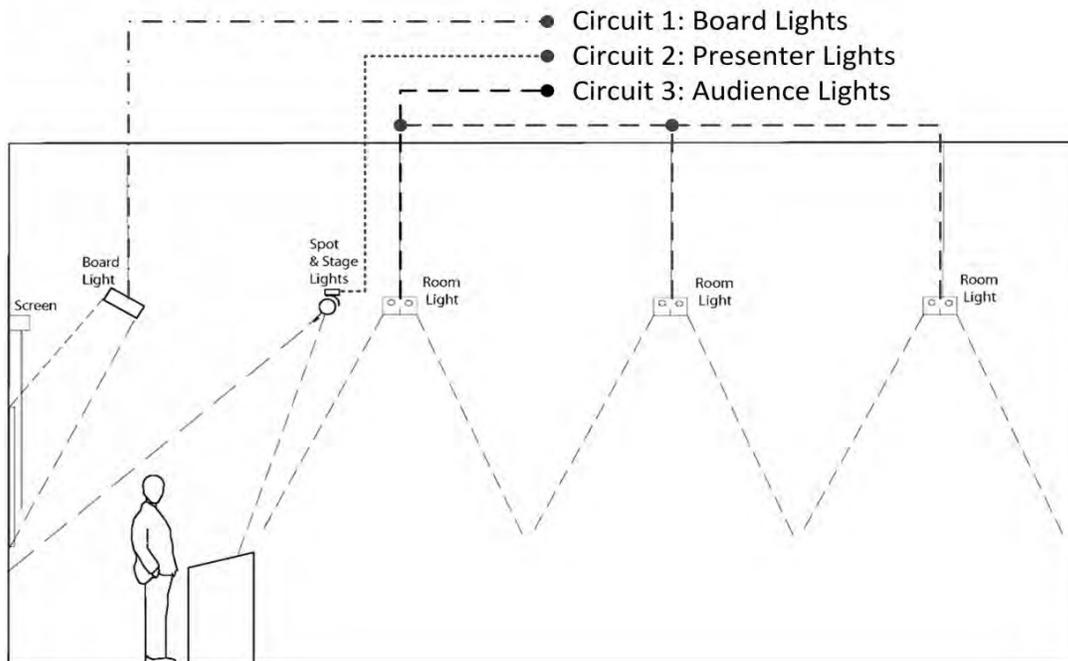
Different activities in a teaching space, such as writing on a whiteboard, group discussion, and projection, require different lighting conditions. It is vital that lighting be adaptable and easily controlled to provide the best illumination for each activity. Usually, each separate activity zone (e.g., the whiteboard, audience area, and presentation area) will have individually controlled lights. This section describes a few typical lighting design scenarios.

##### 4.8.1.1 Small to Mid-Sized Teaching and Presentation Spaces with Projection

For small- to mid-sized teaching and presentation spaces with projection, three lighting circuits are the minimum to allow sufficient zone control of the lighting. Each of the circuits should be controlled by a separate dimmer or a relay-controlled contactor.

Small spaces may require separate light fixtures and switching circuits (figure 16) for:

- Front lights that spill directly on the screen (including board lights)
- Directional task/spot lighting to illuminate the presenter at the lectern or presentation position without spill on the screen
- Audience area room lights



**Figure 16 – Typical three-circuit lighting scheme consisting of separate lighting instruments and control circuits for board lights, presenter illumination, and audience (note taking) lights**

Overhead light is not suitable (particularly if non-directional) and light that illuminates the face needs to come at an angle. Presenter lighting should be angled in a way to avoid blinding the presenter and to enable them to maintain eye contact with the audience.

Note – In small rooms, even if specific board lights are not used, it may be necessary to isolate the lighting nearest the screen surface so that it may be switched off during projection without affecting the note-taking lights over the general audience area.

### 4.8.1.2 Lecture Halls and Larger Presentation Spaces with Projection

Lecture theaters and larger presentation spaces generally require more sophisticated control over the audience and presentation areas. All zones must be under the control of the presenter via dimmers, apart from exit, stair tread, and safety lights (which may be required to be always on).

For example, the space may require separate light fixtures and switching circuits for:

- Board lights (as required)
- Directional front stage area lighting
- Lectern/presentation point-focused spotlights
- Typically, three audience lighting zones (e.g., front, middle, back)
- Aisle lights
- Safety lights
- Other zones/circuits if required (e.g., for demonstration or performance spaces)

For a typical lecture hall, the following four lighting conditions are often required:

- **Full-on, board, or demonstration lighting** — This setting includes all lights on for discussion and other gatherings without projected graphics or auxiliary uses such as cleaning and maintenance.
- **Text and graphics projection** — This is the most used state.
- **Pictorial or detailed projection** — The same as for text, but with reduced audience light to increase the contrast ratio required for the source material.
- **Cinema projection** — This setting should aim for the best available on-screen contrast, with note-taking light only implemented if achievable without excessive spill.

### 4.8.2 Ratio of Projected Versus Ambient or Spilled Light

The clarity of projected images relies on a sufficient contrast ratio between the light from the projector and the ambient or spilled light falling on the projection screen. The relevant international standard regarding contrast ratios in projected images is AVIXA V201.01, *Projected Image System Contrast Ratio*. As this standard applies to the academic environment, we can identify three situations where it can be brought to bear on lighting design:

- Projection of text and graphics (e.g., PowerPoint slides or document camera), where it is expected that reasonable ambient light levels are provided for note taking.
- Projection of detailed photographic images (including medical images and x-rays), where notetaking is secondary to a full-contrast-ratio projected image that allows for the reproduction of detail in the darkest areas of the picture.
- Projection of moving images (film and video), where note taking is secondary to a full-contrast-ratio projected image that allows for the appreciation of detail in both the brightest and darkest scenes in the presentation.

It is the responsibility of the lighting designer, working with the AV designer, to ensure that ambient light from all sources is sufficiently controlled so that the minimum recommendations regarding contrast ratio are achievable at any point on the image area.

## 4.9 Light Sources and Controls

There are special requirements for the lights in each zone of a learning space. Whiteboard lights, for example, must provide an even coverage without glare, while note-taking lights over the audience area should be controlled so as not to spill onto the screen. Creating the right conditions requires the right kind of fixture and the correct means of control.

### 4.9.1 Fixture Selection

During a presentation, different lighting settings may be required in rapid succession. It is essential that the light sources used can be switched on and off (or dimmed) quickly. Lighting that requires long delays between extinguishment and re-strike, or fixtures that take more than 10 seconds to achieve maximum brightness, are not suitable for general-purpose teaching spaces.

To achieve low levels of ambient-light spill onto projection surfaces, select light fixtures of a glare-free design with direct-light distribution only (no upward, incident light), and that have reflectors with **cut-off** or **shielding angles** in the direction of the screen(s). Recessed lights with non-reflective louvers, and suspended lights with sufficient side-shielding reflectors and non-reflective louvers are usually suitable.

Task lights and spotlights that are not turned off during projection must also have either internal cutters or external barn doors to enable illumination of people near the screen, while preventing direct light from falling on the screen.

### 4.9.2 Light Fixture Placement

Near the projection screens, house lights, stage lights, and lectern spotlights must all be carefully positioned to avoid spill on the screen. Care must also be taken when placing spotlights so that the body of the spotlight does not impede a projector's beam.

The vertical positioning of stage lights and lectern spotlights is often a difficult balance between sufficient light on the presenter's face and glare in their eyes. A commonly agreed balance is to position these lights between approximately 45 degrees and 60 degrees above horizontal from the presenter's eye line.

### 4.9.3 Lighting Control

Any space where the basic functionality involves presentation technology should have lighting dimmers installed. Dimming must only be achieved using appropriate dimming technology to suit the installed fixtures. Care should be taken to ensure that no flicker, audible noise, or electronic interference is present throughout the dimming range.

If an AV control system is employed in a space, expect lighting control to be an integrated part of the system. In simple systems, this may be achieved by relay control from the AV controller, but other communication protocols, such as RS-485, RS-232, digital addressable lighting interface (DALI), or IP control interfaces are more common.

### 4.9.4 Occupancy Sensing

To avoid unwanted system shutdowns during long sessions when people may be stationary for extended periods of time (for example, during examinations), any lighting sensor technology must be capable of detecting the presence of stationary occupants — not just those moving around the space (in the case of infrared sensors, for example). A longer-than-usual delay before shutting down lighting should be applied in all teaching spaces.

### 4.9.5 User Controls

Lighting systems should be designed to be operated in one of two modes:

- Standalone, using lighting wall panel(s)
- Wall panel(s), supplement by control via the AV control system

Wall-mounted lighting control panels (or Entry/Exit switches that bring up the appropriate lighting mode) must be placed near entrances in accordance with applicable regulatory requirements and building standards.

### 4.9.6 House Lights

House lighting should be directional in nature, dimmable, low-spill, low-glare, even, and reasonably shadow-free, providing illumination at the audience horizontal reading surfaces suitable to the task

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

when operated at 100 percent. Lighting should be arranged in zones to enable control of lighting for projection needs and spaced so there is significant overlap of beam patterns (so a lamp failure does not create an unusable dark zone).

### 4.9.7 Whiteboard Lights

Light levels falling on the board must at least match the levels on the reading surfaces of the audience section. Lighting should be even across the surface with minimal variance from brightest to darkest point within the board area with board lights, presenter lights, and note-taking lights all ON at nominal levels. Board lighting must be separately controllable.

Board lights should be set back from the boards a sufficient distance to allow even coverage of the whiteboards or chalkboards.

### 4.9.8 Stage Area Lights

Stage lights should be dimmable, narrow-beam, directional lights with excellent control of spill. They should include barn doors or cutters, or other means to accurately shape the light beam to avoid spill on the projection screen, while at the same time lighting as much of the area in front of the screen as possible. For smaller venues appropriate lighting may be achieved with a series of small down lights or directional fluorescent lights with highly effective louvers.

### 4.9.9 Presenter Spotlights

In lecture theaters and large venues, narrow beam focusing spotlights should be installed to light the presenter at the lectern. The spotlights should have full beam control to minimize spill onto screens. Care should be taken to avoid reflections off the lectern surfaces. For large venues, theatrical spotlights are suitable.

### 4.9.10 Aisle Lights

When installed, aisle lighting must meet relevant building codes in terms of edge and step definition. The selected aisle light fixtures must emit no, or minimal, spill onto projection screens. A range of LED-based lights are available that provide both edge definition and vital tread illumination for safety.

### 4.9.11 Exit Lights

Special consideration should be given to the type and location of exit lights in lecture theaters and performance venues. Naturally, exit lighting and emergency illumination must follow applicable local codes, but exit lights can have a detrimental effect on projection quality by producing an unacceptable level of ambient light unless their location and brightness are properly considered.

## 4.10 Special Requirements for Videoconferencing Spaces

Video cameras have many uses in a learning space, including videoconferencing, distance learning, lecture capture, web streaming, image magnification, and recording of student presentations. Unfortunately, lighting for the video camera is different from lighting for the human eye and should be considered differently. AVIXA partnered with IES to produce RP-38-17, *Recommended Practice for Lighting Performance for Small to Medium Sized Videoconferencing Rooms*. For more information, please reference: <https://www.avixa.org/standards/ies-avixa-rp-38-17-videoconferencing-lighting>.

The proper lighting for video camera use will deliver consistent color and skin tone reproduction, maximize efficiency of video codecs, and show presenters in a flattering manner, among other benefits. However, it can be hard to achieve this balance without washing out displays, creating glare for presenters, creating a sustainability problem, or causing other issues. Furthermore, controlling natural light in such a space is more important than in learning spaces that do not use video cameras.

A specialty lighting designer experienced in environments equipped with video cameras is recommended for these applications. Work in conjunction with specialty light designers and interior design team, to ensure the color of surfaces and texture are suitable for video cameras.

### 4.11 Daylighting

In the architectural design of teaching spaces that include projection systems, special consideration should be given to the control of natural ambient light. Where windows or skylights are present, the use of curtains, shades, blinds, or louvers may be required. Roller shades, motorized blinds, or louvers controlled by the AV system are preferable.

As with the electrical and grounding systems design, early coordination between the AV designer and the project's lighting designer is recommended.

### 4.12 Paging and Emergency Communication

There are many ways an AV system in a teaching space may need to interface with the paging and emergency communication system of a building. One example is having an AV system cutoff (or mute) which is activated when a building alarm is triggered. Emergency communication presents a wide-ranging and quickly changing issue. It will be important to consult with local authorities early in the process to understand requirements. Codes and regulations may vary by country, city, or state.

Many higher education institutions have emergency communication requirements written into their building standards documentation. Advice should be sought from the institution's security and facilities groups about integrating AV systems with emergency communication. For information about accessibility requirements for emergency notification, see the corresponding section below.

#### 4.12.1 Audio Alert and Paging Systems

Many universities and colleges have installed building-wide or campus-wide paging, alarm, and emergency communication systems. Where such systems exist, it is likely the AV design will have to provide an interface so audio from PA or program sound systems can be overridden in case of an emergency.

In addition, AV systems usually feed any assistive-listening systems in a teaching space. The ability to override the information being broadcast by the assistive-listening system will often be required.

### 4.13 Video Display and Digital Signage

In addition to audio alerts or voice announcements through a sound system, today's emergency notification systems may need to display information visually. Some institutions require an AV system to be capable of interrupting (or replacing with another message) the video-to-video projectors or monitors in teaching spaces.

Digital signage is becoming more common in higher education. It ranges from an informational display for a venue or department that is updated periodically to a sophisticated high-profile system that displays real-time information to many users.

Another display technology to be aware of is the room status system — typically small electronic signs outside a room indicating if it is open or who is using it. These were first commonly used in business to indicate the status of conference rooms but have become more common in higher education environments.

How this technology will be implemented will hinge greatly on how classroom scheduling is handled on a campus — whether scheduling for a particular venue is managed on a campus level or locally by a department. Like digital signage, these signs may be required to provide emergency or other mass-notification information.

It's important to verify and consult with other departments for integration with AV services for purposes of life safety, live broadcast, and commercialization requirements.

### 4.14 Building and Campus Control and Monitoring

The control and monitoring of various building systems (e.g., HVAC, lighting, and other building features and functions) has become more sophisticated, and more institutions are beginning to employ them. At the same time, AV control systems, which are already used to monitor equipment status

remotely and track conditions such as usage and lamp hours, are growing in sophistication and incorporating lighting control and occupancy sensing.

These two systems have moved closer to complete integration, to the point where they've essentially become one system in some installations.

### **4.15 Asset Security**

When planning a higher education teaching space, it is important to discuss asset security. The security environment on different campuses will vary greatly. Classroom usage hours are different at each venue, as are things like the availability of security/police patrol, room or device tampering alarm systems, or the availability of IT-based monitoring systems.

At the basic end of the security spectrum, most campuses will already have ways of addressing common asset-security issues, such as projector and monitor security. It is usually best to conform to what works for the institution's security staff rather than supplying something unique.

In general, all AV equipment should be secured physically behind a locked door or by using a locked security mount or cable. User access will vary by school (or even department), but some require users to have a key or combination to physically access equipment. At other schools, equipment is expected to be out in the open and usage control is handled electronically.

In many higher education teaching spaces, access is controlled primarily by timer-equipped locks on the doors. Likewise, room occupancy detection in most teaching spaces is merely tied to that room's lighting system or the AV control system. Even when there is a connection to a centralized management system, the application has often been solely installed for energy management and not security.

The migration, however, of building systems like access and lighting control over to some type of networked building management system is becoming more common. It is important to understand the school status or plans with regards to these technologies.

Security needs vary across a building. Some spaces are closely controlled and only host higher-level classes or meetings, requiring significant architectural and/or aesthetic attention. Other spaces may be open and unattended for many hours or host regular public events, which would necessitate a more utilitarian and robust style of design.

### **4.16 Other Building Systems**

AV and IT designs may be recent additions to the typical building specifications, but their potential impact on building systems cannot be underestimated. In a modern building, failing to coordinate their installation alongside other building systems from earlier stages of project planning can have harmful effects on one or more systems.

#### **4.16.1 Fire Systems**

Even fire systems must be coordinated alongside AV and IT. It may be discovered too late that the projector lift, when lowered into position, breaks the optical smoke-detector beam. Moreover, sensors or detectors that project from the ceiling must be kept out of the light path of the video projector.

Sprinklers and detectors may also need to be coordinated so that they are not affected by the hot exhaust from video projectors or equipment cabinets. Such equipment should not be located where it blocks intended coverage zones.

Annunciators should be located where they will not be blocked by projection screens as they're lowered. They should also be kept away from future writing surface locations — often one of the last items installed in a teaching space. More than one university has fire annunciators projecting from neatly framed holes in the middle of chalkboards or whiteboards.

### 4.16.2 Plumbing Systems

Plumbing systems are subject to the same classroom noise standards spelled out in greater detail below. Even if they meet the letter of the standard, locating sources of regular noise (like bathrooms) immediately adjacent to teaching spaces should be avoided.

Additionally, heat sources, such as hot water or steam pipes, should not be routed through areas that may need to be accessed for AV/IT system work or repair. These pipes also should not be routed where they might transfer heat or humidity to wiring or equipment, such as recessed projection screens, that might share the same space.

### 4.16.3 HVAC Systems

HVAC systems are often serious generators of both noise and vibration, two elements that can have a detrimental effect on the mission of teaching spaces.

Spaces that generate high noise and vibration (e.g., equipment rooms) should never be placed adjacent to classrooms. If HVAC equipment must be located above the ceiling in a teaching space, it must be mounted, so as, to avoid transferring vibration to other equipment in the room, such as with spring or rubber mounts.

Even subtle vibration of a device such as a monitor, projector, or camera can make the image difficult to watch. It will also shorten the life of the equipment. Projector lamps are particularly susceptible to vibration. AV and IT cabling can pick up unwanted noise from large electric motors and typically should be kept more than 4 ft (1.2 m) away — even in conduit. Placing ceiling microphones too close to air-handling duct would increase background noise. Also, projector mounts near HVAC units could experience increased vibration.

The location of all these items needs to be coordinated with HVAC system locations. The best solution is to separate AV and HVAC systems. Close, proximity may require isolation mounts for both the AV and HVAC equipment.

HVAC registers should typically be kept 6 ft (1.8 m) or more away from video projectors to keep from affecting their cooling. Exhaust registers should be positioned to avoid blowing air onto any projection screens. Any movement will distort the projected image and be a distraction.

Even the path of ancillary components (e.g., ductwork) should be coordinated such that it does not come too close to an equipment mount or projector lift.

AV and IT equipment also generate additional thermal load in a space that must be taken into consideration. Not doing so may cause cooling systems to work harder in order to compensate, thus increasing HVAC noise. Some AV-specific spaces, such as equipment closets or booths, may require their own cooling systems to maintain temperatures within acceptable limits.

## 5 Architectural Design to Support Technology Infrastructure

This section covers:

- The considerations for the positioning of teaching spaces within a building, especially with respect to acoustics and lighting.
- The space design requirements for different teaching styles.
- Specific design guidelines to provide optimum screen viewing conditions for higher education.
- The major impacts of architectural design on projected image quality.
- How to accommodate the technical infrastructure required for current and emerging AV technologies.

Effective architectural design for teaching spaces requires not just consideration of the pedagogy that will be used, but also planning for the technology that will support the teaching and learning.

## 5.1 Programming (Concept Design Phase) Decisions

The decisions related to programming (or concept design phase outside the United States), which involve locating, sizing, and equipping facilities for teaching and learning/teaching spaces, entail several coordinated requirements based on physical and pedagogical styles. The classroom is an environment designed to promote learning and needs to work for both the teacher and the learner.

### 5.1.1 New Classrooms

In programming of a new classroom, AV designers can use programming guidelines to understand the space requirements. Spaces can vary from one institution to another depending on the classroom capacities, size of the institution, and programs offered. Many institutions use the *Educational Facilities Planner* published by the Council for Educational Facility Planners International.

### 5.1.2 Pedagogy and the Learning Environment

Other factors that impact the AV/IT demands for space are the ability to accommodate a variety of teaching methods, increased use of laptops requiring a larger flat surface, and team and collaborative work.

### 5.1.3 Traditional Classrooms

Traditional classrooms are the most common learning spaces found on campus today.

They are designed for flexible furniture and have a presentation area at the room front. Equipment found in this style classroom includes a projection screen, a writable or an interactive surface, and an instructor's station.

What do you need to ask?
Technology programming leads to several questions: <ul style="list-style-type: none"><li>" Will the teaching station be permanent or movable?</li><li>" Will the equipment be BYOD ready?</li><li>" Will the classroom have hands on computing or BYOD computing capabilities?</li><li>" Is there lecture capture or distance learning?</li></ul>

### 5.1.4 Lecture Halls

Lecture halls can be flat or tiered classrooms with fixed seating or with fixed tables and movable chairs. Sightlines will be important for visual access and a curved configuration is preferred. A trend in tiered seating is to have two rows on the same level with fixed tables and movable chairs. This allows for collaborative group work in the lecture hall environment.

### 5.1.5 Auditoriums

An auditorium is a classroom that typically has a capacity of 150 or more students. Auditoriums can have either tiered theater-style seating with attached tablets or be a flexible large room that might be divisible into smaller classrooms. A curved seating arrangement helps with the sightlines and visual access.

### 5.1.6 Active-Learning Classrooms

Active-learning classrooms are designed to be interactive spaces that may not involve IT at all. The term is usually used to describe a space whose function is not didactic teaching, and active-learning classrooms may include everything from musical performance spaces to science laboratories. Such spaces need to be larger compared with a standard teaching space.

Figure 17 depicts an active-learning classroom.



**Figure 17 – Oregon College and University active-learning classroom**

General-purpose, active classrooms may include multiple flat-panel displays on the walls or as part of the furniture, a large expanse of marker board, group tables for five to nine students, and a central teaching station. The setup works with a variety of styles of teaching, allowing groups to share work, collaborate and participate in class dialog.

The following are some specific planning considerations that should be considered for programming purposes.

## **5.2 Planning Considerations**

AV designers should focus on acoustic requirements, ensuring adequate speaking and listening within the room. The design can provide sound reduction from adjacent teaching spaces, exterior hallway noises, and mechanical systems noises and vibration. There are three distinct design components that respond to noise issues:

- Acoustic finish treatments and room shaping to control the room's acoustic response
- The construction of the room's envelope to minimize noise ingress
- Solutions to control the generation and transmission of noise from building systems

A balance of daylight and electric lighting helps to create a well-lit learning/teaching environment. Where windows are present, the design can provide light control to prevent glare and unwanted light

While entry of natural light should be facilitated in learning/teaching environments, external light should be directed and controlled so that direct light (particularly sunlight) does not affect projection surfaces or monitor screens. Direct sunlight on projection screens will often make text and graphics difficult or impossible to read. Even indirect light, if uncontrolled, will wash out important details on projected photos or video material.

