

PROPOSAL

October 19, 2023

Ms. Diane Kane
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Church Phone: 281-332-1251
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RE: Sanctuary and Fellowship Hall Acoustics

Subject: Proposal for Consulting Services
WA Proposal #1306

Ms. Kane:

It was wonderful to meet with you on Friday, October 13 to briefly review existing conditions in the Sanctuary and Fellowship Hall. We looked and listened to the rooms (without using existing sound systems) and we talked about how speech intelligibility is generally unacceptable in both rooms. This proposal offers our consulting services regarding acoustics and loudspeaker selection in each room. It is offered in response to our meeting and your initial telephone call on October 12.

This proposal includes our planned scope of consulting services (Section 2, starting on page 10), proposed fees (Section 4, page 16), and standard terms and conditions (Section 5). An acceptance page is included at the end of this document, allowing you to convert this proposal into a contract with an authorized signature. Under Section 1, we have included some discussions of key concepts and our notes from initial discussions. Section 3 includes some technical references.

Please understand that I am an independent design consultant. My firm does not sell audio equipment, acoustical treatments or installation services, and we have no affiliations with manufacturers or contractors. Therefore, our recommendations will be based primarily on your expressed needs and the Church's best interests.

1 KEY CONCEPTS & INITIAL DISCUSSIONS

1.1 REVERBERATION TIME

Reverberation Time

The reverberation time of an enclosed (or partially enclosed) room is the time length required (in seconds) for sounds to decay to one millionth of their original energy level (or by 60 dB) after the source emission has stopped. [1] Reverberation time has significant impacts on speech intelligibility and music quality [2] and is considered to be a fundamental description of the acoustical character of a room [3]. Wallace Sabine of Harvard University first developed the concept of reverberation time between 1895 and 1922 [4]. Reverberation times are determined primarily by the size and shape of the room, along with the average coefficients of absorption for the architectural finishes used in design and construction of the room. Generally, as reverberation times become shorter, acoustical support for speech and contemporary music improves while acoustical support for classical or traditional worship music worsens. Conversely, as reverberation times become longer, acoustical support for classical or traditional worship music typically improves, while speech intelligibility and acoustical support for contemporary music are reduced. Without reverberation, the sound quality of classical and traditional worship music would lose beauty and emotional power. [5] Also as reverberation times become longer, many sounds can build in volume (even without sound system support) and be perceived as "loud" or "overwhelming" in that acoustical environment. Reverberation times can vary drastically with respect to frequency content of sounds; therefore, reverberation times are quantified for several frequency bands (typically one-octave bands). A room's "reverberation time" is most often summarized by averaging the reverberation times of the 500 and 1000-Hertz octave bands (or "mid-bands"). [2] [3] Reverberation time can vary significantly with the number of people in the room. Typically, as more people are added to the room, reverberation times become shorter.

Exact goals for reverberation times vary with respect to the size of the room and how that room will be used. Figure 1 includes mid-frequency reverberation times commonly found in various types of facilities, facilities such as Liturgical Churches, Multipurpose Auditoriums, rooms for Speech Presentations and rooms for Amplified Contemporary Music. Our scope of work will primarily include efforts to measure existing reverberation times in each space, compare measurements to Figure 1, choose new target reverberation times (and other design criteria) based on the Church's planned use of each space, and recommend architectural changes that should achieve those targets and criteria.

1.2 BASS RATIO

Bass Ratio

Increased acoustical support for bass frequencies has traditionally been accepted to add sonority and warmth to live *classical music and traditional worship music*. Bass ratio is used to evaluate the tonal balance (especially warmth) of a room (or seat within a room). Bass ratio was first used in 1962 and was a ratio of the low-frequency reverberation times (average of 125 and 250-Hertz octave bands) to the mid-frequency reverberation times (average of 500 and 1,000-Hertz octave bands). Some acousticians recommend bass ratios (based on reverberation times) of 1.1 to 1.45 for classical concert halls with a reverberation time less than 1.8 seconds, [5] and bass ratios of 1.1 to 1.25 for halls with

longer reverberation times. (For organ, reverberation times in the 63 Hz octave band may be 50% longer than in the 1-kHz octave band. [5]) After analyzing numerous symphonic concert halls, Leo Beranek generally concluded that the highest rated halls included bass ratios of 0.95 to 1.2 (occupied) with average around 1.1. [8] For speech, bass ratios (based on reverberation times) of 0.9 to 1.0 are preferred. [6] [9] For contemporary music, short reverberation times in the low frequencies (shorter than 1.1 seconds) are typically of greater importance than an exact bass ratio.

As both rooms will support music, measurements and predictions of bass ratio will be included in our work.

