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Introduction

It is the intent of this report to document the development of an audio/visual and architectural acoustical design solution for the Army Corps of Engineers IET Chapel project. The purpose of the worship space is to provide a spiritual center for everyone in the military community. The worship space should be one that has many functions and is designed to create an atmosphere that can accommodate these events as they occur. This design provides the occupants with a full range of experiences that includes one of quite reflection, joyous celebration, and the spectrum of emotions and enjoyment that comes from live music. The following report includes proposed design solutions that will enhance the performance of this space, as well heighten the experience of the worshiper.

In this study, Kenneth Hahn Architects (KHA), and Theer and Associates (Acoustical Engineers) developed a design for the interior worship space of the chapel which includes the seating/pew layout, basic concepts for the interior design, architectural strategies for treating the acoustics of the space and analysis of these strategies, and an audio-visual system layout.

Seating Design

A number of options were explored for the arrangement and placement of the seating. These included a straight design that was orthogonal with the stage, a curved option that was concave in the relationship with the stage, and a mitered design that places the center section of the audience perpendicular with the stage and angles the edges of the audience to create better viewing angles. The mitered solution is the option that was determined to be the most appropriate for the space.

Next, we examined the flow and circulation of the occupants moving through the space from a code requirement standpoint and evaluated the overall flow and traffic patterns and viewing angles of the occupants. This led to eliminating any seating that would occur in the corners and create bad viewing angles and poor acoustic conditions. The final seating layout can be found at ***Appendix A*** at the end of this document.

The material for the seating was designed around using solid wood and/or furniture grade plywood. The solid wood material sound reflection properties have been accounted for in the acoustical design of the space.

In researching the pew designs that would be best suited for this space several pew manufacturers appear to have products that would fit the design intent which include, but not limited to: *New Holland Church Furniture* and *Sauder.*

Seating Code Analysis

A seating code analysis was performed as part of this report. The following are the basic parameters for the seating design:

Code Research Information

Code Resource Used: 2009 IBC

Occupancy Classification: Assembly Group A

Assembly Type: A-3

Fixed Seating: 18" per person

Occupant Load as determined by Number of fixed seats = 1400 occupants *(Note: this does not include occupants from adjacent rooms in the chapel.)*

Maximum Travel Distance in a Non-Smoke Protected, but sprinkled building: 250'-0" - *with the current door placement, the design complies with this distance.*

Common path of Travel: 30'-0" max (from seat to a point where occupant has choice of two paths of egress) – *See **Appendix A** for the seating layout; worst case scenario in the design is roughly 17'-0".*

Minimum Aisle Width: 42" or (2 times the pew aisle space of 22" = 44" min. (See Below)) – Also *see **Appendix A** for the seating layout; the narrowest aisle provided in this design is 60".*

Seating Row/Aisle Spacing: 12" min (must be increased by .3 inches for every additional seat beyond 14, clear width not required to exceed 22")

Calculation for Pew Spacing in this design: 12 + .3(22-14) = 14.4" min required – *We are showing 22" in our design, see **Appendix B** for clarification.*

Interior Design

As part of the process of designing the interior worship space, some basic concepts for interior design emerged. In looking at the design language from the original design, and blending it with the pew layout that was chosen, we are showing a revised floor plan where the geometry of shapes in the space have been changed from

a mix of angles and a few curves, to all angular design shapes to create a sense of unity of all the forms in the space.

Next, we examined the surface materials and the effect they will have on the acoustical properties of the space. The following are some basic strategies for each surface:

Floors: Porcelain tile aisles *(Note: we looked at whether there is any acoustical improvements from using carpeting beneath the seating areas, but we found that there is not a significant difference between hard flooring surfaces and glue down carpet from an acoustical perspective. Since there will be a considerable amount of traffic in the IET Chapel from troops wearing their field gear, we are recommending that no carpet be installed.)*

Walls: The exterior side walls of the worship space do not provide enough surface area to make a significant impact on the acoustics. These walls and the windows in these walls are shown to be as the original design intended. The rear wall however has been changed to provide enhanced acoustical performance. The original design shows this wall to be constructed in a concave shape from floor to roof, which will create an unwanted focusing of sound back at the middle of the space. To correct this issue, the bottom nine feet of the rear wall is being covered with acoustic absorption panels that shall be covered in a durable and dent resistant product such as poly-scrim or polyester fiber (see acoustical products section under acoustical analysis, later in this report.). Also, we are creating a gypsum board soffit and bulkhead from 9 feet above the finished floor up to the vaulted ceiling. This bulkhead is angular in plan (rather than concave,) for better control of the sound reverberation in the space; see **Appendix C and G** for clarification.

Ceilings: Because of the vaulted pre-engineered structural design for this space constitutes the majority of the reflective surfaces in this space, the majority of the strategies for the architectural and acoustical designs focus on how to treat the ceiling in order to make the space perform properly for speech and music. The next section “Architectural Acoustical Design” will address the ceiling component of the design in greater detail.

Acoustic Architectural Design

The worship space is created by a vaulted pre-engineered building structure. Because of the amount of volume in this space, this becomes the main source of sound treatment for tuning the space acoustically. The two options utilize the vaulted ceiling in

different ways, both of them treating the space acoustically and creating architectural forms that are pleasing and functional for the worship space.

The roof enclosure we are assuming for this study is an insulation system that is typically used for pre-engineered metal buildings, with a standing seam roof above. This type of system provides a vinyl layer on the inner face and which is mounted below the roof purlins. In the event that the design would want to use metal roof deck supported on additional sub-framing between the main bent frame members, that would also be possible, and would be able to accommodate the solutions discussed below.

Careful attention was given to ensure that the alter/stage space was the primary focus point and the most dynamic part of the worship space The altar area was also designed to be an integral part of the proper acoustic performance of the overall Chapel space. The stage area is placed on a raised platform with a choir platform that surrounds the rear area of the stage. In the middle of the choir space the baptismal becomes a feature that creates a strong visual anchor for the language of the ceiling features above. These ceiling features consist of two sloped soffits that create an angled surface that acts as an architectural design feature and a functional way to bounce sound out towards the congregation in the Chapel. These ceiling features also house the recessed roll down video screens and the projector platforms that will serve the space during worship services. On both sides of the stage there are vertical bulkheads that serve to close off the front edge of the space along the sloped roof structure. These bulkheads also house the audio speakers that will be covered with speaker cloth. We recommend placing these stacks of speakers in this type of recessed installation so that they don't cause a visual disruption to the overall aesthetic of the alter space.

The design includes a soffit that has been created along the outer two sides of the worship space along the low end of the roof slopes. These soffits serve two purposes. First, the soffit removes some un-needed volume from the space (which aids in creating an enhanced acoustic solution,) while creating an angled surface to bounce sound down into the corners of the seating area. Another solution investigated as opposed to constructing this soffit was to use suspended "acoustical clouds" in this portion of the Chapel, however we found that these clouds would be too low and would block views of the video screens and interfere with the planned HVAC design. Which leads to the second purpose for the soffit design; it creates a void to enclose the primary supply air ducts in the worship space. Also, the design includes a drywall enclosure around the pre-engineered bent beam structures that serve as an enclosed space to run the secondary supply air ducts as well as fire sprinkler piping runs and other miscellaneous utilities required in the space.