At a minimum, each room needs to have ample physical access to facilitate circulation and appropriate support spaces for large groups of students (including those with disabilities).

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

The room configuration needs to be convenient with respect to other student services, secure, and provide a learning and teaching environment free from distractions (e.g., noise, vibration, poor air quality, inadequate lighting, and limited connection to daylight and views).

Further, the floor plan of the facility needs to be organized so that disturbances from adjacent rooms, such as HVAC plant rooms, workshops and practical areas, cafés and retail occupancies, elevator lobbies, social gathering areas, and print shops, are minimized by distance or intervening spaces. It is good a practice to ensure that potential noise sources are not located close to teaching areas.

Another area that AV designers need to consider in the programming phase is the infrastructure's flexibility.

Equipment does not provide much real flexibility. And, over time, at least some of the equipment will need to be replaced. Flexible learning spaces that easily accommodate emerging and future technologies help schools' future-proof against retrofitting costs without overspending on equipment that will become obsolete, and without sacrificing future performance in order to constrain costs.

Hardware-centric AV system infrastructures impose constraints for future improvements or upgrades, while a software-based system infrastructure offers more options.

### 5.3 Furnishings

Furniture should complement both the pedagogy and the technology provided in the classrooms. Classrooms will range from a fixed lecture hall to a reconfigurable, flexible-learning environment. Think about the activities that will take place in a space when considering furniture: Will there be teaming, project work, presentation and discussion, individual research and reflection, or lecturing?

The architect or interior designer may require tables for specific presentation purposes. The size and location of tables depend on activities conducted in the room. The AV designer may be required to provide tables with AV system input/output connections. Any tables included in the room should be mid-toned in a neutral color (i.e., 20% grey), if the room's activities are to be on camera.

Chairs for presenters and audience are available in a wide range of styles and sizes. The architect or interior designer will likely pick out any chairs that will be included within the room. Chairs should be comfortable, plain, medium color, with no reflective finished parts that will be distracting within video applications. Stackable, multi-purpose chairs are common, as are ergonomic chairs. The room layout may need to accommodate the use of storage dollies to deliver and remove chairs.

Carts are another common element of a room. Carts can be used to hold projectors and monitors. Monitors should be secured to a cart with straps to minimize the potential for damage or personal injury should the monitor slip from the cart.

Lecterns are available in many different styles. The architect or interior designer will likely be interested in helping to select the look of the lecterns for use within the room. Lecterns can be pre-manufactured or custom-designed to meet specific design requirements. Lecterns need to be designed for accessibility and lecterns can provide a good location to install presentation source equipment, such as computers, annotation devices, DVD players, and document cameras. Wiring and equipment integration is an issue when using a lectern as an AV source. To assist with equipment integration and system maintenance, the lectern design should include removable panels, hatches, or doors. Cable pathways designated within the lectern also allows for easier installation and user accessibility.

Some schools are trending away from fixed lecterns to allow more flexibility for faculty to move around the room and instead, using wall cubbies for installed equipment for use in the classroom.

### 5.4 Architectural Acoustics

Learning spaces must maintain a high level of speech intelligibility and limit auditory distractions to facilitate communication and eliminate learning impediments. Proper acoustic conditions are especially important for students with hearing, speech, and language impairments; non-native speakers; and persons with learning or attention-deficit disorders. A proper acoustic environment is achieved through careful attention to the following architectural elements:

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Room acoustics, including room shaping, furniture layouts, and finishes
- Sound isolation, including isolation from interior and exterior noise sources
- Building system noise and vibration control, including attenuation of mechanical, electrical, and plumbing system noise and other noise (e.g., elevators, kitchen equipment, and loading docks).

The topic of acoustics in learning spaces is well documented in ANSI/ASA S12.60-2010/Part 1 (R2015), *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools*. As the name implies, this standard, outlines acoustic design criteria and strategies to achieve proper acoustic conditions in learning environments.

### 5.5 Acoustic Considerations in Technology-Enabled Learning Spaces

With a focus on flexibility and collaboration, educational technology has transformed the form and function of modern learning spaces. It is no longer sufficient for the acoustic design to simply support one-way communication from the teacher to the student in a lecture-style classroom. The acoustic design must accommodate a variety of room configurations, teaching styles, and collaborative activities.

#### 5.5.1 Design Coordination

The room's technology systems must be carefully coordinated with the acoustic design. For example, the integration/design team should:

- Select the style and location of loudspeakers and microphones with due consideration for the room's acoustic environment and vice versa. In rooms with video capture, select acoustic finishes with an appropriate color, reflectance, and pattern.
- Study room elevations and reflected ceiling plans to coordinate the placement of acoustic finishes and technology equipment, such as displays, projectors, loudspeakers, and electronic whiteboards. In addition to considering the optimum technical placement for these elements, ensure their final placement provides reasonable durability and a desirable aesthetic.

#### 5.5.2 Acoustic Enhancement Algorithms

Audio capture and playback systems often use algorithms to overcome poor acoustic conditions, including noise reduction, voice lift, automatic gain control, and echo cancellation. Whenever possible, it is preferable to address acoustic issues directly, rather than apply noise-reduction codecs. As acoustic conditions worsen, these codecs apply increased processing and degrade audio fidelity. As such, these algorithms are most successful when they are used to address subtle issues in reasonable acoustic environments. Further, audio system enhancements cannot address acoustic issues impacting in-room communications.

#### 5.5.3 Equipment and System Noise Generation

Background noise-level requirements for learning spaces are quite stringent. It is important to consider the impact of noise from in-room technology equipment, such as computers, equipment racks, projectors, dimming racks, and other equipment with cooling fans. As appropriate, place this equipment in a sound-attenuating enclosure or install it in a remote location. Also, consider the impact that loud multimedia playback systems will have on adjacent learning spaces.

#### 5.5.4 Technology Infrastructure

Sound-isolation requirements for learning spaces are also stringent. These spaces are often surrounded by expensive and highly engineered wall and floor-ceiling systems. Care must be taken to ensure that these constructions are not compromised by the room's technology infrastructure, including cable baskets, conduit penetrations, floor boxes, recessed outlets, and equipment alcoves. Whenever possible, avoid direct penetrations between noise sensitive and noise generating spaces. As appropriate, use acoustic sealant, outlet backer pads, and other provisions to achieve an airtight seal and preserve the integrity of the surrounding construction. Consider surface-mounted infrastructure and limit penetrations in highly sensitive rooms.

### 5.5.5 Structural Vibration

Structural vibration can present image stability problems for projectors and cameras. Each structural system is unique and subject to different vibration sources; however, the following conditions often present vibration issues:

- Equipment installed on long mounting poles
- Equipment suspended from long structural spans (greater than 30 ft [9.1 m])
- Equipment suspended from lightweight structural systems
- Projectors with long throw distances and cameras with long capture distances
- Projectors and cameras used for ultra-high-resolution image capture and reproduction
- Equipment installed beneath or in close, proximity to mechanical equipment, mechanical shafts, elevators, and public corridors

### 5.6 Designing Screen Sizes and Sightlines

There is much more to teaching than slideshow presentations. Nonetheless, visual aids are often used extensively in higher education, and ensuring students can view material on screen is crucial. The standards and guidelines that are used to create optimum viewing conditions define how the screen is be sized and positioned with respect to the seating configuration within a learning/teaching environment.

#### 5.6.1 Design Guidelines

The acceptable relationship between the audience placement and the screen configuration is determined by these factors:

- The distance to the display from the viewers
- The horizontal and vertical angle of view from the average audience perspective
- The type of content/use case and the resolution of the display/content.

**Note** – Some universities apply their own guidelines to screen sizing and viewing conditions. These should always be followed when designing for such institutions. However, in the absence of institutional standards, the AVIXA V202.01, *Display Image Size for 2D Content in Audiovisual Systems* (DISCAS) standard will ensure display image size and relative viewing positions.

##### 5.6.1.1 AVIXA V202.01, *Display Image Size for 2D Content in Audiovisual Systems* (DISCAS)

DISCAS is a performance standard that can be used when determining image size, text height, Farthest and Closest viewer, and viewing angles. The goal of DISCAS is to create a standard, based on human vision, to define the image size for a given AV system based on audience viewing distance.

DISCAS is concerned with the viewer's relationship to displayed content, so viewers assimilate the information the display contains. As such, it accounts for the size of the image, the resolution of the image, the size of the image's content, and where a viewer should position themselves to experience that content.

The closest viewer is a viewing position that defines how close one can comfortably sit in relation to a display and still assimilate content. It can be uncomfortable to sit too close to a screen. To see different portions of the screen when too close to it, a viewer who is too close cannot take in the screen all at once or might have to tilt their head back uncomfortably.

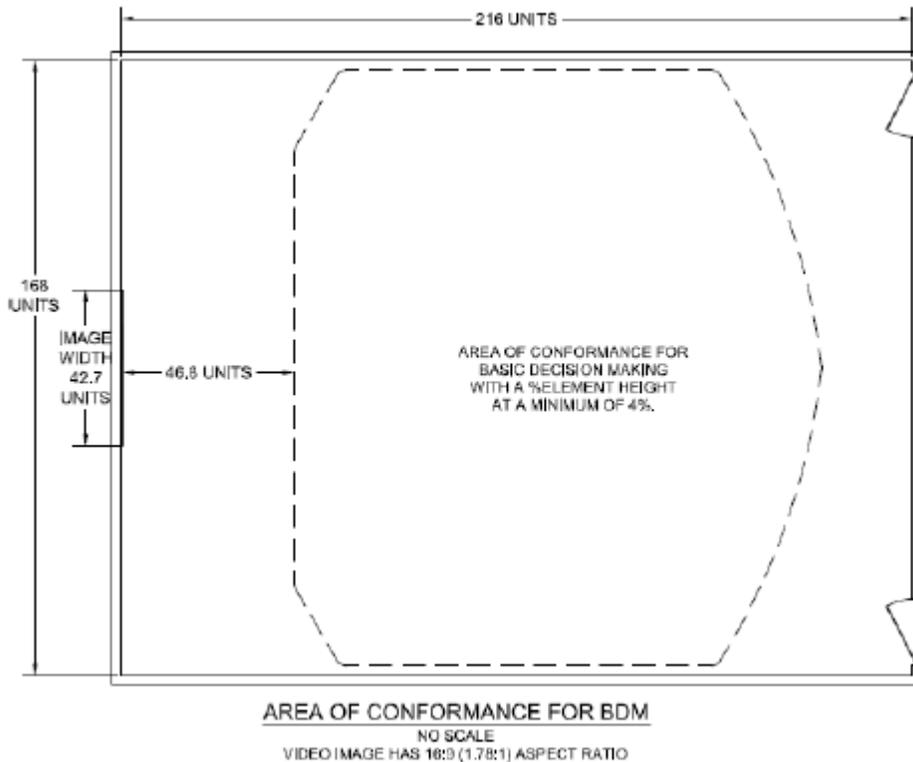
The farthest viewer is a viewing position that defines how far away one can sit from a display and still make out the requisite level of detail. Everyone wants to be able to see the screen clearly and distinctly without straining their eyes to focus. There is a limit to how far one can be from a display to view its details. Making a farthest viewer calculation can ensure that the farthest viewers from a display can discern the detail clearly.

The DISCAS Standard groups content into two types; Basic Decision Making (BDM) and Analytical Decision Making (ADM). In a BDM environment, viewers are more concerned with overall content

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

rather than detail. Viewers will need to comprehend and assimilate the content, but do not need to see detail down to the pixel level. Think of BDM as the most general viewing category with which you will need to become familiar in your most common day-to-day AV projects. In Analytical Decision Making (ADM), the viewers are concerned with the finest discernible details and at this level of critical viewability, discerning individual pixels rather than individual elements, becomes the necessary criteria.

It is recommended that the design team document a given systems DISCAS criteria using a verification form (see Table 2). Drawings should also be provided that show the plan view area of seating that is determined to conform with the standard (see Figures 18 and 19) whether BDM or ADM.

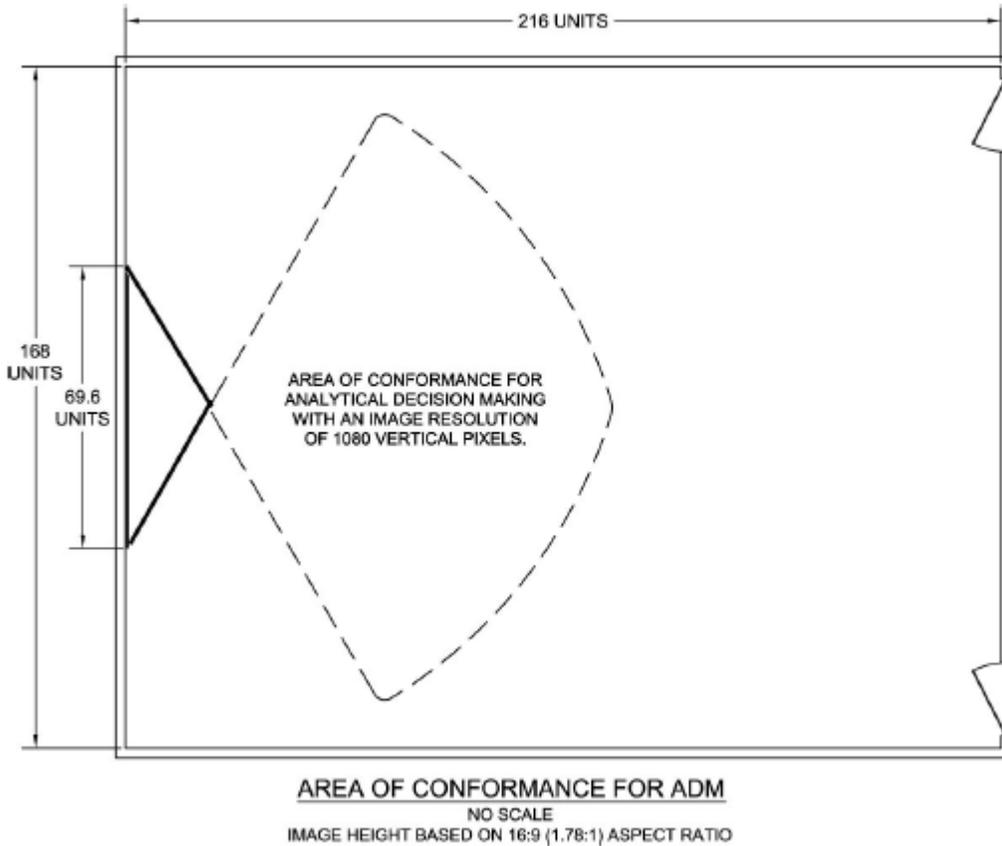


**Figure 18 – Area of Conformance for DISCAS BDM**

**Table 2 – Display Image Size Verification Sheet**

Display Image Size Verification Sheet

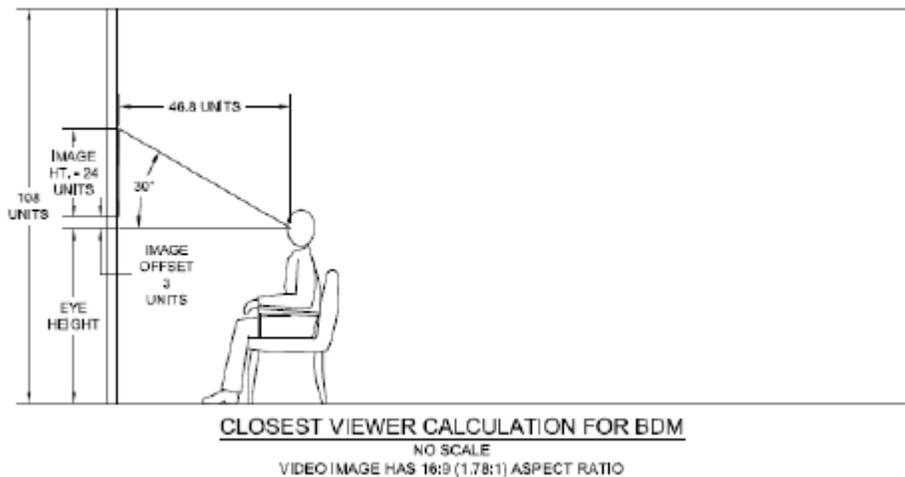
<b>Location:</b>	<b>Date of Test:</b>
<b>Viewing Requirement Category:</b>	
<b>%Element height of content</b>	
<b>Room layout and dimensions, including ceiling height and any space features affecting sightlines</b>	
<b>Display image width</b>	
<b>Display image height</b>	
<b>Display image resolution</b>	
<b>Closest viewer distance</b>	
<b>Farthest viewer distance</b>	
<b>Distance between the bottom of the image and the finished floor</b>	
<b>Eye height of viewers</b>	
<b>Any available or relevant data concerning system application or content to be displayed</b>	
<b>Measurements taken by:</b>	



**Figure 19 – Area of Conformance for DISCAS ADM**

As viewers for ADM are expected to get as close to an image as they need, the maximum vertical viewing angle is most relevant to BDM content use cases.

Figure 20 shows the primary criteria in determining the closest viewer for the vertical viewing angle.



**Figure 20 – Vertical viewing Calculation for Closest Viewer**

AVIXA has training available on applying the DISCAS standard to AV systems design as well as an on-line calculator allowing for the different variables that may be encountered for a given project. Also, AVIXA has an on-line DISCAS calculator for BDM see: <https://www.avixa.org/standards/discas-calculators/discas/bdm>.

### 5.6.2 Sightlines to the Screen

Sightlines need to be checked in both plan and elevation to ensure all students have an unobstructed view of all areas of the screen.

For flat-floor venues with an unobstructed view of the screen, a sensible guideline based on typical ceiling heights and screen sizes is to position the screen so that the bottom edge of the viewable area is no less than 48 in (1.2 m) above the floor. If achievable, the preferred height is 53 in (1.35 m) or more to provide better clearance over front-of-room furniture and allows space for whiteboards.

In tiered venues, the distance from the floor may be lowered; however, the decision on the screen position must take, into account the potential issue of glare in the presenter's eyes from the projector. In labs or other spaces where there are obstructions, the screen must be positioned to allow for a clear view over or around the obstructions while at the same time taking, into account the maximum allowable viewing angles.

### 5.6.3 Multiple Screens

Where screens are used for the presentation of different material, the angles of view and viewing distances must be considered for each screen. In many education organizations, the presentation of two independent images is now a standard requirement for medium to large presentation spaces. Independent dual screens/displays allow educators to present complementary information, for example, a slideshow presentation on one screen and live notation on a document camera/visualizer on the other.

### 5.6.4 Screen Aspect Ratio

Widescreen and high definition are now standard for video and laptops used for display in classrooms. Considering this, the recommended aspect ratio for classroom displays is widescreen format. In circumstances where projection alone is used for display, the 16:10 (width × height) aspect ratio provides an optimum display for computer-projected images, while still providing a suitable match for modern film and television programming.

Most large-screen monitors are available only in 16:9 format, so where a mixture of large-screen monitors and projection is used, a 16:9 aspect ratio is recommended for projection screens to avoid distortion of one format or the other. In a system that has both 16:9 and 16:10 distortions can be avoided by using scaling technology.

### 5.6.5 Recommendations for Flat-Screen Technology

The cost of flat screen display technology has decreased significantly, and for small venues, and especially small videoconference venues, it is now the recommended display technology. The selection and placement of flat-screen displays must be governed by the same size and sight lines rules as for projection screens.

In the smaller venues, it is important to note that the attributes of the flat panel display technology selected may have an impact on the viewing angles and contrast.

At the time of this writing, there are currently three predominant display technologies used in flat screens, LED, LCD and OLED. Some of these technologies use a back lit screen (LCD and LED). Using the back lit panel layer somewhat compromises the viewing angles. While this may not be too much of an issue if the seating area is perpendicular to the display; a seating arrangement where a seat is > 40 degrees +/- off center, the viewer may experience some compromised color saturation (gamma shift or washout) and a lower contrast ratio (raise in black level) or display brightness loss. The OLED technology is emissive and the flat panels do not use a back lit panel. Having a emissive display element improves the off center viewing angles and maintains the color saturation and black levels.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

The evaluation of flat panels is an important step to ensure that the viewing angles for the smaller venue are matched to the seating arrangement. Some limitations for flat panel technologies may be, available screen sizes and cost. However, the careful evaluation of the available flat panel screens and display technologies is an important step in the overall design phase.

### 5.7 Ceiling Heights

In architectural terms, the most important factor in provisioning properly sized screens in teaching spaces is ensuring sufficient ceiling height. Lecture halls and large classrooms require significant height to accommodate screens sized properly for large audiences, and this requirement must be programmed for at inception with the full implications considered. Some universities also wish to utilize ceiling height by positioning projection screens over chalkboards/whiteboards to maximum the space to include both projection and writing on the boards.

Table 3 illustrates how height requirements increase as floor space becomes larger. Please note that the example uses the approximate size image for a BDM use case with 3% element height content.

**Table 3 – Example ceiling height calculations based on BDM 3%EH, 48 in (1.2 m) off floor and screen case under the ceiling**

Distance to farthest viewer	
< 25 ft (7.8 m)	9 ft (2.7 m)
30 ft (9.1 m)	10 ft (3.05 m)
36 ft (11 m)	11 ft (3.4 m)
48 ft (14.6 m)	13 ft (4.0 m)

If bulkheads, air conditioning ducts, beams, ceiling fans, suspended lights, or other ceiling obstructions are present, the clear space under the obstruction is to be considered as the ceiling height available. It is recommended that such obstructions be avoided wherever possible during the development of the architectural design.

### 5.8 Flat and Tiered Floors

Large lecture halls commonly employ tiered floor seating with each row set higher than the one in front. While creating safer flat-floor (vs. raked/sloped floor) circulation conditions in the rows of seats, this approach requires clearly marked and lit steps in the aisles. Tiered or raked/sloped seating provides better sightlines over the next row of seats to the screen and the presenter. In some cases, two rows of seating will be accommodated on each tier to give better opportunities for students to collaborate and form small discussion groups during teaching sessions.

