Acoustics in the Worship Space

Scott Riedel

"Form Follows Function." This fundamental principle of architecture and design is familiar to many. When considering the design of a worship space, the application is simple; the function is worship, so the form must be an envelope to sustain that function. But is the principle really that simple, and is the principle really understood by architects, designers, and planning committees? Let us consider the real function of the space. What do we do when we worship? Worship is primarily a function and an experience in sound. Producing and listening to sound in the form of speech and music are among the foremost activities of worship. Services of communion, preaching, song, prayer, confession, or any other occasion that touches the lives of God's people are all conducted on many levels—aural, visual, tactile, and olfactory. To be sure, the chief vehicle of communication in nearly every worship format is sound. Worship spaces, therefore, must be designed as living spaces for this aural experience. A silent place is exactly what a worship space is not.

The question for the designer is not, "Can one hear?", for any preacher, singer, choir, or instrument can be made audible, even if only by sheer volume and intensity of tone. The character, quality, unity, and spirit of tone is the key ingredient in a worship space. We can view briefly some of the many participants and contributors to the worship experience to see the significance of sound quality to each of them.

The Listener

The ultimate goal of any acoustical environment is to deliver the desired quality of tone to the listener. In the worship space the listener has a dual function, for he or she is both sound receiver (listening to choir, instruments, reading, preaching) and sound source (in hymns, prayers, and responses). The listener desires clear, direct, full, intelligible, and encompassing tone, and must have the tone of his or her own voice reinforced and united with other listener-singers for enthusiastic corporate singing and response. All locations within the space must have equally good acoustical conditions, for there is no room for a second-rate seat in God's house. The listener, as with all earlisters in the drama of worship, must have an acoustical environment free of acoustical fault and unwanted noise.

William Sumner comments, "...it is a well known fact that an organ of indifferent quality will sound tolerable or even well in a resonant (reverberant) building, and that even a fine instrument will sound unimpressive and dull in unsuitable surroundings."

This principle can be applied to any sound source in the worship space, whether it be speaker, preacher, singer, choir, organ, instrument, or congregation.

A friend of mine has confessed the "secret" of his own musical success, based upon listener perception in a superior acoustical environment.

"...repeatedly I hear ... has the finest music in our town," no lesser choir. I am a very mediocre musical director with a very average choir, but of one thing I am certain: it is the acoustics in our church! In that building everything surpasses.

The Composer

Composers of sacred music in our day, as throughout history, have a certain expectation for the acoustical character of the worship space and compose accordingly. Often a composer will dictate his or her efforts toward a particular building or musical group and compose for specific conditions. Even when a particular space is not the object of the composition, the writer still expects and uses an appropriate acoustical condition, in the worship room as a tool of composition, much in the same way that expectations about organ voicing, registration, and temperament are tools of composition. Surely each composer knows that all spaces are not alike, and that his or her music will not always be heard in the most satisfactory setting. However, a certain standard of acceptability of excellence and intelligence must be met to deliver the composer's work effectively. A setting which projects clear and even tone to all locations, reinforces sound, and does not obscure subtle nuances is desired by composers. An appropriate reverberation time is also essential. Many composers feel that the importance of the acoustical setting to the composition and performance of music is simple; the function is worship, so the form must be an envelope to sustain that function. But is the principle really that simple, and is the principle really understood by architects, designers, and planning committees? Let us consider the real function of the space. What do we do when we worship? Worship is primarily a function and an experience in sound. Producing and listening to sound in the form of speech and music are among the foremost activities of worship. Services of communion, preaching, song, prayer, confession, or any other occasion that touches the lives of God's people are all conducted on many levels—aural, visual, tactile, and olfactory. To be sure, the chief vehicle of communication in nearly every worship format is sound. Worship spaces, therefore, must be designed as living spaces for this aural experience. A silent place is exactly what a worship space is not. Certainly, periods of silence may punctuate and lend mood and drama to worship.

Manv performers of note have written on this subject. "Reverberation is of great help to a violinist. As he goes from one note to another the previous note persists, and he has the feeling that each note is surrounded by a strength. If each sound blends into the previous sound, it gives the violinist sound to work with. The resulting effect is very flattering. It is like walking with jet-assisted take-off." Isaac Stern

"An organist will take all the reverberation he is given. He takes quite a bit more, for ample reverberation is part of the organ music itself." E. Power Biggs

"...you have to have a good instrument and good acoustics." Vladimir Horowitz

The Performer

There is probably no successful performer or conductor working in any aspect of serious music that does not realize the impact of the acoustical setting on the performance of a piece. The success or failure of a career in music may in part be attributed to the tonal character of a room. Opera singers will regularly vie for the best position on a stage, giving advantage to their voice. The tempo, dynamic and style of a performance are often a function of the effect of the room. Ensemble, precision, unity, and tuning stability will all be aided by an acoustical setting that provides strong early reflections, even distribution of tone, and an appropriate reverberation period. Amateur groups especially will benefit from the enhancement of tone lent by the acoustical setting. Musical inadequacies may be covered by extended reverberation times.