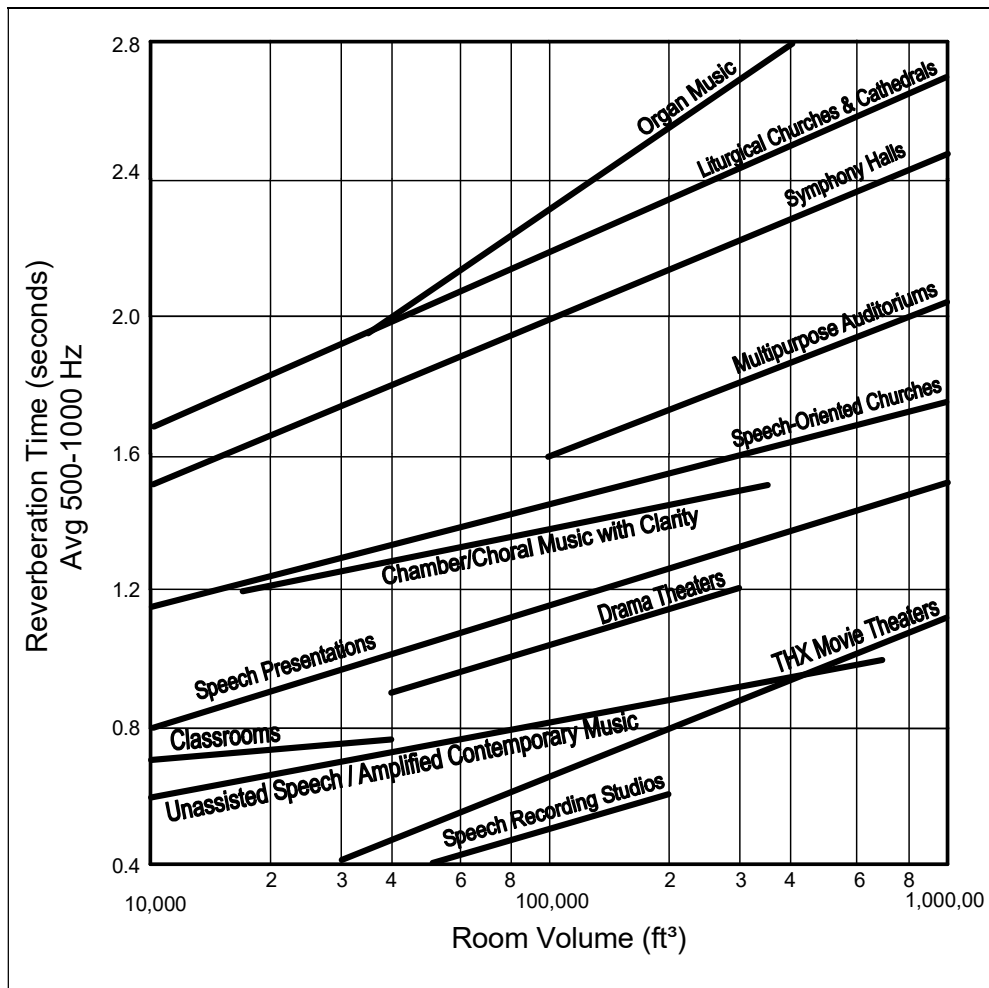


Figure 1 – Reverberation Times in Various Facility Types [2] [4] [6] [5]

1.3 SPEECH TRANSMISSION INDEX

Speech Transmission Index (STI)

The Speech Transmission Index or STI is an objective quantity to measure and predict the intelligibility of speech transmitted from talker to listener. The STI method has been

the subject of ongoing development and refinements since its introduction in the 1970s. STI combines the index values from measurements/predictions in 14 modulation frequencies across each of seven octave bands (125 to 8,000-Hertz octave bands, a total of 98 calculations) into one overall value between 0 and 1. [10] Conditions that affect STI measurements and calculations include source directivity and output level, reverberation, echoes, distance between listener and sound source, and background noise. The standard ranges of STI numeric values and associated ratings are shown in Table 1. Because of the extensive subjective testing that accompanied the development of STI, it is regarded as the best metric yet for speech intelligibility. [5]

The intelligibility of speech in large rooms primarily depends on the combination of natural acoustics in the space (including background noise) and the design of the loudspeaker system. While we do not plan to measure STI in the existing rooms (which would likely be wasted effort using the old loudspeakers that are soon to be replaced), we plan to predict STI values for considered changes to acoustics and new loudspeakers in combination.

Table 1 – Speech Intelligibility Ratings and Associated Ranges of STI and Sentence/Word Scores [12]

Speech Intelligibility Rating	STI Range	Sentence Score	Meaningful Phonetically Balanced Word Score
Excellent	0.75 – 1.00	100%	98-100%
Good	0.60 – 0.75	100%	93-98%
Fair	0.45 – 0.60	100%	80-93%
Poor	0.30 – 0.45	70-100%	60-80%
Bad	0 – 0.30	0-70%	0-60%

From our experience regarding STI criteria, many clients have accepted predictions/measurements of 0.55 or greater in a room with challenging acoustics. And, we have measured STI values of 0.60 in challenging spaces where there had been no complaints. Complaints have been common where we measured STI values less than 0.55.

1.4 BACKGROUND SOUND LEVELS

Noise Criteria (NC)

Steady-state background noise levels for interior spaces (typically due to mechanical systems) are most often quantified in terms of NC curves, identifying a single overall number while taking into consideration the frequencies of sound contained in the noise. The Noise Criteria (NC) curves were first established back in 1957, and these curves (with some refinements along the way) have been the standard of interior noise measurements and predictions for most of the years since. [11] Since 2008, reported NC levels have included suffixes in parenthesis to indicate the standard-octave frequency band at which the maximum perceived sound levels were measured and on which the stated NC level was determined. [12] Low and mid-frequency noises often reduce communication, especially for hearing-impaired listeners. Quiet background noise levels support the contrasts between speech/music communication and the silent pauses that enhance that communication. Quiet levels of background noise also allow listeners to hear the full, dynamic range and spatial qualities of the reverberation, especially behind classical or traditional worship music. [5]

We note that the background sound levels as heard by the congregation during worship (typically from air-handling systems) can be significant enough to reduce speech intelligibility and music clarity. While we have no reasons to anticipate that the actual

mechanical background noises from the existing air-handling systems in the Fellowship Hall or Sanctuary will be significant enough to warrant reductions, we recommend brief measurements of background sound levels (with air-handling systems running) to confirm that no additional investigations are needed.

