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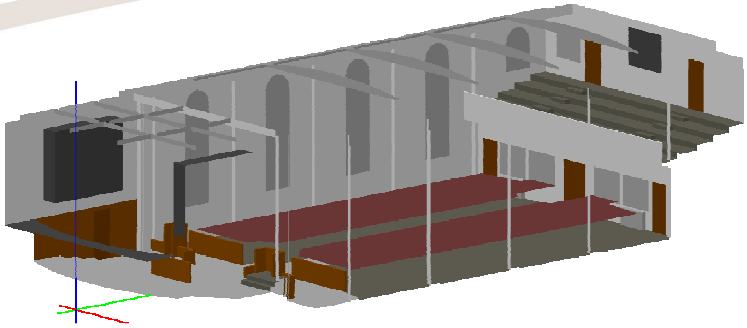
Acoustical Review and Report
For the proposed Worship Space



Ladue Chapel Presbyterian Church
St. Louis, Missouri
July 27, 2013

I. Project Goals

The goal of worship architecture, as regards the acoustical environment, is to provide a setting where the critical aural activities and functions of worship are supported and enhanced. These functions include:

1. The distribution of clear, intelligible speech (lessons, prayers, sermon, etc.) to all worshippers.
2. The blending of acoustic music (choirs, organ, orchestral instruments, piano, bells, etc.) into a rhythmically accurate, well tuned ensemble, and the distribution of that music to all worshippers.
3. The development of a setting where all worshippers hear each other and are reinforced and supported by each other in the corporate activities of hymn singing, and in other sung and spoken parts of the liturgy.
4. The development of a setting where echoes, excessive noise, sound focusing, and/or other similar acoustical faults are controlled and suppressed.

These goals are generally achieved in architectural environments that exhibit desirable design features and elements such as:

A. An adequate ratio of cubic air volume to seating capacity.
B. A non-restrictive geometric shape/form.
C. Good location and proximity of key elements such as singers/instruments, etc.
D. Good ratio of sound reflective to sound absorptive materials, finishes and structures.
E. An appropriate reverberation period.
F. An electronic sound reinforcement system of appropriate equipment design, location and calibration.
G. Adequate sound-isolation from potentially noisy adjacent spaces, outdoor transportation, and/or or machinery.
H. The design and location of building systems and equipment (such as heating/air conditioning HVAC systems) for the control and suppression of noise.

II. Analysis of Proposed Design

Acoustical assets include:

1. The "long-narrow" traditional geometric shape of the room is conducive to a live reverberant space, to good musical blend and projection, and to good speech distribution.
2. Wall materials seem sufficiently dense and rigid enough to provide good sound reflection across the entire frequency range throughout the worship space
3. Majority of current reflective surfaces are conducive to a live reverberant space.
4. There is a good, unobstructed, "long axis" direct path for organ, choral, and instrumental tone to propagate through the space and be distributed to the entire congregation.

Potential acoustical challenges include:

1. The reverberation period is significantly lower than desired for worship (current 1.1 seconds – recommended 2.0 seconds).This contributes to diminished projection, blending, balancing, and enhancement of musical tone. The too low reverberation time also diminishes and discourages active congregation participation in hymns and sung and spoken liturgy.
2. A large amount of carpeting in aisles and under pews within the worship space absorbs significant amounts of sound energy, and is the primary cause of the low reverberation period. This excessive absorbing of sound energy does not provide adequate support for choir singers or organ tone projection. This lack of support contributes to poor vocal performance, especially with less confident singers. Carpeting underneath worshipers is highly undesirable and further inhibits the assembly's participation and worship.
3. The current Chancel seating layout for singers and instrumentalists does not allow musicians to hear each other well (seating is in long, straight rows instead of in an "ensemble" blended format). There is inadequate and inflexible space for musicians.
4. Excessive and interrupting noise is audible in the worship space, primarily emanating from roof-mounted HVAC equipment adjoining the Chancel front wall/window.

The following recommendations are provided to achieve the best possible acoustic result for this space, based on our understanding of your needs at this time. Changes and modifications to these recommendations may be considered at any time, per your request.

