Mixing Techniques for Multi-Channel Sound Reinforcement Systems

By Vance Breshears

The primary goal with any church sound reinforcement system is to provide an excellent listening experience to the entire congregation. The ability of each member to hear and clearly understand preaching, drama and worship are critical to effective communication and providing for a good worship experience. The system should serve to reinforce and enhance what functions take place on the platform, not detract.

Amongst professionals in the industry, there are many opinions as to how best to accomplish these goals through different types of sound system speaker design configurations. However, the design technique that has emerged as the most common is a speaker system consisting of three primary full-range sources - left channel, center channel, and right channel speakers.

For any sound system, the general primary sound system design criterion will often include:

- *Adequate Coverage* – Providing reinforced sound levels that are reasonably consistent at all listening locations.
- *Consistent Tonal Response* – Providing sound that is of a reasonably consistent tonal characteristic to all listening locations.
- *Intelligibility or Clarity* – Providing sound that is of good intelligibility and clarity at all listening locations.
- *Spatial Imaging* – Providing a two-dimensional spatial image spread to all (or as many as possible) listening locations.

Other considerations such as system output, overall frequency response and equipment budget must also be considered. Although not discussed in this article, it is assumed that these issues will be addressed in the design process.

SPEAKER SYSTEMS DESIGN TECHNIQUE

In an attempt to provide an effective spatial experience, many system designers tend to implement a "stereo" system utilizing left and right speaker clusters at the corners of the platform, or in the corners of the room. However, the primary limitation of such design approaches is that "stereo" does not scale to a large venue. When listening to stereo sound in a small listening room, the difference in arrival time from left and right channels will generally be less than 5 milliseconds (5 one-thousands of a second) while the difference in sound level is usually less than 3dB. However, in a large room (1,000 seats or more) where primary speaker sources will be a substantial distance apart, the difference in arrival time from primary sources can be 60 to 80 milliseconds or more, and direct sound level deviations can be 10dB or greater.

An attempt to improve on the stereo design is to utilize a third (or center channel) speaker system for primary sources. However, many such systems are poorly designed and implemented to where each speaker source does not completely cover the entire listening area. The sound from the closest source is what is heard. There is no true stereo. Also, with a lack of training or understanding of how to mix on these systems, the results are often poor.

A method of designing a Left/Center/Right speaker system has been developed that utilizes cross-matrix delay and mixing on an open-architecture digital signal-processing (DSP) platform. Within this design, three primary speaker sources are provided and designed to cover the entire listening area, either from direct sound from the primary speaker components, or from supporting distributed delay devices within the listening area. The unique design approach uses cross-matrix delay and mixing in a manner such that some of the primary source speakers are used as distributed delay devices for other primary sources. In other words, speakers within the system can receive up to three discrete delayed input signals, one from each of the primary sources. The result is three completely discrete signal-aligned speaker systems, each covering the entire listening area, but using common components. All devices within each discrete system are delayed with reference to the primary source.

LIMITATIONS

While this type of design technique can reduce the direct sound level deviations to less than 2dB from each source, the arrival time deviation issue still creates a substantial problem in clarity and intelligibility. If the mix engineer sends signal to each of the three speaker systems simultaneously, there will be three distinct sound arrivals coming from each of the three speakers – left, center, and right. However, if the speaker systems are carefully designed, this type of sound system can effectively meet all the desired design criteria, but only when properly used. Improper mixing technique can still result in a poor sound experience.

Because of the matrixing and mixing involved in the speaker signal processing, signals that are simultaneously routed to all primary channels will be subject to phase anomalies. The same signal will be run through three different delay sections and be mixed back together through various speaker components. Also, if the same signal is routed to two or all three primary sources, listeners will observe two or three non-aligned distinct sound arrivals.

MIXING TECHNIQUES

The tendency for some mix engineers is to assign the routing and panning on a multi-channel system for a two-channel or "stereo" mix as one would do in the studio. In the studio, the engineer would place the lead vocals in the center of the mix by routing to the stereo buss and panning to the center. While this works well in a small room listening environment, and is necessary when mixing in a recording studio for stereo, the result in a large room with a system as described above is a problem. The result is two discrete sound arrivals at any given listening location. Another tendency is to assign a given signal to all three speaker sources. Again, the result will be three non-aligned direct sound arrivals with phasing problems through the matrixed speakers.

