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Best Practices for Audio Systems Design

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Best Practices for Audio Systems Design

Systems design isn't as simple as it used to be, as the industry moves ever closer to audio-over-IP. Here's a blue print to guide you through your your next audio upgrade.

By Dan Daley

In the icon-driven world we live in, where emojis are surrogate for, if not a thousand words then at least some long-distance crankiness, the loud-speaker icon is the stand-in for audio.

And for most churchgoers, that's just fine—the PA system is what they see when they think of listening to the sermon or to the worship band. But the reason they'll clearly hear every word of that sermon, and catch every note and thump of the band, is because behind those speakers is not only the rest of the PA system—amplifiers, processors, mixers, and cabling—but a huge, unseen but absolutely critical process, one that began months and years earlier, as needs began to make themselves felt and the wheels of a calculated response began to turn.

Addressing the sound for church is a complex and complicated series of decisions and actions, each with a distinct purpose—and a concomitant cost—that taken together can



provide any church space with exactly the right systems and configurations that it needs. That's the process that we'll look at here.

The good news is that the physics behind sound haven't changed much in the last few years. Actually is hasn't changed at all for the past few million years—sound waves still interact with the world and our ears as they always have, making many of the decisions that have to be made for sound-system design predictable and manageable.

And the bad news is ... well, there really isn't any bad news, unless you think that too many choices can be a negative thing. At a time when live music has replaced recorded music as the main revenue driver for the music industry, the professional audio industry has been busy churning out ever better, more user-friendly and cost-effective products and systems for installed-sound situations than ever before. The concern is that within

"Networked audio has hugely changed the effort-to-benefit ratio for us."

Bryce Boynton, Audio Director,
Flatirons Community Church, Lafayette, CO



Shown Actual Weight.

Of course the SSM bodypack transmitter is small - in fact, it is smaller than any other full-featured transmitter on the market. But you might not know how light it is. At 2.3 oz. (65.2 g.) with battery, it is half the weight of the most popular alternative, making it easier to conceal and less bothersome to the talent. Even still, the housing is all metal so it is still just as rugged as any other Lectrosonics transmitter. Other cool features include remote setting capable with a smartphone app, superb audio quality with Digital Hybrid Wireless® and a 75 Mhz (3-block) tuning range. Check it out in person sometime soon - it's even smaller and lighter than it looks in the picture.



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Cathedral of Our Lady of Guadalupe in Dodge City, Kan., boasts a rich, natural reverberance that enhances the music but wreaks havoc with intelligibility. Renkus-Heinz IC Live steered arrays focus the sound on the congregation and away from the tiled floor, walls, and windows, keeping reflections under control.

this cornucopia of technological delights is a matrix of decisions, with the potential for as many wrong ones as right ones. That's why when first considering any sound system—new or an upgrade to an existing system—it pays to consult professionals as early in the process as possible.

Building Your Team

There will be no shortage of congregants happy to lend the expertise of their experience hooking up a home stereo, but with a capital investment that can run well into six figures, go with professionals from the start. There are several categories of them that'll you deal with: system designers, systems integrators, consultants, dealers, and acousticians. The fact that any one person or company can offer any or all of these services can be confusing,

but here's what these job descriptions entail and how they create synergy.

Sound system designers – will evaluate the space(s) that a system is intended to serve and, based on calculations such as distances from stage to rear wall and its reverb time (RT: the length of time required for sound to decay 60 decibels from its initial level), can suggest system components—speakers, amplifiers, processors, etc.—and how those go together in a configuration that works for the space. These configurations can be types known as point-source, line arrays or distributed systems.

Systems integrators – are the companies that put these components and systems together, installing them, cabling them, pro-



“Educating and training are key to recruiting volunteers, keeping them for the long term, and producing the most effective services. 5% to 10% of an AV budget should be dedicated to training volunteers.”

Hector La Torre, How-To Sound Workshops

gramming them, processing them, and testing the assembled systems. Many systems integrators are quite competent at designing their own sound systems, but good ones know how to work well with the other categories of professionals.

Dealers – are just that: retail vendors

who sell the products that comprise sound systems. Many of those are also capable of design, as well, but their focus is on sourcing the components that a systems designer has or consultant has specified and doing so with both good pricing and also the project schedule in mind, making sure all elements can be delivered on the timeline the integrator says they’ll be needed.

Consultants – are a combination of designer and technology recommendation specialist.

They’re often also used in an overall project management capacity, able to properly analyze the space, design the right system and bring in and manage a systems integration firm, as well as overseeing bids on equipment, staying with the project through completion and final system tuning.