The appropriate period of reverberation is essential to the success of any acoustical space and musical performance. Many performers of note have written on this subject.

"Reverberation is a characteristic that the musician hears, that helps him find the right tempo. Any note, chord, or phrase has a reverberation period that is basic to its identity. If this period is too short, the note or chord or phrase will lack depth and fullness. . . ." Isaac Stern

"When we talk of reverberation, we should think of it as the repetition of sound for a long time. When a note is sounded it is repeated, or reflected, again and again. . . ." E. Power Biggs

"The question for the designer is not, "Can one hear?"" for anyone can prejudice the performance, for music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment. Even well written music is tailored to an acoustical environment.

Of the series of canticle-settings offered to people and places this is the most extended in scale. (Magnificat and Nunc Dimittis for St. Paul's Cathedral by Herbert Howells. With their compositions for St. Paul's in mind, the nature of this setting would be acutely influenced. Prolonged "echo", notable in St. Paul's, would dictate a less rapidly-changing harmonic rhythm than would be feasible in many less-reverberant buildings. So it is that in the setting harmonic and tonality changes are deployed in more leisureed, more spacious climaxes. Amateurs are built with these conditions there goes a heightened volume of sound, and a tonal opulence commensurate with a vast church.

Due to the present common interest in historical practices, be it organ building, musical performance, or other aspects of the musical art, a church or institution might consider investing in the recreation of not only instruments and practices, but also acoustical settings. This concept may be especially useful to congregations or institutions of strong ethnic heritage for the purpose of recreating a composer's or era's style.
One more example can demonstrate the great influence of acoustics on musical performance. The associate conductor of the Los Angeles Philharmonic Orchestra, Paul Polivnick, has repeatedly commented how often further practice on a work becomes useless in a rehearsal hall, because the entire character of sound will change when musicians are placed in the acoustical environment of the concert hall.

The Speaker

A frequent challenge to the designer is the combination of speech and music in one acoustical environment. Because speech and music are equally important vehicles of expression in worship the requirements of one must not be sacrificed for the other. Many acoustical goals are the same for speech and music; even distribution to all listeners, full tone, and absence of noise and faults. The length of reverberation time is an important issue that divides the two, for longer periods of reverberation necessary to give grace and beauty to sacred sound may also diminish speech clarity and intelligibility. The spoken word, however, will gain power and authority in a reverberant setting, so the two are not as opposed as one may suppose. With careful design and modern technology it is possible to provide settings that are not merely acceptable, but are superior for both mediums of expression.

The existence of numerous worship spaces with exceedingly inferior acoustical characteristics shows a great misunderstanding of scientific principles and an insensitivity to the real activity of worship. Music suffers acutely in the name of speech clarity, when in reality neither music nor speech is given the desirable setting in many spaces. Often, absorbing materials are introduced which removes any and all desired sound energy, and then in compensation organs are only passably voiced, choirs seldom sing in tune or ensemble, and large sums are spent on electronic equipment to increase the volume of the spoken word. In the end much money is spent, and the congregation gets no real benefit. All too often silence is the goal in a misguided conception of the nature of worship. The sounds of life are removed by “acoustical treatments” which simultaneously destroy the vitality and vehicle of aural expression. Surely, this is contrary to every noble ideal of unity and corporate activity in the praise of God. The “quiet” freedom from intruding noise should not be mistaken for silence from within the worship space itself. It should be noted that unexpected “noise” originating from those occupying the worship room is by definition “noise” and “irritation level” is generally not raised or lowered by the acoustical environment.

What then is the nature of a design and building fabric that is an appropriate envelope for the true function and activity of worship—a setting for speech and music? Four physical elements of design must be combined and manipulated to create an appropriate space. These elements are the shape, volume, and materials of the space, along with the placement of people, equipment, instruments and furnishings within the space. The goal of the combination of these elements is a room where sound of all desired frequencies is evenly distributed to all appropriate locations, where sound energy is reinforced, not removed from the space. Reverberant sound must linger the desired length of time, and then decay at an even rate across useful frequencies. Faults such as hot spots, echoes, dead spots, and intruding noise must be suppressed.

Room Shape

Basic room shape is the foundation of an acoustical setting. The overall shape of the room must be designed to achieve acoustical principles and goals, for, even when all other conditions are at the optimum an inappropriate shape can cause nearly irreparable faults. Concave surfaces which can focus sound onto hot spots, walls, and objects which create obstructions and acoustical shadows, listening areas or secondary spaces removed from the source by corners, alcoves and arches are all elements of inherent shape that can be detrimental to a successful design. New designs must be conceived with overall shape and proportion sympathetic to acoustical needs. It is often expensive or impossible to repair acoustical faults in existing structures when basic shape and proportion are the cause of a problem. Most often, these principles will promote a successful result:

1. The room should be higher than it is wide, with maximum sound sources such as organ or choir placed at the end of the long axis.

2. Concave shapes which concentrate reflected sound should be avoided. Overall concave shapes may be acceptable if treated with convex or multifaceted surface configurations which can diffuse sound widely across the listening space.

