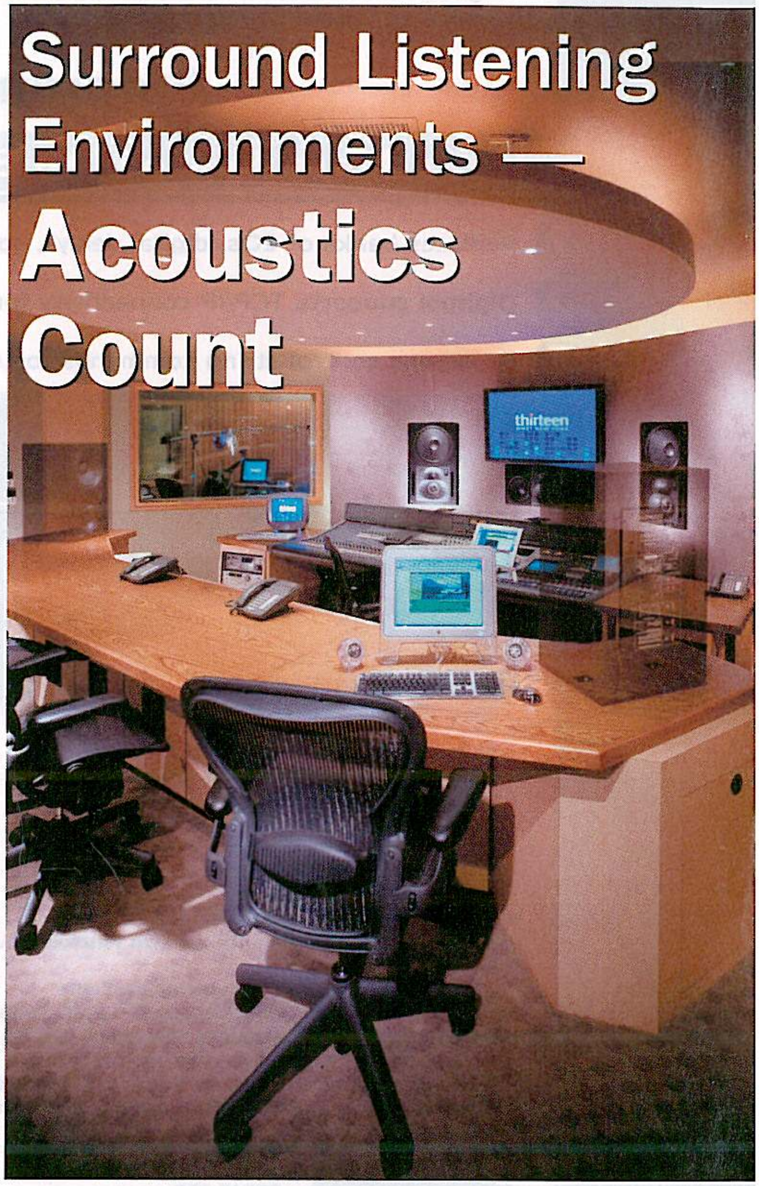
Surround Listening Environments — Acoustics Count



By John Storyk

I am old enough to remember the first time I heard a stereo recording, and thinking how amazing this was. My first thought (I truly remember this) was "Why would you want to listen to anything in mono after this?" I can also remember those early recordings (33 rpm vinyl) often coming with printed instructions on the record jacket illustrating the principals of stereo and how listeners should set up their living room. How novel this idea was to deliver content in a "new" (or revised) medium with playback instructions.

Almost 50 years later, it is interesting to note that there is still is no definitive stereo playback listening position standard (for professional monitoring environments) other than everybody seems to be in agreement that the left and right speakers are symmetrical around a listening/acoustical centerline. Even now, there is no absolute speaker layout axiom. The best we can offer is a diagram such as **Figure 1**. Fifty years to get to this trivial conclusion!

