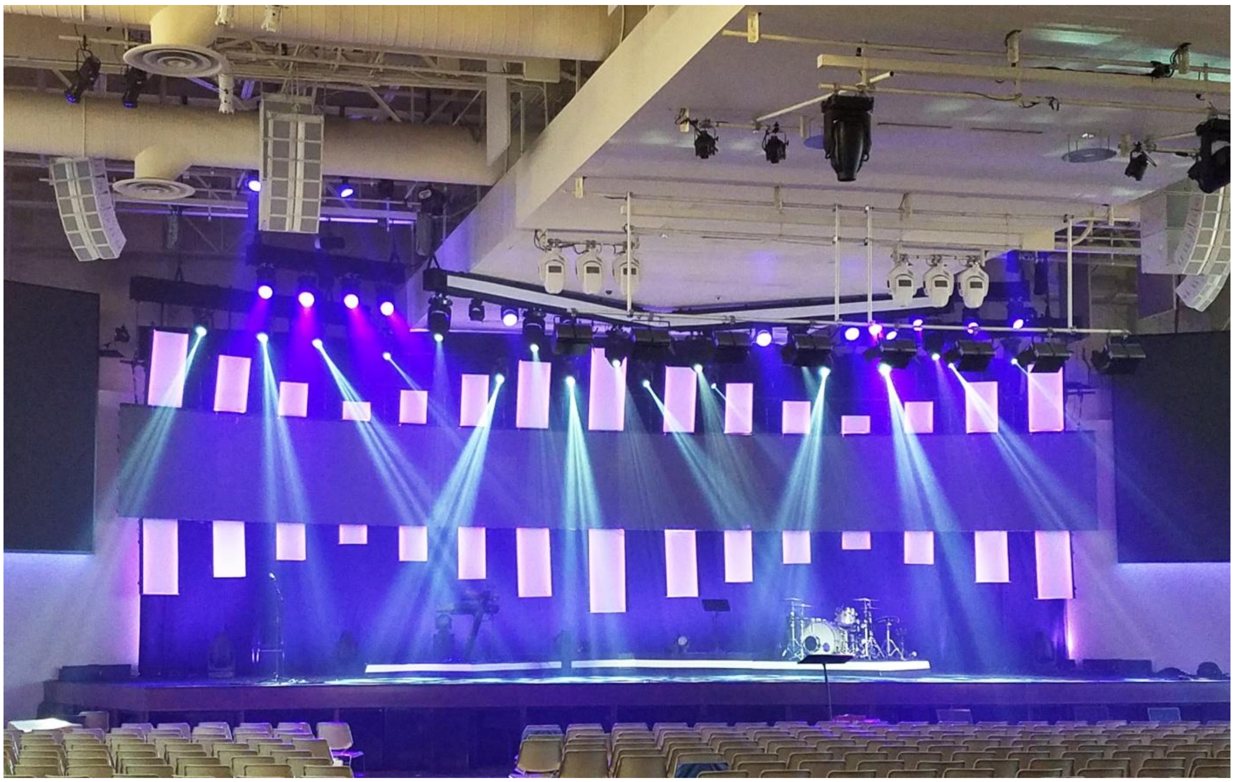
Saddleback Church
Audio & Acoustic Upgrades - Case Study

By Michael Fay, Sr. Design Consultant

There's church sound, then there's mega-church sound. Saddleback Church in Lake Forest, CA is arguably one the five largest houses of worship in America, with weekly attendance averaging over 20,000 across multiple campuses. The main campus worship center seats just under 3,000, in a 31,000 sq. ft. rectangular building that was originally intended to be a temporary facility.

Led by *Purpose Driven Life* author Rick Warren, Saddleback has been in its current facility for nearly 25 years, but with few audio system upgrades—until now. Seeking to improve clarity, intelligibility, and punch to support their high-powered worship team, the church chose Sound Image to design and integrate their new systems.



Clean Stage with House Left, Main and Side Fills in Upper Left Corner

As new audio director Aaron Ruse put it, "After an initial assessment of the existing acoustic space and audio system at Saddleback's Lake Forest Worship Center, several pressing needs presented themselves. In order to improve our audio technology, and best present music and spoken word in a clear and effective manner, it was important to consider a holistic approach to the upgrade."

This Saddleback story is not your typical "everything was wonderful" puff piece. Far from it. There were significant challenges to overcome at every step along the way.