3. Long, flat parallel surfaces should be splayed or interrupted with projections and fenestration to avoid flutter echoes or standing waves (a condition of closely repeating echoes, or series of concentrated hot and dead spots due to multiple reflections).

4. All listeners and sound sources should be within the same basic room or space. Alcoves, archways, corners, and objects which set apart any participants will obscure, confuse, and diminish the effectiveness of incident sound energy.

5. Echo may be avoided if sound energy reflected off of surfaces is directed to useful close locations, and not allowed to travel great distances. Absorbing materials should not generally be used to eliminate potential echo.

Room Volume

One key element in designing for a desirable reverberation period is the cubic volume of the space. A cubic volume near 500 cubic feet per listener seat is essential to reverberation periods appropriate to the worship space. A general rule is that a doubled ceiling height will double reverberation time. In rare modern instances too great a volume will cause a reverberation time so long that sound is muffled and lacks intelligibility. A minimum reverberation period appropriate to church music is two (2) seconds at mid-range frequencies.

Surface Materials

Surface materials and texture in the worship space must be such that incident sound is reflected, diffused, directed to desired locations, and allowed to reverberate. Any absorbent materials which absorb sound and remove sound energy from the space are counter productive to the work of musicians, speakers, and worship participants. Absorbing materials which remove sound energy as a remedy for acoustical faults must be used as a last resort. Incident sound energy from worship participants is worthwhile, necessary, and should not be removed by absorption. Carpeting, drapery, acoustical ceiling and wall tiles, and other porous materials are all absorbants and must be avoided. The texture of cloth and material as art appropriate to worship in forms such as banners, vestments and flags can comfortably be included when all other conditions are suitable, so that acoustical quality will not suffer. Absorbing materials should not be part of the initial design of the building fabric. Materials such as plaster, stone, marble, sealed woods, quarry tile and other natural (hard, dense, and reflective) materials can provide warmth of color and remain an aid to sound. Isolating materials and assemblies within enclosing walls can be used to impede the intrusion of noise from adjoining spaces. It is essential that every interior material and construction assembly be carefully chosen and detailed, for the type of wood or brick, the interior assembly of a wall, even the manner of application of surface finishes, will all influence sound behavior across the entire range of frequencies. In existing rooms it is often possible to resurface or otherwise alter materials to provide acoustical conditions.
Physical Placement

A successful worship-acoustical setting involves careful placement in all aspects and elements of design. From the overall concept of siting, to the precise location of each organ pipe, proximity and placement are important to acoustical goals. The site of a worship building must be chosen so that neighboring noises will not intrude and interrupt the worship proceedings. Noise producing areas of the building such as gymnasiums, or even heating, air conditioning, and mechanical equipment must be located and detailed to prevent noise transmission to the worship area. Within the worship space all musical forces (choir, organ, organ console) must be located together so that musical unity, precision, and ensemble may be promoted. The best plan is one where choir singers are seated directly in front of the organ case, and the organ console is located in front of the choir singers. This allows sound to blend into unity, and gives all musicians direct and clear aural and visual connection. All seats in the worship space must have "line of sight" unobstructed access to the sound sources (clergy, speakers, and musical forces). If any location is around a corner, behind a column, or beneath a secondary ceiling, arch, or transept, even clear sound will not be delivered to that location. Similarly, all worshipers should be in the same room, with no corners, columns or secondary spaces which separate in order to promote unity and community in worship, singing, and response.

A space which will give life and vitality to every medium of worship is the noble goal in creating places of prayer and praise. We can be lifted to unknown heights when the arts, music, architecture, science and people join in common purpose.

NOTES

Acoustics in the Worship Space II

Acoustics in the Worship Space I appeared in the May, 1983, issue of The DIAPASON.

A recent perusal of a popular church management magazine revealed 22 prominent listings, articles, and advertisements, each purporting to deliver or contribute to the aural and acoustical success of the worship space. These listings included pipe organs and electronic instruments, handbells, campaniform and electronic bearing aid devices, and cassette tape machines. While each writer or manufacturer can claim his or her product or concept to have influence upon the acoustical environment, not all can claim significant effect upon acoustical goals and success. Therefore, concepts and materials essential for a successful acoustical, musical, and worship environment must be identified.

This point is especially pertinent in light of the fact that so many unnoticed elements often have the greatest acoustical effect. Here, from the same publication, is a list drawn from 53 other articles or advertisements which have significant acoustical effect, yet are often forgotten in that regard: pew, pew pad, and kneeler manufacturers; stained glass window craftsmen; and lamp, furniture, vestment, and carpet suppliers.

A successful worship and musical environment as related to acoustics must be defined. Of primary consideration in a space functioning for worship, with music provided mostly by the organ and singers, is a desirable reverberation period. This period in most worship environments should be a minimum of two seconds at mid-range frequencies. The reverberation period is the number of seconds required for sound to drop a level of 60 decibels after the source ceases production of tone.) Coupled with the reverberation period are necessary acoustical qualities of a space which will provide clear, intelligible speech and music to all listening locations, and which will promote musical reinforcement, unity and ensemble for all musical participants including organ, cantor, instruments, choir, and the singing congregation. Acoustical faults such as echo, hot spots, dead spots, and standing waves must be avoided.