So, no surprise that after some 10 years of multichannel audio for the home (I discount film multichannel audio for the moment), we are still in a debate about even the most basic notions of surround sound room design, particularly regarding speaker placement. I define a multichannel audio environment as any space where audio is played back on more than two speakers (stereo). For the most part, 5.1 audio (left, center, right, left rear, right rear and a low frequency effects channel – LFE – or '.1') is the reference standard. (Note: this article is NOT the forum for a debate on the merits of 5.1 vs. 6.1 vs. 8.1 and beyond). People have been listening to multichannel audio in movie theaters and theme park venues for quite some time. Simply put, it is VERY exciting. Almost any array of speakers that correspond to an authored multichannel content distribution has the potential For extremely effective aural stimulation. Like any tool, it can be abused or poorly executed, but more often than not, multi-channel audio is wonderful to experience.

So, why even discuss room acoustics for this "new" delivery system or for that matter standards for room ergonomics. Again, the film world provides an apt metaphor. Agreeing to standards in room acoustics and physical system setup requirements, enables an entire industry to more or less create audio for films that can be played back with a reasonable degree of quality consistency throughout theaters. One can argue that the same thinking would prevail for any high quality multichannel audio environment. The debate involving these standards is one of the more exciting discussions in professional audio these days!

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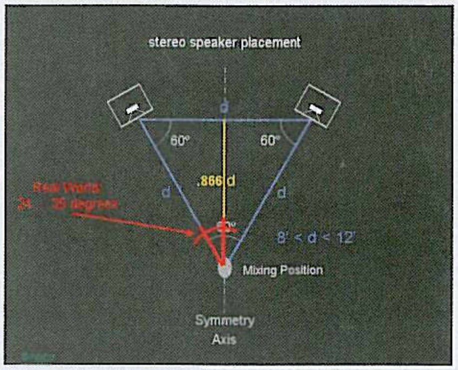

Figure 1 50 years later – a guide to stereo speaker positioning. You would think we would have this standard more formalized!

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Fundamental acoustic issues for surround sound environments remain very similar to those in stereo rooms. These acoustics can be simplified by focusing on two specific issues:

1. Quietness Acoustics
2. Internal Room Acoustics

Quietness Acoustics

Studio and Professional Listening/Production environments need to be quiet. This quietness is typically characterized by a Noise Criteria (NC) value. Values of 15 to 20 are quite common for these types of rooms. Surround sound rooms do not really change these requirements. This level of quietness is obtained by prudent site selection; structural room boundary design that protects the spaces from outside disturbance (i.e. "room within room" construction - highly isolated); and HVAC (air conditioning) design that deals with machine isolation and air velocity control. Quiet rooms are conducive to creative work. I emphasize air conditioning design, since this is often the weak link in accomplishing these levels of quietness. These systems involve oversized ducts; duct configurations to eliminate cross talk between rooms; lined ductwork; and quiet machinery that is specifically mounted to prevent low frequency vibration interference. This commitment is difficult and can be costly, but the results are well worth the effort.

Remember "...Choose a quiet site..." This seems so simple and so obvious yet so often this planning axiom is missed. Why locate a listening room near a machine room or under a bathroom, when you could locate this space in a quiet corner of a floor?