The previous PA was installed when the room was built almost 25 years ago. It served the church fairly well, but audio technology has leapt forward so much in the past decade, they knew that to provide the best experience for the congregation, it was time for a major upgrade.

Main House Right Hang for the Old PA - Mirror Imaged on the House Left Side of the HVAC Soffit

Saddleback chose to replace the site's old, exploded mono, point-source system with a new, hybrid stereo, L-Acoustics (LA) Kara array system. The primary Kara system design was done by LA's André Pichette, using Soundvision modeling software to work through the structural and sightline limitations dictated by the owner. The architectural acoustics package was designed by Fay (SI's Sr. Design Consultant).

When Scott Coyle (SI's Business Development Specialist) and Mike Fay initially met with Aaron and Daniel Scotti (Production/Technical Director), one of the main selling points was that SI could provide both the audio and acoustics work.

Fay emphasized that a room this big will take a lot of treatment in order to tangibly lower the WC's excess reverberation. He went on to point out that most common absorption products stopped working below about 125 Hz. His vision was to design and apply additional, very low frequency (VLF) absorption, to help dissipate the energy produced by the new LA subs. This was a key issue for Aaron, which ultimately tipped the scales in SI's favor.

There were many physical, acoustical and aesthetic challenges. The room is basically a big square box. The back third of the space has bleacher-style seating. Plus, there are huge glass walls down each side of the room, measuring 32 feet high by 80 feet long.

We started with room that had roughly a 2- second mid-band reverb time, and close to three seconds at 63 Hz. Couple that with a worship team the regularly cruises at about 90 dBA. You can probably imagine what that sounded like.

Looking Across from House Right Seating to House Left Bleachers

Prior to choosing the Kara solution, Aaron and his team spent months listening to, and evaluating the various offerings on the market. They heard five or six PAs and kept coming back to L-Acoustics. Aaron called it an obvious choice. “Every time we put multiple PAs head-to-head and ranked them, no PA was consistently in the top three except Kara, which was in the top two every single time.”

Logistics and Timeline

Once the PA was selected, the acoustics design and budget solidified, and the contract docs signed, the field work was slated to begin as soon as possible. However, the contract didn't get signed until October 2016, and the church was pushing for completion in time for Christmas 2016.

We said we would try our best, but in the end, absolutely nothing progressed quickly enough to meet the desired timeline. Beyond what we could and couldn't control on the engineering and vendor side, the WC schedule couldn't accommodate the time blocks necessary to do all the work. The schedule was ultimately revised for us to start the install in early January.

Part of SI's commitment to Saddleback was that they would not be without a functioning PA during their weekend services. After several weeks of rigging design, structural engineering review and certification, a week of rigging prep and wire pull, the old system came down and the Kara system went in, and was ready for commissioning, in just four days. Dave Paviol (SI's Director of Operations) and his crew get all the credit for the efficient field work.

Unfortunately, because of vendor delays, the acoustics work lagged far behind the PA install. More on that below.

PA Configuration

André's design called for two, 6-module Kara arrays to support the main stereo PA channels. To complete the main floor coverage, two more 6-box Kara arrays were installed for side-fill coverage on the far left/right sides of the room. The side fills, front fills, and delay fills all get mono-sum signals.

New House Left, Kara, Main and Side Fill Arrays. 3 Box, Cardioid Sub Array Behind

Additional low-frequency support was supplied by three, SB18 subs, rigged in the air directly behind the main L/R arrays, and configured for cardioid dispersion. All full-range devices and the SB18 subs were powered by LA4X amplifier/controllers. The flown subs where configured as LF extensions to the Kara arrays, and are not assigned to an aux buss.