Which factors, then, are some of the genuine contributors to the acoustical, musical and ultimate theological success of a space?

1. Early planning and consideration of acoustical goals are essential in the design of any worship space. If the basic geometry of the space, and the materials of structural and finish construction are not sympathetic to acoustical goals, repair or correction later in the design and building process will be expensive or even impossible. Geometric shapes and volumes such as concave surfaces which focus tone onto “hot spots” must be eliminated from the design. The selection of basic materials and construction assemblies can either promote or prevent acoustical success. Even the selection of floor brick, or the number of coats and type of wood sealer has extraordinary effect upon musical production.

Spatial needs for organ and choir must be considered. The relationships among musicians, instruments, and listeners must be carefully planned early in the process.

In every situation where a contemplated worship building will house a congregation using music as part of its service, liturgy, or rite, qualified consultation must be sought by the congregation. A sensitive architect, an organ builder with awareness, knowledgeable clergy and musicians, and independent acoustical advice must be identified and then incorporated into the earliest planning stages for the ultimate success of worship by the people.

2. Planning for the future—not wishful thinking, but keen preparation—must be a feature of the design of a worship room. Adequate space for the future pipe organ that cannot be afforded now, allowance for additional musical groups (more choirs, bell ringers, orchestra players) must all be considered in the present design. Of course, any and all future circumstances cannot be foreseen, but spatial limitations prohibiting those aforementioned eventualities are all too common to many congregations. In buildings which are constructed without foresight, the end result is greater expense to the congregation, along with inferior musical instruments. Note also this statement by a representative of a highly respected American organ manufacturer:

I have watched in my lifetime the advent of the suburban parish, and have seen repeatedly these parishes start out on a small scale, and, though I begged for proper space for a pipe organ, they reasoned that they could never afford one, so no space was left. Lo and behold, ten years down the road the church has multiplied and is all paid for. They decide they want a pipe organ. We have two right here that are at that stage, and there is simply no way to get an organ in without major alterations.

3. A sensitivity to real worship needs of the congregation on the part of the designer is essential. Sentimental notions of quiet house of private devotion, or the mystical delivery of liturgical “music” are not appropriate to the needs of most worshiping congregations. Given that the worship space is for many where heaven meets earth, and where all join together in praise and mutual support, only architecture of unity can meet the criteria. Togetherness and unity can be highly promoted through the acoustical attitude of the worship room. In most worship formats people combine their efforts to the greatest degree through the aural sense. Aside from standing and sitting, speech, response and song are often the only common overt actions worshippers enjoy together. The acoustical setting must never suppress the vigorous energy of co-participants in praise. The sound of all worshippers must be reinforced and must reverberate throughout the space. With the congregation as the primary criterion, the favorable circumstance of all sound properly set can result. For the spoken word will gain authority; organ, instruments; and choir will benefit if the room is designed to promote the acoustical unity and vitality of all worshippers. Here is where the pipe organ is the essential link to many congregations. The unique tone of the real organ, only in low acoustical settings, can draw and lead the people to unified and vigorous response in musical form.

4. Short term fads and fashion must be avoided. The negative effects of
dated materials and styles, both in architecture and organ design are obvious in many situations. Often the fads of a brief time, and not the integrity of meritorious principles are followed. New ideas based on scientific data and artistic talent are always appropriate. Short term experimentation with institutions of eternity is inappropriate. The modern counterparts to buried pipe chambers, leathered diapasons, and "Gustavino" tile will likewise not aid worship in the present or future.

Time honored classical principles of acoustical design are essential tools in providing a successful worship space. These classic ideas are proper room shape, generous cubic volume, appropriate surface materials, and correct placement of instruments, musicians, listeners, and worshipers. Note that these concepts are discussed in "Acoustics in the Worship Space I," THE DIAPASON, May, 1983.

The Organ and Acoustics

There is no doubt that the quality of an organ is greatly influenced by the acoustical setting. The finest manufacturers will spend many hours, days, and weeks voicing an instrument in the environment of its use. Builders may even demand acoustical improvement before installing an instrument in a space. The influence of acoustics on every detail of organbuilding has led to many common building practices and theories of design and construction. A brief overview of some discussions held at the recent American Institute of Organbuilder's convention can bring some of this influence to light.

The topic was especially prominent in the opening panel meeting. Here builders, designers, and musicians alike spoke of organ design after Dr. Noehren's fine presentation on Bach and the instrument. Robert Noehren and Paul Manz both agreed on the underlying determinants of organ design: needs of literature, liturgy, and the qualities of the room of their hearing. James Moe also stated his inclination to accept a somewhat inferior instrument giving preference to superior acoustics in selecting a concert location.

A subsequent, and revealing statement regarding acoustics was made by Herr Furtwangler of the Giesecke Pipe Company in his lecture on reed pipe making. He discussed the scaling and design of reed pipes, stating the prerequisite data for the task: the 8' Principal scale of the organ, and the reverberation period, frequency response, and interior finish material specifications of the room. Certainly, the design of pipes of such vibrant and varied tonal palette as reeds must take into account how the room will react to every aspect and color of the tone.

