A Fictional Story Based on a Combination of Real-life Projects

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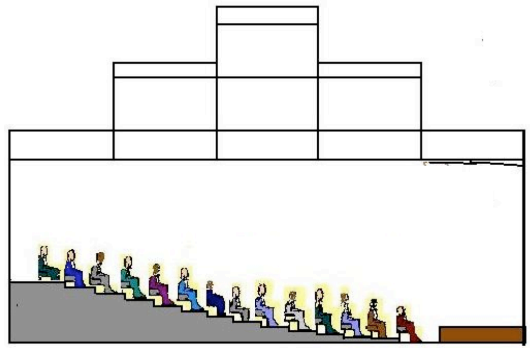


Figure 1: A worship space requiring a simple sound system. The ceiling structure consists of steel beams in a square arrangement with concrete above. The seating plan is roughly square. Seats are upholstered. The mid-frequency reverberation time is approximately 1.6 seconds full and 1.75 empty. There is a moderate bass rise. All finishes are hard and sound-reflecting, and windows and other niches provide enough diffusion to prevent echoes or flutter effects for live speech on the platform. Only matters relevant to sound system design are shown on this longitudinal section.

The worship space is located in the northern Midwest USA. The architect is local. An East-Coast acoustical consulting firm provided acoustical advice, designing a sound system for simple one-microphone semi-automatic operation for the sermon with capabilities for adding a portable control console and additional microphones for drama and other special events. Although designed primarily for worship, like many USA worship spaces, the majority uses are cultural since the room has the best regional reputation for music acoustics. Follow-up work by the acoustical consultant was not authorized, unless it was to be provided without charge.

There are complaints about speech intelligibility, and the architect has asked the acoustical consulting firm to send a qualified representative to evaluate the situation at the firm's expense. The firm's president agreed, with the proviso that normal fees and expenses would be paid if it could be proved that the firm's advice was not followed in any important area.

This was the situation the acoustical consultant found:

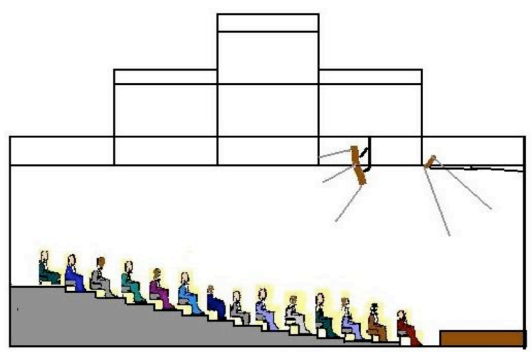


Figure 2: The sound system found on-site. Two high-quality column or line-source loudspeaker systems, one above the other, above the third row of audience seats, plus a small column loudspeaker for on-platform coverage. This was not the design provided by the firm. Discussions provided the fact that a local contractor had family members of the congregation who donated the sound system. The contractor's design had the loudspeakers about half a meter lower, but the architect and building committee insisted on raising the system to the height shown.

Before continuing further to read the rest of this story, take pencil or pen and paper and list all that is right and all that is wrong with this loudspeaker system. Then propose as many good designs as occur to you. You will then be able to check your answers against those proposed by the consultant in the continuation of this story.

The consultant pointed out that the good features of the contractor designed system were: high-quality equipment, adequate power handling capacity, neat installation, and reasonable directional realism for some listeners. Problems were that structural beams in front of the loudspeaker interrupted the line of sight to most of the rear-row listeners, that the loudspeaker location was a bad choice for covering the front rows, and that the front rows also required loudspeaker coverage, particularly the front corners. He performed some random-word-list intelligibility tests that proved the sound system actually reduced speech intelligibility in many seats, despite the increase in speech sound levels. In short, he proved that instead of raising the ratio of early to reverberant sound energy, the system did the opposite in most seats.