When planning AV equipment in tiered spaces, be careful to consider the third dimension and check side and front elevations to ensure that any hanging equipment or fixtures do not obscure the sightlines for students in the rear. Projectors, loudspeakers, or other fixtures, such as ceiling fans, air-conditioning vents, and ceiling treatments, can obscure parts of the screen from an elevated viewpoint in the rear. Consider placement of cameras in lecture capture or video conferencing spaces to avoid blocking camera sightlines with projectors or other equipment.

In older buildings, tiers are commonly constructed from timber, with a void beneath. This type of construction can provide useful access space for installation of services and signal cabling. In modern construction, concrete tiers are more common, requiring careful planning for service and signal cable conduits.

### 5.9 Impacts of Room Geometry and Orientation

Room shape and furniture placement can have significant impact on the sightlines to the screen. The position of the display (projection) wall needs careful consideration at the planning phase.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

In long and narrow rooms, where the presentation areas and display walls are placed on narrow walls, the audience will have to be placed farther from the screen, requiring increased height to accommodate a large enough screen (see AVIXA V202.01, *Display Image Size for 2D Content in Audiovisual Systems* above). Where a long, narrow room is unavoidable, consider installing relay screens part way back in the room to allow all students to adequately view the material presented.

On the other hand, shallow, wide rooms can cause significant parts of the audience area to be outside the allowable horizontal viewing angle to the screen (see DISCAS BDM and ADM criteria above). In this case, it may be possible to use a central presentation position and arrange two screens with identical content — one on either side on the wide front wall to provide proper viewing angles.

When deciding on the projection wall, keep in mind the location of entrances and windows. It is generally better to have exits at the rear (opposite the projection wall and presentation area) so that latecomers or people leaving the room do not disturb the presentation.

Windows should be arranged so that outside light does not spill directly onto the screen. External or internal shade treatments and blinds should be fitted where windows may cause uncontrolled light to spill onto the projection wall.

### 5.10 Designing for Image Quality

The quality of an image displayed by a projector depends on several factors. In the design of educational AV systems, the most important of those factors are:

- Resolution
- Contrast ratio
- Freedom from optical or electronic geometric distortion

#### 5.10.1 Resolution

The resolution of the image, in simple terms, is the amount of detail that is created by the display system. Different picture sources, such as cameras, computers, and video players, feed the display system and may have different pixel resolutions than the display system.

It is vital to have a clear plan for managing DisplayID/Extended Display Identification Data (EDID) such that all source equipment can be appropriately configured to operate with each display system in the teaching space.

#### 5.10.2 Contrast Ratio

To provide acceptable legibility for projected images, the contrast ratio (the difference between peak white and black in the projected picture) must fall within defined minimum limits. If the contrast ratio is too low, images and text appear washed out and can quickly become illegible. Although both monitors and projectors can produce high-quality pictures in ideal conditions, poorly designed learning/teaching spaces can defeat even the best equipment if lighting conditions are bad.

The contrast ratio achievable in a teaching space depends on the brightness of the projected image (the peak white) and, crucially, on the amount of ambient light falling on the projection surface or monitor screen (which determines the black or minimum level).

To produce acceptable results in spaces that use projected images, the architect, AV designer and lighting designer must specify lighting conditions (including the contribution from any windows) and AV systems that together meet the standard AVIXA V201.01; *Projected Image System Contrast Ratio* (PISCR). For information on how to obtain the standard, visit <https://www.avixa.org/standards>. As of this document update, AVIXA was planning release of a replacement to the PISCR standard to be known as ISCR which will cover both projected and direct view monitor images.

**Table 4 – Viewing requirement categories summary chart; adapted from AVIXA V201.01; Projected Image System Contrast Ratio (PISCR)**

Viewing Requirement Categories	Checkerboard Contrast Ratio	Sequential Contrast Ratio
Passive Viewing	7:1	7:1
Basic Decision Making	15:1	20:1
Analytical Decision Making	50:1	125:1
Full Motion Video	80:1	285:1

### 5.10.3 Application of AVIXA V201.01:2018 in Learning Environments

In learning/teaching space design — and particularly in lighting design — ambient light from all sources must be controlled so that the following minimum recommendations regarding contrast ratio are achievable at any location on the image area.

In lecture theaters and other higher education presentation spaces, drapes and other forms of window shading are used to control external light. The lighting in the space is usually controlled by means of dimmers so that the amount of light falling on the screen can be minimized, while still providing adequate light in the student area. Different levels of lighting should be provided depending on the kind of material that is being presented.

This is usually arranged by making several different pre-set selections available on the AV control system. For example:

- Preset one is the non-projection lighting mode with board lights on.
- The second lighting preset, for projected presentations, should provide workable levels of light for student notetaking. This pre-set would correspond to the 7:1 contrast ratio target, as some light from the audience area inevitably spills or reflects onto the screen.
- Commonly, a third lighting preset in a lecture hall provides lower light levels in the audience space. Its purpose is to provide the best image quality possible while still accommodating note-taking. The 15:1 contrast ratio target is appropriate for this pre-set.
- The final preset in a lecture hall is usually reserved for the presentation of cinema or highly detailed material. If the desired 80:1 ratio cannot be achieved, the lower contrast ratio target of 50:1 is sometimes appropriate in an educational environment.
- The control system will then adjust the level of the lights and may control motorized drapes or shades so that different amounts of light are directed to the screen and the student areas.

The AVIXA V201.01:2018 standard may, on occasion, be difficult to achieve while still providing sufficient light to illuminate the presenter’s and students’ writing surfaces. Still, it is important to try and achieve the standard. All uncontrolled light that reflects off surfaces can be detrimental. Light-colored floor coverings and furniture near the projection screens should be avoided as much as possible since they will reflect significant amounts of light from the spot and stage lights onto the screens.

### 5.10.4 Projection Surfaces

Projection surfaces themselves also contribute to image quality. The surface should commonly be matte white, a purpose-manufactured projection screen material with a gain of 1.0 (gain is a measure of screen surface reflectivity). Where high-gain, gray or rear-projection screen material is used, the manufacturer’s recommendations regarding optimum viewing angles should be followed. In addition, the projectors light source brightness should be calculated taking the screen material into account.

#### 5.10.4.1 Walls as Screens

Under certain circumstances, and if image quality is not compromised, walls may be acceptable as projection surfaces if they are painted flat (matte) white and are uniformly flat and perpendicular to the

projector and the audience. Special paint and construction methods are available for projection walls and may be specified by the standards of individual institutions. In this case, maintenance is particularly important since improper painting or partial touch up can hurt image quality.

### 5.11 Architectural Integration of Equipment

Modern teaching spaces require equipment that the instructor operates during the teaching session (i.e., a PC or laptop, microphone, document camera, control panel) as well as backend equipment, such as switchers and amplifiers. The AV equipment location, housing, and access should be planned during the programming or early design phase.

Active equipment (including PC-based equipment) generates significant heat in operation, and excessive operating temperatures dramatically affect system reliability and service life.

Ventilation of active equipment is often overlooked in the design planning of instructional spaces. Cooling and ventilation characteristics for AV equipment vary. To be safe, these potentially enclosed areas need careful HVAC design to accommodate future technology, which will likely need more cooling and power supply.

#### 5.11.1 Provision for Rack-Mounted Equipment

Equipment to be operated during teaching is commonly housed at the instructor's workstation, which may be a bench, a lectern, or a console unit. Adequate bench space must be allowed for control panels, preview monitors, and microphones in addition to user-operated equipment such as visualizers and graphics tablets. It is important to allow space not just for the installed equipment, but also for laptops and other teaching materials that instructors may bring with them to class.

Back-end AV equipment should be installed in standard-sized equipment racks. AV equipment racks have traditionally maintained a width of 19 in (48.3 cm); other widths include 9.5 in (24.1 cm) and 23 in (58.4 cm). The 9.5-in (23.1-cm), or half-rack units, may become more popular in classroom systems as devices get smaller. The 23-inch racks are rarely used for AV systems on higher education campuses. It may be useful to the design/build teams to reference the AVIXA standards: F502.01, *Rack Building for AV Systems* and F502.02, *Rack Design for AV Systems*.

Many AV items are designed to fit within these standard rack widths. Although the rack widths are based on standards, equipment racks are available in varying heights and depths. Note that these dimensions are based on width of the mounting frame, not the overall outside dimensions and should not be used as a baseline from which to design furnishings.

If there is a lectern or console provided in the room, it is usually convenient to mount as much equipment as possible in a rack frame housed within the console. Other options include specialized cabinetry units or rack frames housed in closets or communications rooms.

In all spaces where AV equipment is to be installed, lockable, ventilated, purpose-designed space must be reserved for equipment, which comprises the audio, video, control, and lighting subsystems. Provisions must be made for power and data access to this space, and for the installation and maintenance of interconnecting signal cables. Cooling and ventilation characteristics of AV equipment vary, so, to be safe, all racks need airflow around all sides.

Although it may be desirable to position some equipment, such as power amplifiers, away from the teaching area, due to fan noise and heat, space should be reserved near enough to the presentation area for equipment that might require inserted media (e.g., disks, USB keys,). This may include PCs, disk players, and playback and recording devices in different formats. This equipment should be secured in a way that allows access to loading slots, trays, and connectors.

##### 5.11.1.1 Access for Maintenance

AV equipment needs to be accessible both for routine maintenance (e.g., filter cleaning) and emergency maintenance, in case it fails or does not work properly during a teaching session. Therefore, it is important that equipment be installed in such a way that support staff can access it from both the front and rear of a rack.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Where rack frames are mounted in cabinetry, front and rear access doors should be fitted and lockable. Where rear access or side access cannot be provided, the cabinetry should allow the rack to slide out easily for servicing. If the rack is not mounted on a self-supporting sliding frame, then there must be no platform, and there must be sufficient width and depth (clear of obstructions, such as hinges) for the rack and cable service loop to be removed completely from the cabinetry and turned 90 degrees.

Where racks are fitted in rooms, such as communications rooms, space in the room must be large enough to access the front and rear of the rack. Communications room access doors should be lockable and wide enough to allow removal of the rack without disassembly or removal of the door.

If AV equipment, such as projectors and loudspeakers, are to be fitted to a space with flush plasterboard ceilings, AV maintenance staff from the education institution should be consulted at the design stage to determine the type and location of access hatches required to mount and service this equipment.

### 5.11.1.2 Ventilation and Cooling

Wherever possible, AV control systems should be integrated with HVAC controls in teaching spaces. This allows the presenter to control temperature without leaving the lectern and also provides some automation functions. AV control systems can now be integrated with HVAC systems for ventilation and cooling purposes. Refer to your local HVAC facility providers for integration and coordination.

### 5.11.1.3 Racks in Cabinetry Units

Where active equipment is fitted to racks contained in cabinetry units, the space containing the equipment must be air-conditioned.

The rack space within the cabinetry must be ventilated in such a way that it sucks in fresh air at the bottom and exhausts hot air at the top. Vents should be fitted with appropriate mesh to prevent access to the equipment from unwanted objects, vermin, and unauthorized persons.

Often, forced air ventilation is required, typically using low voltage fans that operate at very low noise levels.

If the active equipment power consumption exceeds 100 watts, two or more fans should be fitted. Air temperature in the interior of the equipment enclosure (worst case) should not rise by more than 15 degrees Fahrenheit (°F [10 degrees Celsius (°C)]) above ambient, even under extended use conditions.

### 5.11.1.4 Racks in Plant Rooms or Communications Rooms

Where active equipment is fitted to racks contained in separate rooms, the space containing the racks must be temperature controlled. Generally, the conditions for AV equipment should be the same as those applying to IT network equipment in the same building.

It is essential that any cabinetry, cupboards, or rack enclosures be provided with ventilation slots at the bottom (to draw in fresh air) and at the top (to exhaust hot air). As above, ventilation slots should be covered with expanded metal mesh to render them vermin proof.

If racks will be in a shared space (i.e., IT closet etc.) then sufficient space should be allocated when racks are placed near fire or electrical panels that require a regulated space for access.

As in the case of cabinetry units, air temperature in the interior of the equipment enclosure (worst case) should not rise by more than 15 °F (10 °C) above ambient.

## 6 Sustainable and Smart Buildings

This section covers:

- Sustainable design elements as well as applicable rating systems, organizations, and standards impacting the work of AV professionals.
- The concept of smart buildings and explains their impact on AV/IT infrastructure projects.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

As far back as the Industrial Revolution, individual and organized advocates have been affecting public policy about environmental issues. In 1987, the United Nations World Commission on Environment and Development defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

As defined by the U.S. National Institute of Building Sciences, [www.wdbg.org/](http://www.wdbg.org/) the main objectives of sustainable design are to:

- Reduce, or completely avoid, depletion of critical resources like energy, water, and raw materials
- Prevent environmental degradation caused by facilities and infrastructure throughout their lifecycle
- Create built environments that are livable, comfortable, safe, and productive

Over the last century, new technologies have continually influenced the way people design, inhabit, and use campus buildings. Since the 1970s, the concept of smart buildings has grown from single-function systems to integrated solutions we see today. Single-function systems incorporated building aspects such as lights, HVAC, CCTV, elevators, and alarms on the one hand, and user aspects such as telephone, fax, PCs, and video, on the other. Today, a smart building represents an environment that automatically responds and adapts to operational and user requirements and facilitates immediate and cost-effective response to changes in those requirements.

The following sections explore how sustainable design and smart buildings affect AV/IT infrastructure.

### 6.1 Sustainable Design and Construction

According to the U.S. Environmental Protection Agency (EPA), <https://archive.epa.gov/pesticides/region4/p2/web/html/sustainabledesign.html> commercial buildings and industrial facilities, including college and university buildings, generate about 50 percent of the nation’s carbon dioxide emissions. Thirty percent of energy consumed in buildings is used unnecessarily or inefficiently. AV systems can contribute to that waste by remaining powered up when not in use. If carefully implemented, energy efficiency measures can protect the environment but also lower operational costs.

IMPROVING ACOUSTICS THE GREEN WAY
LEED for Schools, a certification program administered by The U.S. Green Building Council (USGBC), contains a prerequisite and credit for acoustic performance in core learning spaces. Pilot credits are available for higher education buildings not seeking certification. Completing the acoustics performance prerequisite: <ul style="list-style-type: none"><li>• Can help satisfy certification requirements</li><li>• Provides some assurance that reasonable acoustic requirements will be achieved</li></ul>



To improve energy efficiency in general, colleges and universities can:

- Develop and implement plans to reduce energy intensity across its facilities and operations by following energy management strategies.
- Track, set baselines for, and benchmark building energy performance.
- Educate faculty, staff, and students about energy-saving benefits and methods.
- Guidelines specific to AV for improving energy efficiency in teaching spaces include:
  - Installing energy-efficient light fixtures or bulbs
  - Unplugging battery chargers and power adapters or using power strips as central turn-off points
  - Avoiding the use of standby power mode since it continues to consume electricity.
  - Keeping drapes open during daylight hours in cold weather and closed in warm weather to reduce the HVAC use
  - Using certified energy-efficient equipment

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Several compromises are made to achieve sustainability certification. A frequent complaint about AV systems in sustainability-certified buildings is the acoustical impact of:

- Less material mass used
- The material selection in interior partitions (e.g., glass instead of hard walls) that allows access to more natural lighting.
- Demountable partitions that allow more flexibility
- HVAC tradeoffs that align with sustainability goals but not with acoustical goals

The desire to achieve additional daylighting in a learning space may increase the amount of light that lands on a screen, reducing the contrast ratio and forcing an increase in projector brightness. That significantly increases energy consumption and cost.

Through coordination of sustainability projects with architects and building owners, AV professionals can help to achieve a balance so that AV characteristics are not overlooked or compromised, while ensuring realistic energy and cost savings.

Many rating systems help to evaluate building systems for sustainability around the world. The following sections explain relevant rating systems, standards, and product certifications.

### 6.2 Rating Systems

Depending on the location or campus preference, AV designers may be asked to work to one of the following rating systems:

- BEAM Society Limited (Hong Kong); [https://www.beamsociety.org.hk/en\\_index.php](https://www.beamsociety.org.hk/en_index.php)
- BREEAM Canada (Canada); <https://www.breeam.com/>
- Building and Construction Authority Green Mark Scheme (Singapore); [https://www.bca.gov.sg/GreenMark/green\\_mark\\_buildings.html](https://www.bca.gov.sg/GreenMark/green_mark_buildings.html)
- Green Building Council Australia (GBCA) Green Star; <https://new.gbca.org.au/>
- Green Globes (United States, Canada and other countries through third-party partnerships); <http://www.greenglobes.com/home.asp>
- Strategic Environmental Assessment (SEA [European Union]); <http://ec.europa.eu/environment/eia/>
- United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) (United States and Canada); <https://new.usgbc.org/leed>
- World Green Building Council (WGBC); <http://www.worldgbc.org/>

Most of the rating systems are focused on construction, water, lighting, energy, transportation, and lifecycle impacts. They can have a significant impact on the design. For an example, the LEED Daylight credit measures the amount of daylight into the classroom and, therefore, have an impact on the classroom layout, screen location, and projector capabilities.

#### 6.2.1 Standards

The following is a list of organizations and their specific activities that support sustainable design:

- **ANSI/AVIXA S601.01:2021, Audiovisual Systems Energy Management;** <https://www.avixa.org/standards/energy-management-for-audiovisual-systems>. This Standard addresses power consumption requirements of the audiovisual system as a whole, while allowing the user of the Standard flexibility in system design as well as selection of individual components.
- **ANSI (American National Standards Institute) Energy Efficiency Standardization Coordination Collaborative (EESCC);** [https://www.ansi.org/standards\\_activities/standards\\_boards\\_panels/eesc/overview](https://www.ansi.org/standards_activities/standards_boards_panels/eesc/overview). The EESCC's objectives include addressing standards for building energy and water assessment,

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

energy modeling, systems integration, and communications as well as building energy rating and labeling and more.

- **Consumer Electronics Association (CEA);**  
[https://standards.cta.tech/kwspub/published\\_docs/2004-04\\_PowerManagementforAVNetworkCapableDevices1\\_FINAL.pdf](https://standards.cta.tech/kwspub/published_docs/2004-04_PowerManagementforAVNetworkCapableDevices1_FINAL.pdf)  
CEA published “Power Management for A/V Network-Capable Devices” in 2004. This white paper articulates power consumption levels for networked devices and devices that impact power consumption.
- **Convention Industry Council (CIC) initiative APEX in partnership with ASTM International;**  
[https://compass.astm.org/EDIT/html\\_annot.cgi?E2745+11](https://compass.astm.org/EDIT/html_annot.cgi?E2745+11) or  
<https://insights.eventscouncil.org/Sustainability/Sustainability-Standards-and-Registry>

CIC and ASTM International published standardized sustainability standards for the green meeting industry. These standards include the *Audio/Visual Production* standard, first published in 2010, which specifies evaluation and selection of AV equipment for Green meetings and events. The CIC APEX/ANSI standards also include a *Meeting Venue* standard; [https://drive.google.com/file/d/1rsYEhMeu6Hf48x2lp\\_3BchThKQhfSXUi/view](https://drive.google.com/file/d/1rsYEhMeu6Hf48x2lp_3BchThKQhfSXUi/view) for sustainable event venue selection, an *On-Site Offices* standard for events held at places of business, and the *Transportation* standard to address the environmental impact of travel and in the event industry.

- **Green Meetings Industry Council (GMIC); <http://gmic.eu/>** — The Green Meetings Industry Council issues a formal event policy for Sustainable Meetings and Conferences that incorporates multiple sustainable standards for sustainable meetings and events.

What do you need to ask?
<p><b>Working on green and smart campus AV projects leads to several questions:</b></p> <ul style="list-style-type: none"><li>• What is the project certification scheme and level?</li><li>• Will the selection of components be influenced by component or product level rating or energy performance?</li><li>• What other building factors are influenced (e.g., acoustics, daylighting)?</li><li>• Does the project involve a smart building environment? Is it limited to building automation systems (BAS) or is more comprehensive than that?</li><li>• Is there a design member who's associated with smart building responsibilities?</li></ul>

### 6.2.2 Product Certification

TCO Development established the TCO Certified sustainability certification for IT products. In addition to IT products that TCO has certified for sustainability for twenty years, TCO also certifies AV equipment including projectors and displays.

Learn more about TCO's commitment to sustainable AV from the “Spotlight on TCO: Certifications for Performance & the Environment” blog post.

Another certification used by AV service providers is GREENGUARD Certification (<http://greenguard.org/en/index.aspx>). Part of the Underwriters Laboratories (UL) business unit UL Environment, this certification helps manufacturers create and buyers identify interior products and materials with low chemical emissions to improve the air quality in environments where the products are installed and operated.