Even in his discourse on mechanical chest design, Gerhard Brunzema spoke of the spatial relationship of chest, case, and pipes, maintaining that as much as 10 decibels difference in intensity can be achieved from a single pipe when elements are skillfully placed. He also noted the effect of the acoustical environment on the tremulant, stating his preference for a 15 percent pressure change in a live acoustic, and a 10 percent change in a more absorbent space.

Surely no one can deny the overwhelming influence of the acoustical setting upon musical production. The musical vitality of every organ, singer, or player is directly attributable to the character of the room of their hearing. Given that inspiration and vitality in worship are largely a result of the energy and response of the participants, then a fine acoustical setting is required for every musical and liturgical space. ■

THE DIAPASON

Scott R. Riedel
Acoustics in the Worship Space III  

Scott R. Riedel

Acoustics in the Worship Space I & II appeared in the May 1983 and 1984 issues, respectively, of THE DIAPASON.

The setting is a sleeping compartment on an Amtrak train—the occasion is the return trip after a meeting with a church committee, and I am contemplating the re-design of their worship space: a space that presently meets few, if any, of the needs of its users. I am struck by the design of the Amtrak "Slumbercoach" room—a quick observation reveals a focused and functional design. The railroad car designer surely understood and met the program. The room has some aesthetic features, the window for viewing the passing countryside, the colorful fabric on walls and chair, and the carpeted floor. Every other feature of the space is given to a precise functional purpose. There is a pull-down bed, luggage rack, climate control equipment, plumbing equipment, and an array of associated hardware. The shape and geometry of the space meet the anthropometric needs of the body, and every item has easy access for maintenance and cleaning. The purpose of the space is to house one passenger overnight on the train. The designer hat met the need.

I often encounter worship spaces where the admittedly multi-faceted focus of the design does not meet the needs of the users of the room. The example of the railroad car designer and programmer could be used to help the church in the creation of worship spaces. The designer meets every functional requirement of the passenger, and provides aesthetic amenities that complement the functional needs. The task is more difficult in the church, but it can be done. Real functional needs can be met in a space with aesthetic elegance and spiritual mystery.

In an organization such as the church many "needs" and "preferences" are expressed. The church must focus the "needs" upon the real function, worship. The church must also come to realize the true nature of worship, and the real needs of worshipers in developing a design program. The designer must then prioritize the "needs" and "preferences" in a design solution.

Few pews for comfort and visual effect, luxurious carpeting, heavy draperies—these are all secondary and of questionable necessity to the church, yet receive primary attention in far too many situations. The "average" design solutions of secular architecture such as acoustical ceiling tile should not be adopted by the church, but in fact often are adopted with no thought at all. Unique geometric forms for the sake of "design" alone are secondary to the functional needs of worshipers, yet often receive the primary attention of the designer. Every programmatic and design decision must be thoroughly studied for its full implication to the real needs of the church.

The worship experience is largely, almost exclusively, communicated in sound. The word is proclaimed and preached, the congregation prays, speaks, and sings aloud, and listens to the music of instruments and voices. Every act, every environment, almost every event of worship has a "sonic" dimension. This is one of the issues that programmers and designers must focus upon. The "decorative" aspects of design must only complement the real needs and functions of a space.

Some examples will show how this principle, particularly applied to acoustics, can mean the success of a worship space.

Example I. The setting is a protestant church building, Communion table, pulpit, choir and organ are all in the central front of the space. Seating for the congregation is on the main floor in an open space, or beneath the rear and side galleries. The congregation can also sit in the galleries. Finish materials include brick walls and ceilings, and extremely thick carpeting and pew padding throughout. The ceiling is a series of five domes or arch shapes.

The problems include "hot spots," or points of concentrated high sound levels on the main floor, and "dead spots," or points of almost no sound energy, on the main floor, all caused by the reflection pattern of sound off the domed and arched ceiling surfaces. The extensive amount of carpeting absorbs much sound energy, leaving the sound of choir, organ, and congregational singing dull and lifeless. The real problem, however, is that members of the congregation do not reinforce their neighbors in song and response due to excess sound absorption. They also find themselves sitting in places where they either hear single voices of the choir or organ, or else where they can barely hear the choir or preacher at all! Further, the choir is unwarmed as they are unable to sing in ensemble or in tune in the "negative" acoustical environment, and the congregation never hears the full potential of their own choir.

The plight of worshipers in this build-
Acoustics in the Worship Space IV

Scott R. Riedel


"This country doesn't need any more organbuilders, it needs more good rooms." This statement made by one of the midwest's most skilled organ voices speaks a great truth about what will provide real benefit to the worship life of the church. He realizes that fine acoustics are not only "for the organ", or, "so the organist can play louder". Fine acoustics in the worship space primarily benefit the congregation. The worshiping church can experience enthusiasm and "community" in a room that allows the people to sing, speak, and act together, not sit in silent solitude.