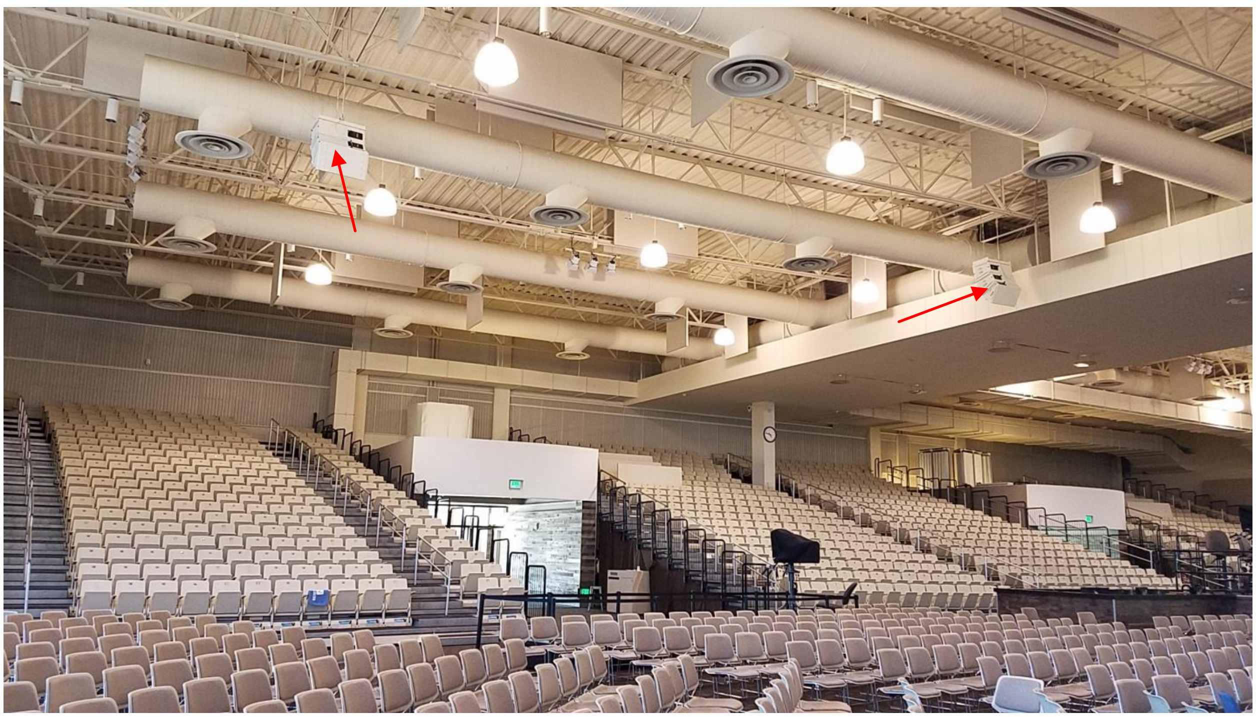
Additional subwoofer support was provided by four KS28, double-18-inch subs, which were placed on the floor, under the front edge of the stage. A single LA12X amplifier/controller provided power for these subs. These subs were assigned to an aux send buss so they could be incorporated in the mix as needed.

Because the main Kara PA is mounted nearly 30' above the floor, front-fills were mandatory. For this, eight X8 coax loudspeakers were installed under the front stage lip.

The back 40% of the room consists of pull-out bleacher seating. Using main arrays long enough to reach the back of the room was not an option due to structural and sight line restrictions. Therefore, a row of ARCS delay fills was added to provide coverage in the bleacher seats.

Rigged in front and above each of the four bleacher sections, each 3-box vertical clusters used a combination of ARCS Focus and ARCS Wide units.

We experimented with a few different stereo configurations for the ARCS delays, but in the end decided the mono-sum signal was the most coherent.



The Red Arrows Show Two of the 3-Box, ARCS Delay Fills, which Provide Bleacher Seating Coverage

Aaron points out that the Kara arrays seem to "feather" out nicely on the edges of the horizontal coverage, which makes blending in fills and delays sound very smooth. To him, this was a big deal given the geometric challenges of the room. But the desired outcome of the new system always went beyond just covering the space. "Our goal for anyone coming here to worship at Saddleback is for them to be able to close their eyes and focus on the message and the music that supports it, with no distractions, and with total clarity in every seat. The new Kara system that Sound Image installed has given us the tools to be able to consistently achieve that goal."

Signal Processing

Even though the LA amplifier/controllers have on-board DSP, which was used for loudspeaker and array alignment, Fay felt it would be best to have a front-end DSP platform for signal distribution, and zone processing. This would allow for minor adjustments to be made without having to touch the discrete channel processing that’s been dialed in during the system tuning/commissioning. The zoned signal distribution also allows for room configuration presets to be easily defined and recalled.

Fay specified and programmed Symetrix Edge processors. The Edge processors were chosen because of their sonic quality, ease of programming and AES input/output card options. With the AES cards, this package allowed us to a maintain a digital signal path from the stereo outputs off their Digidesign FOH console, all the way though to the LA amplifier/controllers.