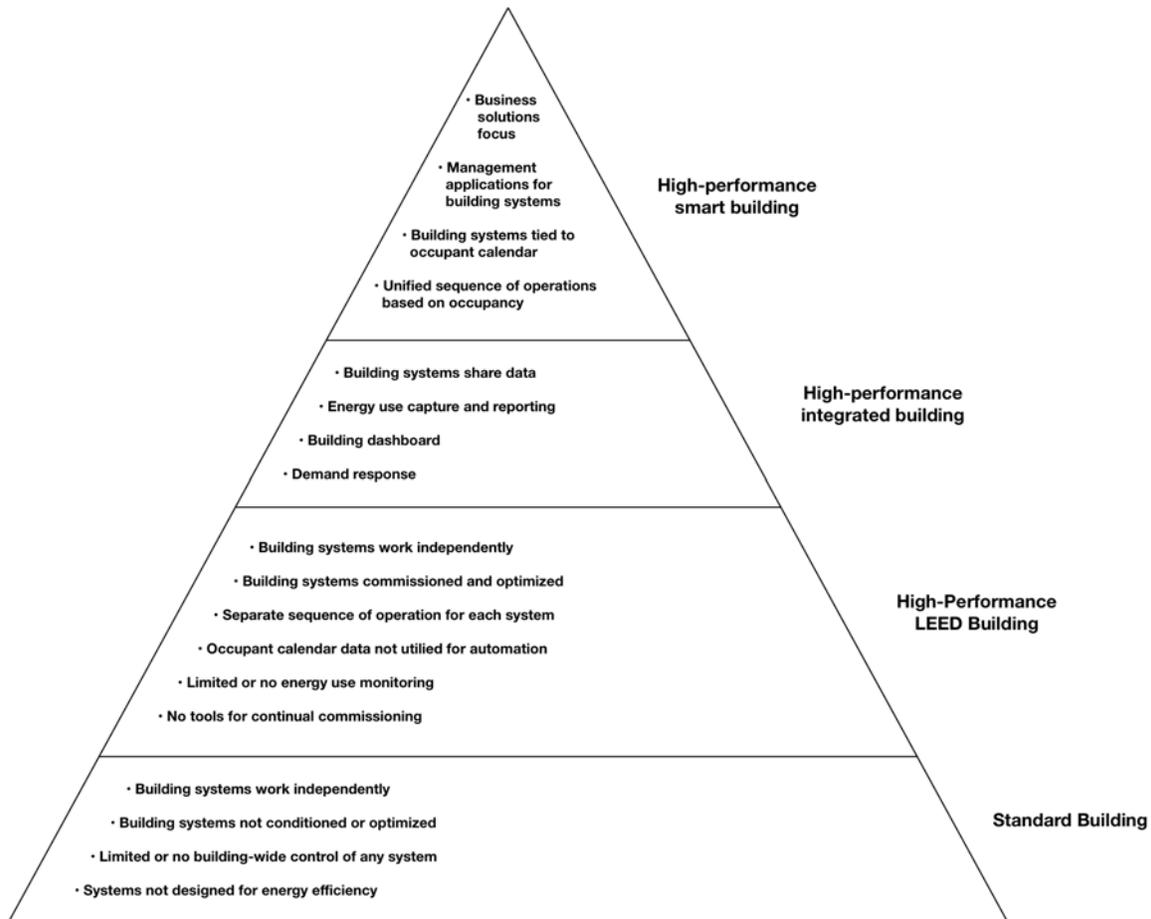
### 6.3 Smart Buildings

Over the years, the AV industry has attempted to be involved in smart buildings with some success. Smart buildings are a paradigm shift that will become a more substantial part of the AV industry's future and will require differentiation in how projects are designed and executed. Smart building systems now integrate a myriad of disparate systems within a building into a cohesive building automation system (BAS) that allows each system to do what it is intended to do, whether it is to provide light, water, energy, HVAC, access, Internet, TV, telephony, fire and personal safety,

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

security, monitoring, information, or communications. In smart buildings, all building systems are coordinated and intelligently and automated through shared sensor networks and feedback systems.

Building systems are integrated into major data structures and enterprise management systems structures and enterprise management systems. Such a platform allows predictive management and maintenance of physical and logical systems. Figure 5.1 shows the progression of buildings from standard buildings to the high-performance smart buildings possible today.



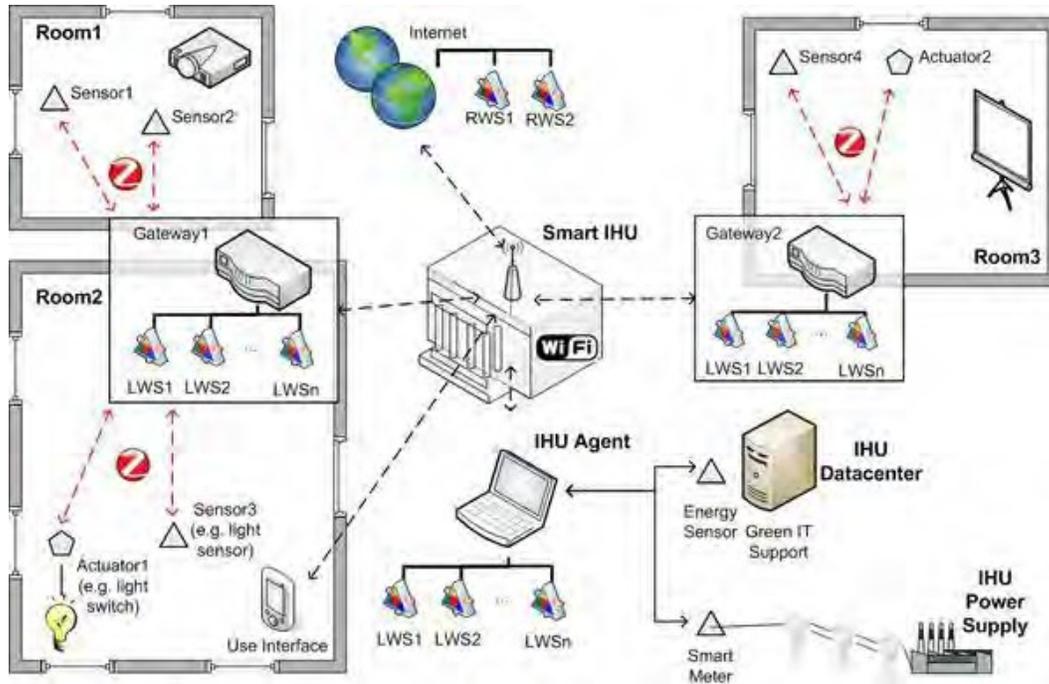
**Figure 21 – Evolution of smart buildings**

This move toward smart buildings has affected the role and training of AV professionals. AV consultants and integrators may be required to:

- Understand features of building technology systems, including related information communication technology (ICT) and smart building technology
- Plan equipment lists, power/heat load requirements and budgets for integrating AV systems into smart buildings
- Coordinate their work with smart building managers or other staff responsible for the smart building's daily management
- Coordinate their work with the IT or data science experts responsible for smart-building analytics, including fault detection and diagnostics, preventative maintenance, predictive maintenance, and system optimization

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

The concept of smart buildings is not quite ubiquitous in higher education, but such implementations are on the rise. Given the expected growth and development of smart building systems, it would be beneficial for higher education tech managers to keep up with the latest developments in that realm. Figure 22 shows an ongoing **smart university** project at the International Hellenic University (IHU) in Greece.



**Figure 22 – Architecture of a smart university system (retrieved from the [Smart IHU Project Website](#))**

The purpose of this system is to aggregate the energy usage data of the building, facilitate an interactive platform for remote monitoring and management of the building's smart devices, and improve the buildings' intelligence through the improvement of automation system interoperability. The project intends to incorporate wireless sensor networks, integrate wireless platforms using semantic web services, and develop algorithms for control of smart devices and energy management.

The AV industry is well versed in the advantages and pitfalls of integrating disparate systems. Typically, AV systems do not come from a single manufacturer. Even if a single firm installs all of the AV systems for a project, the various products may come from dozens of different manufacturers and then must be integrated by the AV installer. That makes AV professionals well suited for integrating systems into smart building environments.

## 7 Accessibility

This section covers:

- Accessibility compliance, including both common legislative and institutional issues.
- Assistive-listening devices.
- Assistance for the visually impaired.
- Mobility considerations, such as accessible furniture and control panels.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Accessible emergency systems.

For purposes of this document, accessibility describes the provisions AV professionals and other project team members make by design, or through the addition of special subsystems, to accommodate people with disabilities. The goal is to provide them with a learning/teaching experience similar to that of people without sensory or mobility impairments.

There are substantial legislative and regulatory requirements pertaining to accessibility. In the United States, many of these provisions are covered under the Americans with Disabilities Act (ADA) – <https://www.ada.gov/> - and in Europe the European Accessibility Act – <http://www.edf-feph.org/european-accessibility-act-1> - but AV designers need to be aware of other obligations as well. Higher education institutions commonly have their own standards for equipment and design to ensure that students can use the same tools and aids wherever they are on campus. Internationally, where ADA does not apply, accessibility provisions may be covered under special legislation or, increasingly, in mainstream national or local building codes, standards, and regulations.

Some aspects of AV system design are intended specifically to meet accessibility requirements. Of these, the best-known AV systems for enabling accessibility are assistive listening devices, components of an audio system that allow students with hearing limitations to participate more fully in the teaching and learning process. However, accessibility should be considered in other aspects that bear on the AV design, including allowing for the operation of AV systems by those with mobility impairment.

### 7.1 Compliance

Accessibility compliance is ensured through fulfillment of requirements stated in regional and international standards and regulations.

In the United States, the Americans with Disabilities Act (ADA) was signed into law in 1990. The goal is to remove barriers and provide people with disabilities accommodation equal to or like that available to the general public. The ADA provides a framework for the many codes and standards that apply in the United States.

Internationally, other standards apply to accessibility, and AV designers and contractors must familiarize themselves with relevant provisions of the local legislation and building codes before commencing system design. One such standard is the United Nations' Convention on the Rights of Persons with Disabilities. (<https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html>)

Most countries now have specific legislation that requires AV systems installed in public spaces, including educational institutions, to include components such as assistive listening devices and to provide for students whose mobility or vision may be impaired.

Most universities and colleges have a department or office to assist students with disabilities. Usually, they have a role in providing guidance on acceptable accessible technology and sometimes in the approval of these systems. These departments may have a variety of titles, such as Office for Students with Disabilities, ADA Compliance Office, and Equity Office, or they may be part of a larger student services department.

Before specifying any accessibility equipment or systems, such as hearing loops, it is wise to refer to international standards and contact the relevant office to determine any standards or specifications that may be mandated for the institution. In most cases the university AV department will be aware of the campus requirements and will be able to assist in contacting the correct person or be able to provide copies of the local requirements and specifications.

In most educational settings, accessible technology systems are standardized across the campus, so students do not need to adapt to different systems in different classes.

### 7.2 Assistive-Listening Devices and Captioning

The requirement to provide assistive-listening systems in educational facilities is now almost universal in the United States under the ADA, and it is very common in countries around the world. Nonetheless,

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

compliance provisions and the details of what must be provided to meet accessibility requirement vary; therefore, local legislation regarding access must be considered when designing audio systems for classrooms and lecture halls.

There are several ways in which hearing assistance can be provided. The main technologies employed are:

- Radio frequency (RF) transmitters and portable receivers (sometimes called frequency modulated [FM])
- Infrared (IR) emitters and receivers
- Inductive loops

Each technology has its own set of advantages and disadvantages. Sometimes, more than one system may be in use. As noted above, most institutions will have a set of specifications that define the way assistive-listening systems must be provided and these must be considered in association with the relevant legislation and building codes.

### 7.2.1 RF Systems

Low-powered radio transmitters, matched with portable radio receivers, are common system in the United States. The transmitters are installed within the AV equipment rack and connected to the output of the PA and program sound systems. The antenna can be installed in the rack or lectern. Students requiring hearing assistance are issued personal receivers. This option has the least impact on the design and construction of learning spaces.

Alternatively, students needing assistive listening systems can be loaned a portable RF system. With this approach, the student carries the system to class and hands a wireless microphone to the instructor, requesting that it be used. This approach presents several issues and may not be acceptable on some campuses.

Even low powered RF-based systems can be prone to interference between rooms, so frequencies must be carefully coordinated.

### 7.2.2 Infrared Systems

Infrared technology is an alternative to RF assistive-listening equipment. Infrared systems operate based on line-of-sight (transmitter and receiver must be able to “see” each other) and confines the signal to the room, which ensures information privacy.

Infrared emitter panels are mounted in the room and students can be issued personal receivers that are equipped with headsets or neck-loops. The wall or ceiling mounted emitter panels can be seen as obtrusive and may not fit the aesthetic goals of some projects. Best practice is to coordinate the appearance and locations with the architect.

The IR signal has an advantage in that it is contained by a room’s walls and thus room to room interference is less likely. Inherent to this, there may be less need for students to use different IR channels or devices as they move to different room/locations.

As for RF and IR systems, the issue of receivers is often managed by the university disability support office, but, in some jurisdictions, legislation mandates how many receivers must be supplied, based on the capacity of the room.

### 7.2.3 Inductive Loops

Internationally, a common assistive technology is an inductive-loop system, which allows audio reproduced through the PA to also energize a wire loop, usually installed under floor coverings around the perimeter of the room or another design to ensure coverage. People with a hearing disability can enable their own hearing aids, which are fitted with a special telecoil (T-coil) switch, to receive the audio from the loop providing clearer reproduction of the sound. The advantage of inductive-loop technology is that it does not require issuing a special receiver. The student (or anyone with a hearing

aid who uses the space) can discreetly use their own listening equipment (if it supports “T-coil” function), which is optimized for their particular hearing abilities.

Technically, inductive-loop systems have some inherent disadvantages. Because the loop typically needs to be installed under floor coverings, they are difficult to retrofit. Also, like RF systems, they are prone to interference between rooms — either adjacent rooms or rooms above or below, in the case of multistory buildings. Special loop design utilizing dual transmitter loops is needed to minimize this problem.

The shape of the wire loops and their positioning in the room is crucial to the effectiveness of the system. Installation of the loops may require modification to floor slabs or otherwise impact construction, carpet installation, furniture installation, and so on. Best practice is to consult the equipment manufacturer and have them design the layout of the loops, based on the floor plans. This should be done early in the design process.

### **7.2.4 Captions**

In cases of video recording/streaming and/or content playback captioning (where the audio channel is converted to text and overlaid on the video) may be required. The methods of doing so differ depending on whether it's for an origination (say live stream of a campus event) or whether it's for an individual's ability to have the embedded captions exposed for viewing during playback. Refer to both ADA and local campus standards for requirements.

### **7.3 Visually Impaired Assistance**

AV design in higher education should accommodate visually impaired students with both room and technology adjustments. Depending on the type of visual disability, students may need to be able to sit in the front, the sides, or the back of the classroom, so the room design needs to allow space for movement of students with walking sticks and dog guides. The space should have clear traffic paths and be free of clutter with cabling out of the way and rugs securely fastened. The design should also consider a proper contrast in furnishings, walls, and floors.

Lighting control for both ambient and task lights is also an important factor due to the impact of glare and intensity on impaired human vision. Technology to assist visually impaired students is sometimes required in media labs or where public access computer are provided. Such technology typically includes screen magnification and readers. Magnification devices may require outlets, which should also be accounted for in the room design. Advice should be sought from the disability support office if these technologies are required.

### **7.4 Furniture to Support Accessibility**

Accessibility must include the needs of both students and teachers. Accessible tables and seating in classrooms need to comply with codes and laws.

#### **7.4.1 Student Furniture**

Here are some examples of student furniture that may meet accessibility requirements:

- Fixed seating areas may require accessible wheelchair seating positions distributed in each room according to the capacity of the room.
- Fixed tables and loose chairs, or fixed seating with tablet arms, should ensure that minimally 36 in (91.4 cm) of clear floor space is provided behind the table for access.
- Adjustable-height tables can be provided.

#### **7.4.2 Lecterns**

Lecterns in accessible learning spaces also require special consideration with respect to AV. For example:

- All access to controls, peripherals, and ports (USB, audio, and media) should be between 15 and 48 in (38.1 and 121.9 cm) from the finished floor and 20 and 25 in (50.8 and 63.5 cm) from the center of where the person's lap is expected to be.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- A lectern must have at least 60 in (152.4 cm) of space between it and the fixed structure behind it. A lectern should also provide a forward approach that is at least 30 in (76.2 cm) long, and a maximum of 36 in (91.4 cm) from the floor.
- Knee and toe space also are required.

A pedestal-style lectern in an accessible learning space should have a table or a collapsible shelf that is an acceptable height (28 to 34 in [71.1 cm to 86.36 cm]), with proper approach clearance space.

Designers should also provide an adjustable monitor or a second monitor that can be viewed when sitting at the shelf or table.

### 7.5 Touch Panel Heights

Control panels in accessible learning spaces that are used to operate the equipment in a podium or in the room should follow accessibility guidelines as follows:

- Wall-mounted panels need to be reachable and viewable by persons in wheelchairs, according to ADA sections 308.2 and 308.3.; <https://www.ada.gov/regs2010/2010ADASTandards/2010ADASTandards.htm>; <https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/ada-standards/chapter-3-building-blocks>
- Podium-mounted panels should be reachable and viewable according to the specific space and user requirements.

### 7.6 Emergency Notification

Where a separate mass notification system is fitted, the AV system in the room must be equipped with a mute function, triggered by the mass notification system.

In an emergency, the room sound system must mute so that occupants can clearly hear emergency announcements made through the mass notification loudspeakers (that may be part of a separate system).

This is arranged either through a relay circuit that interrupts the signal to the AV loudspeakers, or by a signal from the mass notification system triggering a mute command from the room AV control system.

Where an assistive-listening system is installed, arrangements should be made to send the emergency announcements to the transmitters or loop as soon as an alarm is triggered so people using the assistive-listening system can clearly hear the announcements.

It is a common requirement that emergency-alert systems be equipped with a visual display, as well as an audio tone or announcement. This can take the form of a strobe or flashing indicator, or it can be more sophisticated, such as a digital signage system, which can display emergency messages as text. In some situations, all projectors and monitors may be required to automatically switch over to display evacuation or alert messages when alarms are triggered.

The following is a list of actions to complete to ensure accessible AV design for higher education.

**Table 5 – Accessible AV design actions**

Component	Action
Legislative framework	<ul style="list-style-type: none"> <li>• Check compliance with all relevant legislation (ADA or other).</li> <li>• Confirm Institutional policies and standards for accessibility.</li> </ul>
Assistive listening systems and captioning	<ul style="list-style-type: none"> <li>• Provide RF, IR or inductive loop transmission (compatible with existing institutional standards and norms) for all microphones and program sources in teaching spaces. Where required, provide sufficient receivers.</li> </ul>

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Component	Action
	<ul style="list-style-type: none"> <li>• Check requirements for video origination and/or playback.</li> </ul>
Visually impaired	<ul style="list-style-type: none"> <li>• Check requirements for text magnification systems or software.</li> </ul>
Accessible furniture	<ul style="list-style-type: none"> <li>• Check instructor workstations and required number of student seats are accessible by users with mobility impairment or in wheelchairs.</li> </ul>
Controls	<ul style="list-style-type: none"> <li>• Check equipment and control panels can be operated by users with mobility impairment or in wheelchairs.</li> </ul>
Emergency notifications	<ul style="list-style-type: none"> <li>• Check audio muting requirements when alerts are triggered</li> <li>• Check requirements to connect emergency alert tones and announcements to assistive listening systems</li> <li>• Check requirements for captioning or alert text to be switched to projectors, monitors, and digital signage</li> </ul>

## 8 Processes

### 8.1 Project Planning and Coordination

Most successful projects include a series of planned and coordinated processes that help ensure its success throughout the project lifecycle. These processes will carry through all phases of the project and will identify all project-related tasks and who is responsible for each task. Clear and consistent communication between all team members, both internal and external, plays a vital role in any project. This can be achieved by holding scheduled meetings during all phases of the project and would include:

- User needs assessment to understand how the space will be utilized and what teaching methods will be employed
- Technology meetings to understand the requirements of the technical needs
- Design coordination meeting to manage the design efforts and progress with the design team and client
- Pre-bid meetings to review scope with potential contractors if bidding is required
- Pre-construction meeting to review scope of project with all responsible parties
- Construction meeting(s) to review progress of project and address issues found onsite
- Post-construction meeting to review project and close out
- Ongoing maintenance and user support requirements

A proper AV/IT design should be aligned with other relevant plans and initiatives on campus. Some examples are:

- Strategic technology plan
- Technology standards documentation
- Facilities master plan
- Academic plan

Most of this information can be gathered during the startup meeting in the program phase of the project. This would be the first meeting to discover important factors such as how the users want to operate the equipment and what the expectations of the space will be.

#### 8.1.1 Project Phases

Everything that takes place in a project from beginning to end is known as the project lifecycle. The lifecycle connects the multiple phases of the project to ensure a smooth transition from start to finish

**AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION**

(figure 23). AVIXA D401.01, *Standard Guide for Audiovisual Design and Coordination Processes*, describes in detail the definition and coordination of processes, resources, and responsibilities of the design and installation project teams.

AV Systems Design								
Project Processes	Needs Analysis	Program Report	Schematic Design	Design Development	Construction Documents	Construction Phase	Verification	Support Phase
Consultant Processes	✓	✓	✓	✓	✓		✓	
Integrator Processes	✓	✓	✓	✓	✓	✓	✓	✓
Tech Manager Processes	✓	✓	✓	✓	✓	✓	✓	✓

**Figure 23 – AV systems design project phases by role**

**8.1.2 Project Planning and Coordination Meetings**

Projects can be broken down into three phases: program, design, and construction. Each phase begins with a startup meeting that brings all responsible parties together to discuss that phase. These meetings are a time to gather all related information and ensure all aspects of that phase are covered and have been assigned to the appropriate party.

**8.1.3 Program Phase**

This phase has two goals, to identify the needs of the user — a needs assessment — and to propose a narrative solution to support the user’s needs — a program report. It is important to clarify and understand the needs, expectations, and goals of the owners to lead the design team in developing a functional space that meets or exceeds those expectations. During this phase, a needs assessment will be performed to determine more specific details on the project that could affect the design effort. This analysis may include:

- Interviews with end users, IT, facilities, and more.
- Surveys of existing facilities.
- Inventories of existing equipment.
- Discovery of additional project requirements (e.g., existing facility guidelines).

Based on the needs analysis, a program report is created that describes the specific needs, system functionality and probable cost. This report would include:

- **Executive summary** — Overview of the project.
- **Space planning** — Addresses special needs of the AV system (e.g., equipment closets, projection rooms).
- **Systems descriptions** — Nontechnical description of the owners desired functionality for each system in the space. This may include sketches, pictures, or anything that would help explain the use and layout of the space.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- **Infrastructure considerations** — Description of all infrastructure-related items required to support the AV systems. This would include electrical, structural, voice/data, mechanical, lighting, acoustical and architectural.
- **AV budgets** — Discusses probable costs along with possible additional costs and contingencies.

The program report will be distributed to the appropriate stakeholders for approval and may take several rounds to finalize. Once this report has been approved, it will become the basis for the design phase of the project.

### 8.1.4 DesignPhase

The purpose of this phase is to document the requirements needed to meet the owner's expectations or needs. These requirements would include functional, physical and design. Like the program phase, this phase would also produce important and critical documentation needed to get the project moving successfully. Such documentation would include:

- **Architectural and infrastructure requirements** — Documentation and drawings that show how the AV equipment will be integrated with the building and other technologies. This will indicate locations of equipment as well as any specific needs for each device.
- **AV system documents** — Specification and drawings that detail the performance requirements, equipment lists, and connectivity of all devices. This would also include all processes that will be used throughout the lifecycle of the project, such as installation, testing, training, and warranty information.