Acoustical Cloud - Option 1

The first of the two options is an “acoustical cloud” system where individual modular ceiling elements are hung from the structure above. This strategy creates a reflective surface that is placed at an angle that is designed to direct the sound from the altar area to the listener’s ears without much indirect reverberation. The top side of each cloud element has acoustic sound insulation to absorb any sound that gets past the clouds and into the space above so it doesn’t create unwanted interference. The construction of these clouds can vary from pre-manufactured units to on-site clouds constructed of metal studs and drywall. It has been the experience of the design team on similar projects that the on-site construction method has been more cost effective and gives equally satisfactory results. The cloud elements can be constructed on the floor, painted, and raised into position to eliminate the cost of actually building these while up in the air on lifts.

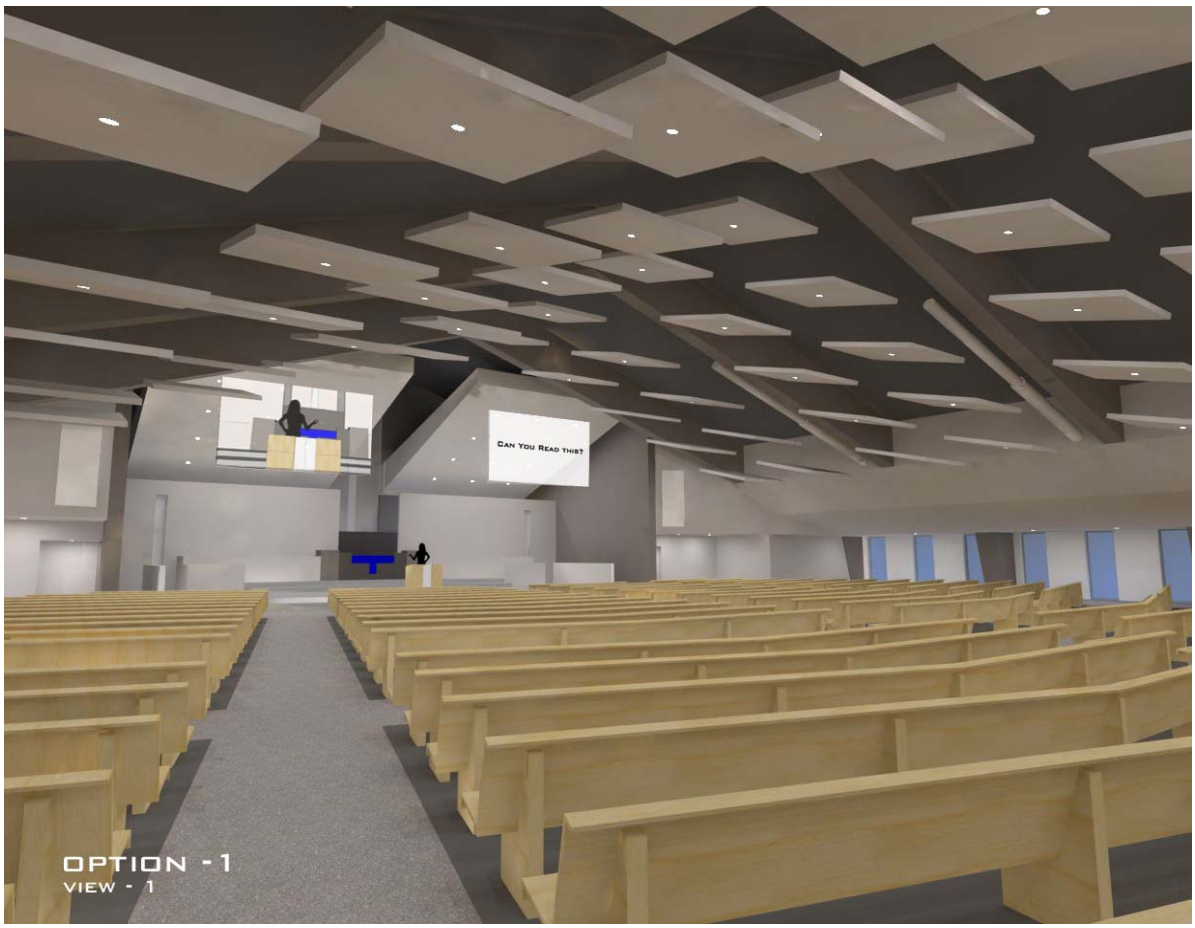
The exposed surface of the pre-engineered structure’s roofing insulation can be exposed in this option. Since this surface will be visible behind the acoustic cloud elements, we recommend that a dark color be used for this surface. The surface considered in this study is the *Simple Saver System*, by *Thermal Design*, which has a vinyl layer that remains visible to the interior. This vinyl layer is available in black color, which would be in keeping with our concept described above. The Simple Saver System features a 75% absorption rate for the sound that gets above the acoustical clouds. The portion of the sound that is not absorbed by the Simple Saver System will be absorbed by the acoustic insulation that lies on top of each acoustic cloud element.

This option would require an examination of how to adequately light the space. The original lighting design shows one downlight point source fixture at 10’-0” o.c. both directions, plus several pendant fixtures. In the computer simulated renderings we are showing one downlight per cloud. This creates a nice ambient glow, but an actual investigation of this lighting scheme would need to be performed. Pendant fixtures that are part of the original lighting design would be difficult to integrate into the acoustic cloud elements. Further study is needed to determine the appropriateness of the light levels provided without these pendants, and with the elevations of the downlights once they are integrated into the acoustic cloud elements.

This option offers the most superior acoustic performance, as seen in the Room Acoustic Analysis later in this report.

***See Appendix – C, D, E, and F for detailed drawings regarding Option – 1**

***See Next Page for Option – 1 Renderings**


CAN YOU READ THIS?
OPTION - 1
VIEW - 1

OPTION - 1
VIEW - 2

Vaulted Ceiling - Option 2

The second option is a simple “Vaulted” ceiling design that may be requested by particular installations. Architecturally, it differs from the acoustic cloud (Option-1) because of its simplicity and its aesthetic that is more familiar to that of a traditional worship space.

This option suffers from some deficiencies in the acoustic performance that is desired for the Chapel, due to its vaulted geometry, which is angling the wrong direction and creating reverberation and speech/music quality problems. See the writeup later in this report under Room Acoustic Analysis for an in-depth look at this issue and the necessary solution which would allow this option to be used.

In order to accommodate this type of design and still have the space perform acoustically, the ceiling space is treated to remove any sound reflection from the ceiling surface and rely on direct sound originating from the altar. This is achieved by providing sound absorption panels on the main vaulted part of the ceiling volume. The sound absorbing panels are mounted onto a metal liner panel that is installed on the bottom side of the vinyl liner surface from the Simple Saver System, being mounted to the structural roof purlins.

The proposed lighting design for Option-2 uses an indirect lighting method to bounce light off the acoustical ceiling panels and down on to the seating areas. To achieve this type of lighting strategy we have selected an acoustical absorption panel that has a paintable type of poly-scrim on the surface that would serve to reflect the indirect light downward, and will also absorb sound. This indirect lighting design would require more investigation to be certain it will adequately light the space. Additional lamps may be added if needed to reach desired light levels.

While still considered to be an acceptable acoustic design, the Option-2 solution does not perform quite as well as Option-1, as described later in this report. Cost is also higher, as seen in the cost analysis that is included as part of this report.