III. Music Area

1. **Music Ministry Area Design Ideals and Goals:**

    1. All singers and instrumentalists should hear each other well to develop good tonal balance, blend, and rhythmic/tuning accuracy.

2. All music should project directly to listeners in the nave without obstruction.
3. The music area should be flexible to accommodate differing musical arrangements, styles, and formats. These include but are not limited to:
    a. Blended Choir
    b. Organ Console
    c. Piano
    d. Hand bells
    e. Orchestral Instruments

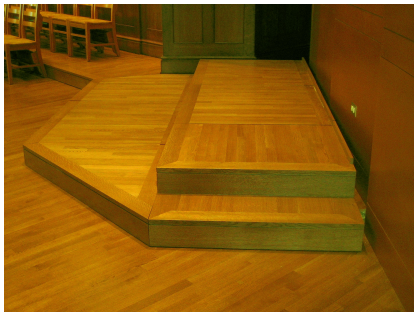
2. **<u>Music Area Design Recommendations</u>:**
    - ✓ Modify existing platform as shown in the drawings provided, adhering to the construction recommendations for the selected organ and selected layout option on drawings CL-01 to CL-10
    - ✓ Revise the choir seating area to be in a curved-ensemble format to allow singers to hear each other well.
    - ✓ Use individual chairs instead of pews for all singers and instrumentalists to allow for the flexible use of the space.
    - ✓ Use moveable modesty rails and panels to allow for the flexible use of the space.
    - ✓ Use hard, sound reflective chairs/seating (wood, cane, or woven chairs are recommended).
    - ✓ Use hard, dense, sound reflective materials (non-carpeted floor, reinforced Gyp-Board or sealed masonry walls, etc.) throughout the music area.
    - ✓ Use sound reflective/diffusing wall surface profiles aside and behind choir singers.
    - ✓ The under-side of the proposed cantilevered side-wall organ cases should be of hard surface and diffusive form design for the purpose of reflecting and blending musical sound energy.
    - ✓ Front wall organ equipment/cases must facilitate organ tone projection and maintenance access, while also providing a sound reflective and diffusing surface behind choir singers.

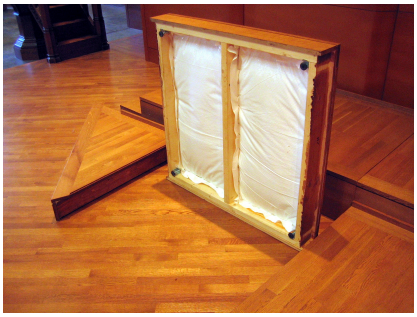
3. **<u>Music Area Technical Accommodations</u>**
    1. Provide adequate electrical service/convenience outlets, boxes and conduits for a variety of uses. Examples include:
        a. Piano light
        b. Organ console lights and equipment
        c. Organ console plug-in operating locations
        d. Piano humidifier/de-humidifier
        e. Sound system monitor speakers
        f. Sound system microphones

Design Recommendations:

a. Use hard, sound reflective chairs/seating.
b. See construction details in Drawing R-01. Risers should accommodate up to 45 singers with chairs and have a min. 6" step-height and 3' depth.

The photos below represent moveable riser formats and are shown to provide construction examples used to suppress foot-fall noise only.





IV. ***Reverberation Period***

Reverberation: Establishing a proper reverberation period is a critical factor in developing desirable acoustical conditions in a worship space.

"Reverberation Period" is the amount of time (in Seconds) that sound energy will linger and travel in a given space. Specifically, it is the amount of time sound energy will take to drop a level of 60 decibels after the source has ceased producing a tone.

The proper reverberation period will encourage participation in congregational singing and spoken responses. It will provide well-blended musical ensemble and expressive support to organ, choral, and instrumental music. Musicians will find tuning and rhythm to be more precise in a properly reverberant setting. A reverberation period that is too short will leave music dull and lifeless, and without tuning stability. A reverberation period that is too long will render music and speech confused and unintelligible. The correct reverberation period is essential to the success of lively corporate worship.

The function and use of a space determines the appropriate reverberation period. In a space of this size and shape, used for mostly traditional/classic worship styles, where speech, sung and spoken worship responses, hymn/liturgical singing, and choral/instrumental music are the primary sound sources, a reverberation period of 1.8 to 2.0 Seconds is desirable, tested during unoccupied conditions.