Achieving a desirable ratio of reflected to absorbed sound energy is a key factor in achieving a desirable acoustical setting for worship. Significant amounts of sound energy must not be absorbed and removed from the space. When there is excessive absorption the speech and singing of worshipers is not allowed distribution throughout the space. Corporate worship becomes a solo event. Excessive absorption of sound energy also inhibits clear and authoritative speech, and prevents blended, rhythmic, and musical production from choir, organ, and instruments.

Of all surfaces in the worship area, the floor offers the greatest opportunity for desirable acoustical reflections. For it is often the surface closest to the main body of listeners and singers: the congregation. The floor also offers the greatest potential danger to the space, for it can easily become the largest absorbent area when carpeted.

A carpeted (and highly absorbant) floor should therefore almost always be avoided, for carpeting's ability to remove desirable sound energy is contrary to the real needs of the worshipers.

Why then are so many worship spaces carpeted, and why do so many advocate the use of carpeting, despite its obvious negative effects? What can be done to improve the situation? Many seem to ascribe qualities of elegance, importance, and warmth to carpeting. These qualities certainly apply to some residential and social environments. However, when one considers the "elegant", "important", and "worthwhile" worship rooms across the world, no carpeting is found. The list might include such places as Westminster Abbey, King's College Chapel, St. Patrick's Cathedral, St. Peter's Lutheran-Citicorp, and many more. The opportunity for design and
elegance available in wood, parquet, ceramic tile, brick, marble, slate, and stone can certainly equal or surpass the elegance and variety available in carpeting. In fact, the selection of carpeting can often be the unimaginative and "easy" solution of least artistic interest.

Uncarpeted environments which may be considered "cold", "unfriendly", and "too live" acoustically can easily become very appealing with the use of warm colors throughout, and the judicious application of specially designed sound absorbers, only if necessary. Worship rooms that are "too live" from lack of absorbing materials are rather rare, especially when one considers that the bodies occupying a space absorb nearly 55% of the sound incident upon them. However, the designer must beware that so much sound is not reflected and re-reflected that music and speech become garbled and confused. The introduction of carpeting for "judicious sound absorption" is usually inappropriate in the worship space, because most often too much sound is absorbed by it.

Factors of maintenance and safety frequently become issues in floor selection. There is some disagreement as to the ease and cost of carpeting vs. hard floor cleaning and maintenance. Spills and stains generally have a greater negative effect upon carpeting.

The wide variety of skid resistant ceramics and other hard floor materials available almost completely eliminate the potential of slipping. In consideration of economic issues, a durable, hard surfaced floor will outlive even the finest carpets.

Frequently a fear of footfall noises results in the selection of a carpeted floor. When a hard floor surface is used, foot fall noise can be suppressed with the installation of absorbent materials both beneath the floor, and within cavities created by raised platforms and risers.

Even after questions of maintenance, longevity, safety, and footfall noise are addressed, some may still fear that the lack of carpeting will promote "noise", created by occupants of the worship room. It can be noted that large spaces with a fitting "live acoustic" will evoke a sense of awe, mystery, and "silent" behavior from its occupants. At the same time, occupants will have the freedom to sing and speak together at the desired moments. Further, it is contrary to the real needs of the entire community of worshipers to "deaden" a worship space, ruin musical ensemble and production, and abandon the sense of a great space, all for the sake of accommodating infrequent "noisy" behavior.

Worship is an experience in sound; preaching, reading, music, and the singing congregation. The worship space must be designed and appointed to serve this noble activity.

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Acoustics in the Worship Space V

"Echo"  
Scott R. Riedel


Of all acoustical matters, "Echo" seems to be the term most familiar, least understood, and most feared by laymen, musicians, and architects alike. The phenomenon of echo has been known and studied for many years. Even during the age of Greek mythology the story was told of the angry and jealous goddess Hera who limited mountain nymph Echo's speech to repeating only what others said.

In acoustical science, echo is a distinct, separate, "repeated" sound, heard when a reflected sound arrives at the listener long after the initial direct sound has arrived. In order to be perceived as an echo, the reflected sound path must be at least 55' longer than the direct sound path from source to listener, and the reflected sound must arrive at the listener at least .04 seconds after the direct sound.

Echo is distinctly different from reverberation. While both are the result of sound reflections, "reverberation" is a set of rather early reflections which reinforce and seem to lengthen the duration of tone, while "echo" is a late arriving reflection; a reflection that is so late it is perceived as a second repeated tone.

Just as the mythological mountain nymph was cursed by the jealous goddess, so is "echo" blamed for many acoustical faults. To be sure, a genuine echo can be considered a severe acoustical fault in a worship space, for it disturbs clarity of speech, and interrupts musical blend and rhythmic accuracy. However, throughout my meetings with various congregations and designers, I have heard such problems as "hot spots," "dead spots," lack of clarity, absence of, or excessive reverberation, the improper selection or placement of speakers, and even poor diction or articulation falsely referred to as "echo.

At the same time, I have encountered few worship rooms with genuine and severe echoes. In one instance the congregation was largely unaware of the echo until I pointed it out.