***See Appendix – G, H, J, and K for detailed drawings regarding Option – 2**

***See Next Page for Option – 2 Renderings**

CAN YOU READ THIS?
OPTION - 2
VIEW - 1

OPTION - 2
VIEW - 2

Room Acoustic Analysis

An acoustical analysis of the design for the Army IET Chapel was performed to examine the effects of the shape, materials, and other design elements on the overall sound quality of the space. The analysis included computer modeling using EASE software to compare multiple configurations, in which reverberation time, speech intelligibility, sound pressure levels, and overall sound distribution were compared. This report will outline the findings of that analysis, which will also include recommendations for the appropriate treatment of the space in order to provide a good acoustical environment. Also included is a *Glossary of Terms*, which provides definitions for all of the acoustic terminology used throughout this report.

Due to the overall size and shape of the space, the initial reverberation time was quite high. An acceptable reverberation time for a multiple use space in which there will be a combination of speech applications and music applications, is between 1.25 and 1.50 seconds. As designed, with no treatment, the reverberation time is well above this, reaching over 4.0 seconds at many frequencies. At that level, it can be expected that there will be poor speech intelligibility, high noise levels, and echoes. Reverberation time is calculated based on the surface area, volume of the space, and the absorption coefficients of the building materials. In order to reduce the reverberation time, one or multiple of these elements needs to be changed.

In order to maintain the required minimum seating capacity, the floor plan of space was not a variable that could be adjusted, but the overall effective volume was something that could be reduced. The ceiling shape allows for the addition of soffits around the perimeters and at the front of the space, which will reduce the overall volume of the space, and in turn also reduces the reverberation time. This alone, though, does not reduce it to an acceptable level. It does however provide angled surfaces along the sides of the space that will reflect sound back down to the audience area and the angled reflectors above the stage area will help to reflect sound out into the audience area as well.

The next step is to change or add materials to the space that have higher absorption coefficients or an overall higher Noise Reduction Coefficient (NRC). In this space, there were several locations in which this is feasible. Due to the fact that the ceiling has a very large surface area, adding absorption to it would have a very high impact on reducing the overall reverberation time. An acoustic deck is an effective solution for an application in which the deck will be exposed. The Simple Saver System is an option that was examined in this space, as it provides an NRC of 0.75. Using just the simple Saver system reduces the reverberation time to a much more adequate level, but it is still high in the low frequencies, and a little bit too low in the mid to high

frequencies, as it goes below 1.0 second in the mid frequencies, which will make the room too “dead” for musical performances. The high reverberation in the low frequencies will not affect speech as much, but will have an effect on music with bass.

Another surface area which can and should be treated, is the back wall. Although the overall surface area is not as large and will not have a large impact on reducing the overall reverberation time, the concave shape will focus sound, and could produce what is called “slapback.” “Slapback” is produced when the sound is reflected back to the source on stage. It can cause sound issues and make it more difficult for a person speaking or playing on stage. These surfaces can be treated in one of two ways, by adding absorption or diffusion. Adding a diffusive surface will change the angles in which the sound is reflected so that it is not focused back to the source. In this application, though, since additional absorption is required, this is an ideal surface to locate it. It is recommended that a 2” absorptive panel with a minimum NRC of 1.00 be applied below the soffets on the back wall. An acceptable product would be the Golterman & Sabo Pinta (PP2) or Acousti-Panel (AP2). Data sheets can be found at the end of this section.

As stated previously, the ceiling is such a large surface area in this space, and therefore changes made to it will have a large impact on the acoustics. Not only can it provide absorption to the space, but can also provide sound distribution throughout the space through the use of clouds. Adding angled clouds throughout the ceiling area will help redirect any sound that hits them back down to the audience area. In addition to providing sound distribution, adding clouds also reduces the perceived volume in the space, as they will be located several feet below the deck, which will in turn help to minimize noise and reduce the reverberation time. The clouds need to be backed with acoustic fiberglass, though, so that any sound that escapes between them to the deck will be absorbed.

Another option that was explored was a vaulted ceiling rather than clouds. The vaulted ceiling also reduces the volume of the space, which in turn reduces the overall reverberation. In this case, though, since the ceiling surface is not angled in such a way to promote good sound distribution, it needs to be treated with an absorptive material to help absorb any sound that reaches the ceiling area so that the space does not have echoes or excessive noise. It will also help to bring the reverberation time to levels that are more acceptable. As with the Simple Saver system, though, the reverberation times in the lower frequencies are still fairly high if a 1” panel with an NRC of 0.80 is used. Using a 2” panel with an NRC of 1.00 has higher low frequency absorption, which will help to improve the reverberation time results.

The option that provides the lowest reverberation times and the best sound distribution is the cloud ceiling system. It reflects sound throughout the audience area so that there are no “dead” areas and it provides high speech intelligibility levels throughout as well. The vaulted ceiling option has acceptable reverberation levels, but the speech intelligibility is lower.

In all of the options, the stage area is used to place the sound source. In the initial room acoustic analysis, the source is placed at the level of a person speaking or singing (or even playing an instrument) so that the room is treated to produce good acoustics without electronic enhancement (i.e. speakers). If the room sounds good without speakers, then the addition of them will only improve the overall sound quality of the space. This is why it is necessary to use the angled reflectors above the stage area in front to help project the sound out into the audience area. In instances where the performers will not be on the stage, and may be located in the corner areas beneath the soffits, it is important to add treatment to help project the sound out so that it does not just resonate in the corner. A ceiling reflector is the best option for doing this, which would need to be at an angle of approximately 10 degrees. The reflectors could be constructed in the same manner as those recommended in the sanctuary, and they would need to have the acoustic insulation backing as well. An alternative would be to use wall diffusers to help diffuse the sound. See the end of this section for a data sheet on acceptable product options.

In addition to the angled ceiling clouds and soffits being used to reflect sound into the audience area, another option that was reviewed was angling the side walls of the chapel as well. Typically, parallel walls in a space have the potential to produce flutter echoes, due to the sound being bounced back and forth between the walls. In this space, though, it was determined that angling the side walls did not have a significant effect in the sound distribution, and due to the width of the space and the primary location of the sound source, there is not a risk for issues from flutter echoes either.

Please review Graphs and Diagrams at the end of this section for supporting data, including tables and diagrams of the results for the room acoustic analysis.

GLOSSARY OF TERMS

All Terms cited from:
Madan Mehta, Jim Johnson, Jorge Rocafort, *Architectural Acoustics Principles and Design* (Upper Saddle River, New Jersey: Prentice Hall, 1999).

Absorption Coefficient: a measure of the sound absorbing property of a surface

Dead Room: a room containing an unusually large amount of sound absorption.

Decibel (dB): a unit of measurement for sound pressure level, sound intensity level, or sound power level. Decibel is the term used to identify ten times the logarithim of the ratio of two like quantities.

Diffusion: the scattering or dispersion of sound.

Direct Sound: the sound that arrives at a receiver along a direct line from the source without reflection from any source.

Echo: a sound that has been reflected with sufficient time delay, and is of sufficiently high level to be heard as distinct from the original sound.

Flutter Echo: a rapid but repetitive succession of sounds from a sound source usually occurring as a result of multiple reflections in a space with hard, flat, parallel walls.

Frequency: the number of (full) cycles per second measured. The unit of frequency is cycles per second (cps), which is also called Hertz (Hz).

Noise: an unwanted sound.

Noise Reduction Coefficient (NRC): a single number rating derived from measured values of sound absorption coefficients of a material at 250, 500, 100, and 2000 Hz. NRC is an estimate of the sound absorptive property of an acoustical material. NRC materials range from nearly 0 for a hard reflective surface material to nearly 1.2 for a highly absorptive material.

Reverberation: the continuation of sound in an enclosed space after the initial source has been terminated.