During the design phase, all aspects of the project will need to be considered. Some examples of these would be, but not limited to:

- Projection and viewing sightlines
- Equipment locations
- Mill craft (joinery) and furniture
- Disability access
- Finishes
- Seating
- Lighting
- Acoustics

It is important to ensure that all design team members understand requirements of the AV/IT systems so that all systems can be integrated without overlap or conflict. To facilitate this, the following drawings will be needed:

- **Design drawings** — These documents include standard keys or legends, schedules, tables, and notes relating to the AV systems. Again, the AV design drawings should conform to the overall project document format.
- **Facilities drawings** — Details the specific locations for all AV/IT systems equipment that will be placed in the facility, along with the infrastructure required to support those systems. These will likely include floor plans, reflected ceiling plans, conduit risers, select elevations, and architectural integration details. Illustrated will likely be:
  - Projection screen and display schedules
  - Cable pathways (i.e., conduits, cable trays, back boxes and in-floor raceways)
  - Power requirements
  - Data locations
  - Technical furniture locations
  - Installation details

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Connections to facility systems such as lighting systems, window treatments and HVAC systems

Some of these elements may be drawn by the AV designer to facilitate communication among the design team members. The architect, electrical engineer, IT designer, and others may decide to reflect the same information on their drawing sets or reference the AV drawings from their drawings or a hybrid of both approaches.

- **AV system drawings** — Detail drawings for specific systems showing major system components, system interconnectivity, and signal flow. This would also include elevation drawings for equipment racks and any specialized details that would need to be noted, such as specialized plates and connectors

### 8.1.5 Construction Phase

Bringing together all the documents created in the program and design phases, the construction phase produces more detailed documentation to be used for procurement and installation. This would include equipment schedules for the ordering of equipment and drawings to be used in the field, known as shop or installation drawings. This phase brings together three main aspects required to successfully install the equipment that has been designed in the project: procurement, coordination, and installation.

### 8.1.6 Verification and Training Phase

As the project ends, it is imperative that a verification report be completed in order to show that the system complies and performs to the expectations defined in the project scope of work. That can cover a tremendous amount of ground.

It is recommended that everyone connected with the design, installation, and operation of the AV system become familiar with and use AVIXA 10:2013, *Audiovisual System Performance Verification Guide* to delineate the many key points to consider, check, or test along the road to delivering a successful AV system. Figure 24 shows part of a sample verification checklist.

**AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION**

Question	Response	Details
<b>Audio Performance</b>		
Verification items within this category verify the audio system's performance, stability, and conformance to requirements provided within project documentation. Project-specific verification items that address capture, transformation, or reproduction of program audio or voice; audio signal management; acoustic environment; and loudspeaker operations shall be listed in this section.		
<b>AP-100 – Emergency Muting</b>	No	Not working, no fire alarm cable / interface installed.
Verify that any required muting or operational change of the installed sound system(s) has been made in accordance with local regulations in the event of a life safety or similar emergency.		
<b>AP-101 – Loudspeaker Zoning</b>	Yes	
Verify that loudspeaker zones are wired as defined in the project documentation.		
<b>AP-102 – Alignment of Multiple Audio Source Levels</b>	Yes	
Verify calibration of permanent audio system inputs such that the difference between any input signal level after the first common gain adjustment meets the requirements of the project documentation. This verification item should require a metric to be verified.		
<b>AP-103 – Audio Buzz and Rattles</b>	Yes	
Verify that no audible noise caused by improper installation of any equipment provided in completed system(s) is present.		
<b>AP-104 – Audio Routes</b>	Yes	
Verify that all audio routes are tested from endpoint to endpoint via the appropriate midpoint(s) for operation and routing as defined in the project documentation.		
<b>AP-105 – AV Room Reverberation Time</b>	Yes	
Verify reverberation time meets the requirement defined in the project documentation. This verification item shall require a metric to be verified.		
<b>AP-106 – DSP Programming</b>	Yes	
Verify that all DSP-based products have been programmed as defined in the project documentation.		
<b>AP-107 – Loudspeaker Physical Alignment</b>	N/A	
Verify that loudspeakers are placed and aimed as defined in the project documentation.		
<b>AP-108 – Loudspeaker Polarity</b>	Yes	
Verify that all loudspeakers have correct polarity as defined in the project documentation.		
<b>AP-109 – Loudspeaker Time Alignment</b>	N/A	
Verify that loudspeaker time alignment performs as defined in the project documentation. This verification item shall require a metric to be verified.		
<b>AP-110 – Phantom Power</b>	Yes	
Verify that phantom power is provided at the correct voltage and correct locations as defined in the project documentation.		
<b>AP-111 – Loudspeaker Transformer Tap Setting</b>	Yes	
Verify the loudspeaker transformer tap setting in constant voltage systems is as defined in the project documentation.		
<b>AP-112 – Acoustical Ambient Noise</b>	No	HVAC noise, balancing issue?
Verify that the background acoustic noise levels within audiovisual spaces are within the required limits as detailed in the project documentation. This test is specifically related to ambient noise levels and not audio system quiescent noise, which is tested separately. This verification item shall require a metric to be verified.		
<b>AP-113 – Assistive Listening Devices</b>	Yes	
Verify that all devices that are part of the assistive listening system have been tested as a complete end-to-end personal listening system. Verify that the assistive listening system complies with regulatory requirements and adheres to project documentation. This verification item should require a metric to be verified.		
<b>AP-114 – Audio Coverage in Listener Areas</b>	Yes	
Verify that coverage of the audio systems in listener areas meets the performance requirements as defined in the project documentation. ANSI/INFOCOMM 1M-2009, Audio Coverage Uniformity in Enclosed Listener Areas should be used. Perform separate tests for all independent systems within the project, including but not limited to program sound, speech reinforcement, and show relay. This verification item should require a metric to be verified.		
<b>AP-115 – Audio Dynamics</b>	Yes	
Verify use of audio dynamics, including but not limited to noise compensation, automatic gain control, gating, feedback suppression, compression, limiting, delays, and levelers meets the requirements defined in the project documentation.		
<b>AP-116 – Audio Level Exceeds Background</b>	Yes	

**Figure 24 – Sample completed verification list (AVIXA 10:2013, *Audiovisual System Performance Verification Guide*)**

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Training is another area that is often missed or given short shrift during a classroom construction project. It is always one of the last things scheduled to happen — just as everybody is in a rush to wrap up and move to other projects. Complicating this is the fact that what training entails must be spelled out in the scope of work — months prior on the front end of the project. It falls upon the clients/end users to do their due diligence here. AV designers should have a clear idea of what they need when the project wraps and get it in writing. If it is not written down, then it might not happen.

### 8.1.7 Roles and Responsibilities

There are several tasks related to AV/IT to be accomplished to result in a successful project. Depending on the scope of the project, these tasks can range from a few hours of work for one individual to thousands of hours of work for a team of professionals.

Some institutions may choose to do a large portion of the tasks with in-house staff. These tasks might include the definition of project requirements, infrastructure design, systems design, specification, bidding, coordination with other trades, installation, software programming, construction administration, and the overall project management for the AV/IT portion.

Completing these tasks in-house is not simply a matter of being well versed in AV equipment. A successful AV/IT project often requires knowledge and skills in related areas such as the architectural process, building construction, acoustics, lighting, and the ability to work in building information modeling software.

Other institutions may choose to outsource the AV/IT tasks to an outside firm or firms. Choosing to outsource is not a reflection of the knowledge base or skills sets of the campus staff but often a reflection of the capacity of the existing staffing level, the complexity of the project, desire for an outsider perspective, and/or general philosophy of the institution.

Of course, there is a hybrid approach as well, striking a balance between relying on campus resources for select tasks and outsourcing select tasks and relying on campus resources for the balance of the project.

What do you need to ask?
<p>The following questions should be asked when considering training needs:</p> <ul style="list-style-type: none"><li>• Who will do the training?</li><li>• Who will the training be for? Multiple units?</li><li>• What aspects of the system or specific equipment will it cover?</li><li>• How much training is expected?</li><li>• Will training happen during normal working hours? In person?</li><li>• Will any training material or documentation be provided?</li><li>• Does the trainer need to have some type of industry or manufacturer certification?</li><li>• Will training involve sending university personnel to the manufacturer's training?</li><li>• Is there an option for further or follow-up training later?</li></ul>

### 8.1.8 Defining the Team

A successful project requires the coordinated efforts from a well-defined team of individuals with specific roles and responsibilities related to that project. This team can be comprised of both internal resources as well as external resources. These resources should be identified at the beginning of the project to ensure all aspects of the project are covered and all responsible parties have a clear understanding of their roles and responsibilities. These resources may include many different examples categorized under internal and external resources.

### 8.1.8.1 Internal Team

For successful completion of any project, customer buy-in is imperative. Value is added by looking at all aspects of the scope that can be heightened by hearing from all the voices in the room. Note that some of these may be interchangeable — similar roles can be found on the internal or external teams, as well as on both teams. Continuous interaction among the desired members will help to support the successful completion of the project.

When recruiting the internal and external teams, please keep the listed stakeholders in mind.

The internal team from higher education will include the following but is not limited by any means.

- **Senior administration (i.e., dean, vice dean, board of trustees)** — This group is typically responsible for setting the vision for the project.
- **Project manager** — This is an important member of the internal team. The project manager will have the ultimate responsibility for making sure that all groups are represented, and the project is completed on time and within budget. The project manager is the coordinator, and most correspondence among the internal team members will be routed through this role. This person may work for the facilities management department or be hired just for a specific project by the school. An individual with AV/IT technology management may act as a secondary project manager – handling the technology aspects in coordination with the facilities PM.
- **Building committee** — This group is the primary interface group that makes final decisions and can be a combined team from any of the groups below.
- **Facilities staff** — This group traditionally includes the project manager named by the institution, who is the primary communication conduit for the external team, which is mainly the architect. They also have valuable insight to previous projects regarding successes and failures of design, installation, and operation.
- **Faculty, curriculum staff, instructional designer and classroom committee** — This group can give valuable input on how the space will be used. For example, it can help determine whether the space will be used by just one department or many, need moveable or static fixtures, who will schedule the space, whether it needs a uniform look, and other necessary information.
- **Technology staff** — This team consists of both AV and IT members. Depending on the organization, it may be formed differently. For example, IT may be involved with the specific requirements for voice and/or data services for equipment. The AV members will traditionally be involved with classroom applications, AV systems and how or what needs to be connected. This group will give input on the network plans, AV plans, and standardization of design. They also are usually aware of emerging technology trends in education.
- **Students** — Allowing students to assist in the design will lead to the most cost-effective use of the space. In the end, they are our ultimate end users. Students offer a completely different perspective from faculty or staff when planning classrooms. They can identify things that only those who spend several hours a week in the space can identify, such as the lack of a clock, obstructions in the view to the instructor, or acoustical or lighting issues.
- **Instructional designer** — They are traditionally responsible for developing educational materials either individual courses or entire curriculums. Considering that they are quite knowledgeable in all that goes on in a learning space, the instructional designer will be a most valuable member of the project team. Unfortunately, the instructional design perspective, either internal or external to campus, is often overlooked when assembling a team.
- Other team members may include:
  - **Registrar** — A lot of design decisions are based on the seat counts for various classrooms depend on the class information from the registrar.
  - **Procurement office** — This group is responsible for the bidding process for the project.
  - **504 compliance officer/disability support** — The higher education institution is held to specific guidelines. It is valuable to have this group involved at the beginning of the process to avoid costly changes further in the project.

### 8.1.8.2 External Resources

Just as there are multiple approaches to project delivery, there are multiple ways to assemble teams to match the delivery model. However, typically, external resources to consider may include:

- **Architect and their design team** — The architectural firm or firms work with the entire team to incorporate all trades and designs into the project. This may include traditional engineering disciplines such as civil, structural, electrical, mechanical, and plumbing, as well as specialized consultants, such as acoustics, food service, lighting, accessibility, historic renovation, and, of course, AV/IT.
- **General contractor and subcontractors** — The general contractor (GC) takes the overall responsibility for performing and coordinating the completion of all building construction-related activities for the project. Typically, the GC will hire a group of subcontractors such as the electrical contractor, mechanical contractor, and drywall contractor. The GC may also have specialty contractors for select low-voltage systems such as structured cabling, as well as building security and sound masking. Typically, the AV/IT systems are contracted directly to the institution rather than through the GC.
- **Traditional engineering consultants** — The architect typically contracts a number of firms to provide specialized expertise in traditional engineering disciplines.
- **Other specialty consultants** — Depending on the project type, the architect may employ specialty consultants to design elements such as security systems, food service equipment, door hardware, historic preservation, science lab equipment, and faculty development.
- **AV designer(s)** — This firm defines, documents, and coordinates all requirements of the AV systems and associated infrastructure for the project. This may be an independent consultant firm that does not also sell or install equipment or an AV systems reseller and installer.
- **AV contractor or systems integrator** — This firm supplies and installs all AV needs for the project. The firm may be selected early in the process to assist with the building and systems design or may be added later in the process, after the building and systems design has been completed by others.
- **IT/structured cabling designer** — This firm defines, documents, and coordinates all requirements of the IT/structured cabling systems and associated infrastructure for the project. This may be an independent consultant firm that does not also sell or install equipment, or it may be an IT/structured cabling systems reseller and installer.
- **Structured cabling contractor** — This firm supplies and installs all structured cabling systems to support voice/data/video networks needs for the project. This work may be included within the scope of work of the electrical contractor or part of a standalone contract to the institution. This same contractor may also supply and install network electronics such as network switches, routers, servers, and telephones.
- **Other technology contractors** — These firms supply and install other technology systems in the building, such as security, sound masking, and emergency communications. As with the AV contractor, these contractors may be selected early in the process to assist with the building and systems design or added later in the process, after the building and systems design has been completed by others.

### 8.1.9 Establishing Responsibilities

Once all responsible parties for the project have been identified, the assignment of specific tasks to each party will need to be documented. Examples of the tasks related to the AV/IT systems are listed in table 6.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

**Table 6 – Responsibilities by phase**

Note: In this example, responsible parties are not assigned.

Phase	Task
Planning and programming	<ul style="list-style-type: none"> <li>• Needs analysis</li> <li>• Physical or virtual benchmarking</li> <li>• Literature review/search</li> <li>• Existing campus plans analysis</li> <li>• Research on emerging technologies and pedagogies</li> <li>• User interviews</li> <li>• Narrative descriptions of the various spaces and systems</li> <li>• Budgeting</li> </ul>
AV and IT infrastructure	<ul style="list-style-type: none"> <li>• Room geometry, layouts, sightlines, and adjacencies</li> <li>• Cable pathways and technical requirements</li> <li>• Architectural integration and aesthetic requirements</li> <li>• Coordination with other design disciplines</li> </ul>
AV and IT systems	<ul style="list-style-type: none"> <li>• Conceptual design and budgeting</li> <li>• Detailed design and budgeting specification</li> <li>• Supply</li> <li>• Installation design and specification</li> </ul>
AV and IT integration planning	<ul style="list-style-type: none"> <li>• Network security</li> <li>• IP addressing and network layout</li> <li>• Physical location of equipment (sharing of IDF closets)</li> </ul>
Lecterns, operator consoles, and other furnishings	<ul style="list-style-type: none"> <li>• Design and/or selection</li> <li>• Supply</li> <li>• Installation and modification</li> </ul>
Control systems	<ul style="list-style-type: none"> <li>• Layout of user interface</li> <li>• GUI flow and user needs</li> <li>• Programming, installation, testing, and debugging</li> <li>• Training</li> </ul>
Construction administration	<ul style="list-style-type: none"> <li>• Shop drawings</li> <li>• Submittal reviews</li> <li>• Infrastructure reviews</li> <li>• Coordination, scheduling, and planning</li> <li>• Final checklist and acceptance testing</li> </ul>
Installation	<ul style="list-style-type: none"> <li>• Definition by specific system</li> <li>• Cable pulling and labeling</li> <li>• Physical installation</li> <li>• Configuration, tuning, and optimization</li> <li>• Testing and troubleshooting schedule</li> <li>• Coordination with other trades</li> </ul>
Training	<ul style="list-style-type: none"> <li>• End user training</li> <li>• Support staff training</li> <li>• Training documentation</li> </ul>
Service and maintenance	<ul style="list-style-type: none"> <li>• Instruction for placing service calls</li> <li>• Maintenance plan and proposed schedule</li> </ul>

**8.2 ProjectSchedule**

Every successful project begins with a complete and planned schedule. The project schedule includes timeframes for specific tasks and milestones to ensure the project stays on track with the preset schedule. This schedule provides an overview of the entire project status and then breaks down into layers with more specific details such as trades and resources. The following are some of the project schedule activities:

- **Selecting and hiring the architectural firm** — This would include the process of selecting the architect for the project as well as the resources they will bring, such as the general contractor.
- **The design schedule** — In the design phase of the project, many trades will need time to develop the design for the system(s) they will be providing. This time will need to be accounted for in the schedule because work cannot begin without the proper design in place.
- **Construction schedule** — This will reflect the onsite work performed by the technology integrator and the time frames for this work to be performed.
- **Installation schedule** — This schedule will include the coordination between all trades to ensure certain dependencies are in place before the next task begins. For example, the ceiling must be installed before the loudspeakers can be installed in the ceiling tiles. This schedule will also include coordination with the school schedule and working with class schedules as well as semester breaks.
- **Project closeout activities** — This would include the scheduling of training for end users as well as support staff. All project documentation will be scheduled during this time as well as a checklist for any items that may need to be addressed based on functionality or the physical install.
- **Post-occupancy review** — The operation of the system is reviewed once the end user has occupied the space and used the system as defined at the beginning of the project.

The following is an example of an AV provider’s scope of work checklist.

**Table 7 – Scope of work checklist**

<b>AV Provider Scope of Work Checklist (Example)</b>	
AV System Programming Services	I Prepare preliminary program questions I Conduct an AV program meeting I Prepare an initial AV program report I Prepare preliminary opinion of probable costs for the AV systems I Conduct an AV program review meeting I Modify the program document if required I Attend (x) additional meetings
Schematic Design Phase	I Attend (x) coordination meetings I Provide space planning assistance pertaining to special AV spaces to address room orientations, furniture layouts, image sizes, and sightlines I Provide preliminary input to the design team concerning AV-related acoustical and lighting criteria and design I Review and comment on schematic phase drawings for AV-related infrastructure issues I Assist with preliminary base building infrastructure budgets
Design Development Phase	I Attend (x) coordination meetings I Refine preliminary equipment layout sketches to address sightlines, projection throw distances, equipment locations and general presentation orientations

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

<b>AV Provider Scope of Work Checklist (Example)</b>	
	<ul style="list-style-type: none"> <li>I Provide additional input to the design team concerning AV-related infrastructure including:</li> <li>I Cooling requirements for AV equipment</li> <li>I Power and grounding requirements</li> <li>I Data/telecom requirements</li> <li><b>I</b> AV-related work</li> <li>I Room acoustics and noise control designs</li> <li>I Provide AV signal conduit and backbox layouts for AV systems</li> <li><b>I</b> Perform a general review of the design team drawings and specifications to address coordination issues related to AV infrastructure requirements</li> <li>I Assist with preliminary base building infrastructure budgets</li> </ul>
Base Building Construction Documents Phase	<ul style="list-style-type: none"> <li>I Attend (x) coordination meetings</li> <li>I Provide final input and coordination to the design team concerning AV-related infrastructure, including:</li> <li><b>I</b> AV-related millcraft (joinery)</li> <li>I Power and grounding for AV equipment</li> <li>I Data/telecom requirements</li> <li>I Room acoustics and noise control designs</li> <li><b>I</b> Lighting designs</li> <li>I Provide final AV signal conduit and backbone layouts for AV systems</li> <li><b>I</b> Perform a general review of the design team drawings and specifications to address coordination issues related to AV infrastructure requirements</li> </ul>
AV System Construction Documents Phase	<ul style="list-style-type: none"> <li>I Provide ongoing coordination and review with the design team</li> <li><b>I</b> Prepare AV system designs in accordance with the approved AV program report and provide to owner team for review</li> <li>I Prepare a final detailed opinion of probable cost including an AV equipment list</li> <li>I Attend (x) coordination meetings</li> <li><b>I</b> Provide (x) copies of final specifications and drawings for the AV systems for solicitation of bids from qualified AV system contractors</li> <li><b>I</b> Provide (x) copies of final AV system design drawings or the AV systems to the owner before installation</li> </ul>
AV System Bidding Phase Services	<ul style="list-style-type: none"> <li>I Establish a list of recommended prequalified bidders</li> <li>I Evaluate potential bidders suggested by the owner</li> <li>I Coordinate the issuance of specifications and drawings to bidders with the project team</li> <li><b>I</b> Conduct a pre-bid meeting</li> <li><b>I</b> Conduct a site tour (if applicable)</li> <li>I Review and comment on questions and requests for information during bidding</li> <li>I Prepare input for document addenda, if required</li> <li>I Review bids and make recommendations for award</li> <li>I Conduct integrator interviews</li> </ul>
Construction Phase	<ul style="list-style-type: none"> <li>I Attend (x) construction meetings</li> </ul>

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

<b>AV Provider Scope of Work Checklist (Example)</b>	
	<ul style="list-style-type: none"> <li>I Conduct one meeting with the electrical contractor to review the AV conduit and power requirements for the project prior to installation</li> <li>I Provide ongoing coordination regarding AV-related base building elements</li> <li>I Make up to (x) site visits at key milestones in the construction process to monitor AV infrastructure installation</li> <li>I Review and comment on requests for information I Review and comment on change order requests I Review AV integrator submittals</li> <li>I Provide detailed AV installation schedule to installation team</li> <li>I Provide (x) copies of final as-built documentation at completion of AV system installation</li> </ul>
AV System Verification and Training	<ul style="list-style-type: none"> <li>I Review the AV integrator's system test reports</li> <li>I Perform a preliminary checkout of the prototypical AV systems, if applicable</li> <li>I Perform a final check of all AV systems and prepare checklists</li> <li>I Conduct (x) training sessions with the technicians and end users</li> <li>I Provide recommendation of final acceptance of the AV systems at completion</li> </ul>
Warranty Phase	<ul style="list-style-type: none"> <li>I Provide warranty service for (x) months after substantial completion</li> <li>I Provide (x) preventive maintenance visits to the site</li> </ul>

### 8.3 The Needs Assessment Process

This section covers:

- The process of gathering and compiling the needs of the users of specific learning spaces, ensuring that all needs are met, and that all parties are represented
- The major phases of a project and the processes included in each phase
- The teams needed on the project as well as the roles and responsibilities of those teams and team members
- Project scheduling

Needs assessment is the process of uncovering, defining, and documenting how the campus intends to use the various spaces within the building. In essence, this step answers questions such as: “How do you want to teach in the new spaces?” “What are your expectations of the technology systems?” “How can AV help to conduct research in this building?” and “How can AV in this building promote a spirit of learning anywhere, anytime?” In the architectural field, this step is typically referred to as the planning and programming phase.