We installed a Symetrix ARC-3 remote control panel too. This was programmed with a handful of presets such as two named Digital and Analog. For redundancy we wired both digital and analog outputs from the console stage box. If the digital path gets damaged or otherwise corrupted, a simple preset switches the main mix and aux sub buss to an analog path.

A Symetrix Prism 8x8 processor was also installed to support the existing 70V distributed system. Aaron wanted that processing to be done independently from the main PA DSP. He now can connect the Edge and Prism devices to their secure, wireless network and set up remote control phone apps for the technical and facility staff to manage presets and remote 70V levels.

Other gear specified and installed by SI included a Cisco SG300 switch, Surgex SU-1000 Li UPS, Belden cable, and lots of channel strut, beam clamps, wire rope, nuts and bolts.

With the large, exposed web joists, a rigging plan wasn’t too hard to figure out, but the California seismic codes added lots of additional hardware and wire rope for compliance. Oh, and yes, everything had to be white, including the channel strut, speaker cable and wire rope.

Acoustic Challenges

With nearly one million cubic feet of airspace, the interior finishes of the WC are mostly sheet rock, glass, metal, concrete and commercial carpet.

As mentioned above, there are very large glass side walls, also a corrugated metal ceiling, and drywall and concrete elsewhere. With the exception of the commercial carpet, thinly-padded plastic chairs, and people, there is very little other absorptive materials. The only other acoustically-helpful finishes are geometric. A few large sheet rock surfaces are angled or curved along the stage left and right walls.

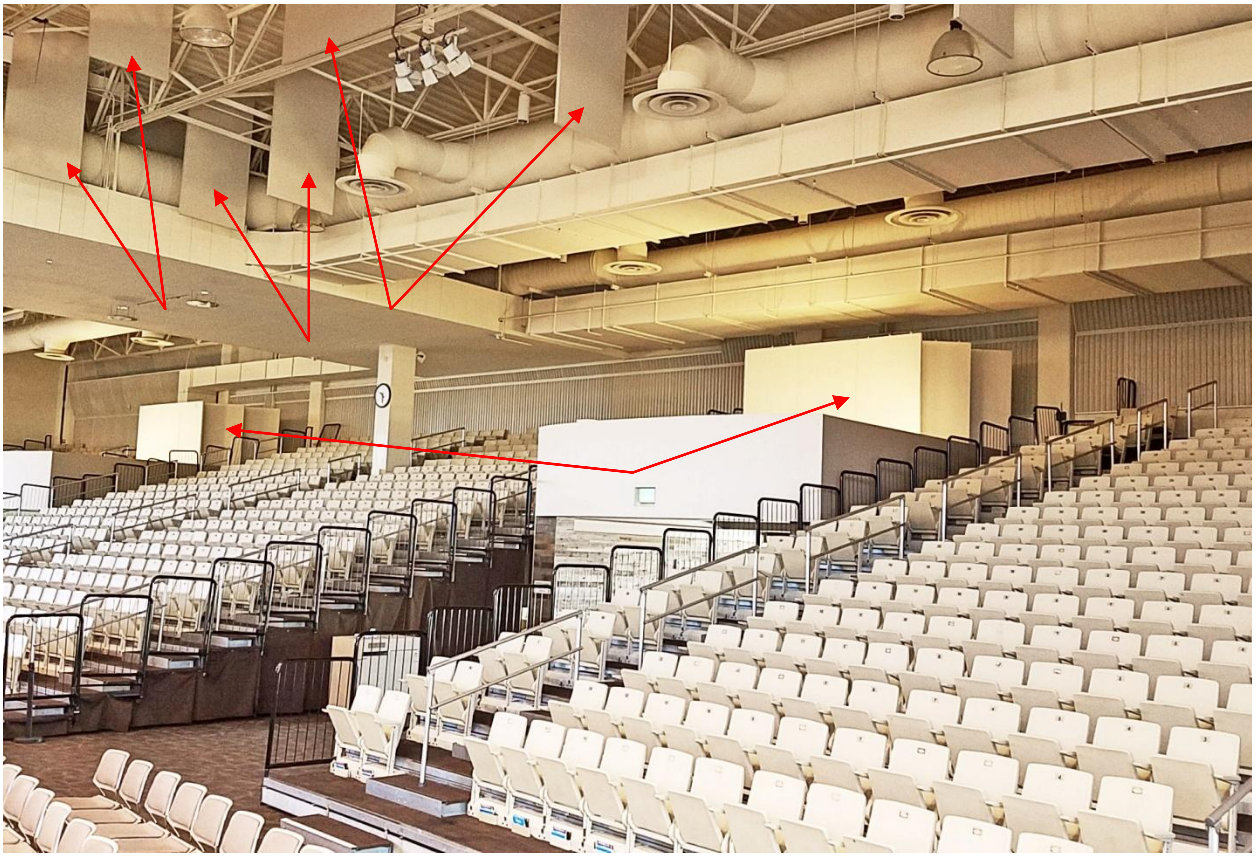
This was a very challenging acoustic environment. To further complicate things, the owner didn’t want any acoustic treatment to extend below the bottom edge of the 4’-6” roof trusses, nor did they want us to use any wall-hung panels. So, with the walls being unavailable, the ceiling would have to carry the vast majority of the broadband treatment.