Conditions influencing the reverberation period include the surface area and relative sound reflecting or sound absorbing qualities of all materials and furnishings in the room, and the cubic air volume and shape of the room. (Generally, a large room with many reflecting surfaces will have a long reverberation time and a small room with many sound absorbing surfaces will have a short reverberation time.) Note that changes in reverberation period of 0.1 seconds are detectable and noticeable to typical listeners.

A number of reverberation time scenarios, resulting from various interior material selections and combinations are shown below. These can assist in identifying the most appropriate set of materials necessary to achieve a desirable level of reverberance.

Existing Conditions Untreated

Tested Conditions:	Reverberation Time (Seconds)				
Frequency (pitch) → (C7)	125Hz (C3)	250Hz (C4)	500Hz (C5)	**1000Hz (C6)**	2000Hz
Consonants	*"Bass"*	*Middle C*	*Alto-Soprano Range*		
Unoccupied$_{(tested)}$	1.54	1.08	1.09	**1.19**	1.21
50% Occupied$_{(predicted)}$	1.33*	1.23*	1.14	**1.05**	0.91
Fully Occupied$_{(predicted}$	1.23*	1.14*	1.04	**0.96**	0.83

* Note: actual RT times in this frequency range may vary due to limitations of low frequency calculations in prediction software.

Single Number Reverb Time Rating: 1.1 Seconds

Reverberation rates are currently lower than desirable and relatively uneven when comparing the bass and treble ranges with a large dip at 250 and 500 Hz. Sound absorbing flooring surfaces will need to be removed, in order to promote good strong reflections throughout the worship space in all octave band ranges.

View looking towards Chancel and pulpit showing existing carpeting (above)

V. Recommended Modifications

Scenario #1: All Hard Surfaces. *(The Recommended Option)*

***See Drawings AC-01 thru AC-08 for complete details ***

Ceiling: As Existing

Floor: Remove existing carpeting from all aisles and from underneath all pews. Recommend insulating under choir risers and new chancel platform per drawing R-01

Walls: As existing, balcony face and rear of chancel add diffusion

Seating: Existing pews with padded seats. Solid reflective hard surface seating for choir

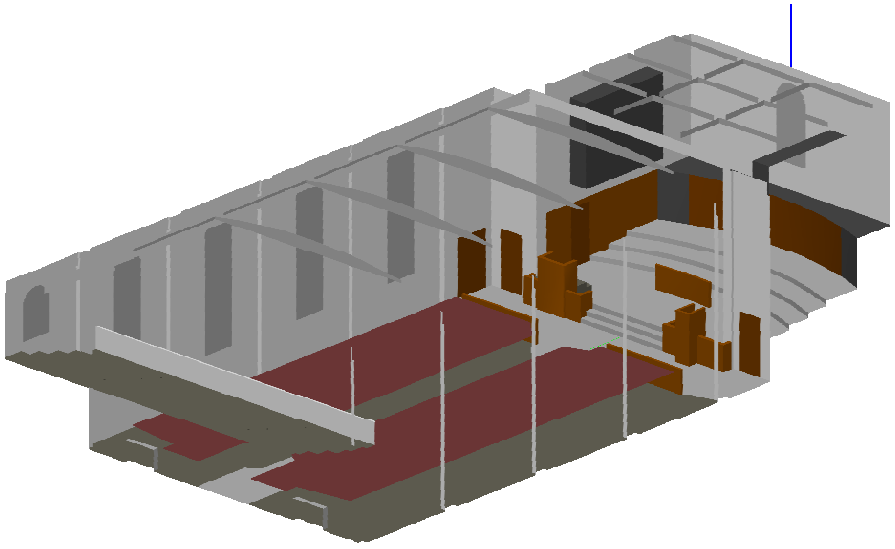
Occupancy Conditions — Reverberation Time (Seconds)

Frequency (pitch) →	125Hz (C3)	250Hz (C4)	500Hz (C5)	**1000Hz (C6)**	2000Hz (C7)
	"Bass"	*Middle C*	*Alto-Soprano Range*		
Consonants					
Unoccupied	1.42*	1.55*	1.69	**1.74**	1.73
50 % Occupied	1.32*	1.42*	1.50	**1.54**	1.51
Fully Occupied	1.22*	1.31*	1.35	**1.37**	1.34

Single Number Reverb Time Rating: 1.72 Seconds

* Note: actual RT times in this frequency range may vary due to limitations of low frequency calculations in prediction software.