1.5 ECHOES

Echoes

Echoes in acoustics are defined as discrete reflections of sound arriving significantly later after the direct sound, and significantly louder than the background reverberation. Sources have varied on how late such a sound needs to be to be perceived as an echo, with some arriving at least 50 milliseconds after the direct sound [13], while others consider anything more than 30 milliseconds after the direct sound as an echo [5]. Echoes are most annoying when the information in the original pattern of sound is rapidly occurring. Slow organ tones are often not affected by echo, but speech and fast trumpet passages are. [5]

Flutter Echoes

Flutter echoes are often heard as high-frequency ringing or buzzing; usually caused by the repetitive interreflection of sound energy between opposing parallel or concave sound-reflecting surfaces, when both sound source and listener are located along the same flutter echo path. [6] Flutter echoes can be particularly audible in rooms with relatively short reverberation times; in rooms with relatively long reverberation times, flutter echoes are often masked by the reverberant sounds. Flutter echoes can be prevented by reshaping to avoid parallel surfaces, providing sound-absorbing treatment, or breaking up smooth surfaces with splayed or scalloped elements. Splaying surfaces by 5 to 10 degrees from parallel will normally prevent flutter echo. [4] [6] Flutter echoes can also be broken up by the presence of occupants, furnishings or columns. Flutter echoes are especially problematic if microphones are positioned along the path, as those microphones can amplify an otherwise localized effect, enabling all listeners to hear the flutter echoes through the sound system.

Late Sounds and Reflections that Reduce Intelligibility

Early reflections of speech sounds (with less than 35- to 50-milliseconds delay) tend to be integrated with the direct sound and increase perceived loudness and assist intelligibility. Late arriving sounds (with greater than 50-millisecond delay) particularly degrade speech intelligibility. [3] Since sound travels at approximately 1130 feet per second, these thresholds of 35 to 50 milliseconds are crossed whenever the reflected path length exceeds the direct path length by 40 to 57 feet, respectively. Rear walls are surfaces that frequently reflect sounds back to the listeners, slightly reducing speech intelligibility for those listeners more than 20 feet from the rear wall, and more significantly reducing speech intelligibility for those listeners more than 28 feet from the rear wall.

We do not anticipate many problematic echoes in either space, nor do we plan to quantitatively measure echoes, flutter echoes or echo-related parameters (e.g., echo-criterion for music or speech). However, we will be listening for identifiable echoes and flutter echoes using handclaps, test speakers and test signals from the installed loudspeaker system in the existing room. Observations will be noted, and recommendations will be developed as appropriate. For new loudspeaker locations, we will additionally perform reflection studies, either using two-dimensional drawings or

three-dimensional models to identify any likely risks of problematic echoes and to develop appropriate recommendations.

1.6 ASSISTIVE LISTENING EQUIPMENT

Assistive Listening Systems

An Assistive Listening System (ALS) is an amplification system utilizing transmitters, receivers, and coupling devices to bypass the acoustical space between a sound source and listener by means of induction loop, radio frequency, infrared or direct-wired equipment. [13] The Americans with Disabilities Act (ADA) requires each assembly space where audible communication is integral to the use of the space (and includes audio amplification) shall include an assistive listening system. [13] Additionally, quantities of portable receivers are required based on seating capacity (typically about 4% of seating capacity). However, the current statute of the ADA exempts religious organizations or entities controlled by religious organizations from compliance with the ADA, including places of worship. [14] However, when non-religious entities rent a religious facility for non-religious purposes, the non-religious entities are required to comply with the ADA and will therefore need assistive listening systems that meet ADA requirements.

As described above, the 4 traditional technologies used for assistive listening equipment have included:

- Induction Loop Equipment (like the Church's existing equipment in the Sanctuary)
- Radio Frequency Equipment (aka, RF or FM Radio, currently the most common type of ALS that we see)
- Infrared Equipment (used mostly in movie theaters and courtrooms where privacy is key)
- Direct-Wired Equipment (rarely used due to costs)

Let's discuss the induction loops a little more, since the Church already employs that technology in the existing Sanctuary.

Induction Loop Equipment

The induction loop technology uses simple magnetic fields and wire-wound receiving coils (much like a loudspeaker or transformer) to transfer audio from the installed loop to the loops within the portable receivers; the installed loop is often a single 14-gage conductor protected in a PVC pipe located in the slab surrounding the audience area. In recent years, we have been seeing more advocates for the hearing-impaired writing articles that request a return to the inductive-loop technology that was more popular for the hearing-impaired 30 to 60 years ago. This technology allows those with cochlear implants and hearing aids that are additionally equipped with "T", "T-Coil" or "Telephone Coil" settings to have sound induced magnetically and directly into their implants and hearing aids from a magnetic loop placed in the floor. This way, such users will not need to pickup a wireless radio receiver or headphones when they enter the facility (or hassle with whether that receiver or pair of headphones is working properly and has fully charged batteries). After some recent research, we believe that there are risks of unsatisfactory performance with the inductive loop technology (primarily due to possible

interference at the receivers from nearby electrical rooms and interference to other facility items, such as some musical instrument pickups in praise bands).