He then asked the architect to display the contract drawings:

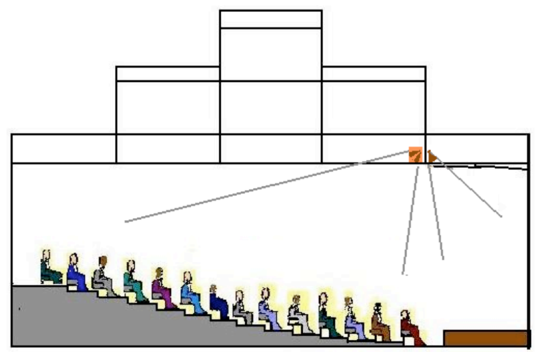
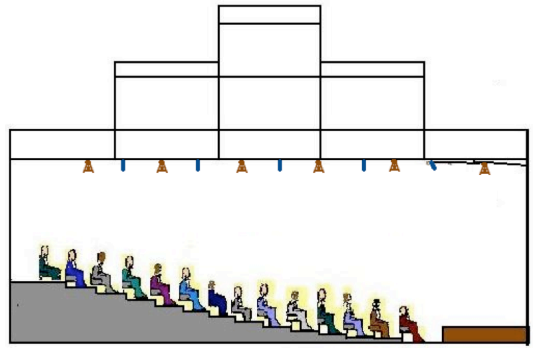


Figure 3: The sound system in the contract documents. Compact bass enclosures with long-throw acoustic suspension 300mm low-frequency loudspeakers flanking two constant directivity skewed coverage of high-frequency horns and drivers with coverage to provide uniformity over the seating area, plus a third similar horn and driver combination to cover the platform. (A Type ”a” system is discussed in Chapter 10.)

The consultant maintained that the designed system installed would have provided excellent intelligibility. However, since he was on-site, he would also suggest several alternatives, considering that between the time of the original construction and his visit, advances in electronic digital control of loudspeakers reached practical applications. These alternatives follow.

Figure 4: A distributed system. (Type “e” in Chapter 10). This is the most expensive alternative, with 300mm coaxial loudspeakers in compact enclosures pointing vertically, located at the bottom of the steel beams with spacing to insure even coverage. The high-frequency portion of each coaxial loudspeaker would be a constant directivity horn and driver, with crossover at 1000 or 1250 Hz., each having a 40 x 40 degree coverage pattern over the stage and front half of the seating area, and a 60 x 60 degree pattern over the rear half. The necessary signal delays, level balancing depending on source location, and absolute protection against feedback



(including real time notch filtering and gain control) can best be provided by distributed digital signal processing. This would allow the use of a grid of ceiling-mounted directional microphones, with geographical control similar to that at the 17th Church Christ Scientist discussed in Chapter 10, but done automatically. This could provide flawless speech reinforcement for audience/ congregation questions and responses, as well as for speech originating on the platform. For music playback, or the very rare requirement for music reinforcement, the ceiling loudspeakers would be assigned to A and B channels on a checkerboard arrangement for a quasi-stereo effect. Cost would be about ten times the originally designed system.