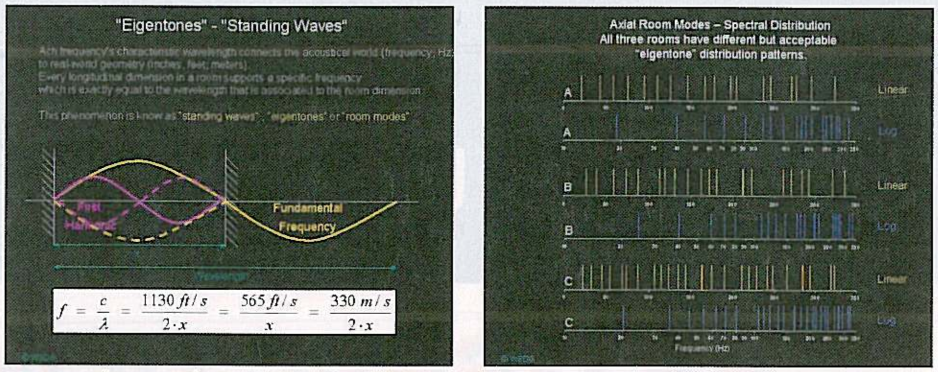

Figure 2 diagram showing eigentone or "standing wave" determination

Internal Room Acoustics

All enclosed environments deal with the behavior of sound once it is propagated from a source position (multiple speakers in our discussion). Our design goal simply stated is to create a space that minimally "colors" that sound with respect to the signal flow from the source to the speakers. If we assume that we will be listening to high quality speakers connected to a high quality electronic chain whose transfer function (frequency response) as well as time domain characteristics (phase response) are relatively uniform, then the goal of the space is to have a minimum impact on that signal flow. As in stereo listening, this is accomplished by paying attention to a few important issues: (now comes the hard part – internal room acoustics in 300 words or less!)

Imagine a critical listening room as being many rooms, each having the same physical characteristics, but behaving dif-

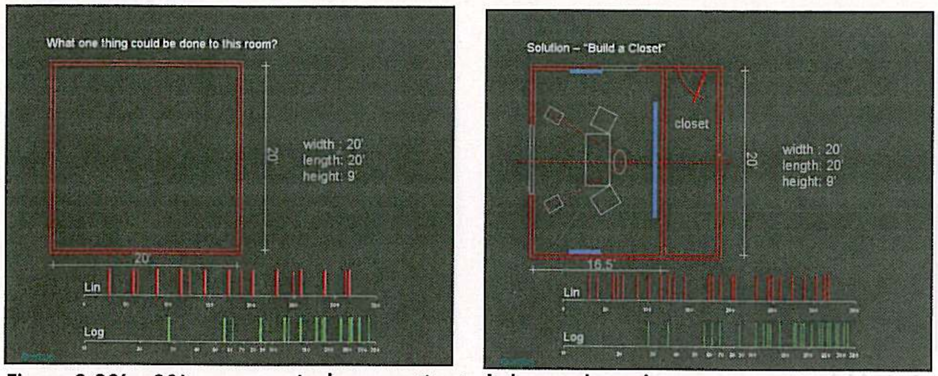

Figure 3 20′ x 20′ room – a single suggestion to help – make a closet.

ferently at different frequencies. We can simplify this concept by examining low and high frequencies. (In reality, this exercise is much more complex). At low frequencies, what is most important is room ratios, which result in the correct or incorrect piling up of room modes - eigentones, often called "standing waves." The determination of these frequencies and their spacing is arithmetic in nature (see **Figure 2**), thus as we go higher in frequencies, the eigentones are more and more dense with respect to octaves (each octave having twice as many frequencies as the lower adjacent octave). A square is, of course, a particularly poor room shape. This is because two of the three primary axis of the room have exactly the same dimensions thus exactly the same eigentone. It would be as if the room is an instrument favoring certain notes. A student once asked for a key recommendation to make his 20-foot x 20-foot basement project studio sound better. After a few seconds, I suggested making a closet! Of course what I was really telling him was to get rid of the square shape! (**Figure 3**).

At a certain point, the "packing" of the eigentones is no longer an issue and therefore the room ratio is no longer an issue. At this point, we are now concerned with room reflections and reverb time (decay time) characteristics. Controlling room reflections is required to avoid comb filtering, (the arrival of energy separated by less than 15 ms in time and within 10 dB of a direct sound source). The resultant combination of these sources causes a frequency response "curve" that looks like a comb (thus the name), and is extremely audible (see **Figure 4**). Eliminating these reflections is easily accomplished by either changing surface characteristics so that there is more absorption in those area causing the reflections OR changing the geometry so that the reflections do not exist. I usually try for the latter, as it pre-