Acousticians – have a very specific role in the systems process: they are brought in to analyze and recommend solutions for acoustically challenging spaces. For

instance, when a church wants to add contemporary worship styles to the choral music they’ve been using, or a pastor has complaints about the intelligibility of his sermons in reverberant rooms, acousticians can recommend treatment products that will absorb, reflect, or dissipate reflected sound, depending on the characteristics of each space. Many integration companies and consultancies have acquired better acoustical analysis capabilities that can solve a range of acoustical issues. But for the truly complicated scenarios, nothing beats a certified acoustician, whose experience and knowledge can usually more than offset the cost of their services by refining the system design to accommodate acoustical challenges.

These professionals will comprise your systems team and will work with church pastors, committees, and staff technologists to create the best solutions for each church. As you would with a plumber or doctor, when making decisions about these professionals, ask colleagues for references and check their websites for examples of church projects similar to yours that they’ve worked on.

Systems Types

We mentioned that the pro-audio professionals that you retain are the people most qualified to determine the more appropriate type of system for your space. However, it’s



There are entire universes of science and opinion when it comes to the relative merits of sound systems, and opinion often dominates the discussion.

worth having a basic understanding of the various types of systems most commonly used in houses of worship.

The two most common types of systems are point-source and line array. A line array PA system features a number of identical, or nearly identical, loudspeakers arranged in a vertical line: hence the name. The taller the stack is, the narrower the vertical dispersion will be and the higher the sensitivity will be on-axis. In the horizontal plane, an array of similar drivers will have the same polar pattern as a single driver. A vertical line array allows sound waves to essentially constructively interfere with each other so that they can send sound waves farther than single-source loudspeakers, in a predictable directional pattern. These types of systems are excellent for achieving precise coverage of specific areas of a room.

A point source loudspeaker is also prosaically named: a single speaker, or multiple speakers placed far apart, broadcasting a full range of sound from a single point. Unlike the line array system, a single speaker radiates sound in a spherical pattern and therefore has less propagation than a line array.

Distributed sound systems can be used as stand-alone systems or as extensions of either line-array or point-source designs. Instead of large speaker enclosures those designs use, distributed systems utilize large numbers of smaller speakers, often recessed ceiling speakers, that can get

sound into areas that are blocked architecturally, such as under balconies. When this type of system design is used as an adjunct to a line array or point-source system, the distributed speakers will often have their signal delayed electronically, by a matter of milliseconds, to allow the sound from the main system (which is traveling by air) to catch up to the distributed signal (which reaches the speakers, as current over wires, at closer to the speed of light).

There are entire universes of science and opinion when it comes to the relative merits of sound systems, and opinion often dominates the discussion. Assuming the team of professionals you've selected to work on your project at least agrees on the basic type of system approach to use, don't get caught up by philosophical arguments.

Audio Networking

Digital audio networking is probably the fastest-growing pro-audio category in the past decade, and represents a sea change in the way audio is transported. Instead of analog electrical pulses moving continuously along copper wires, networked audio has sound transformed into data and moved, in packets, on a data network.

Broadly, network types can be divided into two categories: proprietary formats, which work only within a manufacturer's own ecosystem or are available for inclusion in various manufacturers' products; these



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include Audinate's Dante, Q-Sys from QSC, WheatNet from console maker Wheatstone, and Livewire from Telos Systems and others. Open-standard formats, which are available for inclusion into any product, include the AES67 interoperability protocol, Audio-Video Bridging (AVB), and Ravenna from ALC NetworX, which has been heavily supported by Lawo's product ecosystem. Of these, the Dante system has garnered the lion's share of the market in North America; Dante's rapid ubiquity has led most major audio systems manufacturers to make their products compatible with Dante, with over 280 licensees reported. While the exact brand of networking system used in a house-of-worship sound system may be utterly transparent when in use, broad interoperability is important in order to ensure that any future upgrades to the system are also compatible with the network.

"Wide compatibility is crucial for future-proofing a sound system," observes Ryan Knox, senior consultant at Dallas-area AV consultancy and design firm Idibri. "If we have to switch out amplifiers or other components down the line, it's critical that they be able to work with whatever networking platform we designed the system with."

The benefits of audio networking are significant, including far fewer cables to run—multiple audio channels can run over a single Cat-5 or Cat-6 cable; improved sound quality, since the network con-

nections are simpler and less exposed to ground faults and loops; fast and simple changes for channel assignments, using only a mouse click instead of physically reconfiguring assignments; lower costs in the form of far less cabling; the elimination of analog components including soldered connectors, isolation transformers, distribution amps, and equipment racks for them; channel counts can be increased, with longer runs between endpoints and no loss of signal; and finally, simplified troubleshooting. In addition, the network switches used in networking are the same ones used in a local-area network (LAN); some of the shopping can be done at Best Buy instead of specialty pro-audio stores.