Another type of assistive listening technology not yet recognized by the ADA is the Wi-Fi/Bluetooth technology being implemented with today's smart phones and newer hearing aids that connect to smart phones. We believe that the ADA should recognize this technology soon, and we believe that such technology will be requested by more congregants as the smart-phone generation starts wearing hearing aids.

Wi-Fi/Bluetooth Assistive Listening Equipment

This technology is not specifically recognized by the ADA. But new hearing aids are coming on the market that connect to smart phones using Bluetooth signals (initially for phone communication and for listening to music or other programs on the phone). Many of these hearing aids include smart-phone or tablet applications that allow the user much more personal control over volume and frequency of the sounds heard. There are also Wi-Fi applications that provide sounds from a local venue to smart phones or tablets, enabling users to hear the venue's programs using standard earphones or Bluetooth-enabled hearing aids. This technology is becoming popular in sports bars, where listeners want to hear the audio associated with their favorite game or television set. Listeners with mild hearing loss may also be able to use such smart phones or tablets with Wi-Fi reception and standard earphones to improve their listening experience. Recently, manufacturers (e.g., Listen Technologies) have also started producing dedicated Wi-Fi receivers with earphones and neckloops so that this technology will comply with the intent of today's ADA requirements; however, as with any new products, we have questions regarding costs and longevity of these new receivers.

It is difficult to predict the future; however, we believe it likely that, as those who have been using smart phones and Bluetooth technology most of their lives get older, they may again rely on smart phones and Bluetooth technologies when it comes to choosing their hearing aids rather than relying on the older technologies. While assistive listening equipment using FM-radio technology has dominated the market over the past several decades, it is reasonable that the Wi-Fi/Bluetooth technology may dominate assistive listening in the near future, especially as contractors and facility owners recognize the lowered costs of this technology. It is also our hope that the ADA will recognize this type of assistive listening equipment, acknowledge the broad use of listener-provided smart phones, and eventually reduce the quantity of receivers required for each assembly area. For now, we continue to recommend installation of FM-Radio assistive listening equipment or Wi-Fi/Bluetooth equipment with the minimum number of dedicated receivers to meet basic ADA requirements; however, we are now consistently recommending the installation of Wi-Fi-based audio signals for use with listener-provided smart phones, tablets, hearing aids and earphones.

1.7 DISCUSSIONS & OBSERVATIONS REGARDING FELLOWSHIP HALL

We understand that the existing Fellowship Hall is currently utilized as a multipurpose space, hosting dinners, talent shows, band concerts, drama events, liturgical dance, speech presentations and other events with contemporary music. Most of these event types would be best supported with short reverberation times.

We understand that the Fellowship Hall was built as the Church's first sanctuary to support traditional worship, including a hexagon-shaped floor plan, a high ceiling that peaks above the altar wall with stained-glass windows, and lots of hard, sound-reflecting architectural finishes. We presume that the walls are gypsum board (aka, sheetrock) and the ceiling is a hardwood deck (tongue-in-groove type) likely serving as the underside of the roof deck. The floor is vinyl composite tile (VCT). Wedge-shaped sound-absorbing panels have been added to the walls in recent years to help shorten the excessive reverberations.

From what we could hear in the existing Fellowship Hall (while hearing each other talk and using handclaps and other handmade impact sounds), reverberations were still very long, even with the recently installed wall treatments. We also believe that existing reverberation times are excessively long for the current uses of the space, and that most of the speech intelligibility concerns in this space are due to the long reverberation times. We strongly recommend that the acoustics be improved, whether existing loudspeakers are replaced or not. As part of our work, we will again confirm the many types of events planned for this space.

We discussed how padded pews were once included across the entire space, and some believed that the removal of those pews made the acoustics worse (more reverberant). We support that theory based on our past experiences, because most padded pews provide more sound absorption per empty seat when compared to the existing stackable chairs now used in the space; also, the pews would have offered more seating capacity than typically included in the space with dining tables and large stage areas. We also discussed the idea of adding carpet to this space as an acoustical treatment. Today's carpets are typically only 1/4" to 3/16" thick with no padding (direct-glue type), such that they primarily absorb high-frequency sounds (typically reducing the "s" and "t" sounds). It is rare that we would recommend carpet as an acoustical treatment, especially in a space where food and drinks are likely to be served.

We recommend that reverberation times be measured so that we can better identify the sound absorption provided by the existing ceiling, existing acoustical panels and other finishes. In our predictions for changes, we also need to employ methods that differentiate the results based on which axes the new treatments are placed (i.e., x, y and z axes, or walls versus ceilings) so that we can identify the limitations of placing treatments only at the walls. While no one wants to cover parts of a beautiful wood-stained ceiling with acoustical treatments, if such treatments are needed, we want to show the Church our justifications for such recommendations and how most other reasonable configurations were considered, but fell short of the goals.

