When working with any sound reinforcement system, we must first ask ourselves one important question: “What do we hope to accomplish with this system?” In most cases we are using it to “move” the talker/performer closer to the listener so they can better hear the presenter. We must consider several things when considering loudspeaker placement. This article will examine the physical placement of and problems associated with loudspeaker placement. Future articles will discuss the following topics: type of speaker, number of speakers, special purpose speakers, and output capabilities of the speaker.

“What do we hope to accomplish with this system?”

The listener needs to be able to understand the words, whether spoken or sung. People often complain about not “hearing” the person speaking when what they actually mean is that they can’t understand what is being said. Naturally technicians tend to simply turn up the volume thinking they’re helping the listener’s intelligibility. Turning up a system may not help and may actually make matters worse if the problem is due to improper loudspeaker positioning. Clarity makes the difference not volume. How many times have you tried to talk to someone across a gym floor? While you are able to hear them at a loud enough volume, you have a hard time understanding what they are saying because the sound is reflecting off the hard walls and floor and acting like many loudspeakers; therefore, the sound arrives at you ear many different times (referred to as reverberant space).

This article, however, will focus on a relatively “dead” type of space (one that doesn’t have a lot of reverb or flutter echo problems). Unlike the speed of light (186,000 miles/second), sound travels relatively slowly through the air (1130 feet/second) Our ear/brain system tends to average or smooth out different arrival times of the identical signal up to about 35ms (.035 seconds). We perceive any two arrivals under that time as a single event. Beyond 35 ms, two signal arrivals begin to sound like an echo. An echo lessens the listener from understanding the talker. Reverberation and echo effects often enhance music, but they are a detriment to understanding the spoken word partly because we process speech on the analytical side of the brain and music on the “artsy” side of the brain.
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To demonstrate this fact, picture a talker behind a pulpit on a chancel stage in the middle of an auditorium. The talker is 15 feet away from, you, the listener. The loudspeaker is 40 feet away (to the side) from the talker. Using simple triangulation and the speed of sound, we find that the direct sound from the talker gets to you in 17ms, and the direct sound from the loudspeaker gets to you in 48ms. The difference between these gives you two arrival times that are 31 ms apart. Though the ear hears two events, the brain processes them as a clearer, single event. If the loudspeaker was 60 feet to the side, then the difference in arrival times would be 52ms. Your brain would process an echo, and you would have more trouble understanding the talker. Ideally arrival times between talker and loudspeaker or between two loudspeakers should not be longer than 35 ms.

Ideally the two arrivals should be close together; however, tonal quality problems almost always show up next, yet they are easier to fix. The graph below shows the frequency response when the distance between two loudspeaker arrival times is one foot apart. Notice the large hole around 500 Hz, and subsequent holes that are 1100 Hz apart. (Those holes are the problem causing poor quality or tonality of the sound.)
The next graph shows holes with the arrival distances are four feet apart.

Note that the lowest hole in the response is much lower in frequency, but the higher holes are much narrower than the arrivals that are one foot apart.
Here is a graph of arrival times that are twenty feet apart. Note that the width of the holes is much narrower in the middle/upper frequencies (the range in which we get our understanding or intelligibility from). Our ears tend to naturally smooth these holes.

The above examples show a phenomenon known as comb filtering, named so because the holes in the response look like the teeth of a comb. Let the following example explain the idea behind comb filtering. Imagine throwing two rocks in a pond one slightly after the other. Picture how the ripples interfere with and overlap each other. Now equate the rocks as loudspeakers and the ripples to be the bumps and holes caused by comb filtering. The holes (ripples) from a single loudspeaker (rock) allow for smooth intelligibility, but interfering holes from a cluster of speakers “overlap” not allowing the listener to clearly understand the spoken word.
To further understand the “ripples in the pond” analogy, consider the graph below which shows a room’s coverage pattern from a single speaker. Notice how the coverage resembles ripples in a pond.
Next observe how this room’s coverage pattern changed when another identical speaker was added to the first two feet away. Suddenly the ripples turn into “fingers.” This demonstrates comb filtering as in the examples mentioned early.

The basic problem remains: get the loudspeakers far enough apart to avoid comb filtering but not so far apart to cause an echo, or put them so close together that they act as a single source. Many loudspeakers make the claim that they are arrayable; however, only very few actually are.

The underlying audio problems that these situations create include uneven coverage, poor fidelity, decreased gain before feedback, and a “distant” sounding system among others.

Commonly people think they can simply add more speakers to the room—that is usually the worst thing you can do! There are several reasons not to add loudspeakers. First, sound from a loudspeaker does not cover just a particular area (as common sense would dictate). There is a lot of energy, generally low to mid frequency that comes off the sides and rear of a loudspeaker. That energy will interfere and add to the other speaker’s energy as the second speaker tries to cover its particular area.
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Have you ever walked behind a speaker and noticed that you can’t hear the high tones anymore, but you can still hear the low tones? Adding loudspeakers also causes frequency response problems and localization issues, i.e. where is the sound coming from? We want all the sound to appear to be coming from the front of the room.

Still another problem that arises is what we call the “N” factor, the number of sound sources in a room. When a lot of speakers are turned on, energy starts to bounce off walls at greatly varying times simulating a gym-type effect. Whenever an additional speaker is turned on anyplace in the room, everyone will notice a change in the sound quality at their seat—for the worse! Think of lots of pebbles being thrown in a pond and lots of ripples interfering with each other. As is with combs, interference causes chaos. Save money and aesthetics by remembering that “less is more” when dealing with loudspeaker coverage.

Ideally a single loudspeaker should cover a room. Sometimes this can be done, but often not; however, the concepts we’ve reviewed must be fulfilled by choosing the best loudspeaker(s), understanding location, and considering digital signal processing equipment etc. Together these factors are important so that the listener “hears” the sound coming from a single point.

As you can see, loudspeaker placement is very important to achieve a quality sound—smooth coverage and intelligibility. There are many more points to consider when choosing a loudspeaker system (see incomplete list below) which future articles will review.

Points to Consider when choosing a loudspeaker system:

- Acoustics of the room (dry-reverberant-echoes)
- Coverage pattern of the loudspeakers
- Height/width/depth of the room
- How loud does it need to be
- Cost
- Physical size