

# ACOUSTICS AND SOUND SYSTEMS IN THE CONTEMPORARY CHURCH

by Jim Brown

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AUDIO SYSTEMS GROUP, INC.

4875 N Ravenswood Ave

Chicago, IL 60640

773/728-0565

[jim@audiosystemsgroup.com](mailto:jim@audiosystemsgroup.com)

Jim Brown is an acoustic consultant based in Chicago, where he specializes in the design of large sound reinforcement systems for theaters, churches, stadiums, arenas, and broadcast facilities. He has also done extensive production work and mixing for broadcast, recording, and reinforcement. He received his BSEE from the University of Cincinnati in 1964, has worked in professional audio since 1970, and has been a full time consultant since 1984. His client list includes Wrigley Field, United Airlines O'Hare Terminal, Northwestern University's Football Stadium, Liberty University, Grace Cathedral (San Francisco), NBC, ABC, CBS, NPR, WTTW-TV, WGN-TV, and numerous churches and performance facilities. He earned FCC First Class Radiotelephone (broadcast) and Amateur Extra class licenses in 1959, and is occasionally active as W9NEC.

The contemporary church is built around communication - verbal, musical, and emotional - as well as worship. The minister communicates with the congregation by preaching, leading prayers, and announcing church activities. Music attempts to communicate ideas and concepts while it simultaneously enhances the worship experience through emotional involvement. The acoustics of the worship space have a profound effect on all of these functions.

What is acoustics? It is a science, governed by the laws of physics, that helps us understand and predict the way that sound behaves in an environment. A space is said to have good acoustics if it provides the sound environment conducive to the way we want to use it. For a worship space to have good acoustics it must allow good verbal and musical communication. It has poor acoustics if it makes that communication difficult.

The acoustics of a space are determined by its architecture -- its geometric shape, the way in which it is finished -- and by the number of people that occupy it at any given time. Sound waves travel in approximately straight lines, bouncing off hard surfaces or being absorbed or "soaked up" by soft ones. The sound from a person speaking in a large space with hard walls (glass, stone, tile, wood, etc) will bounce around a long time before it dies out, and it doesn't take much vocal effort to be heard (but not understood) everywhere in it. Such a space is said to be reverberant or "live", and the sound bouncing around the room is called reverberation. Similarly, the sound from a person speaking in a room with soft walls (curtains, carpets, seat cushions, people, or acoustic tiles, etc.) will not bounce much at all before it dies out. It will take a lot of vocal effort to be heard over an equivalent distance in this non-reverberant or "dead" space, but the sound which does get through will be easier to understand.

Sound travels at a definite speed (a little faster than 1 foot per millisecond). Sound from a person speaking in a very reverberant space will consist of one sound wave traveling in a straight line and a lot of sound waves that have bounced around the room for a long time. All of these sound waves will take different lengths of time to get to the listener, arriving at different times. This reverberation can be a thing of great beauty, as the listener is able to hear many notes of a musical solo layered on top of each other, enriching the sound beyond measure. Reverberation can also be disastrous, as the listener is subjected to different parts of a word or sentence piled on top of each other at the same instant, making it difficult to understand speech. This is the basic conflict of acoustics which are great for music but bad for speech. A well designed sound system can overcome this kind of conflict.

Not all music benefits from reverberation. As an example, the music Bach wrote for the intimate drawing rooms of his patrons was very different from his weekly compositions for the large cathedrals where he was employed as an organist. Each was composed for the acoustics of the environment in which it would be performed as well as for the soloists who would be performing it and the tastes of those who had commissioned it.

Most contemporary music is written to be performed in less reverberant spaces, and is hurt by reverberation rather than being enhanced by it. This is because tempos in modern music are faster, bass lines are more prominent, and because lyrics and rhythms are usually more important. Reverberation that piles notes on top of each other blurs rhythms and lyrics as it does speech. At the same time, some reverberation is very desirable to enhance singing by the choir and the congregation. It is hard to sing in a dead, non-reverberant church.