Reverberation Time (RT): the time it takes for sound intensity to decay by one millionth of its steady state value after the sound source has been terminated. The corresponding decrease in sound pressure level (or sound intensity level) is 60 dB.

Sound Absorption: the process of dissipation of sound energy, or the sound energy absorbed by a component or an entire room.

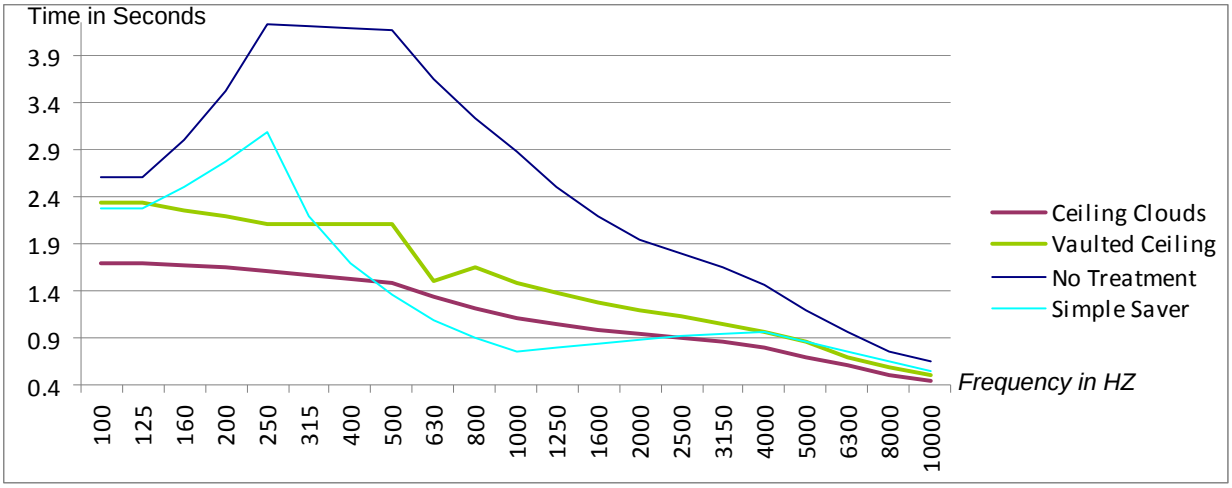
Sound Pressure Level (SPL): a quantity expressed in decibels of airborne sound which is ten times the logarithm of the square of the sound pressure of interest to the square of the standard reference pressure of $2x10^{-5}$ Pa.

Speech Intelligibility: the accuracy with which a normal listener can inderstand a spoken word or phrase.

Speech Transmission Index (STI): a measure of speech intelligibility.

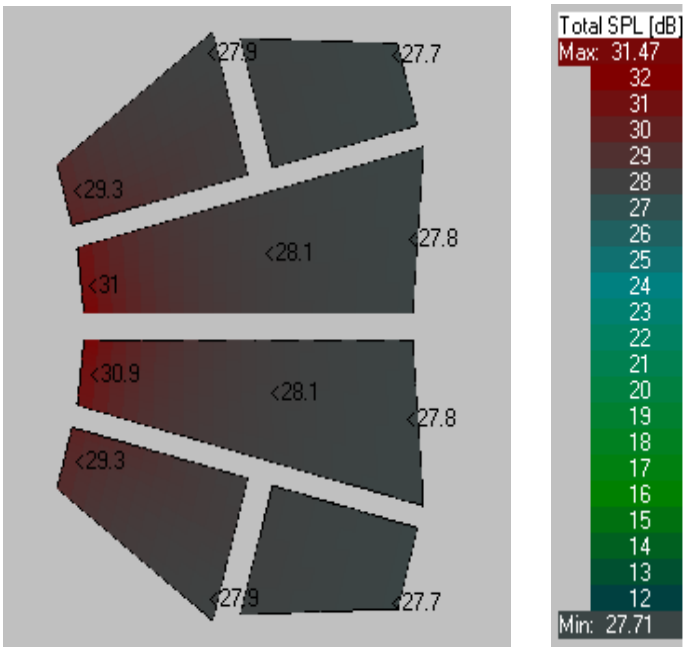
GRAPHS AND DIAGRAMS

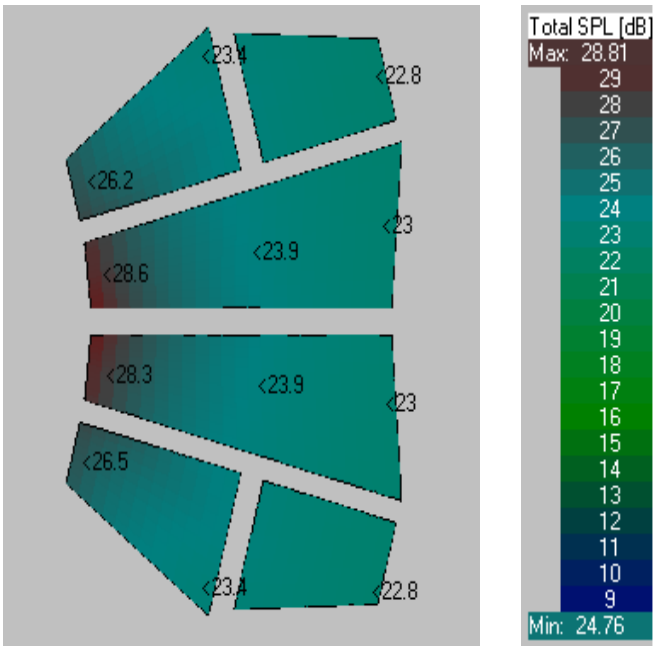
Reverberation Time Comparison:



A-1 The ceiling clouds provide the most optimal reverberation time across all frequencies as it is has the most even slope without any dips or spikes, which will provide a better sound quality in the space.

Sound Distribution Comparison:

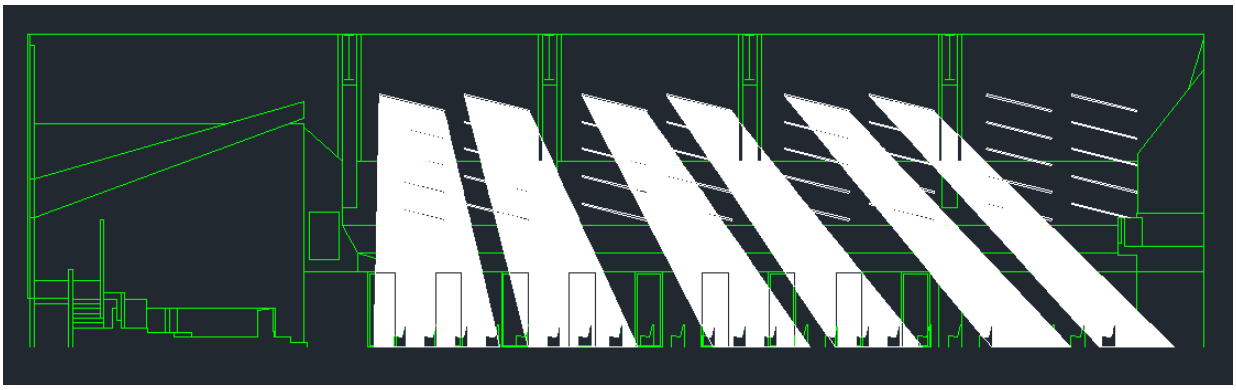




A-2: Ceiling Clouds **A-3: Vaulted Ceiling**

The sound distribution is even throughout the space in both options, but the sound levels are higher in the ceiling cloud option, A-2, which will provide for better listening