We also discussed how the Fellowship Hall sound system would need to include assistive listening equipment to properly support the hearing-impaired and to comply with the Americans with Disabilities Act when renting the space to users outside of the Church.

1.8 DISCUSSIONS & OBSERVATIONS REGARDING SANCTUARY

The Sanctuary is used primarily for worship services on Sundays and Wednesdays. Worship music is described as traditional to blended. Instrumentation typically includes: a large and growing choir, pipe organ, piano, and praise band. The style of music provided by the praise band was compared more to folk music rather than contemporary music (i.e., rock- or pop-style music). Music occasionally includes handbells, strings and other orchestral instruments. The Sanctuary can also be used for piano concerts and string ensemble concerts.

The Sanctuary was originally constructed in 2003. All floors were carpeted with a raised platform at the front of the room. Pews were fully padded, and the raised choir/orchestra area was relatively large along the congregation's right side. Walls and ceilings were assumed to be gypsum board. The floor plan was six-sided, but more closely matched a rotated square rather than a hexagon. Sound and video control was originally located in a small room at the back with a small opening into the Sanctuary.

The existing sound system appeared to be a "center-cluster" design, with loudspeakers located above grill cloth at the ceiling over the front aisle. The grill cloth appeared to have been discolored over the years (likely due to dust and/or mildew) and needs to be replaced. Replacement can occur when the existing loudspeakers are replaced or removed.

The existing sound system includes induction-loop technology for use by the hearing-impaired, but does not yet include Wi-Fi/Bluetooth technology for users with newer hearing aids. It was also unclear as to whether portable receivers were available for use with the existing loops. Sound operators should use portable receivers to periodically check and improve the sound quality provided through the induction loops.

We talked about how sound operators in the back room are likely hearing qualities of sound that are much different than those heard by the congregation (due to different acoustics in the sound booth and different loudspeakers); this makes it very difficult for operators to properly judge and improve the clarity of sounds on behalf of the congregation. While the existing sound system included an early digital mixer as manufactured by Presonus, we saw no Local Area Network connections for use with a Wi-Fi adaptor or Apple iPad for remote control. (We encourage Church operators to investigate this potential feature and network port themselves to confirm its absence or presence.) Given the location of the mixer in a small room where operators are unable to properly hear, a mixer with iPad remote control would likely ease the operation of sound in the Sanctuary. This is a change that can be implemented soon, after which operators can walk the rear aisles or sit in the pews while adjusting sound via the iPad.

Speech intelligibility was reported to be unacceptable for listeners in the front five rows of pews, while speech intelligibility was better in the rows further back. We discussed how many of these center-cluster designs included one short-throw horn (or loudspeaker) and multiple long-throw horns/loudspeakers. Assuming such a design

philosophy was implemented, one reasonable hypothesis would be that the short-throw device has failed. Another possibility is that the short-throw device was intentionally turned down in volume to reduce the risks of microphone feedback. However, given the age of the loudspeakers (20 years, with an expected lifespan generally up to 24 years), we recommend that the existing loudspeakers be replaced as soon as possible.

We perceived the reverberations that we heard in the existing Sanctuary to be reasonable for supporting traditional or blended worship music. While the acoustics and loudspeaker selection have to work together to provide acceptable speech intelligibility, we are more concerned in this space about the age and performance of existing loudspeakers more than the existing acoustics. We believe that replacement of the sound system is the most critical next step to improve speech intelligibility in the Sanctuary. However, before recommending new loudspeakers in such an environment, we must measure the existing reverberation times for use in our predictions of STI. And, we should allow for the possibility of improving the acoustics for the Church's upcoming use of the Sanctuary.

We also discussed how some Sanctuary events could use more floor space if the Church was willing to remove some of the pews. We caution the Church against such pew removal until more is known about the potential impacts to acoustics and speech intelligibility. Removal of any pews will likely lengthen reverberation times and degrade speech intelligibility by some amount. Once we have the measured reverberation times, acoustical model and prediction methods verified, we will be able to better predict the impacts of pew removal on speech intelligibility and music quality.

2 PROPOSED SCOPE OF SERVICES

We believe that the following scope of services will meet your immediate needs for this project. Please feel free to contact us if there are any questions or needed changes.

2.1 OBSERVATIONS DURING WORSHIP & EVENT

When we are working to improve existing spaces sonically, and when there are no specific plans for significant architectural renovations, it is often beneficial for us to hear the existing space in use. Such experiences often help us better understand current usage and help us identify additional ways to improve the acoustics and sound. Under this work item, we plan to perform the following specific tasks:

- 2.1.1 From our office in Houston, witness one worship service as distributed to the Internet for Sunday worship in the Sanctuary. Observations may include appropriateness of sound levels and balance (speech and music), general quality and tonal content of sounds heard, levels and types of background noise heard, intelligibility of speech (especially for elderly listeners at home), and appropriateness of reverberation heard behind sounds. (No similar activity is planned regarding the Fellowship Hall.)