The many acoustical requirements and potential faults require special attention in the design of a worship space. Important matters such as reverberation period, proper finish materials and the location of sound sources and listeners are all too often forgotten or deferred to the end of the design stage, while much unwarranted attention is devoted to preventing "echo"—which seldom occurs as a genuine problem, and is relatively easy to repair. Unfortunately the unnecessary "treatment" of imaginary, feared echo often ruins other important acoustical features of the space.

The prevention or elimination of echo can be accomplished by either absorbing sound energy rather than allowing it to reflect, or by redirecting the reflection to a location where it will not be manifest as an echo. Most often the use of absorptive materials such as carpeting or absorbant wall and ceiling tiles is inappropriate in the worship space where useful sound energy must be maintained for all listeners. The redirection of sound energy by proper orientation of hard and reflective surfaces is the preferable method of repairing echo. This maintains useful sound energy in the space and allows it to be reflected to locations where it is needed.

The proper design of the worship space involves careful consideration of all acoustical matters. We must, however, beware of overcompensating for imaginary echoes with absorbants, to the detriment of other necessary acoustical reflections.

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Acoustics in the Worship Space VI
Padded Pews

Scott R. Riedel


The matter of installing pew and chair pads in a church, and the influence of the pads upon the acoustical environment is an issue which frequently arises during church design and decorating. It is not possible to state the absolute acoustical effect of pads, because conditions vary in each situation. Some general observations and scientific principles can be noted, however.

The potential problem with the presence of padded seats is that they absorb sound energy, and reduce it from the listening space. This is most often contrary to the acoustical requirements of the worship space, where the sounds of preaching, reading, singing and sacred music should be distributed and reverberated, not removed from the room. Therefore, just as carpeting, draperies, sound absorbing panels and acoustical ceiling tiles are often inappropriate materials for the worship environment, so can padded pews and chairs be undesirable.

Two contrary points of view generally present themselves, and neither is entirely true, nor absolutely false. Some may hold that 1) "Padded seats in a church always absorb too much sound energy, and should not be allowed," or 2) "The people sit on the pads, covering them, thus eliminating their ability to absorb sound energy." The unoccupied padded seat will indeed absorb a significant amount of sound energy - specifically an average 60% of arriving sound energy is absorbed, per square foot. (Note that an upholstered seat absorbs less than 1/2 of that amount of energy.) Depending upon many other conditions, these rates of absorption may or may not be significant to the overall acoustical condition of the room. Typical dependent conditions are the cubic volume of the space, the number of seats, the relative amounts of other sound absorbing or reflecting materials and the number of occupants. Therefore, it is not quite possible to make a definitive statement that padded seats should always or never be allowed.

The occupied padded seat is indeed covered by the person, mitigating the acoustical absorption of the pad. All absorption, however, is not prevented, for rarely do people truly sit "side by side." Note also that when the people stand to sing a hymn or speak responses the pad is uncovered and fully absorbent. This is at the very moments of the service when sound quality within the congregation is critical.

Pads do simulate the absorbing qualities of the body, so that during rehearsal periods the unoccupied room with padded seats does respond similarly to the occupied room with occupants seated. It must be clearly noted again that once the occupants stand the pads are free to absorb significant amounts of sound energy. Local practice sitting or standing during hymns and occupancy rates will determine some of the overall effect of the pads.

It may be helpful to list the positive and negative features of padded seats in the worship environment, along with specific suggestions.

1. The pads tend to equalize the acoustical environment from occupied to unoccupied conditions.
2. Padded pews represent a relatively small sound absorbing area as compared to typical areas of carpeting or acoustical ceiling tile.
3. Pads add an element of comfort and texture to the room.
4. Padded seats are often the sound absorbing materials that are nearest the congregation as they sing and speak, unavoidably absorbing sound energy at the source.
5. When the congregation stands pads are exposed, and able to absorb sound energy.
6. When occupancy in the room is low, uncovered pads often absorb far more sound energy than is desirable.
7. Padded seats are more likely to be acoustically acceptable in a relatively large space that has little or no other absorbent materials (such as carpeting, acoustical tile, or drapes).
8. The pew backs, and rear side of pew backs should not be upholstered, for these surfaces become far too absorbent, even when worshippers are seated.
9. During times of less than full occupancy, pads could be removed from rear seating spaces, both avoiding sound absorption, and encouraging occupants to sit more forward and together.
10. Leather, vinyl, and closed cell interior foam pads are preferred over heavier fabrics in order to reduce the rate of sound absorption.

As a general rule, and given the typical size and cubic volume of worship spaces in the U.S.A., along with typical rates of occupancy, decorating trends, and practice in many congregations, it is best to avoid the use of padded seats. This will not only assist organ and choral music production, but will especially help the corporate spoken and sung response of the congregation.

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Acoustics in the Worship Space, VII

Scott R. Riedel


Can't microphones fix any acoustical problem?

Contemporary society employs "state of the art" electronic technology in many and various facets of everyday life. The use of electronic technology and equipment can solve many problems and perform many functions. Electrical and solid state electronic equipment can help to prepare a meal in the form of a microwave oven, control the heating, air conditioning and light in a room, send a "FAX" message across the country in minutes, create synthetic music, and even write a magazine article such as this one with the aid of a computer.