At Denver-area Flatirons Community Church, the switch to a network-based audio infrastructure has brought about all of the aforementioned benefits, says Bryce Boynton, audio director at the Flatirons. "But furthermore," he adds, "it has allowed us to do some new creative things. For example, with two mouse clicks, I can re-route the cue bus from the monitor console to a wireless pack and let the monitor engineer move freely on the stage to help each musician shape their mix from where they're standing. Two more clicks and that IEM pack is back as a normal band mix. Two clicks and I can set up some additional house mics in the middle of the room and route them to the recording studio through-



So many churches either broadcast a live stream of services or post-produce a version for the web, **so the web-based audience is a critical segment.**

some great preamps for post-production. Two clicks and I can re-route a lead vocal mic through a different preamplifier and DAC that has some unique character to use for a special song. This is only possible because the flexibility of decentralized network audio allows us to route anything from anywhere to any destination. On occasion I want to have a volunteer live mix on a smaller console out in our lobby for overflow seating. No problem. We can run an additional switch via fiber to the lobby, plug in two Dante ports, and everything is there, directly off the preamp. Networked audio has hugely changed the equation of the effort-to-benefit ratio for us.”

Indeed, networked audio’s only major drawback is how fast it’s gaining ground, leaving many AV integrators scrambling to get up to speed.

Recording/Streaming Capabilities

Houses of worship have long been also the sites of content creation, in the form of recorded music. For most of that time, recordings have been made with the technology to do so almost an afterthought. That’s changed considerably in

recent years, thanks in part to the music industry’s increased reliance on live music as its main economic engine. With that has come a new generation of multi-channel interfaces to make multi-track recordings that can be used for everything from CDs for sale to virtual sound checks.

Dedicated hardware recorders, such as the 24-track Alesis HD24 or HD24XR, the Fostex D2424LV MkII, and the JoeCo Black Box recorder are all good choices that interface with the FOH console. Other options include digital interface with laptops. The bottom line is that the cost of integrating a good multi-track recording system into a sound system, with the FOH console as the interface point, is virtually nil considering the returns it can offer.





More than 20,000 people per week attend one of Flatirons Community Church's three campuses located in Denver, Golden or the 4,000-seat main campus in Boulder, Colo.

Flatirons Church uses multi-track recorders for both post-production use and virtual sound check. “The virtual sound check process alone has been a game changer regarding our ability to refine a mix and tighten transitional elements,” says Boynton. “We rehearse Thursday nights and record the session entirely. Then Friday or Saturday morning we will refine the mix in our own timeframe in peace. By the time the band walks in to rehearse Saturday afternoon, our mix already sounds great and scenes are preset on the board. What this means is that the FOH engineer has the freedom to be fully engaged with the band as they rehearse, to really be that ‘fifth member’ of the band. Also, our Dante backbone allows us to multi-track record

all channels directly into ProTools HD for post-production. So many churches either broadcast a live stream of services or post-produce a version for the web, so the web-based audience is a critical segment. Between the simplicity and flexibility of audio networking, and the power of multi-track recorders and DAWs, we can’t underestimate the importance of recording our rehearsals and services to be able to create excellent environments for people to bump into Jesus.”

The Changing Wireless Environment

Wireless microphone systems have been a regular part of the presentation aspect of worship for decades. What you really need to know now is that the wireless landscape