Figure 1 shows the direct sound arrival information for a signal that is assigned to all three primary sources and their respective cross-matrix delay components. A representative listener seat was chosen toward the right side of the seating area. Delay speakers have been omitted for clarity.

From this direct sound arrival information, it is apparent that there are three distinct direct sound arrival groups, one from each of the three primary speaker source locations. The arrival time differences at the extreme sides of the room are a direct function of the distance between the three speaker source locations.

From this illustration, it becomes apparent that assigning a vocal or instrument to all three (Left, Center, and Right) channels will result in three distinct sound arrivals severely degrading intelligibility and clarity.

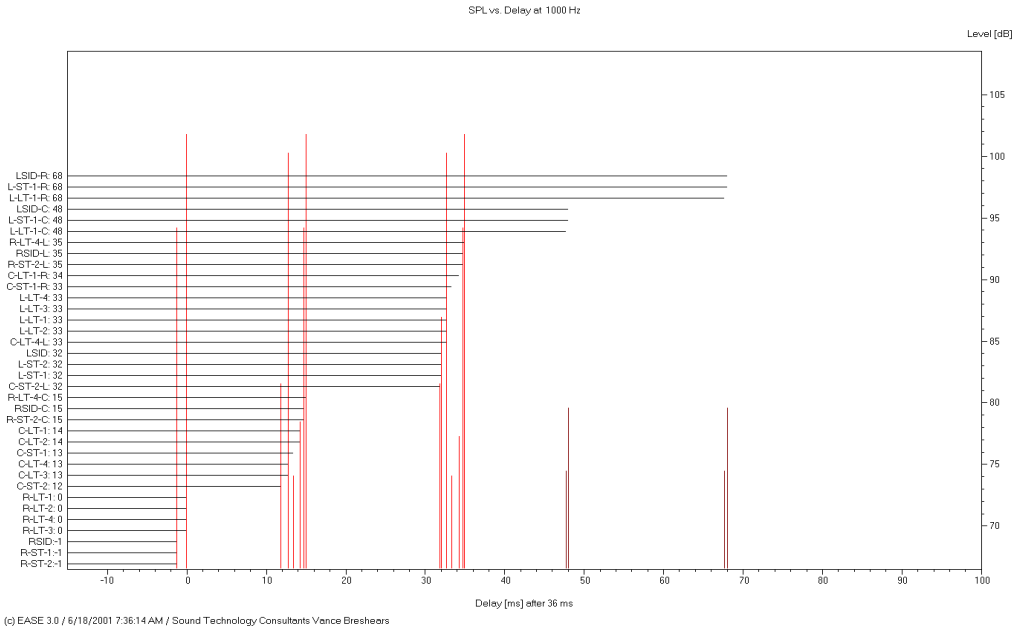

Figure 1
Direct Sound Arrivals from Left, Center and Right Active Components

SIGNAL ROUTING ASSIGNMENTS

The preferred approach to mixing on a system as described above is to assign all primary and percussive sources discretely to the center channel. These primary sources might include speech and lead vocals, and instruments such as drums, percussion, and bass. Each of these sources is best presented in a discrete, single sound arrival to the listener. By discretely routing all primary sources to the center channel, the listener gains all benefits of a discrete mono system. Figure 2 illustrates the resulting direct sound arrivals from the center channel speakers with associated delay components. Nearly all sound arrivals come within a 2-3 millisecond window (with the exception to speakers on the opposite side of the room aimed in the opposite direction).