At first, there appeared to be many attachment opportunities near the ceiling, but just to challenge the treatment layout further, the fire suppression sprinkler system significantly limited where we could place nearly 200 acoustic panels, without reworking the entire sprinkler system. Obviously, that wasn't going to happen.

And last, but far from least, was the need for VLF control and absorption.

Acoustic Solutions

Effective acoustic solutions are largely about cost and opportunity. With a one million cubic foot room, a lot of material (and money) was needed to make a noticeable difference. Based on EASE an Modeler acoustic modeling mock-ups, the design called for nearly 20,000 sq. ft. of absorptive treatment, just to bring the broadband (defined here as the 8 octave average between 63 Hz and 8 kHz) reverberation time (T60) down to a workable number. Our T60 goal and expectation was to get close to a 1.25 second room, while also pulling about one second out of the 63 Hz T60.



The Red Arrows Show Hanging Fiberglass Panels, and Bass Trap Locations Above Each Entry Door

The opportunities were mostly there. Because we could install hanging baffles across a wide swath of the roof structure, we could provide 64 sq. ft. of absorption from each edge-hung, 4'x8' panel, regardless of its horizontal or vertical orientation.

To help mitigate cost, we used the custom white, fiberglass panels in all areas that were visible to the public, while using recycled cotton panels in less visible locations. Also, to add more safety into the equation, each hanging fiberglass panel had secondary and tertiary safety wires installed.

Hanging 45 lb panels (with embedded eyebolts and hardened edges) over the congregation's head was not an acceptable solution. Additional safety measures were required. The SI engineering and operations team worked with our go-to structural engineer to design a cost effective, nearly invisible, wire sling solution that provides a 13:1 safety ratio for each baffle.

Another great opportunity was the space below the bleachers. Here we were able to accomplish two goals: Install many additional sq. ft. of 4'x8' and 4'x4' cotton panels to absorb whatever broadband energy collected below, and also soak up some VLF energy too. As you can expect, prior to this treatment a lot of low-frequency energy lingered in these unpopulated areas.

Acoustic Materials

12,224 sq. ft. of 2", 6 PCF panels: These panels were specified with as a mix of 4'x8' and 4'x4' sizes, and where finished with a custom "white" color, which required an additional white scrim cloth behind the acoustical cloth so that the yellow fiberglass color wouldn't show through.

With a few exceptions, all these panels were suspended from the very highest point below the roof deck so that the 4' vertical dimension would not drop below the bottom of the 4.5' roof trusses.

While the attachment method was not too difficult to design and install, finding a symmetrical layout to accommodate hundreds of panels, while avoiding the sprinkler head spray bubble diameter of 36" (fire code) at each head, was. The sprinkler heads are all spaced at 15' intervals. To further complicate things, there were lots of air ducts, lights, and steel cross-bracing to avoid. We had to get real creative to find a place for all these panels.

7,424 sq. ft of 2", 3 PCF recycled cotton panels: There are two large areas that are not in public view, but are in the volume of the room - A large service mezzanine above and behind the stage, and the space below the stadium-style bleacher seats. In these areas we hung the recycled cotton panels. These panels saved money, while providing the additional absorptive treatment that was needed.

Recycled Cotton Panels Hanging Under Bleach Seats.

2,700 sq. ft. of R30 Batt insulation was used to dampen under the stage lip, and above the central HVAC soffit, which runs front to back through the center of the room.

The stage has a 36" high, by about 40" deep, wrap-around bunker that holds the stage front subs and the front fill speakers. This area represented another good opportunity for broadband absorption. We packed R30 insulation all around in this bunker, then covered it with black scrim cloth. This cost-effective solution provided additional damping in an areas that are traditionally problematic if untreated.