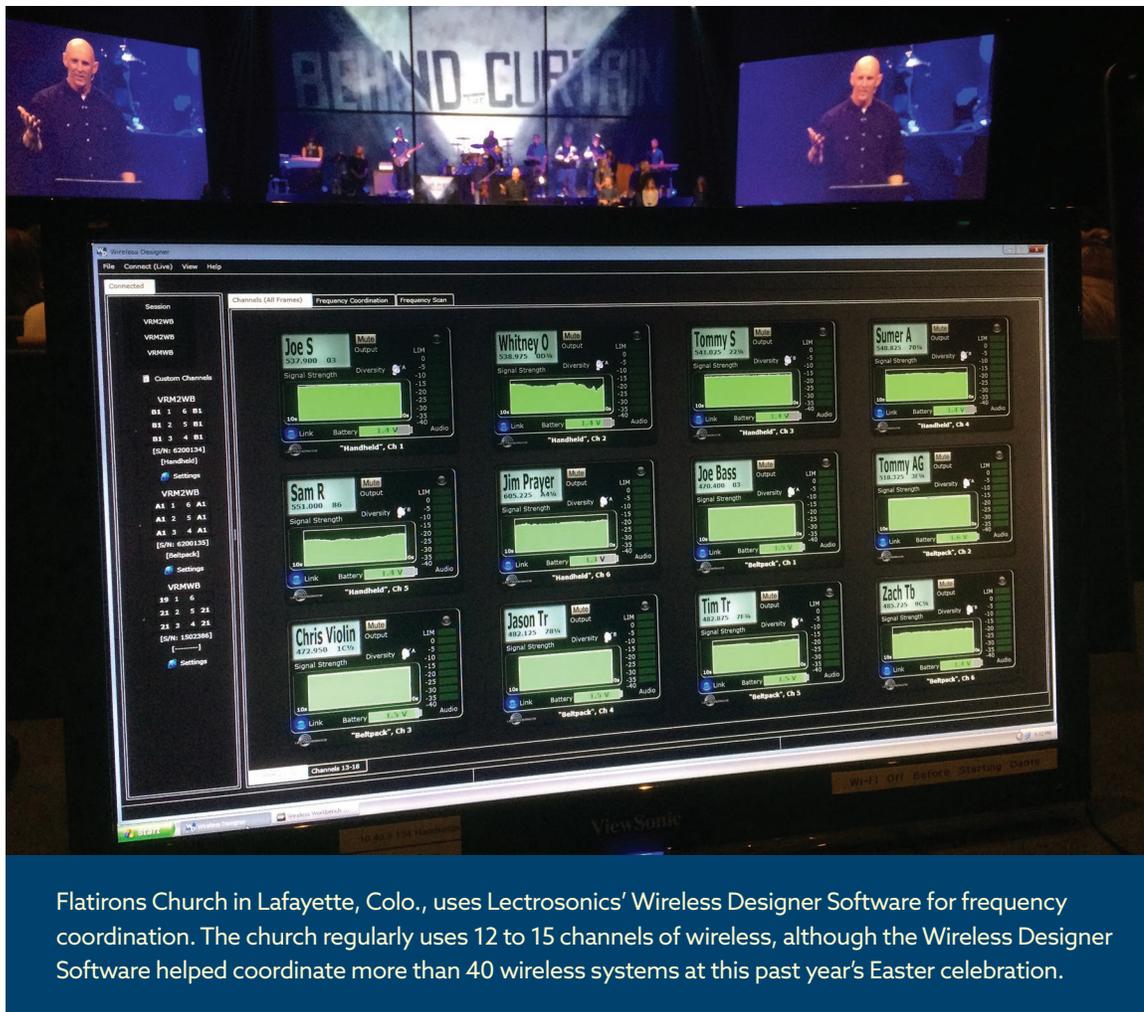


has been undergoing radical changes for the last several years, with more to come, and how those changes impact the house of worship.

First, some background. As the use of mobile devices such as smartphones grew, consumer wireless providers clamored for more spectrum—bands of radio frequency (RF)—to expand into to accommodate millions more users. Some of the best spectrum was that occupied by television broadcasters. Unfortunately, much of that was also utilized by professional wireless-microphone users, including touring concerts, theaters and churches. Part of the attraction of these bands, which were largely in the (broadly) 600- to 800-MHz range, was

the ability of those radio waves to penetrate walls, as well as the fact that its use by television stations meant it was an extremely stable part of the spectrum—attributes that also made them attractive to mobile providers like Verizon Wireless and AT&T.

The first Federal spectrum auction took place in 2008 for the rights to operate the 700 MHz band, resulting in the need for other users to vacate that RF range within a proscribed time frame. That pushed wireless system manufacturers to move into the 600-MHz range, which still offered many of the same benefits as 700 MHz. However, another auction, which commenced in March 2016 put that spectrum on the auction block. The spectrum reallocation



Flatirons Church in Lafayette, Colo., uses Lectrosonics' Wireless Designer Software for frequency coordination. The church regularly uses 12 to 15 channels of wireless, although the Wireless Designer Software helped coordinate more than 40 wireless systems at this past year's Easter celebration.



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Hector La Torre, How-To Sound Workshops

process has left professional wireless users with fewer options. Wireless systems manufacturers like Shure, Sennheiser, Audio-Technica, and others are developing wireless systems that will use a variety of other spectra, including the 2.4-GHz and 5-GHz bands, commonly used for Wi-Fi, and the 1,920 MHz - 1,930 MHz unlicensed PCS band and ultrawide band systems using 3.1 to 10.6 GHz. Users of the 600-MHz band will have a maximum of 39 months from the end of the spectrum auction to migrate to these other frequency ranges.