Providing a good reverberant environment is much more complicated than simply making a large space with hard surfaces. Some geometric shapes work much better than others, and some can be downright awful, no matter what the intended use. Some kinds of curved surfaces can cause destructive focusing of sound; a wall in the wrong place or at the wrong angle can cause a troublesome echo. A good reverberant environment is one which provides a pleasing mix of direct and reflected sound to enhance the musical experience. This is accomplished by a careful combination of regular and irregular room geometries and surface finishes.

The worship space must be quiet enough so that worshippers are not distracted, and so that noise does not interfere with music or speech. This means that noises which originate outside the church (street traffic, airplanes, etc) and inside the church (ventilation systems, elevators, children in a nursery, groups meeting in adjacent rooms, etc) must be controlled. This kind of acoustic problem is called noise control. The solutions are good structural design, thoughtful building layout to keep major noise sources away from worship spaces, and proper design of the noisy systems.

### **SOUND SYSTEMS AS PROBLEM SOLVERS**

Well designed sound systems can help overcome acoustic problems and enhance the worship experience. To work well, they must work hand in hand with room acoustics. They are used in churches in three basic ways.

Sound systems make sound louder, so that a weak voice or musical instrument can fill the church without great effort. They can reach into distance seating areas such as those in and under balconies where worshippers would otherwise feel isolated or have difficulty hearing.

Sound systems can provide speech intelligibility in spaces that would otherwise be too reverberant. The right kind of sound systems can eliminate the acoustic conflict between music and speech by bringing amplified speech more directly to the listener without allowing it to bounce around the walls of the worship space in an uncontrolled way. The church is still reverberant; its acoustics can support traditional church music that demand reverberation. The sound system provides an additional means of controlling the sound. Music which needs reverberation does not utilize the sound system, taking advantage of the acoustics of the room.

Sound systems can sometimes allow contemporary music to be effective in an environment than would otherwise be too reverberant. They do this in the same way that they control speech -- by controlling the amplified sound, carefully focusing it on listeners rather than allowing it to be turned into reverberation by the acoustics of the space. Sound systems that will be used for contemporary music need to be capable of providing the naturalness, impact and dynamics the form requires.

A well designed sound system can often be invisible, with loudspeakers built into walls, ceilings, or even pews. The best systems will sound very natural; when a system is working at its best, worshippers may not even know that one is being used but will hear the preacher and music ministry more clearly and distinctly. A single integrated system can meet all of a congregation's needs, including music, speech, and a shut-in or broadcast ministry. It can serve adjacent areas such as a kitchen, narthex, nurseries, and overflow seating, and provide for events in a parish hall.

### **GETTING THE ACOUSTICS AND SOUND SYSTEM RIGHT**

The factors that make for good sound in a church need to be built into the design from the beginning. Since the acoustics of a space are so highly dependent on its shape and finishes, improving the acoustics after the building is completed is often a very expensive proposition. Having the proper loudspeaker and microphone systems installed in the right place is fundamental to good sound system performance. If the architect has not provided for the right loudspeaker system in the original building design, the congregation has to make a choice between looking at ugly loudspeakers that work well, not seeing loudspeakers that don't, or spending a lot of money to hide them after the fact.

Not all churches need the same kind of acoustic environment. Good acoustics for one congregation may be unsatisfactory for another. A Gothic structure is a wonderful environment for a congregation whose normal liturgy is rooted in European music and Gregorian chants, IF it has a good sound system to make speech intelligible. The same church would be unusable for contemporary Christian music, and wouldn't work very well

for a jazz mass or a choir in the contemporary gospel tradition.

Acoustic consultants work with churches and their architects to provide an acoustic environment that fits their form of worship. When a church is being built from the ground up, this means helping determine the size and shape of the worship space, as well as the choice and placement of finishes and furnishing within it. It also means looking over the design of mechanical systems and room layouts to insure that the church is quiet and free of interfering noise. If the church building already exists, it may mean major rebuilding and/or refinishing of the worship space.

The sound system consultant develops a complete system design, providing information to the architect and other members of the design team. He must integrate loudspeakers, microphones, electrical conduit for system wiring, location and cooling of system electronics, and develop an appropriate sound control location. He produces system drawings and a full specification that can be used to purchase the system at a competitive price from a good contractor. The consultant works with the contractor to make sure the system is properly installed, and inspects the completed system for compliance with the specification.