- 2.1.2 Travel to the Church and attend the 10:00am Sunday service in person to observe Church use of the space and audible results from several listening positions. Observations are likely to include style(s) of worship music, music instrumentation, any unusual content to the service, estimates of attendance or percentage occupied, and types/locations of primary microphones used. Subjective evaluations may include acceptability of speech intelligibility from various seating areas, appropriateness of reverberant sounds behind the music, background sounds heard other than speech and music, and amounts of congregational participation (which can be affected by acoustics and music sounds).
- 2.1.3 Travel to the Church and attend one event in the Fellowship Hall to observe typical use of the space and audible results from several listening positions. Overall observations are likely to include sources of speech or music, style(s) of music, any unusual content to the event, estimates of attendance or percentage occupied, and types/locations of primary microphones used. Subjective evaluations may include acceptability of speech intelligibility from various seating areas, appropriateness of reverberant sounds behind the event, background sounds heard other than speech and music, and amounts of crowd participation or crowd sounds (which can be affected by acoustics and sound sources).

2.2 ONSITE OBSERVATIONS & MEASUREMENTS

- 2.2.1 Travel to the Church and perform brief listening tests of acoustics in the Sanctuary and Fellowship Hall (without the installed audio system, using portable test speaker and prerecorded sounds/signals provided by Worley Acoustics). Note observations. Identify any echoes observed. Identify any observed late reflections of speech energy by surfaces at the rear of the room. Activities in each room will be scheduled on separate days.
- 2.2.2 In each room, select up to eight (8) listening (receive) locations throughout the space at which sounds will be measured. In the Sanctuary, one listening location will be selected at one of the seats on the platform, one in the choir, and the remaining locations spread throughout the pews. In each room, select up to three (3) source locations from which measured sounds will originate. In the Sanctuary, one source location will be at the platform (e.g., Pulpit), one in the choir, and one in the front half of the congregational seating.
- 2.2.3 For each of the three source locations measure Room Impulse Responses under unoccupied conditions at each of the eight selected receive locations (without reinforcement from the audio system, 24 measurements total). Later (as office work), qualify and calculate from these measurements the room reverberation times for the 125, 250, 500, 1000, 2000, 4000, and 8000-Hertz frequency bands (i.e., standard octave bands). [Test equipment, field measurements and data qualification methods to generally conform to ISO Standard 3382-1 (2009).]

Measure average air temperature, relative humidity and air pressure during acoustic measurements.

- 2.2.4 With test signals injected into the existing sound system (or with test speaker placed behind a primary microphone), perform brief, subjective observations regarding existing sound system performance in delivering speech and music to listeners. Identify any echoes observed. Identify any observed late reflections of speech energy by surfaces at the rear of the room. (No measurements are planned, as we understand that sound systems in both rooms are aged and will likely be replaced soon.)
- 2.2.5 With air-handling systems set for normal operation as they would be during worship (or Fellowship Hall events), measure steady-state background noise levels in standard octave bands (from 16 to 8,000 Hertz) at each receive location. Identify primary sounds heard during each measurement. Later (as office work), calculate Noise Criterion (NC) for each position. [Test equipment and measurements to generally conform to ANSI Standards S1.13 (R2010) and S12.2 (2008).]
- 2.2.6 Identify the existing architectural finishes in each room. Photograph each room as appropriate for later reference.
- 2.2.7 While at the Church (or later as office work using available drawings), build a 3-dimensional computer model of the existing interior architecture in each room using EASE software (Enhanced Acoustic Simulator for Engineers as manufactured by AFMG Technologies, version 4.4). Identify predicted geometric volume. This model will later help confirm surface areas of various finishes and predictions regarding any considered loudspeakers.

The acoustic measurements and observations of items 2.2.1 through 2.2.5 will likely require ten hours of dedicated access to each room. During observations and measurements, each room will need to be:

- **unoccupied,**
- **quiet,**
- **with all furnishings in place for most common events, and**
- **with all air-handling systems set for providing temperatures and humidity normal for occupied events.**

The reviews and creation of the model for each room as described in items 2.2.6 through 2.2.7 may require an additional sixteen hours of access (not necessarily exclusive access) to each room (32 hours total). Use of available electronic files, including architectural drawings, will make this process faster.

2.3 TABULATION OF DATA & MEETING WITH CHURCH

- 2.3.1 Tabulate and graph measured values of reverberation times, bass ratios and NC levels. Compare to known references.
- 2.3.2 For each room, draw floor plan of approximate test locations (source and receive locations).
- 2.3.3 List any observations not otherwise included in the data above.
- 2.3.4 Perform predictions of reverberation times in each room based on existing architecture and furnishings, compare to measurements, and identify any needed corrections to predictions.
- 2.3.5 Travel to the Church and meet once with Church representatives. Review observations, measured data, and predictions to date. Discuss the Church's worship style(s) and range of worship music in the Sanctuary. Identify the Church's overall goals with respect to Sanctuary acoustics and any upcoming changes to worship music. Discuss all event types held and planned in the Fellowship Hall, along with different configurations of furniture. Discuss potential changes and upgrades to acoustics and sound equipment in each room. (Specific recommendations regarding architecture and loudspeakers will not be developed at this point.) Identify any Church priorities expressed in the meeting regarding furniture changes (e.g., pew removal), treatment types, loudspeaker types, sound qualities or acoustical goals. If necessary, this meeting can be held on two separate days for the two separate rooms. If necessary, meetings can take place via Zoom or similar conferencing software.