This task may include discussions regarding available technologies to meet the owner’s needs and a review of systems and infrastructure proposed to support the project goals. Components of this analysis may include:

- Interviews with end users, facilities managers, faculty, and administration (focus groups).
- Site visits of existing facilities to benchmark the systems.
- Online surveys available to a wide range of stakeholders.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Inventories of existing spaces, equipment, and infrastructure equipment.
- Discovery of additional project requirements, such as sustainable building guidelines.
- Benchmarking of facilities at peer and aspirant institutions.

Whenever possible, spaces that may need AV/IT should be identified at the outset. Identifying the rooms during the programming phase of a project will allow the spaces to be designed so that they can fully provide the intended functionality. As the project progresses, users must define more specifically the functionality required for each space. The overall room design and the actual technology to be included will follow this specification. Once the general design of the room has been established, it will be possible to talk more specifically about components and specific solutions for accomplishing the desired functionality of the space. This process will generate the detailed drawings, design specifications, and infrastructure requirements for each learning space.

### 8.4 Assess Existing Institutional Infrastructure

This section addresses important areas that need to be researched prior to start of the project. AV designers need to determine who will be using and support the technology once it is deployed, how the project will align with the existing plans, what standards need to be consulted, and how the technology will be updated.

#### 8.4.1 Campus Culture

The success of any project, whether it consists of AV/IT or not, is largely determined by its alignment with the campus culture. For example, much time could be devoted to designing a system to incorporate videoconferencing into a project, but if the campus has not yet accepted a video policy to share content and expert knowledge externally, the system will go unused, wasting much time, money, and effort. However, if the case is reversed and campus culture expects to be able to readily engage in videoconferencing and no system is added, end users may be disappointed.

It is extremely important to have proper input from administration, faculty, staff, and students to establish a baseline of the expected outcome for uses of the space. A complete input would be obtained through discussions with the financial, technical, and student groups.

#### 8.4.2 Technical Support Structure

A crucial portion of needs assessment is planning. Part of that planning should be devoted to how the technology will be supported once it is deployed. Questions that will guide the process include:

- Will the support be internal?
- Which department will handle the space?
- Will the systems be supported remotely and centrally, as part of an enterprise-wide effort?
- Will support be outsourced to an outside firm, or will the needs for this support be contracted out? The needs and expectations should be detailed in a Service Level Agreement (SLA).

The design needs to be able to sustain an acceptable level of support. Expectations related to staffing, basic policies, processes, timing, and funding devoted to support should be explored during a needs assessment.

#### 8.4.3 Alignment With Existing Plans

During a needs assessment, AV designs should develop a plan for the project within the context of other plans for the campus. Institutions invest an enormous amount of time, money, and energy developing various plans, some of which will be highly relevant to AV/IT systems within a specific building.

The most obvious example is the strategic technology plan for the campus. Of course, all technology plans for individual projects should be aligned with the overall strategic plan. In addition, the academic plan may indicate campus-wide initiatives with significant impact on individual projects. The plan may call for smaller class sizes, more active learning, or deeper support for asynchronous learning. The

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

facilities master plan may reveal that the building in which the systems will be installed is planned to be decommissioned or significantly modified within 10 years.

### 8.4.3.1 Role of a Campus Standard

Many institutions will have a campus standard for AV and IT systems. Some standards include very specific room designs and system configurations, including specific manufacturer and model numbers. In the absence of standards, manufacturer preferences and best practices may be used. They may leave room for interpretation and tailoring to fit the specifics of the project.

Campus standards may be based on laws, regulations, and institutional policies and addressed through the campus design and construction manuals. For further information, check with the campus facilities team or capital improvement project team.

#### 8.4.3.1.1 Advantages of Campus Standards and Preferences

The practice of following well-planned and implemented standards, or at least manufacturer preferences, has several benefits for both individual projects and campus-wide operations.

Standard approaches can simplify user training, technical support staff training, and technical support; streamline the inventory of consumables (such as projector lamps), spare parts and replacement units; and deliver a consistent user experience across campus.

Control systems are the most obvious element within an AV system that benefit from standardization. Generally, control systems are not interoperable among manufacturers, either for hardware or software. An institution developing programming skills to support control systems will likely want to concentrate resources on a single technology platform. Standards in control systems also allow instructors to move from room to room and easily use a space even if the internal equipment varies.

#### 8.4.3.1.2 Disadvantages of Campus Standards and Preferences

AV designers should exercise some caution with respect to campus standards, however. Overly prescriptive standards or unduly strict adherence to specific approaches and components may hinder open inquiry and genuine discovery during the planning and programming phase. For many projects, this is counterproductive to achieving the overall goals of the project. For example, if one of the goals of the project is to create innovative learning environments, simply applying a standard approach to teaching and the technology systems is not appropriate.

Finally, given the relentless development of technologies and the differing pedagogical practices among faculty, some aspects of a defined standard may become outdated quickly.

Ultimately, most projects should strive to achieve a balance of campus-standard approaches vs. a best-of-breed approach.

### 8.4.3.2 Funding/Refresh Cycle

When a campus project is in its infancy at the design phase, a budget is established. It is extremely important to incorporate a refresh cycle for design add-ons, as well as the system upkeep. If this is not incorporated, the new technology-rich room will soon become a non-functioning space that is rarely used.

Traditionally, refresh cycles run from three to five years, depending on the institution and the type of equipment. A plan should be developed indicating at what phase of the cycle certain technologies will be refreshed. Some systems, such as wireless projection systems, may need more attention than an IP-conferencing system. Each higher education institution will have its own policy for overall funding and refresh-cycle funding.

## 8.5 Needs Assessment for Renovations

For a project that renovates existing spaces and systems, the design team should examine the inventory of existing spaces, systems, and infrastructure during the needs assessment phase. A careful analysis of any learning spaces that need to be renovated is key to establishing a starting point

**AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION**

so a proper path to the desired endpoint can be developed. Although this step is more important for renovation projects, new construction projects also benefit from evaluating existing spaces on campus.

When assessing existing spaces, particular attention should be paid to ceiling heights, column spacing, acoustics, lighting, telecom rooms, and room adjacencies. Some factors will be easily observable, while others, such as vibration, RF spectrum, and condition of the decking and cable pathways behind walls, will require special investigation.

Assessing the existing systems typically includes investigation of the control systems, video service and distribution, accessibility compliance systems, projector inventory or preferences, and wireless devices. Equipment should be evaluated with respect to reuse in the project, lessons learned, and manufacturer preferences. Reuse of existing equipment should be carefully considered depending on the level of renovation planned, age of the equipment, timing of the equipment migration, and the ability to decommission and reinstall the items.

Often, equipment is in proper working order but is slated for replacement with the new project. Assuming it is still in proper working order when the new systems are online, the older units can be used as spares and portable systems or repurposed elsewhere.

Information related to the specific site should be gathered during on an onsite visit. This will ensure that all details of the proposed space are discussed and noted. Some important tools should be included and brought to the survey, including:

- Checklist
- Tape measure/laser tape
- Light meter
- SPL meter
- Camera
- Flashlight
- Source material

The following is a needs assessment checklist with sample data and grade ranges.

**Table 8 – A sample needs assessment checklist**

Item	Data	Grade	Comment	Sample Data or Grade Range
<b>IDENTIFICATION DATA</b>				
Assessor Identification (email)				
Assessment Date				
Space Owner (Organization)				
Building Name/Code				
Room Number				
Common Space Name				
AV Equipment Inventory (link)				
<b>SPACE DATA</b>				
Approximate Room Dimensions				Length x Width = Sq. Ft.

**AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION**

<b>Item</b>	<b>Data</b>	<b>Grade</b>	<b>Comment</b>	<b>Sample Data or Grade Range</b>
Shape of the room				Ex. Square, long narrow, wide-short
Ceiling Height				
Approximate Build or Renovation Age				4–6 years
Room Seating Capacity				355
Room Category				Traditional teaching space
Room Type				Seminar classroom
Technology Tier				CU Tier II
Pictures (Front, Rear, Lectern)				
AV Use Goals of Typical User				Recording capability; located in ways to promote community; network connectivity
Budget/Performance Grade				0–4: 0 = low; 4 = excellent
<b>ENVIRONMENT CRITERIA</b>				
Lighting Type				Fluorescent; basic zoning
Lighting Quality				0–4: 0 = no visibility; 4 = excellent
Undesirable Light				0–4: 0 = extremely distracting; 4 = excellent
Acoustic Treatment Type				Acoustic ceiling tile
Acoustical Quality				0–4: 0 = poor; 4 = excellent (no echo)
Undesirable Noise				0–4: 0 = extremely distracting; 4 = not distracting
Room System Controls				Low-voltage switches with presets
Room Controls Quality				0–4: 0 = poor; 4 = excellent
Serviceability of AV Systems				0–4: 0 = poor; 4 = excellent
Accessibility				Some ADA provisions noted
Safety				No concern noted
<b>AUDIO CRITERIA</b>				
Audio Program Type				Loudspeakers in display devices
Audio Program Quality				0–4: 0 = poor; 4 = excellent
Audio Reinforcement Type				None
Audio Attributes				0–4: 0 = poor; 4 = excellent
Assistive Listening Type				Induction loop
<b>VIDEO CRITERIA</b>				
Video Display Type				Direct-view LCD panel
Video Display Quality				0–4: 0 = poor; 4 = excellent
Video Attributes				0–4: 0 = poor; 4 = excellent

**AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION**

<b>Item</b>	<b>Data</b>	<b>Grade</b>	<b>Comment</b>	<b>Sample Data or Grade Range</b>
Captions Decoding				Built into display
User Interface				
Control Type				Basic push-button panel
Control Quality				0–4: 0 = poor; 4 = excellent
Control Attributes				0–4: 0 = poor; 4 = excellent
Adaptive/Accessible Controls				None
<b>OTHER</b>				
Green and/or LEED Attributes				None
Network Connectivity				Wireless RedRover
End User Assistance Info				0–4: 0 = poor; 4 = excellent
Technical Documentation				0–4: 0 = poor; 4 = excellent
<b>DESIGN FEATURE (ADJUSTMENT)</b>				
Room Feature Type				Seat tiering and layout enhance collaboration
Room Feature Quality				0–4: 0 = poor; 4 = excellent
Audio Feature Type				Digital signal processing (DSP)
Audio Feature Quality				0–4: 0 = poor; 4 = excellent
Video Feature Type				Native widescreen screen display
Video Feature Quality				0–4: 0 = poor; 4 = excellent
Control Feature Type				Full (duplicate) controls for technician
Control Feature Quality				0–4: 0 = poor; 4 = excellent
	<b>Basic Components Score</b>			
	<b>Basic Weighted Score</b>			
	<b>Weighted with Design Adjustment</b>			

**8.6 Project Documentation**

This section covers:

- AV specifications
- AV system drawings
- AV system verification
- AVIXA documentation standards

AV designers may get caught up in the particulars of educational technology and enthusiasm for its enhancements to the teaching environment. It is also easy to think of it only as standalone technology, overlooking the necessity to integrate it as an architectural element. Many people understand the application of the technology, but do not consider how important it is to successfully incorporate it into furniture, walls, ceilings, and floors. The individual components of AV systems are in many ways construction elements that must be carefully planned and prepared for. The AV industry is part of the construction industry and should be treated in the same manner, including how its projects are documented.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

The framework for documenting construction projects is well defined by the architectural/engineering/construction (AEC) community. AV systems integration should be a part of this documentation framework from the outset of the project for the most successful outcome. To that end, AVIXA, as the AV industry trade association, has made great strides in creating standards, best practices, and examples that illustrate how AV systems installations can be harmonized with the language and techniques of the rest of the construction industry. This is accomplished with a variety of drawings, specifications, coordination meetings, progress reports, processes, contracts, and descriptions. This section explores the many vehicles available for defining an AV system, its architectural infrastructure, and the architectural requirements necessary to support it.

### 8.6.1 Design, Coordination, and Process Issues

The documentation associated with a construction project is organized according to the contractual arrangements of the project, the phases of the project, the type of materials or systems being described, and the order in which the construction spaces and elements are to be sequenced during the construction itself. In the case of an AV system, there are additional considerations that AEC team members need to coordinate and consider:

- Is the issue one that involves the planning of the space, such as room shapes and sizes, adjacencies, or purposes?
- Does the issue involve other specialized designers or consultants, such as acousticians, lighting designers, or interior designers?
- Is the issue of an engineering nature, such as heat loads or power distribution?
- Does the AV technology overlap/interconnect with other technologies such as IT, security, or building systems?
- How does the hierarchy of the project team dictate how milestones, changes, and tests are reported and accepted?

### 8.6.2 Drawings and Specifications

A typical AV system design package consists of four basic components:

- Contract documents
- Specifications
- Drawings (e.g., facility, design, and system)
- Custom application documentation

System contract documents are the one common and essential element of the design deliverables among almost all the building trades, including AV. Specifications are a structured written description of standards, products, and execution that guide the installation. The drawings depict how the systems are intended to be configured.

There are multiple contract delivery methods and procurement vehicles including design-build, design-bid-build, integrated project delivery (IPD), alliance scheme, and lean design.

Depending on the delivery method, there may be differences in what the documentation is called. Furthermore, the division of labor is also dependent on the delivery method, and the documentation is critical in communicating responsible parties for all deliverables and actions. In the bid process, the design documents must include enough information for the design intent to be conveyed and a reasonable amount of detail so the bidders' responses can be accurately and fairly compared. In a design-build project, this detail is developed as the project progresses through the integration firm's departments and professionals. In any case, attention to external communications with other designers and trades is paramount. Most of these activities are included in the AVIXA documentation standards, which deliberately do not specify who the responsible parties are, to allow for various procurement models.

### 8.6.2.1 Contract Documents

Tech managers often hire outside help, which may include equipment suppliers, consultants, and integrators.

Supplier contracts should include:

- Introductory information
- Bidding requirements
- Contract forms
- Conditions of the contract
- Project specifications

### 8.6.2.2 AV System Specifications

AV systems cannot be designed or installed without the consideration of other trades. Since typically a limited amount of space in a facility is allocated for infrastructure, the coordination of the AV design with other members of the architect, engineer, and consultant team is important. This includes not only the devices and their functional or physical locations but also power, cable pathways, cable, furniture, lighting, air conditioning, and other infrastructure. The standards of all applicable organizations must be strictly regarded. Incorporation in the project of such standards must be effectively communicated to the team members.

Drawings do not provide enough information or instruction needed to proceed with installation. Since it is not practical to include sufficient notes on construction drawings, a separate set of written instructions, known as specifications, is created to describe in complete detail all of the product quality and installation methods. These specifications provide further guidelines on how to proceed and put all of the elements together.

All the accompanying documentation (e.g., warranties, instruction, and customers manuals) should be collected. Some companies gather all manuals for security and reference during the job and then create a customer binder with the information when the project is complete.

Sometimes, technicians want their own copies of manuals for new or popular products. Many times, these manuals can be found online and printed.

### 8.6.2.3 AV System Drawings

The language of architecture and construction is drawings. As always, documentation is a critical part of this process. AV designers use applied AV theory, accepted AV system design techniques, and available AV components to create a clear and comprehensive set of project documentation that can be used by the installation team to install the AV system. There are specific types of drawings that are required to define an AV system, and these fall into some general categories:

- Infrastructure coordination drawings
- System drawings
- Detail drawings
- As-built/record drawings

#### 8.6.2.3.1 Infrastructure Coordination Drawings

Systems infrastructure design refers to how AV and other components are interconnected to create a system intended to meet specific client presentation needs. This process includes the design of behind-the-scenes elements, such as electrical systems, cable runs, and racks, which the end user does not usually interact with. By its nature, infrastructure design requires the AV professional to work closely with allied trades to ensure that the AV system can be smoothly integrated into the space.

AV professionals may not be directly responsible for the implementation of the infrastructure, but their recommendations and requirements regarding the AV system's needs must be communicated to the other professionals on the project team. These requirements are communicated as floor plans,

reflected ceiling plans, and site plans, that show the general locations of devices and infrastructure in the facility. Some of these requirements include:

- Control systems
- Electrical considerations
- Acoustics
- Mechanical considerations
- Structural considerations
- Equipment racks
- Lighting

Facility drawings help installation professionals analyze the physical capabilities of the building. This information is then used to determine the mounting needs. In certain cases, it may be necessary to request the opinion of a structural engineer for life/safety purposes.

### 8.6.2.3.2 System Drawings

System drawings are sometimes referred to as **block**, **flow**, or **schematic** diagrams. They indicate an overview of the system signal flow in its entirety and illustrate the interconnection of the audio, video, and control subsystems.

- **Functional diagrams** — Functional diagrams include references to related subsystems and provide the reader with a clarification of the boundaries of the AV scope of work. The diagrams include contractor-provided and owner-furnished equipment, as well as equipment supplied by others.
- **Subsystems** — Audio, video, and control subsystem functional diagrams indicate the interconnection of all technical components (e.g., sources, processors, power amplifiers, switchers, loudspeakers, and displays). If there are multiple systems involved, multiple functional diagrams may be necessary.

### 8.6.2.3.3 Detail Drawings

These drawings include whatever the AV designer needs to show as a requirement that may elaborate on systems aspects from other drawings, or they may be standalone. Details are a powerful way for the designer to communicate any sort of information that is important, including tables, schedules, and photos. Some common details include:

- **Equipment mounting details** — These drawings provide specific details for the mounting of AV devices to the floors, walls, and ceilings of a facility for each device requiring mounting, rigging, or other suspension including blocking or other structural supports, cabling routing, and special notes for mounting that may be manufacturer specific.
- Indications for the mounting of equipment, layouts of patch panels, and rack elevations should be included as required by the project.
- **Custom components details** — AV systems frequently require customized components such as plates, furniture, and brackets that are not off-the-shelf.

### 8.6.2.3.4 As-Built/Record Drawings

During installation, construction drawings are modified. Drawings of record or as-built drawings are the corrected construction drawings that reflect the actual installation configuration. The drawings of record, in turn, become part of the drawings in the project contract. After the entire project has been tested and verified for conformance, drawings of record should be gathered and put together for future reference. In addition, this set of drawings can be a useful tool for end-user training.

### 8.6.2.3.5 **User Interface, Control, Signal Processing Systems, and Operations Documentation**

Various components of an AV/IT system generate a documentation set that is in addition to the design documentation. Such documentation may include final software code, final graphics files, user operation manuals, and control systems documentation.

### 8.6.2.3.6 **Final Software Code**

If an AV control system is being considered, AV designers should discuss code ownership with the system owner. If an institution owns the uncompiled code for a system, it will be able to go to any programmer for future upgrades and changes to the system. If it does not, it will be having to refer to the original programmer or vendor for all future work. A license agreement should be signed between the programming company and the user of the software which delineates ownership of the programming code in a clearly defined manner. An agreement should be included in the scope of work regarding the ownership of the AV programming code, architectural designs, system drawings, etc.

It is recommended to include a grace period after owner acceptance to customize the control system. Such contingencies do not only apply to fixes due to problems with the software but are also intended to accommodate minor changes in the programming or interface if requested by the AV designer or the end users. If any major changes beyond this contingency are needed, then they would require contractual action to implement.

### 8.6.2.3.7 **Final Graphics Files**

There are several ways that the user interface and programming can be incorporated into the design documents. The system description may be detailed enough to have some control system functionality included, but much more detail is generally needed. It is best practice to provide GUI layouts and button-by-button functionality in design documents.

### 8.6.2.3.8 **User Operation Manuals**

The success of a completed AV project lies not only in the systems design and execution, but also in the ability and willingness of the user to utilize the system to its full potential.

Considering the often-significant investment in the AV system itself, it is imperative that there be sufficient follow-through with the owner's personnel to ensure the system functions at its optimal level. This can only be accomplished through proper training and user documentation. Training documentation should include functional use of the system and not just creating a binder of vendor manuals.

Operational documentation may also be included in the spec and/or contract, including system-specific custom user guides and manufacturers' owners and service manuals. Even if user documentation is not required by contract, training material should still be prepared.

Simple and practical explanations of basic functions could be a part of a quick start guide. In the case of multiple systems, small, laminated guides may also be appropriate.

### 8.6.2.3.9 **Control Systems Documentation**

Control system documentation is required on different levels, from hardware, through software, to network connectivity. Documentation includes which devices the client needs to control, how these devices may be controlled, and possible control points.

- **Control functions script** — A control functions script includes the list of devices and the possible/required device actions. A control functions script is an itemized list of devices to be controlled that helps to organize what needs to be done by everyone on the project, such as the client, programmers, designers, and facility engineers. It contains the required action(s) for each device and interconnection information, such as the control point and connector type. A control functions script also assists the AV designer in creating a control system that meets the required client needs.

Some of the items on the list may not be AV related at all, for example, drapes, lights, and temperature sensors.

**Control flow diagram** — The control flow diagram provides an example of how to depict control signal flow within an AV system. This diagram depicts the general organization of the system, and the logical flow of control. It may or may not depict device locations, but it will depict devices that are grouped for some functional purpose, such as an equipment rack.

Like audio and video system flow diagrams, control system flow diagrams show that signals generally flow from left to right, although this flow architecture is quickly evaporating as more devices need to be connected. This left-right concept is not hard and fast, however, due to the bidirectional nature of most control signals. User interfaces are shown on the left, the central processor in the center, and controlled devices on the right. Equipment is shown within and outside of the equipment rack. Cables that terminate at wall or floor boxes are shown, with their connectivity continuing to the device. Control signals from outside of the system are also shown, such as LAN and voice lines. Environmental devices such as lighting and shades are shown as controlled devices. Attention to power switching, control buses, and the organization of similar signals grouped together, such as IR and RS-232, provide instructions to the installers.

The process for creating a control system flow/function diagram is like the process for creating general system diagrams, such as audio or video block diagrams. The designer must determine how to represent control systems in drawings, and how much detail is required in flow diagrams and in the schematic/wiring diagrams.