### **THE CONSEQUENCES OF POOR ACOUSTIC AND SOUND SYSTEM DESIGN**

**POOR SPEECH INTELLIGIBILITY** Bad acoustics and/or an inadequate sound system can make speech difficult to understand. Everyone can hear the preacher, but most can't understand or, at best, have to strain to understand. The result is wandering attention to the message and poor communication between the praise and worship team and the congregation. Worshippers feel isolated from the mass; their understanding of the message, lessons, and announcements is hampered and their participation is more distant. This can directly impact attendance and contributions to every phase of parish life.

**CHOIR AND CONGREGATIONAL SINGING IS DIFFICULT** Bad acoustics can make choir and congregational singing muffled and forced. The choir just can't seem to be heard, no matter how hard they try, and the congregation doesn't hear the choir or themselves well enough to join in. The organ may sound dull and lifeless.

**THE ACOUSTICS ARE BAD AND EXPENSIVE TO FIX** Bad acoustics can make music sound bad and require a more expensive sound system. When this is the case, music will never sound good until the acoustics are fixed, often at great cost and with a big mess during construction.

**SOUND SYSTEM IS NOT PROPERLY PROVIDED FOR** If there is no adequate sound system design, the electrical conduit for loudspeakers, microphones, power, and control of the system is not provided, or may be provided in the wrong place. One possible solution to some really difficult acoustic problems can be miniature loudspeakers mounted under or on the backs of pews. Adding conduit after the building is completed can often be so expensive or so ugly that desired functions or solutions have to be eliminated.

**NOISE** Air handling systems for heating, cooling, etc. may be so noisy that they intrude on the worship. The units can be silenced, but ducting may need to be removed and re-sized or re-routed, duct silencers added, and motors replaced or remounted. Re-mounting the motors can be accomplished easily, but replacement motors may not fit; necessary duct work can be very expensive or impossible due to lack of space for the proper solutions.

**MONEY IS WASTED ON AN INADEQUATE SOUND SYSTEM** Most parishes do not have people capable of choosing between the proposals of different contractors to supply sound systems. Some churches do have members who are "hi-fi" hobbyists, teach in colleges, work in broadcasting, electronics, or even for sound contractors, and want to help with the sound system. Unfortunately, the acoustics in churches and the system components that are used are so different from what these people are familiar with that their ability to help is limited. The most common result is the installation of a poor sound system that will be replaced after only a few years. A sound system should last for at least twenty years if its design is well

thought out and it is properly installed.

**IN SUMMARY**

- ♦ It is important to get advice from good acoustic and sound system consultants early in the design process and before construction begins.
- ♦ Room acoustics is the most important factor affecting speech and music in a church, and is determined entirely by the architecture and finishes of the room.
- ♦ Fixing the acoustics after the building is built is often quite expensive; getting it right before construction starts is not.
- ♦ Money spent on hiring the right sound system consultant is money that will be saved when purchasing and using the sound system.
- ♦ Fine sound systems can often be made invisible if the consultant and the architect work together.
- ♦ It is always cheaper and better to do it right the first time.
- ♦ If budgets are limited, it is far better to have the design work done correctly and defer the purchase of options such as an organ or a sound system.
- ♦ Acoustic and sound system consultants are good insurance against serious problems later on.
- ♦ Acoustics and sound system design are applied physics, not "black magic". Poor acoustics and sound system performance means either that the design team made mistakes or their recommendations were not properly implemented.
- ♦ Good acoustics rarely happen by accident. Poor acoustics are a far more likely result than good acoustics when there is no consultant on a project.
- ♦ No sound system can remove reverberation from a space. If contemporary music will be part of the worship, reverberation must be carefully controlled.
- ♦ Contemporary music and traditional European music make very different and conflicting demands on room acoustics. It is quite costly (and often impractical) to provide a workable acoustic environment for both forms in the same space.
- ♦ Any architect who knows ANYTHING about acoustics will hire a good acoustic consultant for any church or other large space. And the opposite is also true -- any architect who doesn't hire a good acoustic consultant for these spaces thereby demonstrates his incompetence.
- ♦ Some of the worst acoustic environments I've ever experienced were designed on the advice of an organ builder. Not only were they nearly impossible for the spoken word, they were awful for the choir, congregational singing, and other musical components of worship.