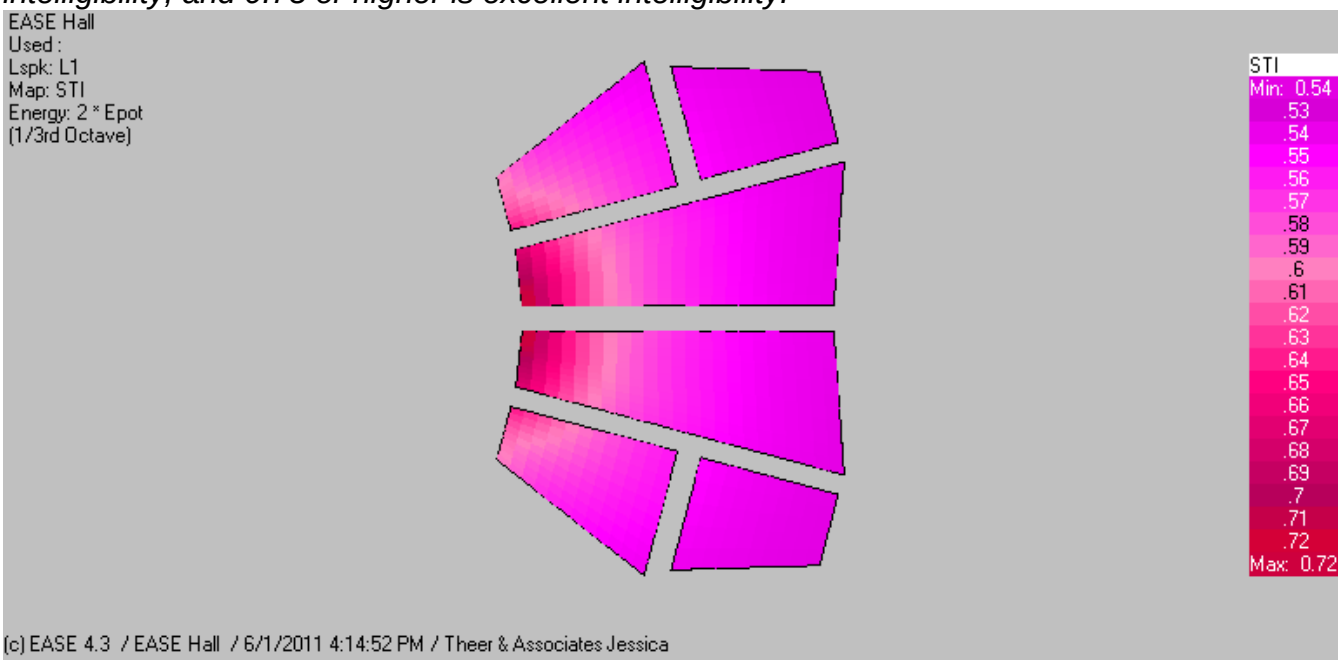
experience in the rear and sides of the space. There is at least a 3 dB difference in the SPL between these options, which is perceivable by the human ear. The difference is even greater in the rear of the chapel, almost 5 dB, which illustrates the improved sound distribution provided by the clouds. This is due to the fact that the clouds have been designed at the correct angle to properly distribute the sound to all seats in the space.



A-4: This shows the coverage achieved with just the top row of clouds. The shaded areas below each cloud show the coverage area in which that cloud will reflect sound down to. The clouds that are below these on each side will provide further coverage in the areas in between. With a flat surface, as with the vaulted ceiling option, you do not get as wide of a coverage area, as the rays are just reflected back down at an angle equal to the incident angle that hits the surface. Since the ceiling is angled on the sides as well in the A-Frame shape, there may be some sound that is bounced back and forth between the ceilings at the higher points that does not even reach the audience area.

Speech Intelligibility Comparison:

Speech Intelligibility is measured by the Speech Transmission Index (STI). It is quantified in levels from 0 to 1.0, with 0 being the lowest and 1.0 being the highest. Anything less than 0.50 in considered to be poor intelligibility, 0.50-0.74 is good intelligibility, and 0.75 or higher is excellent intelligibility.



A-5: Speech Intelligibility w/ Vaulted Ceiling: Min=0.54 Max=0.72

A-6: Speech Intelligibility w/ Ceiling Clouds Min=0.66 Max=0.84

PRODUCT INFORMATION

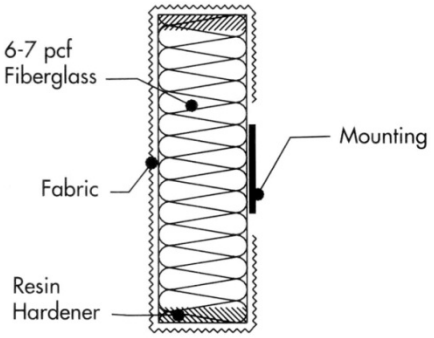
Acousti-Panels AP

CONTROLLING sound BEAUTIFULLY

Our most **economical** sound-absorbing wall panel. AP panels create a comfortable environment by reducing noise reverberation. **Durable** enough for a gymnasium, beautiful enough for a boardroom.

AP panels absorb a wide range of sound frequencies depending on the panel thickness. To make your selection, review the acoustical performance for each core thickness listed below.

Core Section



Core
6-7 PCF fiberglass, 1/2" to 4" thick

Sizes
Custom sizes and shapes up to 4'x12' and 5'x10'

Mounting
Adhesive, impaling clips, magnetic tape, Velcro

Finishes
Fabric, vinyl

Edges
Square, beveled, radiused, chemically hardened

Corners
Square, radiused

Flammability
All components have a Class "A" rating per ASTM E84

Sound Absorption

Hz	125	250	500	1000	2000	4000	N.R.C.
AP .5	.07	.09	.35	.77	.98	1.03	.55
AP .75	.04	.19	.59	.91	1.05	1.02	.70
AP 1	.07	.29	.80	1.01	1.05	.99	.85
AP 1.5	.31	.58	1.03	1.10	1.05	1.04	.95
AP 2	.42	.89	1.12	1.07	1.10	1.09	1.05
AP 3	.75	.89	1.11	1.21	1.21	1.20	1.10
AP 4	.87	.87	1.24	1.26	1.26	1.25	1.15

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Pinta PP

CONTROLLING sound BEAUTIFULLY

Golterman and Sabo's Pinta PP are painted, sound-absorbing wall panels that add a new dynamic to interior sound absorption and design. Our panels are **painted** with your choice of colors to **match** or **contrast** with other painted finishes in your room.

Pinta panels have a compound core of 6-7 PCF fiberglass with a paintable scrim fiber facing sheet. The fiberglass core absorbs sound and the scrim fiber sheet allows for an evenly painted finish.

Our Pinta wall panels are painted on the face and edges for a completely finished appearance. In addition to decoration, Pinta panels provide **outstanding sound absorption**.

Pinta panels are ideal for situations where acoustical panels must blend with the background. Many churches, lobbies, and auditoriums already use Pinta PP wall panels.