*****Please see Appendix A for full RT curve results***



Bird's Eye view of new chancel layout showing reflective flooring (above)

Reverberation Period has been increased to an acceptable level however that single number qualifier is not always the whole story. Even though the single number falls just short of the goal of 1.8 - 2.0 seconds that does not mean that there will not be a very significant improvement in the space. These goals are set to agreed upon industry standards as to the appropriate

reverberation time for a house of worship emphasizing traditional worship styles and organ music based on the overall cubic air volume of the space. Though this reverberation period is the overall goal the unique physical geometry of the space also plays a large role as to how the sound decays within it and often changes the character of the room slightly in ways that an overall assumption of the cubic air volume cannot account for. As mentioned above the average listener can detect changes in the reverberation period of .10 seconds. Adhering to the above recommended modifications should increase the reverberation period a minimum of 0.62 seconds or over 6 times what the average listener would perceive as a noticeable difference. Due to the large flat untreated Balcony face there may be echoes that occur within the space when an amplified sound system is introduced. Due to the increased reverberation period these echoes will become more pronounced and noticeable, causing distractions to both musicians and the congregation during worship services. *This is the Recommended Option*

VI. Materials Recommendations

A. Material Selections

1. Any new interior **wall surfaces** (primarily in the Chancel as side wall and organ case design finishes) should be hard, dense, and sound reflective to generate the musical support and a desirable "warm" full frequency range reflective support. Non-porous Masonry, Reinforced Gypsum Wall Board, Plaster, Wood Paneling, or equivalents can be used. (Any wood paneling must be reinforced and strengthened in order to provide low frequency/bass reinforcement, reverberation, and balance.) Layers must be glued & screwed to form one composite panel. Materials options include:

    a. Three layers staggered seams, min 5/8" gypsum board total 1-1/2" thickness, glued and screwed/nailed together and to studs/joists/bracing 16" o.c. max) AND/OR
    b. Min. 1-1/2" wood paneling assembly (layered plywood or plywood and MDF Board) on studs/joists/bracing 16" o.c. AND/OR
    c. Non-porous or painted/sealed masonry veneer AND/OR
    d. Equivalents can be evaluated upon request

Note Regarding glued layers: the glue is necessary to form one heavy, composite, reflective surface, rather than two thinner resonating surfaces. The drywall contractor will need special instruction regarding this issue. Glue must be standard construction adhesive applied in a thin, even layer to entire gypsum wallboard surface. Do not use "Green Glue" or other resilient compound products in this application. All layers should be rotated and offset.

2. **Flooring**:
   Floor materials throughout the room (Chancel, music area, aisle, under congregation seating pews and in balcony) should be hard, dense, and sound reflective throughout (i.e. no carpet). Preferred sound reflective floor material options include quarry tile, porcelain, ceramic, stone, slate, and equivalents. Hard Wood floor and Vinyl Composite Tile are acceptable. Specific materials can be provided or evaluated, upon request.

3. **Congregation Seating:** It is strongly recommended that the congregation seating in the nave remain as having padded seats and hard wooden open slat back construction for moderate sound reflection.

4. **Music Area Seating:** Solid wood music area chairs (without padding) will improve tone projection for the choir and are strongly recommended. Other acceptable options include cane or woven rattan seats.

5. Potential **Footfall Noise** for the music area (from hard surface flooring on wood/cavity built up structures) can be suppressed by maintaining a massive, stiff floor material and filling the under floor cavities with sound absorbing fiberglass insulation. Screw and Glue all wood structures and floor installation to prevent nail-squeak as materials age. Potential treatment materials include:
    a. Install a poured Concrete floor system (if structural capacities allow) OR
    b. Use dense, rigid built-up riser floor material with minimum 1.5" composite thickness (.75" Finished Floor over .75" plywood). All Layers must be glued & screwed. AND
    c. Both Options: Install several layers of standard fiberglass batt insulation in under-floor cavity
    d. Drawing detail examples of under-floor treatment options are shown in Drawing R-01.
6. **Rear of Nave Balcony Railing**: The lower flat surface of the balcony railing should be treated with sound reflective and diffusing features (to avoid echoes from hard, flat surface reflections). A pattern of recessed panels with stiles and rails, or horizontal or vertical battens can be used to create the necessary sound diffusion.

