Multi-Channel Sound Reinforcement Systems

By Vance Breshears

Multi-channel sound can provide a greatly enhanced worship experience if properly implemented. Having sound come from more than one source gives a feeling of spaciousness and dimension that cannot be duplicated with a single channel system.

In sound reinforcement circles, multi-channel sound seems to be one of the latest trends. But what is all the fuss about? Isn't multi-channel sound just putting up more speakers and sending signal to these sources separately?

To some, that may be the case. But to those who are chasing after the ultimate in a sound experience for worship, it might not be quite that simple. First, let's take a look at how systems are designed and what the important issues are.

Design Issues

When designing any sound system, there are some standard issues that need to be addressed in order to provide a good listening experience to all seating areas. These can be summarized by answering the following questions:

- Will the system get loud enough for the program?
- Does the system have adequate frequency response? (Does it go low and high enough in frequency for the program?)
- Will the speaker systems adequately cover the entire seating area with a minimum of variation in level and frequency (or tonal) response?
- Will there be a single sound arrival at each listener that will provide clear and intelligible sound? Or will there be clarity-degrading multiple sound arrivals (echoes) after the direct sound, either from room reflections or from multiple sound sources? (This is the primary argument in favor of a single channel sound system.)
- Will the sound system provide accurate localization to the actual sound sources?

Given these criteria, we are assuming that the acoustics of the room is not a problem and have been addressed. If not, there may be some other sound system/room interaction problems that will need to be addressed first before a good sound system can be implemented.

These criteria apply to all systems designs. But when it comes to multi-channel sound systems, there are some additional issues that need to be considered.

Covering the Room

The first of these additional criteria is that each primary speaker source should provide even sound coverage to the entire room. This means that if there is a left channel speaker system, the speakers at this location need to cover the entire room and not just the portion of the room in front of those speakers.

The Time Factor

Sound travels at approximately 1130 feet per second. At that speed, and given the way the human hearing system works, most people will hear a distinct echo when sound arrives from two sources that have a difference in their path length of more than 40 feet. This also equates to a difference of approximately 35 milliseconds or .035 seconds. Now this is critical for certain types of program material that is percussive or speech oriented. But here's the important part. Other types of sound sources that are not percussive (choir, piano, strings, etc.) can actually sound better when they are smeared over time. With these instruments, it is not so critical that we have a single discrete sound arrival at the listener. We want only one single discrete sound arrival from all our critical percussive sources (such as drums, bass, vocals, speech, etc.) but don't mind multiple arrivals from some of our other sources.

The shortcomings of some multi-channel systems

One of the standard touring sound design methods is to fly left and right (or stereo) speaker clusters above the stage or to use stacks of speakers on either side of the front of the stage to provide sound to the seating area. But these methods also have some distinct limitations. These systems do not provide a balanced stereo sound to the majority of the seats in the room, other than a strip of seats along the center of the room. If you are sitting off to one side of the room, you will hear the speakers closest to you and will most likely not hear any information coming from the opposite side speakers.

Another of the design techniques that has been used over the past several years is to install multiple or alternating left/right clusters, particularly in large fan-shaped rooms. While this design technique may provide some spatial imaging as a result of the multiple sources, these systems lack the single point source speakers that provide good intelligible speech and clear music reproduction.

Other "stereo" or L/C/R (left / center / right) systems may not cover the entire seating area from each of the primary sound sources. In a case such as this, the listener may only hear one source – the closest one – and the imaging or stereo effect is lost.

Delay Systems

Before we go any further, we need to discuss the principle of delay speakers. Many systems, whether they be single or multi-channel, can utilize the benefits of delay speakers. In a nutshell, delay speakers are generally designed to cover the rear portions of a room that are too far away from the main speakers to be covered at the same sound level as the front seats. Unfortunately, the laws of physics dictate that sound dissipates as it travels out away from a source. There comes a limit at which we can throw sound effectively. Beyond that limit, delay speakers come in handy.

The key to a good delay system is that the signal that feeds these speakers is delayed so that it coincides with the arrival of the direct sound from the main speakers. In fact, a good designer will add an additional bit of time to the delay processing so that the ear will actually localize up front to the primary speakers, even though the delay speakers may be louder. We tend to localize to the first arrival, even if it's slightly lower in level. So we add just a little additional delay to fool the brain, but not enough to make it sound like an echo or a separate source.

The nice thing about delay speaker systems (if they are properly setup) is that they seem to be invisible. It is difficult to discern any sound coming from them until they are turned off. Then you notice the lack of sound and presence in the area of coverage.