The instruments themselves. High loudness levels from sound systems, however, are often not necessary when applied to music in the worship environment.

Electronic sound reinforcement is most often unnecessary, inappropriate, and even damaging to many classic and traditional sacred music forms. Composers and musicians expect and require a natural and architectural acoustical setting to reinforce, blend, support and project musical production. Typically, a good architectural setting for musicians implies a rather high ratio of sound reflecting materials, and proximity between musicians. This type of architectural acoustical setting not only assists musical ensembles (whether they be choirs, instrumentalists or divisions of organ pipes) to work together, but also creates a sense of architectural fit, realism, and presence for the listener. To rely on electronic systems rather than architectural acoustics for classic and traditional musical forms can be to function contrary to the desire of the composer, musician, and listener.

Sacred music often functions to lead the congregation in hymnody, psalmody and liturgy, rather than only functioning with the congregation as "listeners." It is in the application of leading the congregation's music that choir and instruments can easily pass from support and leading into a "performance" role if too high "sound system" volumes are used.

Finally, a good corporate acoustical environment, where the unity and acoustical involvement (in music and speech) of all worshipers is desired, cannot likely be achieved through the use of electronic systems. It is the involvement of all present in liturgy, and responses that is the key element of corporate worship. Short of providing microphone "pick-up" and speaker "distribution" from and to the entire body of the congregation, electronic systems are inappropriate for this purpose. Note that electronic equipment is available which can raise the reverberation periods in "dead" rooms, thus improving the "corporate" acoustical experience. Such systems are highly sophisticated and are appropriate alternatives when true architectural acoustical measures are not possible.

The cost of an effective electronic reinforcement enhancement system might exceed the cost of architectural/acoustical remodeling in a building. It is the essential realism and unity of presence, both visual and acoustical, that truly great worship architecture, not "systems," can and must provide.

The proper architectural means to the goal of a good "corporate" acoustical environment is through the use of room size, shape, layout, and finish materials which support desired sound energy. Such rooms have adequate cubic volume, and a relatively high ratio of sound reflecting materials (few sound absorbing carpets, acoustical tiles, etc.), and reverberation periods of approximately 2.0 seconds or greater, occupied.

The use of microphones and "sound systems" are appropriate and useful in many applications, particularly for the clarification of speech, but a fine "architectural acoustic" is truly the key element for fine worship acoustics where music and corporate activity are used. In such spaces, worship is truly enlivened and communicative in speech, music, and the participation of all who attend.

...
"A Church is not a Concert Hall"

An all too common response from those involved in church building or remodeling projects to the notion of acoustical planning is, "We need not worry too much about acoustics in our church—after all, this is a church, not a concert hall."

To many, the "concert hall" is thought of as a critical acoustical environment, while a church is considered a "quiet place of prayer" without other significant acoustical concern. The fact is that the church has many critical and complex acoustical needs. A concert hall has far less complex acoustical needs than a church!

A careful examination of the functional use of the room and behavior of participants in a worship service will reveal that a typical church service is very much an acoustical event, with the activity of the service largely communicated through sound. In a typical service there is a wide variety of sounds introduced—speech of sermon, lessons, prayers—music of organ, choir, instruments—and the participatory sounds of the congregation in hymns, psalms, and sung and spoken responses.

The church room, therefore, must provide a setting where all of the various sounds can be projected from diverse source locations to all listening locations. These "locations are truly diverse. Note again: speech emanates from pulpit, altar, ambo, font, speakers, etc., while music emanates from organ, choir singers, instruments, etc. The important participatory sounds of the congregation (in hymns and liturgy) emanate from every seating location in the room. "Listeners" must receive this sound energy at all locations as well. The entire room, then, is critical as a sound distributor and receiver for music and speech.

By comparison, in the typical concert hall the less complex acoustical requirements are these: distribution of sound energy among musicians on the stage, and careful distribution of sound energy from the stage to the audience.

Critical acoustical differences between church and concert hall in this context are the one primary sound source location in the concert hall (the stage) compared to the many aforementioned sound source locations in the church, and the behavior of those in attendance. The audience is passive and quiet in the concert hall. The church demands an active, vocal, participating congregation.

Note that the technical and architectural means to acoustical success in a church or concert hall are both complex, requiring extreme technical precision. There are many architectural elements in the church space which contribute to its unique acoustical success. In most cases the use of a relatively high ratio of sound reflective materials in and around the congregation's seating area is important. Sound absorbing materials such as carpeting, pew pads, or acoustical tile ceilings remove sound energy from the congregation. The effect is inhibited or prohibited congregational participation in speech and song. Sound reflecting materials such as wood, ceramic, vinyl, etc., floors, and plaster, stone or well sealed wood ceilings and walls can reinforce and distribute reflected sound energy among the congregation. In this way the congregation can become active aural participants, and not simply quiet observers. Appropriate room volumes, geometric form, and location of participants are also important to acoustical success for worship.

The functional differences make the church worship space more, not less, demanding upon the architecture for a truly desirable acoustical setting.