VII. Echo Control: *Sound Diffusing and Dispersing Surfaces*

It was noted during reverberation testing that the possibility of an echo exists in the center of the Nave coming from the untreated face of the balcony rail when introducing an amplified sound system. This has the potential to generate undesirable slap-back during participation in the musical and congregation speaking portions of the service. These echoes may have the potential to disrupt speech intelligibility and bring confusing rhythmic anomalies to music. Applying Sound Diffusive (dispersing) treatments on balcony face will eliminate these echoes while allowing a desirably reverberant environment. When sound encounters a diffuser, it reflects and scatters. Diffusers are typically 3-dimensional shapes scientifically calculated to disperse sound energy and prevent discrete echoes.

Specific diffuser designs can be provided/evaluated/approved, upon request. A few ideas:

To prevent echoes, "flutter", "slap-back" and other acoustical problems, certain surfaces must be treated to become sound *diffusive*. Truly diffusive wall surfaces utilize calculated geometric features to effectively scatter and disperse incoming sound. The basic diffusion necessary to eliminate most discrete echoes and flutter can be accomplished through a great variety of options, including commercial diffusion products or custom built 3-D geometric patterns. Specific designs may be coordinated with the Architect.

The following locations may require Sound Diffusive Features:

- Vertical face of the Balcony.
- Underside of the cantilevered chancel side wall organ cases (details to be developed with the church's selected organ builder).

Alternative Wall Diffusion Options

a. "**Modffusor,**" "**QRD**," "**Diffractal**", or "**Omniffusor**" diffusion panels available from RPG Diffusor Systems, Inc. 651-C Commerce Drive, Upper Marlboro, MD 20774, Tel: 301-249-0044, www.rpginc.com. OR
b. Equivalents can be provided/evaluated upon request

VIII. Sound Isolation: *(Noise Control from Outdoor Spaces):*

Provisions should be made to minimize and/or prevent unwanted noise/sound transmission from the roof mounted HVAC equipment outdoors adjoining the chancel. Option #1, increasing the rigidity and density of the rear chancel wall is required. If this does not satisfactorily reduce the noise being generated from the HVAC equipment, employ option #2 and construct an enclosure or barrier of exterior grade absorbing material to contain the remainder of the sound. Sound levels of the new chiller unit were NOT tested during our initial visit due to the non-operational status of the equipment. We are available to return at a later date, if the church desires, to measure the levels introduced by the added equipment and include this as part of the background noise calculations.

It was also noted that there were larger sources of background noise in the space, which include the existing blower for the organ as well as the existing sound system. These

were noticeable largely in the bass frequency ranges and should be reduced once new equipment is in place.

Treatment options include the following:

1. Increase the sound attenuating properties of the front wall of the nave:
    A. Retain current masonry exterior wall
    B. Thermal insulation batt between studs
    C. 1" air space
    D. 2 lb. / sqft. Mass Loaded Vinyl sound barrier
    E. Added metal stud wall with thermal insulation between studs
    F. 3 layers gypsum board, glued and screwed.
    (All Organ Builders must be notified of the added thickness of this wall assembly) OR other Design

Mass Loaded Vinyl Barriers

2 lb/sq ft

- *Sound Away Mass Loaded Vinyl Barrier:* SoundAway Corporation 2336 La Mirada Drive, Suite 100 Vista, CA 92081 t:1-866-SOUND81 (1-866-768-6381) http://www.soundaway.com/Mass_Loaded_Vinyl_Barrier_s/31.htm
- *Trademark Soundproofing: 2lb Mass Loaded Vinyl :* t: 1 (845) 352-3200 http://www.tmsoundproofing.com/Mass-Loaded-Vinyl-2-pound.html
- *Acoustiguard Mass Loaded Vinyl:* 1515 Matheson Blvd. East Unit C10 Mississuaga, Ontario, L4W 2P5 Toll Free: 1-888-625-8944 Tel: (905) 625-8944 http://www.acoustiguard.com/Barrier-materials/mass-loaded-vinyl/
- *Sound Proofing Company Inc. Mass Loaded Vinyl:* Sound Proofing Company Inc. 1311 Straits Dr. Bay City, MI 48706 t:1(800) 397-8791 http://www.soundproofingcompany.com/soundproofing-products/mass-loaded-vinyl-soundproofing/mass-loaded-vinyl/
- *equivalents*