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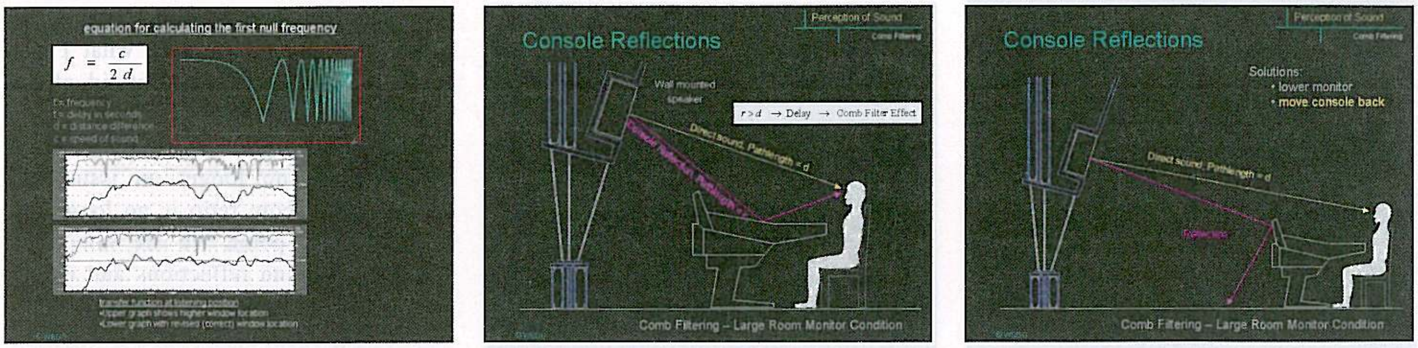

Figure 4 Comb Filtering – this response is quite undesirable!

serves reverberation and "musicality" in the room, as well as saves money. A combination of both these approaches is the correct solution (see **Figure 5**)

There is no argument for these principals not being applied to multichannel listening environments. In fact, with more speakers, solving some of these problems becomes more complex. For example, putting massive diffusion on a rear wall of a room, might be very effective in a stereo setup, but due to rear surround speakers, (especially if they are not flush-mounted), this might not be such a good idea. During the past five years, we have taken many RT60 measurements (essentially decay measurements at 1kHz) in surround sound control rooms. Although there are also ITU guidelines for RT60 values (see **Figure 6**), we have found that in fact these value are a bit high for surround rooms and we recommend reducing them by about 20 – 30 percent. They do however seem to be good guidelines for stereo only environments.

Speaker Layout

More conversation has been devoted to this one issue than almost anything else in surround sound room design. There is little argument for not having surround speaker configurations arranged symmetrically. This applies to stereo layouts and simply stated is... "Make your room symmetrical..." (end of story!). Having said that, there are many real world instances when this is difficult (a window on one side of a space with a fantastic view, doors that are not symmetrical. Sometimes equipment configurations, racks and esoteric pieces of gear simply can't be completely symmetrical. Do

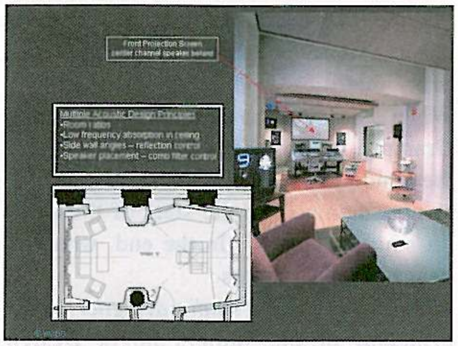

Figure 5 Multichannel listening control room – multiple acoustic design solutions

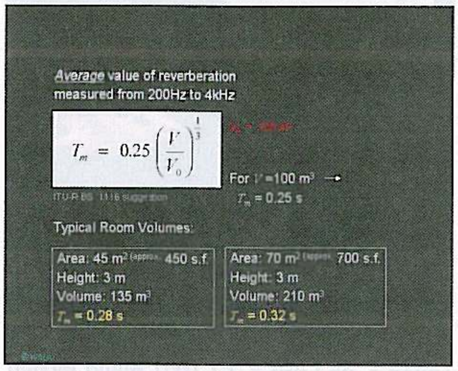

Figure 6 Reverb Time (RT60) Recommendations – ITU. We find these numbers to be a bit high in multichannel listening environments.