What this means for houses of worship is yet another round of wireless systems purchases. However, the transition window is over three years long at this point, and manufacturers, who have come to see the church market as a critical one for their bottom lines, will create offers and incentives, such as trade-ins and trade-ups, to encourage sales of new compliant systems. Churches and their AV partners would be well advised to look for and take advantage of these when they come along.

Volunteers

Perhaps the single most unique aspect of any church media-technology system is how it interacts and supports operation by a corps of volunteer operators. Volunteers are the lifeblood of many, if not most,

churches—more than 90% of sound techs are volunteers who work at other jobs during the week,” says Hector La Torre of How-To Sound Workshops—and as the number and complexity of AV systems rises, the ease of use of those systems needs also needs to increase. That’s not always an easy goal to achieve, so operational facility has to be near the top of any list of features on any major system or platform.

For instance, the number of audio channels needed for services and events has been increasing steadily, and audio console manufacturers have had to develop ways to accommodate and manage those channels without overwhelming part-time operators. Some of the ways manufacturers have accomplished this is by layering channels, allowing the user to determine which ones are most important at any given time, putting those on the work surface, such as vocal channels, while less critical ones, such as prerecorded playback channels, can sit on other layers, out of sight until recalled for use.

As the house-of-worship market has become more important over time for AV manufacturers, they have also put more effort into making the operation of their equipment more effortless. Church tech leaders should do the same, as part of any system installation or upgrade. However,



...for the truly complicated scenarios, nothing beats a certified acoustician, whose experience and knowledge can usually more than offset the cost of their services by refining the system design to accommodate acoustical challenges.

La Torre, has a different view. “No matter how you slice it, live sound systems, while making life easier for professionals, are making life more complicated, not less, for non-technical church volunteers,” he asserts. “That’s because now volunteers have to at least minimally understand, if not to master, computer-based digital consoles, digital monitor systems, wireless system controllers, and more. Digital mixer menus and channel layers makes things easier to recall once you’ve set them up properly, but as with any computer, there’s a ton to learn before you can really run a service cleanly.”

La Torre advises that at least 5%-10% of an AV budget be dedicated to training volunteers. “Education and training are key to recruiting volunteers, keeping them for the long term and producing the most effective services,” he says.

Infrastructure – Think Long Term

A final note: Think in terms of the future. Sound systems are expensive and complicated, and you want to extract as much return on investment from them as possible. This isn’t as simple as it used to be: while the physics of acoustics and electricity haven’t changed, much else has and will

continue to, from signal transport—the industry is moving ever closer to audio-over-IP—to the user interface, as those who have mixed sound on iPads will attest.

Ask questions: will we need overflow rooms, cry rooms, where audio will need to be piped in? Will this church embrace the satellite model? If so, will we live stream or will we move media in other ways between locations? In any event, should we consider a policy of purchasing equipment that can scale across locations of various sizes, or should we make purchases based on what we need at the time that we actually need them?

Audio systems are no longer one-and-done propositions. They’re complicated, and the technology will continue to change. But we hope that what you’ve just read will give you something of a blueprint to follow when the time comes.

Dan Daley is a journalist and author who specializes in the confluence of business and technology. He lives in New York and Nashville, Tenn., and is a regular contributor to Church Production and Church Designer magazines.



An additional word about acoustics: It's called the invisible science for a reason

While committees can see and touch speakers and amplifiers, the cost estimate for acoustical services can seem unnecessary to the untrained ear, but their value is real. Acousticians understand the relationship between sound and the surfaces that it comes into contact with at an architectural level. For instance, contemporary worship music styles can really amp up the bass, but those low frequencies can cause substantial vibrations in walls, floors and ceilings that can cascade into larger problems, both sonically and structurally. Generally, larger spaces will have more and more complex acoustical issues, although

smaller spaces with lots of hard surfaces have their own potential issues, such as flutter echoes. In acoustically challenging spaces, a solid acoustical analysis and plan will form the foundation for an effective sound system.

“I can say that proper acoustic design should always be the first step in every house of worship AV design,” reports Garth Hemphill, associate principal for audio/video at acoustical consultancy Jaffe Holden. “As AV systems designers, we can only do our best work in proper acoustic environments. Without that crucial step, everything we do is at best a compromise.”

“I can say that **proper acoustic design should always be the first step** in every house of worship AV design.”

Garth Hemphill, Associate Principal for Audio/Video, Jaffe Holden, Norwalk, CT

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