- **Network diagram** — As AV systems are also fundamentally network systems, it is advisable to include a diagram that indicates connectivity between AV devices and the network. This should clearly show what type of functionality is required (including Power over Ethernet [PoE]) of the AV device, particularly if network infrastructure is being used for non-network purposes. Color-coding is useful in these cases, to differentiate between Ethernet devices and hybrid AV/IT devices (i.e., AV equipment that resides on the network).
- **Power management diagram** — Systems that are designed to conform to standard ANSI/AVIXA S601.01:2021, *Audiovisual Systems Energy Management* should also include a power management diagram. Such a diagram shows the logical organization of components and their power sources, including which devices can be powered off while not in use while the rest of the system is in operation.
- **DSP routing diagrams** — So much of the digital signal flow of a modern AV system occurs within core physical pieces of equipment versus through discrete cabling/equipment, that it is mandatory to indicate how this routing occurs. This can be shown on a device-by-device basis using line drawings to indicate the virtual connections within the device, or by using a chart or schedule. Typically, each of the modes of the AV system will be shown separately to allow the DSP programmer and the user to understand the intention of the system flow. It is also common to indicate this, using screenshots from the DSP programming software, available from the device's manufacturer.

### 8.6.3 Verification Through Documentation

Since AV systems are technical by nature yet architectural in their implementation, professionals must be familiar with both types of drawings and project management styles. As a way of ensuring that the goals of the system are met, one of the most important concepts in project flow is used: verification. The organization of AV verification tasks ties together the goals of the project, the design intent as detailed in drawings and other project documentation, and the verification that the systems perform and continue to perform as originally intended.

The completed project includes all such documentation as a record that can be used to maintain, troubleshoot, and restore the system to its original performance specifications.

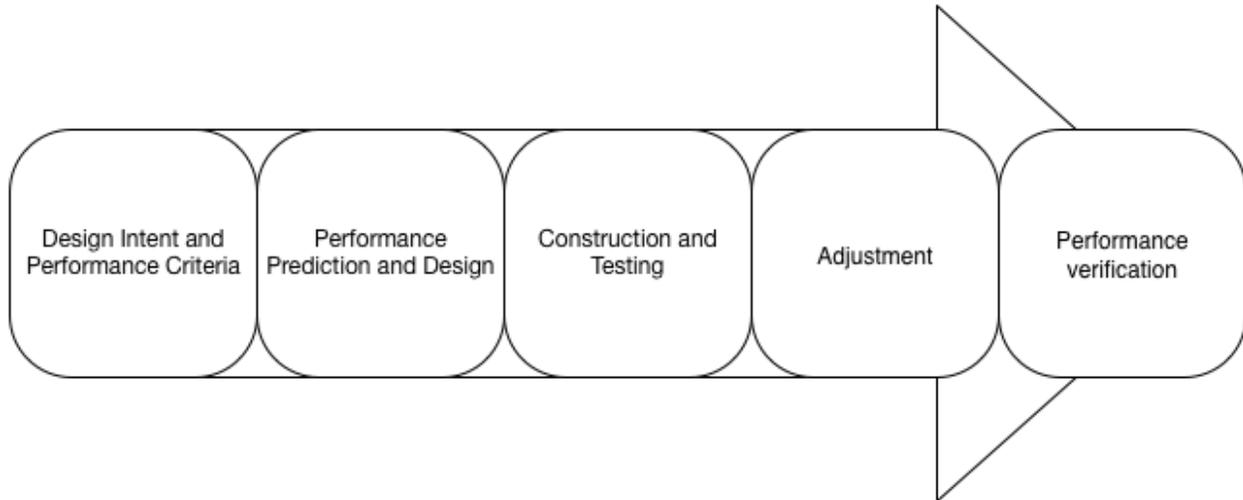


Figure 25 – The verification phase

#### 8.6.4 AVIXA’s Documentation Standards

All of the above issues are normal in AV projects and represent some of the greatest challenges for the design and construction team. Two AVIXA standards and their accompanying guidebooks are available to assist AV practitioners in the successful implementation of their systems:

**ANSI/INFOCOMM 2M-2010; Standard Guide for Audiovisual Systems Design and Coordination Processes** — A successful professional AV system installation depends on the clear definition and coordination of processes, resources, and responsibilities of the design and installation project teams. A properly documented AV system provides the information necessary to understand and implement the system goals and project requirements in a logical and efficient manner. The documentation should complement and coordinate related architectural, engineering, and construction documentation. This Standard outlines a consistent set of the standard tasks, responsibilities, and deliverables required for professional AV systems design and construction.

**ANSI/AVIXA 10:2013, Audiovisual Systems Performance Verification;** — This Standard provides a framework and supporting processes for determining elements of an AV system that need to be verified; the timing of that verification within the project delivery cycle; a process for determining verification criteria/metrics, and reporting procedures.

Architects, clients, consultants, contractors, facilities managers, integrators, manufacturers, owners, and technology managers who have verification processes in place can integrate those existing processes into the framework this Standard provides, adding customized items to those already defined in the Standard.

By using these two standards in conjunction with each other, it is possible for the AV project manager to organize all the project documentation in whatever detail is necessary for that project. Ideally, it is possible to ensure that authorizations to proceed with next steps are procured such that the project can move along as planned. This includes verifying that each portion of the system conforms to the design intent and any standards that dictate performance or functionality. Ultimately, it is possible to demonstrate to the owner or major stakeholder on the project that it is finished and have their signature to prove their satisfied acceptance.

## 9 General Budgeting of Technology Systems

This section covers:

- The distinctions between the base building budget and the furniture, fixtures, and equipment budget.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- The proper usages of budgeting per square foot vs. budgeting per system and per space.
- The process of working with cost estimators.
- Ways to manage the budget considering capital expenditures vs. operating expenditures, refresh plan, and total cost of operation.

Budgeting for technology on higher education campuses is a complex yet essential task that requires input from several stakeholders including faculty, campus operators, AV designers, IT designers, contractors, and AE design professionals. Approaches among campuses vary widely and are influenced by factors such as: centralized budgeting vs. decentralized budgeting; revenue sources, internal and external to the institution; projected enrollments; campus master plans; and, of course, the strategic technology plan for the institution.

Accurate, well-defined, and timely cost estimates are crucial to the success of virtually any sizable project. Fortunately, budgeting AV/IT systems for a project is significantly less complex.

### 9.1 Base Building vs. Furnishing, Fixtures, and Equipment

When budgeting for an individual project, an important distinction to draw early in the process is whether AV/IT technology elements will be considered part of the base building budget and which will be part of the furnishing, fixtures, and equipment (FF&E) budget.

The base building budget typically includes all costs for items that will eventually be provided by the general contractor as part of constructing the building. This includes site excavation, building structure, walls, doors, windows, ceilings, lights, electrical systems, HVAC systems, and security systems.

AV/IT technology-related elements in the base building budget are often the cable pathways (e.g., cable tray, back boxes, and conduit), in-wall blocking to support wall-mounted flat panel displays, infrastructure hardware from which to hang projectors, projector lifts mounted above the ceiling, specialty floor boxes, and the structured cabling systems or cable plant to support the building. Importantly, the projection screens are often included in the base building as well; these are often the largest single line item in the base building budget under the direct control of the technology designer.

The FF&E budget typically includes items not attached to the building, such as tables, desks, chairs, filing cabinets, specialty instructional equipment for labs and most AV/IT systems.

These items are typically not provided by the general contractor but are purchased through a variety of different specialty suppliers. The FF&E budget is a broad category ideally segmented into separate groupings such as furniture, lab equipment, AV systems, and network electronics.

The bulk of most AV components (i.e., projectors, flat panel displays, video cameras, microphones, loudspeakers, signal routing, and control systems) are included within the FF&E budget.

The IT systems, on the other hand, are split between the structured cabling systems, or the cable plant, and network electronics. The cabling portion of a structured cabling system includes backbone cabling, horizontal cabling, and work area components such as faceplates and patch cords. In addition, related items for the entrance facility and the equipment rooms or telecom rooms, such as equipment racks, power conditioning and uninterruptible power supply (UPS) units are also considered part of the structured cabling system. These items are typically passive devices and often included in the base building budget.

The outside plant (OSP) includes the cabling and supporting infrastructure to connect the building to the rest of the campus, and thus the rest of the world. The cabling may be a combination of fiber, copper and/or coax, with ample spare capacity included. Other items may include utility tunnels, duct banks, vaults, conduit, maintenance holes, and handholes. Costs for the OSP are often included in the base building budget.

The network electronics line consists of network switches, routers, servers, electronic storage, wireless access points, network management tools, and so on. These are typically budgeted under a network electronics line item within the FF&E budget.

### 9.2 Establishing a Budget

Once the distinctions are made between base building and FF&E, budgeting for the AV/IT systems can begin. As with the rest of the project, the technology systems often start with rough order-of-magnitude cost estimates; these are general estimates based on early decisions and do not include detailed designs or fully developed solutions. At this stage of the project, the AV/IT systems are budgeted as if painting with a broad brush.

#### 9.2.1 Budgeting by Square Footage: Handy Tool or Hand Grenade?

In the early stages, very large projects can be budgeted based on a cost per-square-foot (meter) basis or on per-space and system basis. Per-square-foot/meter is a simple calculation and can be used under certain circumstances but is less accurate in most applications.

For structured cabling systems, budgeting is done by estimating the average floor space (number of square feet or meters) that can be served by a single network port, multiplying the number of ports by the cost per port, and accounting for other costs to cover wireless access antenna locations, entrance facility, and telecommunications rooms. Early in a project, this is a reasonable and common method for budgeting.

Budgeting IT systems using a square footage calculation, however, is a bit riskier. The number of network ports calculated for the structured cabling system can be used to determine the number of ports needed for the network switches. This is relatively straightforward. However, more analysis will be needed to budget for the routers, servers, electronic storage, telephone systems, telephone handsets, wireless access points, network management tools, and other IT requirements. Budgeting these items using a square footage basis is typically not recommended.

For AV systems, however, budgeting based on floor areas (e.g., square footage) can be off substantially and should be avoided whenever possible. A small room can be very AV-intense and very expensive, while a large room may be inexpensive on a square footage basis.

Consider the square footage costs for AV in a recording studio, network operations control room, or immersive virtual reality space. For these specialty spaces, the square footage costs for AV might be \$1,000 or more per square foot; applying this calculation to an entire building would be misleading.

Conversely, consider the AV/IT costs of a large lobby or pre-function space with only background music and support for portable AV equipment. The square footage costs for AV might be only \$1 per square foot. The difference in the AV cost per square footage between these examples — particularly when multiplied across a large project — yields a result that is unusable at best and disastrous at worst.

In some circumstances, using a square footage multiplier to budget for AV and IT has some value. If used, this method should be applied carefully, and used only very early in the project.

##### 9.2.1.1 Budgeting per Space and by System: Time Consuming but Accurate

A more accurate method of budgeting AV and IT systems is to estimate costs for each space and system type in the building. Budgets for each unique type of space may begin with room listings from the architect — room data sheets or early drawing sets. System types are building-wide systems such as digital signage, room scheduling, video streaming and distribution, and software licenses. Budgeting with this method is more time consuming and staff intensive than cost estimates per square footage but is far more accurate when done properly.

This approach is most challenging early in the project when thinking is still at a conceptual level and there are so many unknown variables. When the architect does not know whether the building is three floors or four, the AV designer should not be counting rack spaces and selecting microphones. However, an educated and rational cost estimate early in the project is much preferred to a blank line item or square footage calculation.

Early in the project, this approach relies on past experiences, an assessment of general expectations for the specific project, and an evaluation of the market conditions at the time of system bidding.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

As the project progresses through planning and programming, each space and each system type should be discussed with the end users and operators in detail, with a focus on the intended uses of the spaces and systems. Once the network ports can be counted with some level of accuracy and the number of telecommunications rooms is known, the structured cabling budget should be updated to reflect per-port costs rather than a square footage estimate.

After these requirements are approved, a more accurate budget can be established. Ideally, the AV and IT budget will be revisited at the end of each major phase of the project.

### 9.3 Managing the Budget

All the various budget estimates for the whole project are typically compiled and managed by the architect and/or the project manager for the campus.

#### 9.3.1 Working With Cost Estimators

On large projects, the project documentation is shared with a cost estimator to verify all of the various costs for the project as planned. This estimator, or estimating firm, may be part of the architect's design team, a third party hired by the owner, or a hybrid — larger projects may have multiple cost estimates performed by different firms, with the various results reconciled by the various parties.

Typically, these firms are hired to provide multiple cost estimates throughout the project, such as at the end of each architectural phase. When more than one cost estimate is submitted, the architect will often be responsible for reconciling the various figures and establish the overall project budget.

Most firms offering cost estimating services have deep expertise in the costs of the building industry and the areas of civil, structural, mechanical, and electrical, and plumbing. However, these firms are unlikely to have significant expertise in AV and IT and their evolving technologies and performance requirements, and typically plug in cost estimates from technology designers. Cost estimators will often include costs for the infrastructure required to support the AV and IT systems, such as conduit, back boxes, and the AC power.

Technology designers should carefully review the cost estimates to ensure that the technology systems are being represented properly, with nothing overlooked and no elements counted twice.

##### 9.3.1.1 CapEx vs. OpEx

**Capital expenses (CapEx)** typically are the one-time costs associated with the specific project. This includes the direct hard construction costs (e.g., the building shell, concrete, walls, roof, and HVAC systems), plus the indirect soft costs (e.g., design fees, land acquisition, insurance, and permits).

The bulk of the costs of technology systems purchase and installation found in the FF&E budget may be considered either hard or soft, depending on the project. Whether considered a hard or soft cost, as a one-time investment specifically associated with the project, AV/IT systems will be considered a capital expense and covered by the project budget.

However, if the cost is a recurring expense, such as lease or utility costs, whether monthly or annually, it is considered to be an **operating expense (OpEx)** and is typically outside the budget for the project. Examples within AV/IT technologies are cloud services, bandwidth, television programming, content management for streaming events, annual software licenses, extended equipment warranties, and managed services from AV systems integrators. Some campuses may utilize a chargeback system, where the central IT group charges the department or building a monthly cost per data outlet or per television connection or similar service. Depending on the campus, this funding may need to come from a separate budget, not the project budget.

Even though the OpEx costs may not be covered by the project budget, these should be carefully considered in the planning and design of the project. Equally key for lifecycle operations implications, and often overlooked, is the rapidly increasing energy (e.g., electric power and cooling

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

requirements) costs of this equipment. For further discussion, see a section below on total cost of ownership.

### 9.3.1.2 Refresh Plan

Another often overlooked aspect of project planning and budgeting is the means to refresh the equipment in the future. With some equipment, the need for replacement is driven by the amount of downtime and repair costs experienced. With AV/IT equipment, the various refresh cycles are more often driven by the desire for more powerful and capable equipment.

Different AV/IT components will have distinctly different refresh cycles even on the same campus. For example, computers and software will often have the shortest refresh time period, projectors and flat panel displays a bit longer, with power amplifiers, loudspeakers and projection screens among the longest for AV components.

Structured cabling systems are designed for much longer refresh cycles. Some manufacturers of such systems warrant their products for 15 or 25 years; other manufacturers have a lifetime warranty when installed and tested by certified installers.

### 9.3.1.3 Total Cost of Ownership

Total cost of ownership (TCO) is a comprehensive tabulation of all costs associated with owning a particular asset for the life of that asset.

For IT systems, the practice of managing via TCO is well established. For AV, this practice is not as prevalent. However, given the rising costs and the mission-critical nature of today's AV systems on campuses, utilizing a TCO approach is recommended. Software tools to help manage AV systems can also generate critical information to feed such analysis. This includes enterprise-wide or building-wide software solutions that allow campuses to track usage of various items and systems, remotely diagnose equipment problems, track service calls, and manage downtime, among other capabilities.

For AV, a TCO study should include all the various costs to own, power, operate, and maintain the system for the life of the system. The obvious costs to capture include service or maintenance contracts, charges from the campus IT group for support, recurring software licenses, and consumables (e.g., projection lamps and batteries for wireless microphones). Less obvious costs, and often more difficult to capture accurately, are the staffing associated to operate and maintain the systems. Also, initial training may be covered by the project budget as a capital expense but retraining of new employees and additional users in the future should be considered in the TCO calculations.

AV designers may also choose to consider the cost of electricity and other utilities to operate certain components. The amount of AC or even DC power required by some larger video projectors, for example, can vary greatly among different manufacturers and models. This should factor into budgeting decisions. And as refresh occurs, the power demand, maintenance, and cost implications should be investigated.

Of course, funding for a refresh plan should also be considered to truly evaluate the TCO for a given system.

#### What do you need to ask?

Budgeting leads to a number of questions to ask the cost estimator, including but not limited to:

- Have the various infrastructure items, such as conduit, cable tray, floor boxes, and other cable pathways, been included in the base building budget?
- Has a proper technical power system, suitable to support the AV systems, been included in the base building budget?
- Have the appropriate projection screens been included in the base building budget? Are they adequately sized and properly planned for the various spaces and applications? In which portion of the budget are the screens included?

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

- Have the proper lighting systems, as coordinated with the AV designer, been included in the base building budget?
- Have the AV cost estimates, per system and per space as generated by the AV designer, been included? In which portion of the budget?
- Have the structured cabling cost estimates, as generated by the structured cabling/IT designer been included?
- Have the IT network electronics cost estimates, as generated by the IT designer, been included?
- Is there any duplication for any of the above items?

### 9.4 Project Closeout and Post-Occupancy

This section covers:

- The steps to closing out the project.
- The verification phase.
- The importance of post-occupancy.
- The types of maintenance.

Project closeout needs to be straightforward so that all stakeholders have an understanding and full documentation of the work as completed. For project closeout and project post-occupancy, much detail is required. This phase will include conducting user training and system orientation with the appropriate parties. The system will also demonstrate functionality as fitting the end-users' needs as well as ensuring total user comfort and technical capability before the project is signed off. A complete as-built system drawing/documentation package should be provided upon completion. The manufacturer warranty cards, and information should be provided at this time as well. The standard warranty period will begin typically when the client signs off. Additional managed service plans may be available, as well as system training sessions.

#### 9.4.1 Project Closeout

Project closeout is discussed in detail in standard AVIXA 10:2013. The standard contains verification procedures and documentation that will guide the AV designer through this process. The project documentation should include the following:

- As-built drawings
- Audio system test reporting
- Control system test reporting
- Final verification report and system turnover
- Required closeout documentation
- Software licensing
- User manuals
- Video system test reporting
- Warranties
- Final acceptance

Sections 8 and 9 of AVIXA 10:2013, note verification reporting and reference verification items for the system owners. These sections of the Standard provide an in-depth guide of performance verification. Performing these steps will ensure a level of quality and system reliability for the move into the post-occupancy phase.

##### 9.4.1.1 Systems Verification

Systems verification is vital and should be carried out prior to the handover. The goals are verification and optimization of the new system. This will allow for final testing of all of the

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

components, resulting in a report that states if there are any problems, and identifies any outstanding items on the checklist and the need for any additional work.

The verification should be performed when the installation is finished and all documentation is ready. An experienced AV professional, but preferably not the project installation team should complete this step. But, the lead install technician should be present as they have the highest working knowledge of the new system.

The following are recommended systems verification steps.

Step	Description	Detail
1	Perform preliminary tests of the completed system	<ul style="list-style-type: none"> <li>" Verify all equipment has been delivered</li> <li>" Confirm communications and networking systems are installed and working</li> <li>" Test all signal paths for video and audio systems</li> <li>" Verify successful control system operation</li> <li>" Test video monitors and projects</li> </ul>
2	Generate the checklist	<ul style="list-style-type: none"> <li>" <a href="#">Damaged wiring</a></li> <li>" Poor AV connector terminations</li> <li>" Physical installation issues (e.g., camera position)</li> <li>" Workmanship issues (e.g., unacceptable cable management)</li> </ul> <p>NOTE: During this phase, change orders may be required. It is important that when a project is close to completion that all involved are aware of what has been initial contracted work, and what are add-ons to a project. This is called a change order. Some cases where this may be necessary are a discontinued product, a change in the intended use of the system, or discovery of incompatibility within the system.</p>
3	Establish substantial completion	<ul style="list-style-type: none"> <li>• Complete steps 1 and 2</li> <li>• Complete the system per the contract</li> </ul>
4	Inspect, test, and align	<ul style="list-style-type: none"> <li>• Perform a facility inspection</li> <li>• Acquire available drawings</li> <li>• Take inventories</li> <li>• Perform objective testing of the system</li> </ul>
5	Train the AV/IT team	<ul style="list-style-type: none"> <li>• Provide training should for staff that will be maintaining the technology with support material</li> <li>• Include a syllabus and training obligations if more dates are part of the package.</li> <li>• Allow vendors to record training sessions for reference</li> <li>• Establish the method of follow-up contact</li> <li>• Establish a support model</li> <li>• Empower the end users to use the technology as a tool to enhance instruction</li> <li>• Pass the final drawings and programming code to the AV service team</li> </ul>
6	Sign off and start the warranty period	<ul style="list-style-type: none"> <li>• Check that all checklist items are completed</li> <li>• Check that all documentation has been delivered</li> <li>• Check that change orders are completed or a date for completion has been set</li> <li>• Check that all contractual obligations have been met</li> <li>• Define warranty periods and service level agreements (SLA)</li> </ul>

Once the building and AV systems are complete and verified, the warranty period begins on the building and the AV systems. There can be product or manufacturer's warranty and a system warranty. The timeframe will be different for various projects, but this is typically a one-year period during which the contractor is required to correct any problems because of the system installation.

A service level agreement (SLA) is a contract between a service provider and a customer that specifies what services will be provided and with specific measurable terms. It can include performance benchmarks or standards, roles and responsibilities of all parties involved, the duration of the agreement, and evaluation criteria.

### 9.4.2 Project Post-Occupancy

Post-occupancy reviews are a valuable method of obtaining feedback on recently completed construction or upgrade projects from the personnel who were involved in the process, as well as occupants and other end users. A continuous verification of work is established to verify if there is a maintenance agreement with the vendor or if maintenance will be managed in-house. Higher education institutions require verification that the system can be reset to a pre-failure state.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

One of the support types includes remote support and monitoring that includes basic troubleshooting, initial issue discovery, and escalation of issues to the appropriate parties as needed. Managed AV services provide a high level of communication and infrastructure. These services may include support and maintenance contracts, remote access support, outsourced onsite support, and asset management services.

For the system's longevity, it is important to have a refresh or update plan. This plan will allow the institution to obtain the maximum value out of their initial project investment. As AV technology evolves at a rapid pace, replacement cycles are necessary. Replacement costs, enhanced productivity, staff support time, learning curve, and support costs need to be considered. These plans typically suggest a five-year revolving projection or a refresh plan.

### 9.4.2.1 Identification of Roles

In the post occupancy or maintenance phase, the roles need to be pre-identified to ensure the AV equipment remains functioning through its lifecycle.