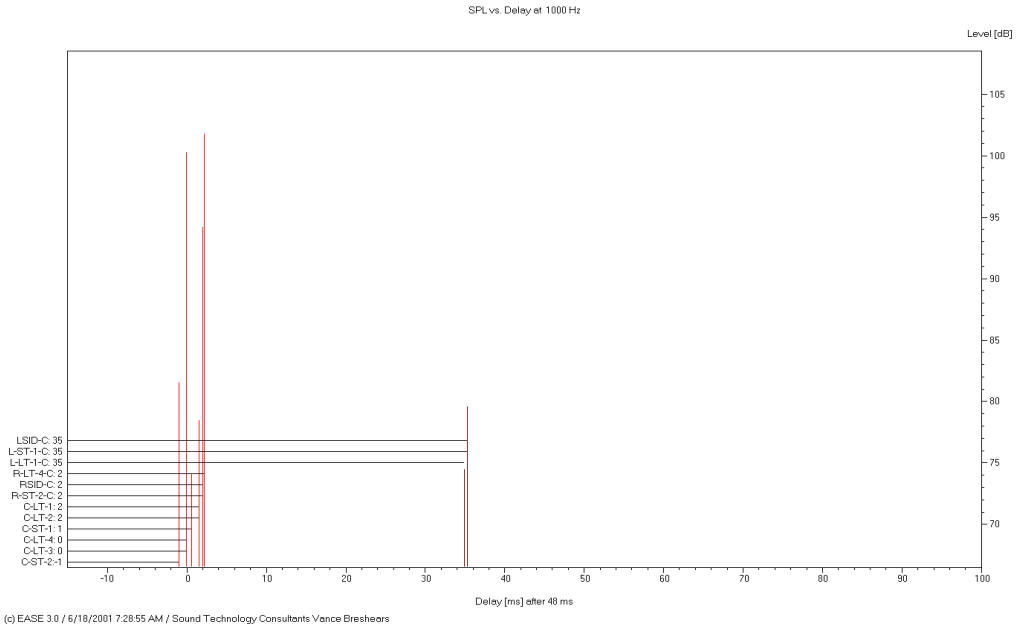

Figure 2
Direct Sound Arrivals from the Center Channel and Associated Delay Components

Other musical sources such as piano, electronic keyboard, strings, woodwinds, background vocals and choir may be more pleasing and can actually benefit from some time smearing. These sources, when routed into the left and right speaker sources, can provide the basis for a wide spatial mix. But in order to effectively accomplish this, each source must have two microphones that are discretely routed – one to the left channel speaker and the other to the right channel speaker. The result is an extremely coherent and clean mix that has a wide spatial image. Figures 3 and 4 illustrate the resulting direct sound arrivals from the discrete left and discrete right channel speakers with associated delay components. Most all sound arrivals come within a 2-3 millisecond window (with the exception to speakers on the opposite side of the room aimed in the opposite direction).

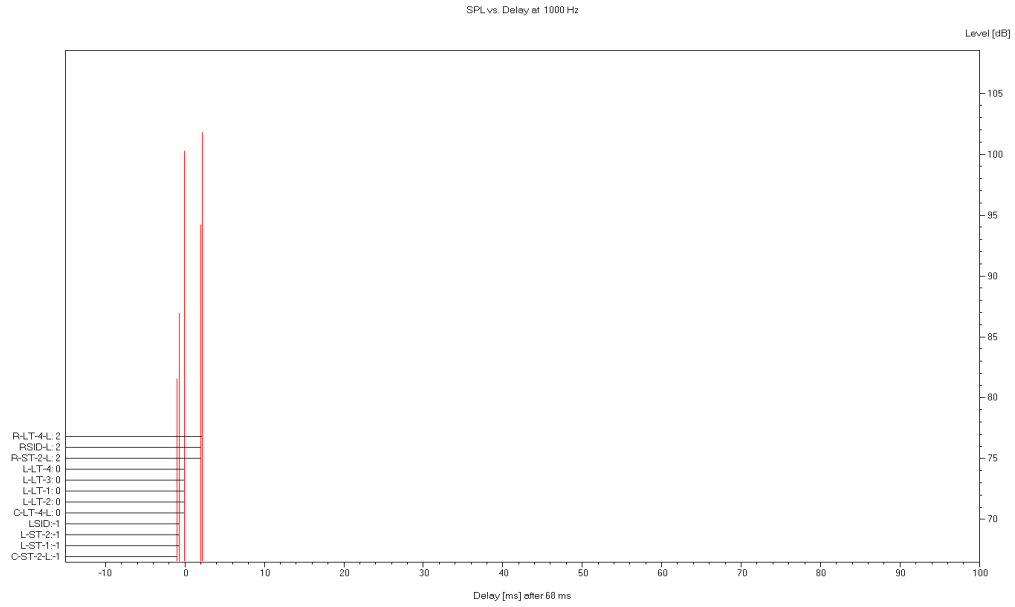

Figure 3
Direct Sound Arrivals from the Left Channel and Associated Delay Components