Putting all the pieces together

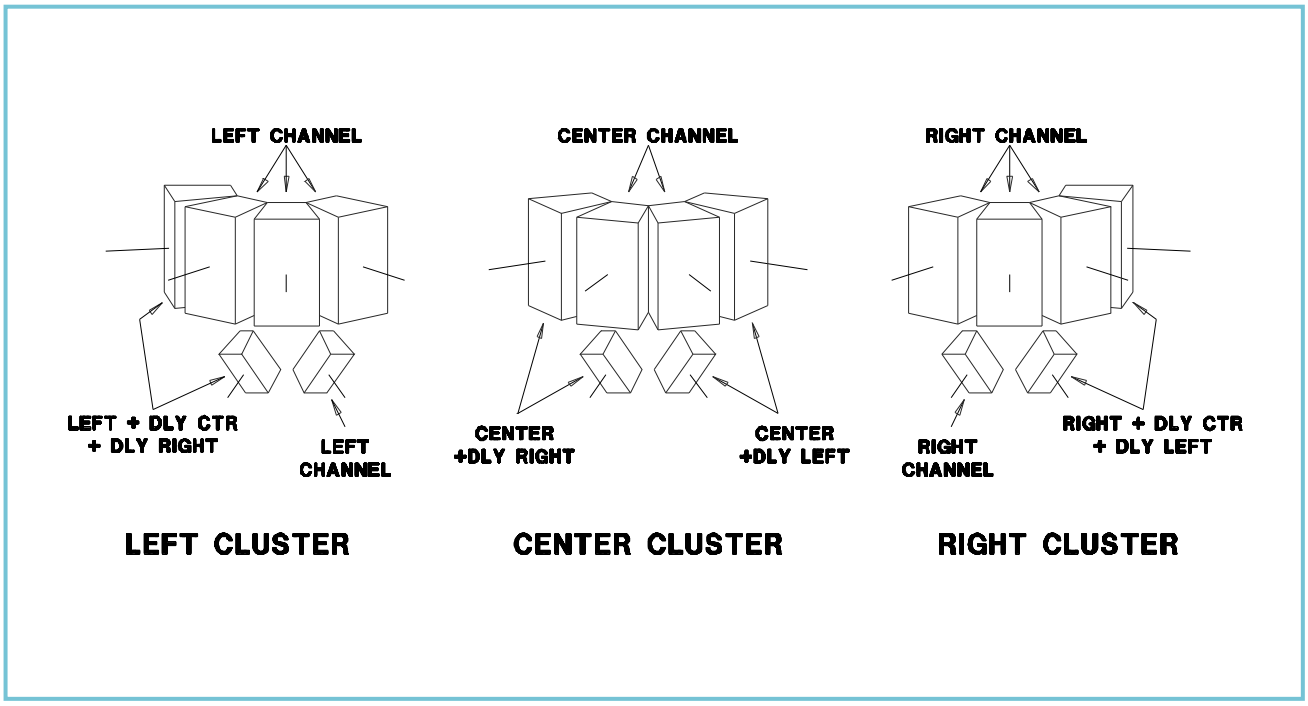
So now we have some additional design criteria to consider when we start thinking about a multi-channel system. But the nice thing about advancing technology is that we have some additional tools at our disposal. The advent of some of the newer programmable Digital Signal Processor (DSP) based equipment has made it possible to meet all our design criteria with a new design technique that otherwise would have been impractical.

The system uses a combination of discrete speaker clusters for primary sources and distributed delay speakers for support. Several things make this design approach unique from other systems:

First, some of the various components of each of the primary clusters may be used as support delay speakers for the other sources. In each case where this is done, a discrete delayed signal is summed into the audio feed for that particular device and combined with the primary audio signal source. For example, the far outside mid/high section of the right side speaker cluster will not only receive the

primary right channel sound, but it will also receive a center channel feed that is delayed (with reference to the center cluster) and summed back in with the right channel sound feed. In this way, the right side speaker of the right cluster will act as a delayed side fill speaker for the center cluster. This approach is followed on several of the components of each of the main clusters.

The following graphic summarizes this approach and which signals are distributed to each of the system components.



The other unique design item is that each of the distributed delay speakers are supplied with discrete delayed signals from each of the primary sources, and then summed together and routed to each speaker. This provides a discrete delay speaker in support of each of the primary sources that is signal aligned for coherent sound. This design approach can also be thought of as if there were three completely different stand-alone systems, each with distributed delay devices.

Each component that is involved within the center channel signal chain is delayed with reference to the center cluster. This provides a very coherent sound distribution from that source giving us all the same benefits of a single channel system. But at the same time and in the same way, each of the side cluster components are signal aligned with reference to each of the side clusters. This gives us the multiple source spread imaging or stereo effect.

System Operation

Left / Right channel localization is very effective with this design approach. Discrete sound arrivals with minimal time smearing (from each of the primary sources) is achieved. However, the primary limitation to this system is the time difference in sound arrivals from various primary sources at the extreme sides of the room. At the left side of the room, the right channel sound can arrive significantly later than the direct left channel sound. Because of this limitation, the audio mix must be set up to minimize the negative effects caused by this difference in arrival time.

For example, the best approach to mixing on this sort of system is to route audio signals to either the left and right systems, OR the center channel system, but never to both. Vocals, percussion, rhythm instruments (such as electric bass) will suffer a lack of clarity when played through multiple sources. Instead, these should all be routed to the center channel. Piano, strings, ensemble vocals, choir, etc. can be routed to the left and right channels and mixed appropriately. However, it is recommended that every instrument or source that is routed to the left and right channels is derived from a stereo microphone pair and each of the channels is discretely panned left and right as appropriate. This technique will eliminate any phasing anomalies that might occur with multiple bussing assignments.

And Finally

If properly designed, implemented, and operated, this systems design approach can provide dramatic multi-channel sound with excellent imaging to most seats in an audience area. The improvement from having coherent sound from each of the three primary sources is significant and provides for a wonderful listening experience.

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This article was published in "Technology for Worship Magazine" March/April 2000.