2.4 ANALYSES & REPORT

- 2.4.1 For each room, identify recommended acoustical design criteria for reverberation times, bass ratios, STI and possibly other acoustical properties based on discussed usage and Church goals.
- 2.4.2 Where acoustical changes are needed, develop conceptual recommendations for changes to architecture (primarily room finishes) that result in estimated conditions meeting the design criteria. Recommendations will include brief descriptions of the products or architectural changes required. For any specialized materials recommended, we will also provide names of contractors, manufacturers or other representatives who will assist the Church, Church's Architect or Church's Builder further with detailed design-build proposals, product data, product samples, and shop drawings. (Under this scope of work, we are not offering design drawings or contract specifications for the installation of acoustical treatments nor for any recommended changes to architecture, should they be necessary.) Include design criteria, predictions and recommendations in

an Acoustics Report for each room. Should we have any budget information for the recommended changes based on our past projects, we will provide that information separately from the report. Analyses for the Fellowship Hall are expected to include various configurations of furniture. Analyses for the Sanctuary are expected to consider the removal of some pews.

- 2.4.3 For each room, develop conceptual recommendations for changes to loudspeakers that result in estimated conditions meeting the design criteria and Church goals. Recommendations will include brief descriptions of the loudspeakers (manufacturer and model), locations and orientations required. (Under this scope of work, we are not offering design drawings or contract specifications for the installation of audio equipment.) Also perform reflection studies in drawings and/or models based on proposed loudspeaker locations, and recommend additional acoustical treatment where needed. Include loudspeaker design criteria, predictions and recommendations in Acoustics Report for each room.
- 2.4.4 If we are unable to meet the STI criteria for speech intelligibility for recommended loudspeaker selections using the planned reverberation times, determine the reverberation times necessary for achieving the recommended STI criteria. Return to item 2.4.2 to determine which architectural changes are needed to achieve the STI criteria, and update the Acoustics Report with the associated analyses and recommendations.
- 2.4.5 Identify any other significant sound equipment recommendations that we believe to be critical to meeting the Church's stated goals (e.g., assistive listening equipment, mixer types for loudspeakers, mixer types for streaming, and wireless microphones).
- 2.4.6 Provide separate Acoustics Reports for Fellowship Hall and Sanctuary to Church in PDF format via email.
- 2.4.7 If needed and requested, visit the Church (in person or via Zoom) to review the Acoustics Reports with Church representatives, and answer questions with any readily available information. If necessary, this meeting can be held on two separate days for the two separate rooms.

2.5 RELATED WORK NOT INCLUDED

To save the Church from additional fees and to avoid any misunderstandings regarding our proposed scope of services, we note that the following items are currently excluded from our work. Please contact us if any changes are needed in these matters.

- Detailed reviews, measurements or predictions regarding existing sound equipment
- Acoustical analysis or recommendations regarding any spaces outside of the Sanctuary and Fellowship Hall, as we anticipate work only in those spaces

- Recommendations for changes to architecture or mechanical systems in each room to improve control of mechanical noises, as we do not currently anticipate the need for such services
- Sound isolation studies or recommendations to control sound transmission between any separate spaces, as we are unaware of any such concerns
- Sound isolation studies or formal recommendations to control impacts from sound sources outside of the buildings (e.g., highway traffic, aircrafts, railroad traffic, thunder, etc.), as we are unaware of any specific concerns
- Recommendations regarding video or lighting systems
- Designs utilizing Building Information Models or Autodesk Revit models, as all electronic design/drawing files received by Worley Acoustics and provided by Worley Acoustics will need to be compatible with Adobe Acrobat, AutoCAD LT 2021 or Microsoft Word
- Creation of drawings and detailed specifications for the installation of acoustical treatments, as we have found such services to be unnecessary on previous projects of similar size and scope
- Specifications or drawings for new or renovated audio equipment, as such services (if needed) will be provided in a future phase
- Significant assistance to the Church in requesting design-build proposals from contractors based on our reports, as such services will be added later if needed
- Review of contractor-provided proposals, submitted data, submitted samples, or installation, as such services will be added under a separate proposal if needed
- Retesting of the renovated acoustical environment following the installation of recommended treatments, architectural changes or new loudspeakers, as such testing services are usually unnecessary and will be added under a separate proposal if needed

3 REFERENCES

- [1] V. O. Knudsen and C. M. Harris, *Acoustical Designing in Architecture*, 5th ed., New York, NY: Acoustical Society of America, 1978.
- [2] W. J. Cavanaugh, G. C. Tocci and J. A. Wilkes, *Architectural Acoustics Principles and Practice*, 2nd ed., Hoboken, NJ: John Wiley & Sons, Inc., 2010.
- [3] ISO Standard, *3382-1 Measurement of Room Acoustic Parameters - Part 1: Performance Spaces*, Geneva: International Organization for Standardization, 2009.
- [4] M. D. Egan, *Architectural Acoustics*, New York, NY: McGraw-Hill, Inc., 1988.
- [5] M. Kleiner, D. L. Klepper and R. R. Torres, *Worship Space Acoustics*, Fort Lauderdale, FL: J. Ross Publishing, 2010.
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- [7] L. Beranek, *Concert and Opera Halls How They Sound*, Woodbury, NY: Acoustical Society of America, 1996.
- [8] W. Ahnert and W. Schmidt, "Fundamentals to Perform Acoustical Measurements, Appendix to EASERA," AFMG Technologies GmbH, 2002.
- [9] IEC Standard, *60268-16 Objective Rating of Speech Intelligibility by Speech*