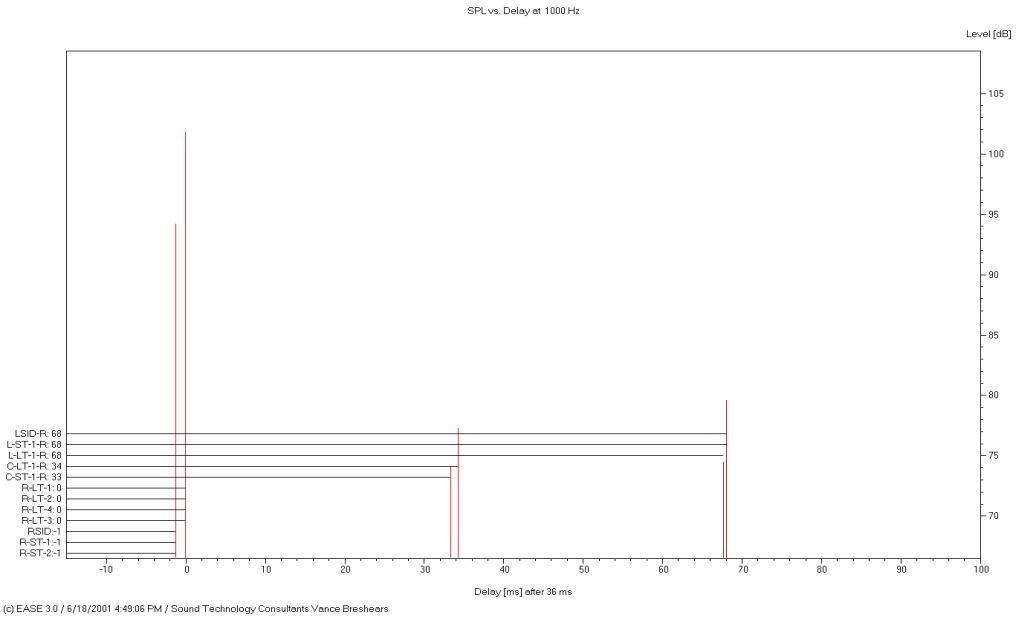

Figure 4
Direct Sound Arrivals from the Right Channel and Associated Delay Components

CD PLAYBACK

Due to the speaker locations in many of these systems, the stereo playback of a CD through the Left and Right speakers can cause some problems, particularly at the sides of the room. Differences in arrival times of the direct sound for percussive instruments when sourced through both speakers creates a flanging or phasing effect that can be quite annoying.

Instead of just playing back a CD through the Left and Right channels, it is best to use a Dolby Pro Logic processor that will take a stereo input and create left, center and right channels. This created center channel signal provides a discrete mono source for all of the instruments and vocals that would otherwise be reproduced through the left and right channels.

MIXING RULE SUMMARY

When each individual input is routed to a single discrete source – either Left, Center or Right - the resulting sound will be distinct, clear, and highly intelligible. Never should any single input be assigned to all three speaker sources. By stereo mic'ing or mic'ing in pairs the various non-percussive sources and discretely routing these sources to Left and Right channels, the result will provide for the desired spatial imaging. All primary sources should be mixed mono through the center channel only. ■

Vance Breshears is the owner and Principal Consultant for Sound Technology Consultants in El Cajon, California. In addition to designing multi-channel systems for several large churches, he has also published a technical paper on the topic. An article on the design of such systems appeared in the March/April 2000 issue of Technology for Worship Magazine.

Additional information can be found at the Sound Technology Consultants' website: www.sound-technology.com