2. Exterior Absorbing and Barrier Panels/Walls:

Outdoor Absorption Panels

A. Perforated Metal Panels with Polywrapped Acoustic Fill, 2" thick from O'Neill Engineered Systems, Inc. Hartland, WI 53029 - Phone: 262-538-0215 - toneill@noiseproblems.com

B. All Weather Sound Panels®, 2" thick sound absorption core with aluminum frame and perforated metal grill. Manufactured by Acoustiblok. Tampa, Florida U.S.A. 33616 Tel: (813) 980-1400 Fax: +1 (813) 849-6347 http://www.acoustiblok.com/industrial2.php

C. ***Quietperf*** durable perforated metal sound absorption panels available from Noise Barriers, LLC. Schaumburg, IL 60173 – Phone: 847.843.0500 Fax: 847-843-0501 www.noisebarriers.com

D. ***Architectural Absorption Panels*** w/ 2" thick bagged acoustical fill with a thermal setting powder coat finish and aluminum or stainless steel construction. available from Metal Form Manufacturing Inc. Phoenix, Az 85043
Tel: 602.233.1211
http://www.mfmca.com/absorption_panels.html

E. ***LSE Absorptive Noise Barrier System*** fully sound-absorptive sound wall designed for outdoor noise mitigation available from.Sound Fighter Systems, L.L.C., Shreveport, LA 71137, Phone (318) 861-6640 http://www.soundfighter.com/

F. ***All Weather Sound Panels™*** by Acoustiblok International, Tampa FL 33616 - Phone: 813-980-1400 - http://www.acoustiblok.com/industrial2.html

G. ***Acoustic Facing*** and outdoor sound absorptive treatment available from Durisol USA, Inc., McLean, VA, USA 22102, Tel: 866-801-0999, www.durisol.com/

Outdoor Barrier Wall Systems

H. ***Barrier Wall Systems*** available from Metal Form Manufacturing Inc. Phoenix, Az 85043 Tel: 602.233.1211
http://www.mfmca.com/barrier_wall_systems.html

I. ***Paraglas Soundstop®*** transparent outdoor noise barriers available from Durisol USA, Inc., McLean, VA, USA 22102, Tel: 866-801-0999, www.durisol.com/

J. ***LSE Absorptive Noise Barrier System*** fully sound-absorptive sound wall designed for outdoor noise mitigation available from.Sound Fighter Systems, L.L.C., Shreveport, LA 71137, Phone (318) 861-6640 http://www.soundfighter.com/

K. ***Panl-Wall®*** Outdoor Noise Barriers by Industrial Noise Control, Inc., North Aurora, IL 60542, Phone: 630-844-1999, http://www.industrialnoisecontrol.com/outdoor-noise-barriers.htm

L. ***Acoustifence®***, 1/8th inch thick, 6' x 30' (3mm x 1.83m x 9.14m)mass loaded vinyl sheet intended to be attached to a chain link fence. Manufactured by Acoustiblok. Tampa, Florida U.S.A. 33616 Tel: (813) 980-1400 Fax: +1 (813) 849-6347
http://www.acoustiblok.com/industrial2.php

3. Noise Attenuating Glass added to existing Chancel stained glass window (exterior application):

Acoustic Windows

A. ***900 Series*** STC 48 triple glazed window by St. Cloud Window (Configurations up to STC 60 are available), St. Cloud, Minnesota 56302 , phone: 800-383-9311,

email: info@stcloudwindow.com , Fax: 320-255-1513 , Web: www.stcloudwindow.com

B. ***Sound Control Extreme Windows***, Available From Larson Doors (Sound Control Storm Doors) Tel: 1.866.282.5722, Fax: 1-800-888-9006, www.scswindowsanddoors.com