Core
Facing: Scrim Fiber
Backing: ecoCoustic 6-7 pcf fiberglass, 1/2" to 4" thick

*Formaldehyde and Phenol free
*GREENGUARD Certified
*GREENGUARD Children & Schools Certified
*35% Post-Consumer Recycled Content

Sizes
Custom sizes and shapes up to 4'x12'

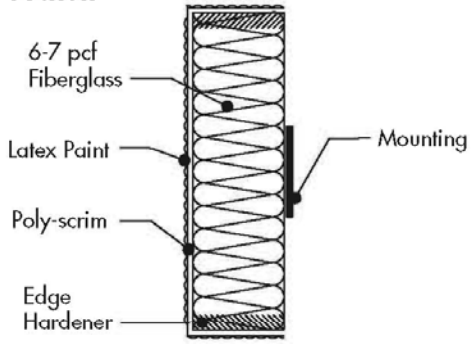
Mounting
Adhesive, impaling clips, two-part Z-clips

Finish
Sherwin Williams Latex paint

Edges
Square
Chemically hardened

Flammability
All components have a Class "A" rating per ASTM E84

Core Section



Sound Absorption

Hz	125	250	500	1000	2000	4000	N.R.C.
PP 1	.06	.32	.82	1.05	1.05	1.02	.80
PP 2	.43	.81	1.09	1.04	1.03	1.02	1.00

GOLTERMAN & SABO
www.golterman.com
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Wall Sound Diffusers

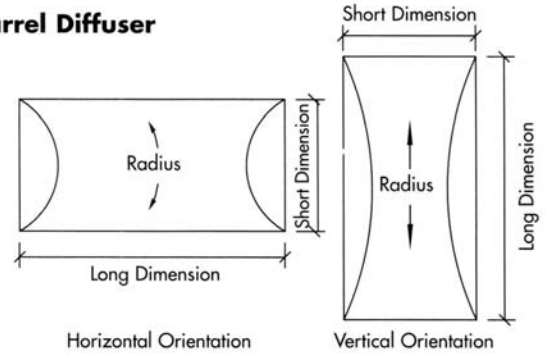
CONTROLLING sound BEAUTIFULLY

G&S barrel-shaped wall diffusers combine shape and high-impact hardness to **reflect sound evenly** across the room. This allows for the control of "flutter" and "echo" effects from the sounds in the room.

Also, our sound diffusers are **excellent low-frequency sound absorbers**. They absorb low-frequency sounds while reflecting the higher frequencies. This allows the room to maintain a "bright" sound.

We offer three types of diffusers: standard (WD), low-frequency absorber (WDA) and a sound-reflective diffuser (WDL). Select a sound-diffusion system using the tables shown below.

Barrel Diffuser



Core
WD: Glass fiber mat with fire retardant resin, N.R.C.=.20
WDA: Add 1-1/2", 1-1/2 PCF fiberglass backing, N.R.C.=.35
WDL: Add resin hardener N.R.C.=.05

Sizes
2'x 2', 2'x 4', 4'x4', 4'x5', 4'x6', and 4'x8'
Custom sizes also available

Mounting
Two-part clip system with hook and loop Velcro

Finishes
Textured gelcoat in white and black or fabric

Flammability
All components have a Class "A" rating per ASTM E84

Sound Absorption

WD - Standard Barrel Diffuser

Hz	125	250	500	1000	2000	4000	N.R.C.
	.38	.51	.19	.09	.01	.02	.20

WDA - Barrel Diffuser with low frequency absorption

Hz	125	250	500	1000	2000	4000	N.R.C.
	2.06	.62	.47	.25	.15	.21	.35

WDL - Barrel Diffuser with resin liner for more sound reflection

Hz	125	250	500	1000	2000	4000	N.R.C.
	.15	.05	.06	.03	.02	.02	.05

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A/V System

Note: all Designations refer to locations called out on Drawing L

Worship Center A/V System

Provide a fully functioning sound reinforcement and AV system for Army Chapel. Sound Reinforcement system will include monaural output to two clusters (S01 & S02) of line array loudspeakers capable of delivering sound to the entire house seating area evenly. Loudspeakers shall be minimum 9' tall and include at least one sub-bass module. The full range loudspeakers will be tri-amplified, i.e. 3-way speakers with independent amplifier channel for each frequency range, and shall have sufficient amplification power to provide 95 dB at 1kHz (1/3 octave measurement) from a pink-noise source. Amplification can be built into the loudspeakers or independently provided in a rack at the back of the stage area.

Audio input signals shall include a minimum of 8 XLR microphone inputs on stage installed in the floor pockets (J01-J05) and 8 along the stage walls near performing musicians (J06&J07). All inputs shall be connected directly to a digital mixer, it is permissible to go via a digital snake or similar device, no analog patch bay shall be used. The digital mixer shall be located at the rear of the seating area in the control booth. Additionally, two hanging choir type microphones shall be hung to be situated approximately 18" in front of the first row of rear stage risers and about 9' A.F.F., evenly spaced off of the center line, avoiding the projected image path between the projector and screen. Four wireless "combo" systems shall be included, each system shall include a receiver, beltpack transmitter with headworn and lapel mic, and handheld transmitter.

Playback sources shall include, but not be limited to a CD player, 3.5mm "aux" connection for a mp3 or similar device, a DVD player, and a laptop input (audio and video) at the control booth desk (R01), plus an additional computer input (audio and video) at the front center of the stage (J03) - input shall be in the floor box plus supplied cables run concealed within the lectern for easy connection. Additional computer inputs can be added to any of the other junction boxes depending on needs. Ensure an adequate number of inputs are included on the video switcher.

Image magnification (IMag) will be provided by two manned cameras (V21&V22) located at the control booth platform. The cameras shall be HD quality (720p minimum) and provide sufficient zoom to be able to focus in on a half body shot of a person on stage - at least 77mm focal length lens for a 1/3" CCD camera. The cameras shall be mounted on heavy duty, two handle tripods with smooth rotating head with control of the

camera's zoom and focus available via tripod handle mounted controls. Signal shall be sent from the two cameras plus the DVD player and two (minimum) computer inputs to a seamless switcher that also provides picture-in-picture functionality and scaling to the main projector's native resolution. The video operator shall have a minimum of two video monitors for viewing the preview and program output of the switcher.

Video output shall be provided by two 10,000 lumen 3DLP projectors (V01 & V02), projecting onto two rear-projection screens (V11 & V12) hung near the front of the stage. Ensure stage lighting does not interfere with projected image, either by the physical location, or controlling any nearby lights to automatically dim whenever the screen is in use. The projector will be installed in a fixed location at the rear of the stage at an acceptable height and location (less than 12' A.F.F. Screen shall completely roll up into stage cloud when desired (motorized screen).

The image projected onto the main sanctuary screens will also be fed to the office spaces - 143, 144 & 145; 131-Multi-Purpose Room, 132-Multi-Purpose Room, 135-Classroom, and 140-Multi-Purpose Room via the building CATV feed on an unused channel. Ensure there is no interference on this channel by using a "brick-wall elimination filter" before the modulated signal is piped into the building feed. Audio and video will be "tuned in" via a LCD monitor with tuner in each of these rooms.

A Control system will provide control to the system and shall include wired control panels at the control booth desk (R01) and at the portable stage lectern (J03). Since the stage lectern is portable, the control panel provided at this location must have its connectivity via the floor box, all cabling is to be concealed within the lectern. System on/off button will be provided at the control desk to allow a user, with a single button push, to turn the entire system on and off in a sequenced order to avoid audible pops from the loudspeakers.

At the control booth a large rolltop desk will house the audio mixing console, video monitors, and control panel. Control booth furniture, both the desk and any standalone equipment racks shall all be securable and lockable.