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- [10] ANSI Standard, *S12.2 Criteria for Evaluating Room Noise*, Melville, NY: American National Standards Institute, Inc., 2019.
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- [12] D. A. Bohn, *Pro Audio Reference*, Second ed., Mukilteo, WA: Rane Corporation, 2006.
- [13] United States Department of Justice, *2010 ADA Standards for Accessible Design*, Washington, DC: www.ada.gov, 2010.
- [14] United States Government Publishing Office, "United States Code," 2009. [Online]. Available: <https://www.govinfo.gov/content/pkg/USCODE-2009-title42/html/USCODE-2009-title42-chap126.htm>. [Accessed 2023].
- [15] L. L. Beranek, "Subjective Rank-Orderings and Acoustical Measurements for Fifty-Eight Concert Halls," *Acta Acustica United with Acustica*, vol. 89, pp. 494-508, 2003.

4 CONSULTING FEES

We offer our consulting services on a "Time-and-Materials" basis. Work in acoustics and audio will be performed primarily by Mr. Wade R. Worley at an hourly rate of \$80.00. Assistants to Mr. Worley may be employed during work on this project at similar or lower rates. Our estimated fees and expenses for the above scope of services are shown in the table below. Additional work items not described in the scope above, such as additional trips to the site, additional meetings, and additional reviews may cause the fee budget to be exceeded.

Description	Estimated Fees Fellowship Hall	Estimated Expenses Fellowship Hall	Estimated Fees Sanctuary	Estimated Expenses Sanctuary	Totals
2.1 Observations During Worship & Event	\$520.00	\$45.00	\$840.00	\$45.00	\$1,450.00
2.2 Onsite Observations & Measurements	\$2,560.00	\$135.00	\$2,560.00	\$135.00	\$5,390.00
2.3 Tabulation of Data & Meeting with Church	\$3,680.00	\$45.00	\$3,520.00	\$45.00	\$7,290.00
2.4 Analyses & Report	\$2,560.00	\$45.00	\$2,800.00	\$45.00	\$5,450.00
Subtotals	\$9,320.00	\$270.00	\$9,720.00	\$270.00	
Grand Total					19,580.00

We will invoice monthly only for the hours worked and the expenses incurred. The total authorized budget of \$19,580.00 will not be exceeded without written authorization.

5 TERMS AND CONDITIONS

FEE: Worley Acoustics shall be reimbursed for its services or the services of any sub-consultants on the basis of the number of hours expended on the project multiplied by the applicable hourly rate including all time spent in travel. The total authorized budget will not be exceeded without written authorization. Consulting fees are based on the work being performed once. If a redesign or cost review is necessary due to a condition beyond the control of Worley Acoustics, the redesign or cost review will be considered an additional service with additional fees.

EXPENSES: Worley Acoustics shall be reimbursed for the following expenses incurred in connection with services: travel and subsistence costs, specification/report reproduction, drawing reproduction, equipment rental, and other reasonable costs associated with the project on the basis of actual costs. A receipt shall not be required for any expenses under \$20. (For projects requiring drawings or specifications produced by Worley Acoustics, Worley Acoustics will not invoice for expenses incurred during plotting and printing of master documents, that is, the original set of drawings and specifications for each issue of design by Worley Acoustics. Only the costs associated with any necessary reproduction of those documents, including a file set for Worley Acoustics, will be invoiced.)

INVOICING AND PAYMENT: Invoices shall be rendered monthly and will itemize hours expended, expenses, and any applicable taxes or duties. **Net payment for each invoice is due 30 days from date of invoice.**

TERMINATION: Either party may terminate this agreement in whole or part at any time by written notice to the other; such notice is effective upon receipt. In the event of such termination, Worley Acoustics shall be paid in accordance with this agreement for services rendered and expenses incurred or committed to before and including the date of termination.

SCOPE: The services and fees offered in this proposal are based upon our best assessment of the client's needs and the corresponding work as identified in this proposal. If the scope of services requires modification, a new scope of services and revised fees will be provided for consideration and approval.

GOVERNING LAW: Interpretation, construction, and enforcement of this Agreement shall be pursuant to the laws and statutes of the State of Texas.

Ms. Diane Kane
Webster Presbyterian Church in Webster, TX
Sanctuary & Fellowship Hall Acoustics
Proposal for Consulting Services

WORLEY ACOUSTICS
Wade R. Worley, Principal Consultant
WA Proposal #1306
October 19, 2023

6 ACCEPTANCE

To accept the Scope of Services, associated Consulting Fees, and the Terms and Conditions of this proposal, please provide an authorized signature below. Please send a complete and signed copy of this agreement to Worley Acoustics. The fees and terms of this proposal will remain valid if an accepted copy of this proposal is received before December 15, 2023. Work will be scheduled upon acceptance and not before.

WORLEY ACOUSTICS



Wade R. Worley

Principal Consultant
Title

October 19, 2023
Date

1306
Proposal Number

WEBSTER PRESBYTERIAN CHURCH

(Authorized Signature)
Printed Name: _____

Title

Date

Purchase Order Number (if needed)