C. ***ArmaClad Sound Barrier Windows,*** STC-40 Package, Available From Sound Solutions, 4422 W. 46th Street, Chicago IL 60629, Phone: 773-254-2077, Fax: 773-254-2045, www.armacladwindows.com/sound-barrier-windows.php

D. ***Serenity Series*** STC 40 rated acoustical windows available from Quiet Home Windows Sunnyvale, CA 94089 Main Office: 408-541-8000, http://www.quiethomewindows.com/

E. ***Model No. 5592278*** STC 55 Dual Glazed Fixed Window Assembly, by Overly Door Company, Greensburg, PA, Telephone: 724-834-7300 www.overly.com/door/

F. ***Noise Lock Windows*** available from IAC America, Bronx, New York 10462-5599, Tel: 718-931-8000, www.industrialacoustics.com

G. ***Sound Trap Acoustical Gasketing Systems For Custom Windows***, Zero International, Bronx, NY 10455 Phone: 1-800-635-5335 Fax: 718-292-2243, www.zerointernational.com

H. ***Kriegersonic®*** custom manufactured acoustical noise control windows available from Krieger Specialty Products, Pico Rivera, CA 90660, Tel: 562-695-0645, http://www.kriegerproducts.com/acoustical

I. ***Sound Proof Windows,*** Additional glazing mounted over existing window system. Available From Soundproof Windows, Inc., Reno, NV 89502 , Phone: 877.438.7843, Fax: 877.226.4063

IX. Sound System

These acoustic recommendations are developed with the goal of obtaining a higher reverberation time than the current sound system was originally tuned for. It may be necessary to re-calibrate or make other adjustments to the current sound system in order to maximize its performance in an environment with an increase reverberation period.

Acoustical Review and Report
For the Proposed Worship Space Renovation

Ladue Chapel Presbyterian Church- St. Louis, Missouri

Acoustical Report Summary Checklist – July 27, 2013

The following checklist/review is intended to facilitate a thorough execution of our acoustical recommendations. Detailed measures for achieving each of the following points are provided in the full July 27th Acoustical Report.

- Use hard surface flooring throughout the worship space (chancel, aisles, under pews, at choir area, and in balcony)…stone, slate, hardwood, or tile preferred.
- Remove All carpet from aisles and underneath pews
- Use Three Layers of 5/8" gypsum wall board at Chancel walls adjoining organ pipes/cases and choirs/instrumentalists.
- Adopt foot-fall noise suppression features under built-up floor levels and choir risers.
- Adopt ensemble format choir seating plan.
- Adopt flexible modesty railings in choir area.
- Employ organ case materials and design features to reflect and diffuse musical sound energy.
- Use non-upholstered individual chair seating in the choir area.
- Provide adequate electrical power and A/V system service in Chancel area.
- Close upper nave side wall ceiling soffits with gyp-board infill.
- Add sound diffusing features/materials to lower balcony railing.
- Used hard surface reflective seating in the main worship area. Back rests should be a reflective hard surface or open slat style.
- Increase the sound attenuating design/assembly of the front Chancel wall
- Increase the sound attenuating properties of the Chancel Window
- Add a noise attenuating barrier wall to surround the roof mounted HVAC equipment
- Check with A/V system provider for any recommended adjustments to the sound system to function in the increased reverberation environment.

Appendix A: *(Reverberation Graphs for Scenario #1):*

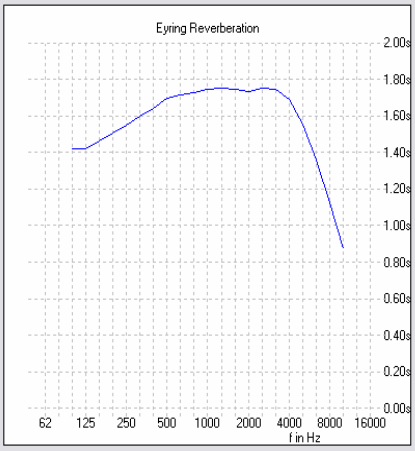
Pews Unoccupied

Project
Hall: Ladue Chapel Town: Ladue, MO
Version: Modified materials and chancel RT desired: 0 s