your best to make these features appear acoustically correct as possible. At a private studio outside of New York City, a fantastic view of the Hudson River created the need for one side of the room to have a magnificent bay window, while the other side of the room had a sliding glass door to an office. The room boundaries are not exactly symmetrical, but they are angled in a non-parallel fashion (to eliminate flutter echo) and thus create enough

Figure 7 Second Act Studios, Hasting on Hudson, New York – showing enough acoustic symmetry for side boundaries and use of multiple of acoustic treatments (plan and photo).

of an acoustic symmetry which effects a reflection control that serves as an acceptable frequency domain transfer function. (**Figure 7**)

Figure 8 represents perhaps the most common speaker configuration standard, one that has evolved over he past ten years. This diagram shows five full frequency speakers arranged symmetrically around a listening axis (room centerline). This arrangement was borne of numerous listening tests performed in Europe and has become a "starting point" for setting up many multi-channel room layouts. I refer to the well-known standard (ITU-R BS 1116-1, 775-1 & EBU Tech. 3276-E).

But no sooner than presenting this diagram, than I must report that I see more rooms set up in ways that are slightly different in a various characteristics. The reasons vary.

In small rooms (less than 300 s.f.) equipment, doors and other "real world" issues often get in the way of the rear speakers.

A. In small rooms (less than 300 s.f.) equipment, doors and other "real world"

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issues often get in the way of the rear speakers. Rear speakers frequently need to be further distanced from the listener than the front speakers. Up to 3-4 feet, this does not seem to be that important. In larger rooms where the speakers can "float" in the room, this is not an issue (see **Figure 9**).

B. It is common to see rear surround speakers that are "similar to the 3 front mains, but smaller in size. So that, if one were specifying three Genelec 1038s (a common surround room speaker that works very well in 5.1 environments), one might see 1032s for the rear surrounds. Ironically, when presented with this type of choice WNET (see cover) chose NOT to compromise the equal speaker specification and insisted on equal distance from the speakers, even when it meant a rather complex solution of speaker positioning on motorized lifts when the room was to be used in a 5.1 mode!

Conclusion

What do we conclude from this brief discussion? My suggestion is that we continue exploring how rooms best serve

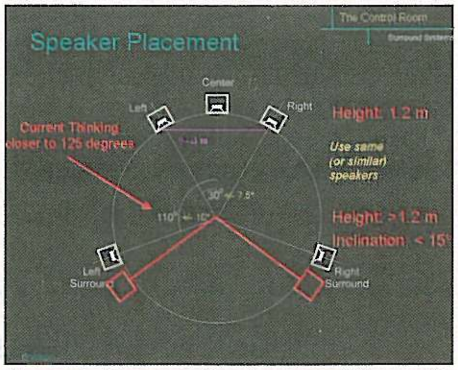

Figure 8 Five- speaker layout – ITU specifications – showing five speakers that are identical and that are equidistant from the listening position.

multichannel audio, since I am genuinely convinced that this wonderful audio experience is here to stay. We need to establish standards, so that the performance bar is always pushed higher, but at the same time we should never forget that standards should be re-visited often and challenged when necessary.

At Mi Casa Studios (**Figure 9**), a ITU 5 speaker layout was initially installed. After a while, owners Bob Margouleff and Brant Biles moved the rear speakers to the rear of the room, essentially changing the 110-degree off axis position to one closer to 125 degrees. (I have seen many facilities do this very same thing). When I asked Bob (lifetime friend and Grammy award winning engineer) why they ended up with this configuration, his answer summed up the state of the art... "It sounded better". In the end, what we hear is all that counts.

John Storyk is a studio designer and a principal of the Walters-Storyk Design Group

Figure 9 Mi Casa – 5.1 DVD Audio Mixing Suite – Five Genelec 1038s – equal distance from the main position in a room with complex acoustic treatments, symmetry and NC15 quietness.