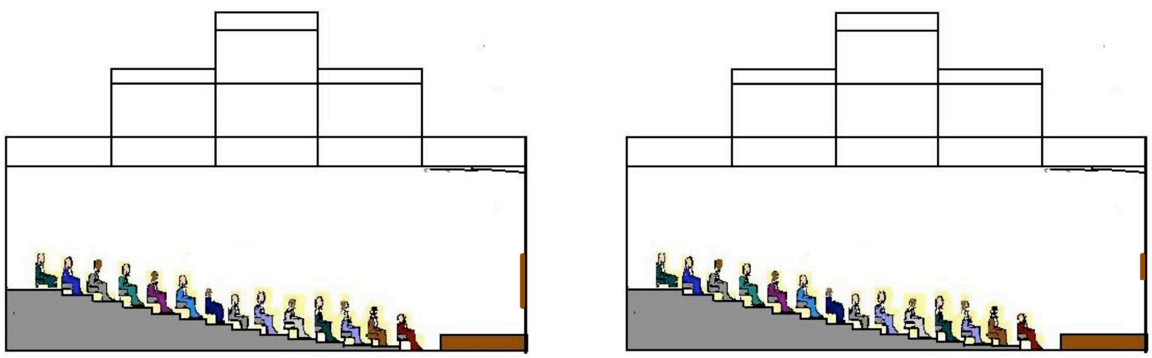


Figure 5: Re-use of the contractor-supplied column loudspeakers. Two alternatives involve removing the ceiling pendant and relocating the two loudspeakers for inconspicuous appearance in niches on the wall behind the platform. The left figure shows both column loudspeakers on at the center of this wall, one above the other, and the right shows each half-way between the center and the left and the right front corners. The contractor was willing to experiment to try to make either system work to the satisfaction of the congregation.   (The left can also be termed a Type “a” system, the right Type “b.”)

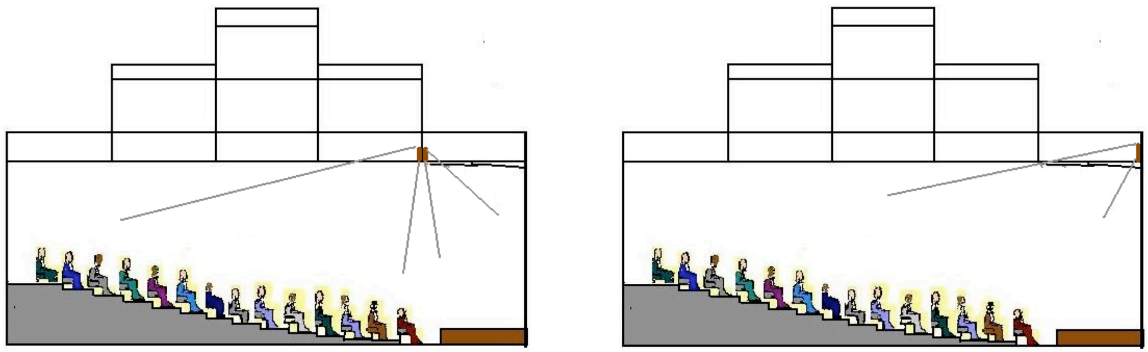


Figure 6: State-of-the-art central sound system. With advances in digital processing, steered-array line-source and array loudspeaker systems can provide even greater control and evenness of coverage as compared to the horn and bass-box combination while preserving good frequency response and dynamic range. The left configuration provides better coverage for those events when audiences are located on the platform, but requires an additional loudspeaker system. With either approach, an additional loudspeaker system on each side can add stereo capabilities for playback of recorded music. Without that capability, costs would be approximately equal to the originally designed system.

The contractor suggested that a small change might be applicable. He noted that the consultant had adopted the specific strategy (a cross-eyed configuration) in an important auditorium in Cambridge, Massachusetts:

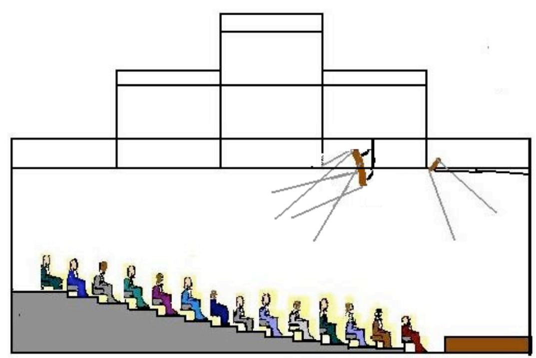


Figure 7: Contractor's suggestion for keeping the pendant. Rejected for lack of coverage of the front rows and probable phase interference effects half-way back in the seating area.

The consultant noted that lack of coverage of the front rows and phase-interference harshness in the overlap zone between the two column loudspeakers would be problems, and that the effort in making the change would be wasted. The Massachusetts installation involved high-frequency horns only, with much smaller total height, putting the phase interference effects well above the 2000 Hz band most critical for speech intelligibility. The consultant expects one of the two Figure 5 alternatives to be installed.