Geometry
Room Surface: 20014.62
Volume: 93126.78 cu.ft

Absorption
Avg. Abs. Area: 2455.26
Avg. Abs. Coeff.: 0.12

Mean Free Path
Length: 18.61 ft
Time: 0.02 s



Band	RTime [s]
100 Hz	1.42
125 Hz	1.42
160 Hz	1.46
200 Hz	1.51
250 Hz	1.55
315 Hz	1.6
400 Hz	1.64
500 Hz	1.69
630 Hz	1.71
800 Hz	1.73
1000 Hz	1.74
1250 Hz	1.75
1600 Hz	1.75
2000 Hz	1.73
2500 Hz	1.75
3150 Hz	1.75
4000 Hz	1.69
5000 Hz	1.55
6300 Hz	1.36
8000 Hz	1.13
10000 Hz	0.87

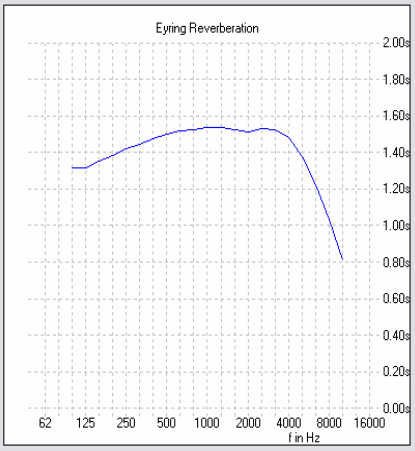
Pews 50% Occupied

Project
Hall: Ladue Chapel Town: Ladue, MO
Version: Modified materials and chancel RT desired: 0 s

Geometry
Room Surface: 20014.62
Volume: 93126.78 cu.ft

Absorption
Avg. Abs. Area: 2766.62
Avg. Abs. Coeff.: 0.14

Mean Free Path
Length: 18.61 ft
Time: 0.02 s



Band	RTime [s]
100 Hz	1.32
125 Hz	1.32
160 Hz	1.35
200 Hz	1.38
250 Hz	1.42
315 Hz	1.44
400 Hz	1.48
500 Hz	1.5
630 Hz	1.52
800 Hz	1.53
1000 Hz	1.54
1250 Hz	1.54
1600 Hz	1.53
2000 Hz	1.51
2500 Hz	1.53
3150 Hz	1.52
4000 Hz	1.48
5000 Hz	1.38
6300 Hz	1.23
8000 Hz	1.03
10000 Hz	0.81

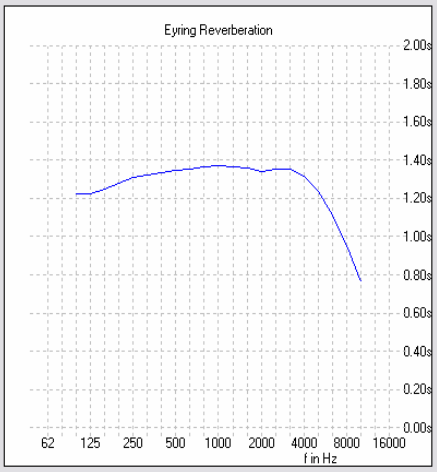
Pews 100% Occupied

Project
Hall: Ladue Chapel Town: Ladue, MO
Version: Modified materials and chancel RT desired: 0 s

Geometry
Room Surface: 20014.62
Volume: 93126.78 cu.ft

Absorption
Avg. Abs. Area: 3077.98
Avg. Abs. Coeff.: 0.15

Mean Free Path
Length: 18.61 ft
Time: 0.02 s



Band	RTime [s]
100 Hz	1.22
125 Hz	1.22
160 Hz	1.25
200 Hz	1.28
250 Hz	1.31
315 Hz	1.32
400 Hz	1.33
500 Hz	1.35
630 Hz	1.36
800 Hz	1.36
1000 Hz	1.37
1250 Hz	1.37
1600 Hz	1.36
2000 Hz	1.34
2500 Hz	1.35
3150 Hz	1.35
4000 Hz	1.32
5000 Hz	1.23
6300 Hz	1.11
8000 Hz	0.95
10000 Hz	0.76