Running the entire depth of the building is a giant HVAC soffit, which is mostly made of sheet metal, angle iron and gyp board. During our preliminary evaluations it was obvious this soffit was an acoustical problem. When we muted high-level program material, we could hear the VLF energy travel through the air ducts - for well beyond three seconds.

Here again, the design called for damping the top side of the main soffit with R30 insulation. This didn't eliminate all the extraneous rattles and buzzes in the area, but it helped considerably with the traveling rumble.

Bass Traps

To bring additional VLF treatment into the equation, Fay designed custom DAPCO™ PZBT-32 appliances. DAPCO is an acronym for damped, anharmonic, parametric, coupled oscillator.

The appliances are designed to absorb, diffuse and otherwise dissipate audible, VLF sound energy. DAPCO™ appliances are designed around quarter-wave dimensional theory, and the physical, energy-reduction mechanics of resonance, friction and diffusion.

PZBT-32 Bass Traps Being Assembled Above Entry

A total of 20 PZBT-32 appliances were installed. Each appliance contains 32 - 7' long, spring-tensioned, resonating tubes, enshrouded by a FM-Approved, fiberglass slip cover.

Here again, opportunity was our friend. The Saddleback WC has two large areas that are unusable for public activity. They are the full-width mezzanine behind the stage, and the exposed roof tops above the two main entry ways into the WC.

In the mezzanine, a total of 12 appliances where installed in corners and at the apex of several large, positive displacement, 63 Hz anti-node locations along the wall. The appliances were positioned in groups of two.

Above each entry doorway, a cluster of four appliances were positioned at their respective 63 Hz, anti-note hot spots.

Because of cost and size, PZBT-32 appliances are a very custom, opportunity-based VLF treatment solution. Saddleback had an obvious need, the desire, and sufficient budget and physical space to take advantage of this design.

Four PZBT-32 Appliances on Mezzanine Floor. Cotton Panels Hanging From Above

Proof of Performance

As proof of performance, SI offered pre/post testing of the WC acoustics. The primary reason for this effort was to objectively document the perceived results of the specified acoustic treatments.

For those who aren't familiar, T60 represents the time it takes for a given octave band of sound energy to decay 60 dB below the initial sound pressure level received at a reference microphone.

The following table shows the average T60 of the 8 frequency bands tested. Both pre- and post-treatment values are represented. Rational Acoustics Smaart v7.5 software was used to capture, process, and average impulse response (IR) files, as captured in multiple locations around the WC seating areas.

	63 Hz	125	250	500	1 kHz	2 kHz	4 kHz	8 kHz	8 Octave Avg.	500 Hz - 4 kHz Avg.
Pre-Treatment	**2.72**	2.53	2.45	2.35	2.12	1.63	1.21	0.79	**1.98**	**1.83**
Post-Treatment	**1.61**	1.47	1.40	1.32	1.34	1.32	1.15	0.76	**1.30**	**1.28**

T60 Slope Ratio

One final comment on modern acoustic goals and treatments. T60 Slope Ratio ($T_{60}SR_7$) represents the proportional relationship between 63 Hz and 4 kHz. These two frequencies bookend the seven significant octaves under evaluation. Should any of the middle five octaves measure longer or shorter than these two, it would suggest a whole different set of problems.

8 kHz is intentionally not included in the $T_{60}SR_7$ evaluation. Because of air absorption, short T60 values above 4 kHz unreasonably skew the ratio.

This author believes the optimal $T_{60}SR_7$ for contemporary worship should be between 1.1 and 1.2:1. Unfortunately, this goal is very difficult to achieve in any large room.

The Saddleback WC pre-treatment $T_{60}SR_7$ averaged 2.24:1. This means the 63 Hz T60 lasted 2.24 times longer than the 4 kHz T60. Conclusion - a poor acoustic environment for amplified music.

The post-treatment $T_{60}SR_7$ is now 1:40:1. Conclusion - a much better acoustic environment for contemporary worship. Not optimal, but significantly improved.

Summary

Mega-church projects come with mega challenges and expectations. Few companies have the skills, resolve, manpower, financial resources and stability to effectively take on and complete projects such as this. Sound Image is proud to have been selected to do this work, and worked tirelessly though all the challenges in an honest and professional manner.

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L-Acoustics PR team contributed to this report