Divisible Multi-Purpose Rooms (131 & 132)

The divisible multi-purpose rooms can act as two independent smaller rooms, or one large space. All equipment is located at the front half of the room, with a large (65"-70" diagonal) flat panel TV (V31 & V41) and optional loudspeakers (S31&S32, S41&S42) alternative would be to use speakers built into the display) centered on the front wall, and a computer input (V32 & V42) and control panel (C31 & C41) on either side. The

Control System will have buttons for: combine rooms or independent rooms, source selection, system power on/off, and volume up/down. A DVD player will be located in each space (V33 & V43) for local control, and the video matrix switcher for both spaces will be located in the casework on the sidewall (V43) along with the TV Tuner(s) - only a single TV tuner is required if different cable channels are required simultaneously.

Stand Alone Multi-Purpose Room (140)

The stand alone multi-purpose room is almost identical to the divisible room, without the room combining aspects. All inputs (Computer - V52, TV Tuner & DVD - V53) shall go to the switcher (V53), and inputs are selected at the wall mounted controller (C51).

Classroom (135)

The classroom is a split system, allowing use of only overhead ceiling loudspeakers (70-Volt feed) to monitor the feed from the Worship Center, or as a small presentation space with a discrete computer input. The cable TV video will also be fed to the display, which requires a built-in TV tuner to view the feed.

Offices (143, 144 & 145)

The offices have an audio feed from the Worship Center. The volume is locally controlled from a volume control knob on the wall. Volume control and loudspeakers are on a 70-Volt feed from the Worship Center.

A/V System Options

Projection

The two main choices for projection are front or rear projection. We are recommending rear projection primarily due to the convenient location it puts the projector. In a front projection environment, the projectors would most likely need to be located at the rear of the room near the control booth. A long throw lens that would be required, and additional equipment would be present in the room, adding noise and heat. With rear projection a slightly brighter projector is necessary that would be required for front projection, but in addition to the space and noise benefits, it is also more immune to ambient light assuming the light behind the screen can be controlled - if light will not be controlled behind the screen, front projection has more options for dealing with light control. Either option can be provided in a retractable motorized screen.

Loudspeakers

There are a dizzying number of choices of loudspeaker types. We are recommending line array type because of the ability to serve the entire room from one location in the front, freeing up the ceiling architecture to be directed by aesthetic and acoustic purposes, instead of being dictated by angles required for the loudspeakers to "see" a maximum number of seats. Line arrays also typically provide excellent vertical directionality, so we can hit the people with the sound, rather than spraying the stage, ceiling and rear walls with sound that could be potentially detrimental to the room. When additional loudspeakers are added to the ceiling, we are forced to incorporate processing to fool the congregants' brain into thinking all sound is coming from the front, when for the rear half of the room, most of the sound they hear is actually coming from above them. Line array systems almost always are capable of producing higher audio levels than conventional distributed loudspeakers, providing a more impactful event.

Alternatives to the line array system include a more standard left and right main cluster with delay rings system which would involve several loudspeakers at the front location and then loudspeakers distributed throughout the back half of the room to fill in the mid and high frequency sound that dies out with distance. Another alternate would be a distributed system with a higher quantity of speakers evenly distributed throughout the ceiling. The system cost falls in the order presented above, with line arrays typically the most expensive and distributed the least.

Support Space Feed

To get sound out to other spaces within the building there are a few options. The base recommendations use the CATV system for distribution of both the audio and video. This gives all the benefits at no additional costs by supplying audio and video on a system that will already be present in the building.

One alternative includes providing a 70-Volt ceiling loudspeaker system to carry the audio to all of these spaces. Typically each room will have an independent analog volume control on the wall near the room entrance for local volume control. This only provides audio and if any video feed is desired, it will need to be supplied by a different method.

Another alternative, similar to the CATV distribution method, is to give each space a high quality A/V feed off of the main Chapel system and feed it directly to the in-room display or A/V system. This solution is highly desirable if the building is fed from a NTSC feed, and high quality image and audio is desired in the room. It would consist of adding a Distribution Amplifier (“DA” – optionally one that converts the signal to be run over UTP network cable) to the Chapel, and then sending that directly to each room, where you would select that signal as a separate input into the system, rather than selecting the TV Tuner input and going to the correct channel feed.

CATV

Cable television has undergone a transformation in recent years. The long-standing standard has been NTSC modulated signal. With the advent of HD and cable companies trying to offer advanced services to compete with internet offerings, we also have to look at ATSC, QAM and cable provider scrambled signals. The selected system greatly depends on what type of incoming signal is supplied to the building at the Telecom equipment room.

If HD premium cable channels are desired, use of a cable provider supplied cable receiver is required, consult with the cable provider on if it is possible and how to insert in-house generated signals. If HD quality is desired, ATSC or QAM is required. QAM has more product options for modulation and demodulating an in-house signal, so is the recommended modulation scheme when a choice is available. NTSC is typically only used when that is the incoming signal type, and the cost to convert the signal is beyond the project scope.

Cameras

Manned cameras are the only cameras shown on the drawings. These cameras are beneficial because they can all be simultaneously and quickly controlled by operators and have a wide choice in camera style. Pan-tilt-zoom ("PTZ") cameras can also be incorporated into the system or replace manned cameras all together. PTZ cameras are smaller and can be adjusted by preset, allowing repeatable views. By using a smaller camera, additional point-of-view locations are possible, where a manned camera would not physically be possible, such as on the side wall, or on stage (manned camera is possible but could detract from the stage presence). If trained operating personnel are not available, PTZ cameras can allow the video operator to also be the camera operator. By incorporating both manned camera(s) and PTZ cameras, the manned camera(s) can take any moving shots, and the PTZ cameras can be used for difficult angles, and for preset recalling, i.e. full stage view, band view, lectern view, etc.

"ProSumer" level camcorder has been called out in the recommended equipment list due to a factor or benfits. Alternatives and their disadvantage to the "ProSumer level include: Studio Camera (expensive), Inexpensive camcorder (not enough zoom to get an on-stage upper body shot at 100' away) or still camera (have selectable lenses, but are lightweight so any telephoto video can appear "bouncy"). It should be noted that even at the recommended camera level, a high quality tripod and smooth pan head are mandatory. At the distance from the control booth to the stage, all jiggles or bumps with be greatly magnified.

Video Control

The main two methods we approached for switching between video sources include using a control system (Crestron, AMX, Extron, etc.) with RS-232 or LAN control back to a seamless switcher, or using a broadcast style switcher including an input/output rack mounted module and a desktop analog-style controller. Recommended is the broadcast style controller because the physical buttons and joystick-style controls provide a more “hands-on” approach allowing for finer and more accurate control.

We have a control system currently included, but only for basic controls. If we are controlling all the video sources and PIP, transitions, etc. from the control system, a much larger touch panel would be recommended, adding roughly equivelent cost of the broadcast controller. The benefits to going with a larger touch panel control include smaller space footprint required on a desk.

One item to note, with either level control system, commands can be sent via LAN (or WAN if properly configured) and controlled from virtually anywhere if a trained operator is not available.

Video Transport

A primarily analog system has been recommended, but the digital alternative needs to be kept in mind. Intel has scheduled to stop supporting VGA (HD15) outputs in 2015, though the large install base of VGA monitors and projectors will keep VGA on computers for several years after, so the transition is already coming. At this point digital video transmission still has many kinks to work out, most regarding content protection (HDCP). Many laptops currently turn on content protection for all content going out a digital connection, preventing a standard PowerPoint type text presentation, with no protected content, from being sent out over the CATV system because it does not support content protection.