The campus facilities may be responsible for coordinating efforts between architects, consultants, and end users to finalize the project. They may also be the group that ultimately takes possession of the space. Once the project is handed off, a document that identifies responsibilities will need to be created.

This leads usually to the AV/IT support team. This group is not always just one; it may be a cross-section of different departments within the institution. Some of the responsibilities may need to be contracted. The support group will be primarily responsible for the daily support of the technology. They will need to liaison with other AV/IT groups at the institution to guarantee a well-run system.

AV support staff typically train and support the end users. The training needs to be comprehensive to teach the end users how to use the system while reducing service calls that are a result of user error. This will also reduce the possibility of improper use that could damage the room system. However, if the end users do not use the equipment, the project has not been successful.

Faculty development is extremely important because newly configured spaces drive different pedagogies. In higher education, with the constant change in technology scope, comes an equally fast change in how classes are taught. Flipped classrooms, small group work, learner-centered focus, collaborative learning, and case studies are just a few of the current trends in higher education. Faculty will need training in how to develop their content to fit the pedagogy, which may be heightened as an effect of using AV systems installed in their teaching spaces. This can promote greater teaching effectiveness and faculty and student satisfaction. The institution may have an instructional technologist on staff to assist the faculty with the curriculum. They would also be available to develop training documentation for the end users.

### 9.4.2.2 Preventive Maintenance

Preventive maintenance is an important step in protecting the university's investment as well as ensuring that the spaces are functioning as designed.

Preventive maintenance is an equipment strategy that is based on inspection, replacement, or dismantling of items or room-installed AV equipment at a fixed interval, regardless of the condition at the time. Such maintenance can be provided by in-house staff or contracted to AV integrators.

Preventive maintenance may include:

- Checking hardware systems functionality and alignment
- Replacing bad cables/connectors
- Cleaning and/or replacing filters
- Rebooting systems if required

### 9.4.2.3 Corrective Maintenance

Corrective maintenance is needed when a failure is noted in the system. At this time, again either in-house or contracted staff repairs, restores, or replaces faulty system components. It is an immediate need that should be addressed as soon as possible. Each university will have its own procedure for this type of maintenance.

### 9.4.2.4 Break-Fix Maintenance

A break in service that would prevent the classroom from functioning as desired is a cause for break-fix maintenance. An institution should have a plan on how users are to report issues and failures in the system and, more importantly, who to report them to. Such maintenance can be performed through a ticketing system generated electronically or by a help desk. It is extremely important that the faculty knows when the issues will be repaired.

Maintenance agreement/contracts may include any of the following components:

- Web-based customer ticketing system and detailed service reporting.
- Guaranteed response time for phone support and service level agreements.
- Replacement or repair of non-functioning AV equipment.
- Proactive monitoring, software/firmware upgrades, testing, and continuous training.
- Manufacturer escalation and management.
- Priority part replacement (expedited delivery of replacement products to get things moving quickly for timely repairs).
- Security best practices recommendations to ensure locked access of the AV systems.
- Touch panel optimization with button relabeling and location changes; button additions that do not require physical install or licensing; color and source priority changes; updated training materials; and additional training sessions for end users.
- Annual AV tune-up/assessment that features physical inspection; testing and cleaning of all system components; system update documentation; equipment replacement; check and cleaning for all filters and input/outputs; reviews of past year service tickets; refresher training on controllers and keypads; and recommend best practices.
- Field repair that provides onsite support for two site visits and unlimited remote service per year per location (labor and trip charges apply to onsite support after two site visits or eight hours of service per year per location).
- Assistance with move/adds/changes with appropriate system documentation updates.
- Continuous training to meet specific needs and applications.

Depending on the depth of the project, it is important to check and document that all phases have been carried out to the user's expectations.

AV integration into a higher education learning space is never done. It is an ongoing process that just cycles into the next project. By following some of the guidelines mentioned within this chapter, campus AV staff should be able to transition their staff, faculty, and students into their new space with minimal disruption to the learning process.

## Annex A Teaching Space Examples

The following are additional teaching space examples categorized by pedagogy.



**Youngstown State University (courtesy of The Sextant Group)**



**University of Missouri (courtesy of The Sextant Group)**



**Figure A.3 – Small group collaborative  
University of Houston (courtesy of Gensler)**



**Figure A.4 – Kinesthetic or physical learning classroom  
Western North Carolina (courtesy of The Sextant Group)**



**Figure A.5 – Synchronous distance learning/asynchronous learning classroom  
Duke University**

## Annex B Relevant International and National Standards

The following are standards referenced in this guide as well as other useful standards:

Acoustical Society of America. ANSI/ASA S12.60-2009/Part 2 (R2014). *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 2: Relocatable Classroom Factors.*

ASTM International. ASTM E2129–10. *Standard Practice for Data Collection for Sustainability Assessment of Building Products.*

↓ ↓ ↓ ↓. ASTM E2742–11. *Standard Specification for Evaluation and Selection of Exhibits for Environmentally Sustainable Meetings, Events, Trade Shows, and Conferences.*

↓ ↓ ↓ ↓. ASTM E2745–11. *Standard Specification for Evaluation and Selection of Audio Visual (AV) and Production for Environmentally Sustainable Meetings, Events, Trade Shows, and Conferences.*

Consumer Electronics Association. CEA-931-C R-2012 (ANSI). *Remote Control Command Pass-through Standard for Home Networking.*

↓ ↓ ↓ ↓. Joint Industry Guide (JIG) 201. *Material Composition Declaration for Packaging of Electrotechnical Products.*

International Organization for Standardization. ISO 9001:2008. *Quality management systems — Requirements.*

↓ ↓ ↓ ↓. ISO 14001:2004. *Environmental Management Systems.*

↓ ↓ ↓ ↓. ISO 14004:2004. *Environmental management systems — General guidelines on principles, systems and support techniques.*

↓ ↓ ↓ ↓. ISO 15392:2008. *Sustainability in building construction — General principles.*

↓ ↓ ↓ ↓. ISO 16813:2006. *Building environment design — Indoor environment — General principles.*

↓ ↓ ↓ ↓. ISO 20121:2012. *Event sustainability management systems — Requirements with guidance for use.*

↓ ↓ ↓ ↓. ISO 21929-1:2011. *Sustainability in building construction — Sustainability indicators — Part 1: Framework for the development of indicators and a core set of indicators for buildings.*

↓ ↓ ↓ ↓. ISO 21930:2007. *Sustainability in building construction — Environmental declaration of building products.*

AVIXA. ANSI/AVIXA 1M-2009. *Audio Coverage Uniformity in Enclosed Listener Areas.*

↓ ↓ ↓ ↓. ANSI/AVIXA 2M-2010. *Standard Guide for Audiovisual Systems Design and Coordination Processes.*

↓ ↓ ↓ ↓. ANSI/AVIXA 3M-2011. *Projected Image System Contrast Ratio.*

↓ ↓ ↓ ↓. ANSI/AVIXA 4:2012. *Audiovisual Systems Energy Management.*

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

↓ ↓ ↓ ↓. ANSI/AVIXA 10:2013. *AV Systems Performance Verification*.

↓ ↓ ↓ ↓ AVIXA F501.01:2015, *Cable Labeling for Audiovisual Systems*.

↓ ↓ ↓ ↓ AVIXA F502.01:2018, *Rack Building for Audiovisual Systems*

↓ ↓ ↓ ↓ AVIXA RP-C303.01:2018, *Recommended Practices for Security in Networked AV Systems*

United States Department of Education. *Individuals with Disabilities Education Act*.

United States Department of Justice Civil Rights Division. *2010 ADA Standards for Accessible Design*.

United States Department of Labor. *Rehabilitation Act of 1973*.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

### Annex C: Further Reading

The following list includes other international organizations and programs that affect the construction and technology of higher education institutions:

Organization/Program	Description
Association of Educational Technology Managers (AETM [Australia])  <a href="https://www.aetm.org/">https://www.aetm.org/</a>	A professional association that represents AV and educational technology managers and specialists in the Asia/Pacific region.
BEAM Society Limited (Hong Kong) (BEAMPlus Assessment Tool)  <a href="https://www.beamsociety.org.hk/en_index.php">https://www.beamsociety.org.hk/en_index.php</a>	A non-profit organization committed to promoting and developing the tools for assessing green buildings and training professionals in the Asia Pacific.
BREEAM (United Kingdom)  <a href="http://www.breeam.com">www.breeam.com</a>	An environmental assessment method and rating system for sustainable buildings.
Building and Construction Authority (Singapore) (BCA Green Mark Scheme) <a href="https://www.bca.gov.sg/greenmark/gmis.html">https://www.bca.gov.sg/greenmark/gmis.html</a>	An agency under the Ministry of National Development for built environment in Singapore.
Canada Green Building Council (CaGBC) Leadership in Energy and Environmental Design (LEED) Canada  <a href="http://www.cagbc.org/">http://www.cagbc.org/</a>	An organization whose mission is to lead and accelerate the transformation to high-performing, healthy green buildings, homes and communities throughout Canada
Consortium of College and University Media Centers (CCUMC [United States])  <a href="http://www.ccumc.org/">http://www.ccumc.org/</a>	An organization providing leadership and a forum for information exchange for media and technology support professionals in higher education settings
Council of Educational Facility Planners International (CEFPI)  <a href="https://www.tsn.com/organizers/council-educational-facility-planners-international-cefpi">https://www.tsn.com/organizers/council-educational-facility-planners-international-cefpi</a>	A non-profit association whose mission is improving the places where children learn.
EDUCAUSE (United States) EDUCAUSE Learning Initiative  <a href="http://www.educause.edu/eli">http://www.educause.edu/eli</a>  Learning Space Rating System (LSRS)	An organization dedicated to helping information technology leaders, managers, and users to shape strategic IT decisions at every level within higher education.
Energy Star  <a href="http://www.energystar.gov/">http://www.energystar.gov/</a>	A U.S. Environmental Protection Agency voluntary program that helps businesses and individuals save money and protect the climate through energy efficiency

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Organization/Program	Description
<p><b>European Commission (European Union) Strategic Environmental Assessment (SEA)</b></p> <p><a href="http://ec.europa.eu/environment/eia/sea-legalcontext.htm">http://ec.europa.eu/environment/eia/sea-legalcontext.htm</a></p>	<p>The executive body of the European Union divided into several departments based on the specific policy area or service. SEA is mandatory for plans/programs that are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste/water management, telecommunications, tourism, town and country planning, or land use.</p>
<p><b>Flexible Learning Environments Exchange (FLEXspace) [United States]</b></p> <p><a href="https://flexspace.org/">https://flexspace.org/</a></p>	<p>An open access repository of high-resolution images and related information that describes detailed attributes of learning spaces from institutions across the globe.</p>
<p><b>Future of Education Technology Conference</b></p> <p><a href="https://www.fetc.org/">https://www.fetc.org/</a></p>	<p>For over 40 years, the National Future of Education Technology® Conference has gathered the most dynamic and innovative education leaders and professionals from around the world for an intensive, highly collaborative exploration of new technologies, best practices and pressing issues. It is known to educators and technologists as the best place to engage with the thought leaders and pioneers who are leading the charge in classrooms, schools and entire districts.</p>
<p><b>Green Building Council Australia Greenstar</b></p> <p><a href="https://new.gbca.org.au/">https://new.gbca.org.au/</a></p>	<p>A national, non-profit organization committed to developing a sustainable property industry for Australia by encouraging the adoption of green building practices.</p>
<p><b>Green Building Initiative (United States) Green Globes Program</b></p> <p><a href="http://www.thegbi.org/green-globes/">http://www.thegbi.org/green-globes/</a></p>	<p>A non-profit organization whose mission is to accelerate the adoption of building practices that result in energy-efficient, healthier and environmentally sustainable buildings by promoting credible and practical green building approaches for commercial construction.</p>
<p><b>Green Globes (United States and Canada)</b></p> <p><a href="http://www.greenglobes.com/home.asp">http://www.greenglobes.com/home.asp</a></p>	<p>An online environmental design and management tool used primarily in the United States and Canada, which includes an assessment protocol, rating system, and guidance for green building design, operation and management. The assessment covers the design of new buildings and renovation, management and operation of existing buildings, and sustainable interiors.</p>
<p><b>Indian Green Building Council (IGBC) IGBC Rating Systems</b></p> <p><a href="https://igbc.in/igbc/">https://igbc.in/igbc/</a></p>	<p>An organization that offers a wide array of services which include developing new green building rating programs, certification services, and green building training programs.</p>
<p><b>Institute for Building Environment and Energy Conservation (IBEC [Japan])</b></p> <p><a href="https://www.ibec.or.jp/english/">https://www.ibec.or.jp/english/</a></p> <p><b>Comprehensive Assessment System for Building Environment Efficiency (CASBEE)</b></p> <p><a href="https://www.ibec.or.jp/CASBEE/english/">https://www.ibec.or.jp/CASBEE/english/</a></p>	<p>An organization performing technology research and development related to environmental load reduction, providing guidance, and promoting the effective use and conservation of energy in buildings.</p>
<p><b>Korea Green Building Council (KGBC)</b></p>	<p>An independent (non-government) and non-profit organization committed to applying environmental best</p>

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Organization/Program	Description
<p><a href="https://www.koreagbc.org/">https://www.koreagbc.org/</a></p>	practices to facilitate the transformation of the global sustainable building industry.
<p><b>Multimedia Educational Resource for Learning and Online Teaching (MERLOT II [United States])</b></p> <p><a href="http://www.merlot.org/merlot/index.htm">http://www.merlot.org/merlot/index.htm</a></p>	A curated collection of free and open online teaching, learning, and faculty development services contributed and used by an international education community.
<p><b>National Fire Protection Association (NFPA [United States]) Codes and standards</b></p> <p><a href="http://www.nfpa.org/codes-and-standards">http://www.nfpa.org/codes-and-standards</a></p>	An international nonprofit association whose mission is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education.
<p><b>New Media Consortium (United States) Horizon Project by the New Media Consortium</b></p> <p><a href="http://www.nmc.org/horizon-project">http://www.nmc.org/horizon-project</a></p>	An international community of experts in educational technology, including the practitioners who work with new technologies on campuses, the visionaries who are shaping the future of learning, its staff and board of directors, and the advisory boards and others who help the NMC conduct their research.
<p><b>Philippine Green Building Council (PHILGBC)</b></p> <p><a href="http://philgbc.org">http://philgbc.org</a></p>	A national non-stock, non-profit organization that promotes the sharing of knowledge on green building practices to the industry to ensure a sustainable environment.
<p><b>SCHOMS (United Kingdom)</b></p> <p><a href="http://www.schoms.ac.uk/">http://www.schoms.ac.uk/</a></p>	The professional body for Senior Managers working within UK Higher Education
<p><b>Society for College and University Planning (SCUP [United States])</b></p> <p><a href="http://www.scup.org/page/index">http://www.scup.org/page/index</a></p>	A community of senior, higher education leaders who are responsible for, or are involved in, the integration of planning on their campuses and for the professionals who support them.
<p><b>Taiwan Green Building Council Green Building Grading System</b></p> <p><a href="http://www.taiwangbc.org.tw/en/">http://www.taiwangbc.org.tw/en/</a></p>	An organization promoting green buildings, facilitating international cooperation, and assisting with the globalization of the construction industry of Taiwan.
<p><b>TCO Development</b></p> <p><a href="http://tcodevelopment.com/">http://tcodevelopment.com/</a></p>	The organization behind the TCO Certified sustainability certification for IT products, which provides businesses and organizations with a way to reduce their environmental impact and improve their work environments and efficiency.
<p><b>U.S. Green Building Council (USGBC [United States]) Leadership in Energy and Environmental Design (LEED)</b></p> <p><a href="http://www.usgbc.org/certification">http://www.usgbc.org/certification</a></p>	An organization committed to cost-efficient and energy-saving green buildings and working toward its mission of market transformation through its LEED green building program, robust educational offerings, a nationwide network of chapters and affiliates, the annual Greenbuild International Conference & Expo, and advocacy in support of public policy that encourages and enables green buildings and communities
<p><b>World Green Building Council (WGBC)</b></p>	A network of national green building councils in more than one hundred countries. Its report (linked on the left)

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Organization/Program	Description
<b>“Health, Wellbeing and Productivity in Offices: The Next Chapter for Green Building”</b>  <a href="https://www.worldgbc.org/news-media/health-wellbeing-and-productivity-offices-next-chapter-green-building">https://www.worldgbc.org/news-media/health-wellbeing-and-productivity-offices-next-chapter-green-building</a>	explains how office design significantly impacts the health, wellbeing, and productivity of staff.

## Annex D: Bibliography

Association of Educational Technology Managers. *Audio Visual Design Guidelines: Tertiary Teaching Spaces, Second Edition*. Crawley, Western Australia: 2012.

AVIXA. *Audiovisual Best Practices*. Fairfax, VA: 2005.

↓ ↓ ↓ ↓. *Audiovisual Systems Performance Verification Guide*. 2014.

↓ ↓ ↓ ↓. *AV Design Level 1: Environment Online*. 2014.

↓ ↓ ↓ ↓. *AV Design Level 2: Infrastructure Online*. 2014.

↓ ↓ ↓ ↓. *AV Design Level 3: Applied Design Online*. 2014.

ICT Today, The Official Trade Journal of BICSI, *AV over IP and Complex Enterprise* by David Shamir July, 2020

**Annex E: Glossary**

Term	Definition
asynchronous learning	Learning that takes place from the common material at different places and times.
authority having jurisdiction (AHJ)	An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. In some areas of the world, authority having jurisdiction is known as a "regional regulatory authority."
blended learning	The practice of using both online and in-person learning experiences when teaching students.
Bluetooth	A wireless technology for low-cost, short-range radio links between mobile devices, computers, and other consumer devices.
building information modeling (BIM)	A term coined in early 2002 by industry analyst Jerry Laiserin to describe virtual design, construction and facilities management. BIM processes revolve around virtual models that make it possible to share information throughout the entire building industry.
building management system (BMS)	A computer-based control system used in buildings to controls and monitor the building's mechanical and electrical equipment such as ventilation, lighting, power, fire, and security systems.
contrast ratio	The dynamic video range of a display device as a numeric relationship between the brightest color (typically white) and the darkest color (typically black) that the system can produce.
design development (DD)	A phase whose goal is to move beyond major coordination issues to the basic floor plans. During this phase, all major design decisions are made and finalized with the owner so the building floorplan is set, engineering systems selected, and detailing can commence.
dynamic host configuration protocol (DHCP)	An IP addressing scheme that allows network administrators to automate address assignment.
electromagnetic interference (EMI)	The improper operation of a circuit (noise) because of interference from electric and/or magnetic fields.
fan coil unit (FCU)	A simple device consisting of a heating or cooling coil and fan. It is part of an HVAC system found in residential, commercial, and industrial buildings.
flipped or hybrid classes	Classes in which students watch lecture material online, to free up classroom time for interactive activities.
Haas effect	A psychoacoustic effect whereby a listener can distinguish the original source location even if there are strong echoes or reflections that may otherwise mislead the listener.

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Term	Definition
high definition television (HDTV)	A technology that provides vertical resolution that ranges from 720 lines with progressive scanning (720p) to 1080 lines with interlaced scanning (1080i).
information and communications technology (ICT)	Any communication device, application, or service related to radio, television, cellular technology, computing, networking, and satellite systems, including services such as videoconferencing and distance learning.
integrated services digital network (ISDN)	A communications standard for transmitting voice, video and data over digital phone lines or the traditional telephone network. Common applications of ISDN include telecommuting, Internet access, video conferencing, and data networking.
Leadership in Energy and Environmental Design (LEED)	A green building certification program that recognizes best-in-class building strategies and practices.
learning analytics	The measurement, collection, analysis, and reporting of data about learners and their contexts for purposes of understanding and optimizing learning and the environments in which learning occurs.
massive open online course (MOOC)	A course of study made available online without charge to a very large number of people.
media access control (MAC) address	The physical address local area networks (LANs) use to communicate.
noise criteria (NC) rating	Originally developed by Leo Beranek in 1957, NC curves were developed to establish satisfactory conditions for speech intelligibility and general living environments. Measurements are taken at eight center octave frequencies from 63 to 8,000 Hz and plotted against a standardized curve.
pedagogy	The method and practice of teaching.
quality of service (QoS)	A term used to refer to any method of managing data traffic to preserve system usefulness and provide the best possible user experience. Typically, QoS refers to some combination of bandwidth allocation and data prioritization.
radio frequency interference (RFI)	Radiated electromagnetic energy that interferes with or disturbs an electrical circuit.
room criteria (RC) rating	Developed by Warren Blazier in 1981 and based upon an American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) study of heating, ventilating, and air conditioning noise in office environments.  Measurements are taken at eight center octave frequencies from 31.5 to 8,000 Hz and the RC is the average of the measurements taken from 500, 1,000, and 2,000 Hz and includes additional steps to rate the

## AV/IT INFRASTRUCTURE GUIDELINES FOR HIGHER EDUCATION

Term	Definition
	background noise as (N) for neutral, (R) for rumbly or (H) hissy.
schematic design (SD)	A phase during which the conceptual design is developed to a more detailed level, beginning to show more detail such as double lines for walls, door locations and room orientations.
screen gain	The reflective properties of a screen. A perfect diffusion screen is used as a reference point as it uniformly reflects light and it is said to have a gain of 1.0. A gain of less than 1.0 typically refers to a screen that is gray instead of white and it is used to increase the contrast of the image. Screens with a gain higher than 1.0 do not scatter the light perfectly but reflect most of the light energy back in a specific direction. Higher gain screens are more tolerant of higher ambient light conditions.
simple network management protocol (SNMP)	A set of Internet Engineering Task Force (IETF) standards for network management, including an Application Layer protocol, a database schema, and a set of data objects. SNMP exposes management data in the form of variables on the managed systems, which describe the system configuration. These variables can then be queried, and sometimes set, by managing applications.
sound pressure level (SPL)	A measurement of all the acoustic energy present in an environment. It is typically expressed in decibels (dB SPL).
sound reinforcement	The combination of microphones, audio mixers, signal processors, power amplifiers, and loudspeakers that are used to electronically amplify and distribute sound.
virtual local area network (VLAN)	A network created when network devices on separate LAN Segments are joined together to form a logical group that can communicate via switching.
voice over internet protocol (VoIP)	Protocols and technology that allow the digital transmission of phone calls and multimedia over the Internet and other networks.
Wi-Fi	The wireless connection known defined by the IEEE 802.11 standard and revised several times to keep up with the growing demands for wireless communication.