High definition signals are at equally high quality over an analog connection (as long as line loss has to be accounted for) and the added expense and content restrictions leave a very viable system for the future.

Digital (HDMI) vs Analog - The primary reason to go with digital transport as of 2011 is because of content protection. HDCP is the main term used when referring to content protection, and is used by almost all of the major movie studios to protect their digital high definition content on BluRay discs. BluRay players will likely soon require a digital connection to view the content in HD, and in the future, many laptops might not come with analog outputs, requiring digital transport or a converter.

However, the necessity to work with existing systems will keep analog (VGA) ports on laptops for years to come, and the higher resolution that BluRay provides over DVD is rarely required. So, for the time being, in large systems, such as the sanctuary, while

adding digital transport still adds significant cost, we feel it should be considered an option, rather than a requirement. In smaller systems (multi-purpose rooms) where HDCP sources (BluRay players) can connect directly to HDCP compliant 'sinks' (display) for little to no additional cost, it makes perfect sense to go ahead and install digital.

Auxiliary Spaces

In all the smaller rooms with A/V equipment (multipurpose rooms, classroom) several pieces of equipment can be incorporated into the display. All of the below components are currently discrete in the multipurpose rooms, and integrated in the classroom, though the classroom has a separate distributed audio system that supplements the Worship Center CATV feed.

Loudspeakers - The primary advantage of external loudspeakers, as opposed to using speakers integrated into the display, is more even coverage and higher sound levels. This is primarily realized in larger or noisy spaces.

CATV Tuner - Some displays have a CATV tuner built-in (almost all consumer level televisions, fewer commercial level displays). By separating the tuner out from the display, we are able to more effectively output the signal to the video matrix switcher in the divisible multipurpose rooms, thus allowing the signal to be combined or discrete between each of the two rooms. It also gives us a high quality audio output to send to the room loudspeakers from the CATV feed, so we can use one set of loudspeakers for the in-room A/V functions as well as for the Worship Space CATV feed. All of these functions are possible through many display's built-in tuner (for a much lower cost), but ease of programming and availability on different models is extremely varied, and must be judged on an individual basis. The external tuner gives us easy access to those functions regardless of display selected, and gives access to multiple types of incoming CATV signals.

Control System and Video Switcher - The reasons to have a discrete control system and video switcher are much the same as for a CATV Tuner - ease of use and higher flexibility in combining components. A video switcher or a series of distribution amplifiers is required to have the divisible feature for the multipurpose rooms, because the same signal must be present on both displays. A control system is desirable in a facility like this with many people coming and going because a hard-wired, wall mounted control is always in place, while the alternate, to use the display's built-in video switcher and toggle between inputs via the included IR remote controls can easily be misplaced.

A/V Equipment List

Worship Space System

1) Cameras (V21&V22)
    a) JVC GY-HM7000L17S
    b) Panasonic AG-HPX370
    c) Include with system:
        i) Handle mounted zoom and focus control such as JVC HZ-FM13U
        ii) ENG tripod and head such as Manfrotto 516, 535K Pro ENG Kit
2) Audio Mixer
    a) Allen & Heath - iLive T112 with iDR-16 and xDR-16
    b) Roland - M-480 with two S-1608
3) DSP
    a) Biamp - Audia Flex
    b) BSS Soundweb London BLU
4) Loudspeakers
    a) Electrovoice - Xlci
    b) JBL - Vertec 4888
5) Wireless microphones
    a) Audio-Technica - 3000 series
    b) Shure - ULX-P series
    c) Sennheiser - ew 300 G3 series
6) Video Seamless Switcher - Chapel
    a) Analog Way - Octo Value with RTK-500T event controller
    b) Extron - ISS 506 with RCP-2000
    c) TV One - C2-8110 with CC-300
7) CATV – QAM modulation
    a) Contemporary Reesearch – QMOD-HD
    b) Blonder Tounge – AQM
    c) ZeeVee – Zv280
8) Control Booth Desk (R01)
    a) HSA Rolltop - mirrored pair of Series II Standard Rolltops
9) Pull-out Rotatable Rack (R02)
    a) Middle Atlantic WR-44-42
    b) Lowell LHR-4442
10) Projector (V01&V02)
    a) Christie W10k-M
    b) Digital Projection Titan 1080p-700
    c) Panasonic PT-DW100
11) Projection Screen - Ceiling Recessed electric roll-up screen (V11&V12)
    a) Draper Signature/Series V - 108" x 192" with Cineflex Rear Surface
    b) Dalite Tensioned Large Advantage Electrol - 108" x 192" with Da-Tex (rear) surface
    c) Stewart Filmscreen ABB ElectriScreen 108" x 192" with FilmScreen 100

12) Control System
    a) Extron - TLP 350MV with IPL 250
    b) Crestron MPC-M50
    c) AMX - NXD-435P with NI-2100
13) Assistive Listening
    a) Listen Tech - LT-800-72 transmitter
    b) Williams Sound
    c) Include full system including antennas, beltpack receivers, headphones, charging case, tele-coil, etc.

Divisible Multi-purpose Rooms System

1) Video Switcher (portion of V43)
    a) Extron - ISM 482
    b) Kramer - VP-747
    c) TV One - C2-8110
2) Control System (C31 & C41)
    a) Extron - TLP 350MV with IPL 250
    b) Crestron MPC-M50
    c) AMX - NXD-435P with NI-2100
3) Monitor - 70" with RS-232 Control (V31 & C41)
    a) Sharp - LC-70LE732U
    b) NEC - P701-AVT
4) Computer Input (V32 & V42)
    a) Extron - Extender D
    b) FSR - CI-5BWPA
5) Amplifier (portion of V43)
    a) Electro-Voice CPS 4.5
    b) QSC CX254
    c) Crown CTs 4200
6) Loudspeakers (S31&S32 & S41&S42)
    a) Electro-Voice - EVID 6.2
    b) JBL - Control 5

Stand-alone Multi-purpose Room System

1) Video Switcher (portion of V53)
    a) Extron - IN1508
    b) Kramer - VP-730
    c) TV One - C2-3350
2) Control System (C51)
    a) Extron - TLP 350MV with IPL 250
    b) Crestron MPC-M50
    c) AMX - NXD-435P with NI-2100
3) Monitor - 70" with RS-232 Control (V51)
    a) Sharp - LC-70LE732U
    b) NEC - P701-AVT

4) Computer Input (V52)
    a) Extron - Extender D
    b) FSR - CI-5BWPA
5) Amplifier (portion of V53)
    a) Electro-Voice CPS 2.4
    b) QSC CX302
    c) Crown CTs 600
6) Loudspeakers (S51 & S52)
    a) Electro-Voice - EVID 6.2
    b) JBL - Control 5

Classroom 135 System

1) Volume Control (C61)
    a) Lowell - 25LVC
    b) Atlas Sound - AT35D
2) Monitor - 52-55" with RS-232 Control (V61)
    a) Sharp - PN-E521
    b) NEC - E551
    c) LG M5203CCBA
3) Computer Input (V62)
    a) Extron - Extender D
    b) FSR - CI-5BWPA
4) Loudspeakers (S61 & S62)
    a) Electro-Voice - EVID C8.2
    b) JBL - Control 226C/T

Office Audio System

1) Volume Control (C71, C81, C91)
    a) Lowell - 25LVC
    b) Atlas Sound - AT35D
2) Loudspeakers (S71, S81, S91 & S92)
    a) Electro-Voice - EVID C8.2
    b) JBL - Control 226C/T