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REALTRAPS - Setting Up a Listening Room
Optimizing placements

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Straight talk about finding the ideal loudspeaker placement and listening position.

By Ethan Winer

It's well known that placing your loudspeakers and listening position correctly is the first step toward getting good sound, especially at low frequencies. While positioning alone won't eliminate the need for acoustic treatment and bass traps, it's an easy and free way to help reduce low frequency response errors. In this article I'll describe a simple yet effective way to determine the optimum placements for both stereo and multi-channel listening rooms. I'll also explain how to calculate the first reflection points when the walls are parallel and the ceiling is flat, which is typical for most rooms. The dimensions used in these examples are similar to those of the REALTRAPS Lab, a working recording studio we built within the REALTRAPS factory to help us research acoustic treatment and related issues. Also see the expanded version of this article on our **Videos** page.

LOUDSPEAKER ORIENTATION

As you can see in the drawings below, loudspeakers should face the long way into a room. Peaks and nulls become worse as you approach the rear wall behind you, and this orientation puts the listening position farther from that wall. (Figure 3 below shows the response in the same room measured both ways.) The next step is to identify the ideal listening position within the room, and from there you can determine the best speaker placement.

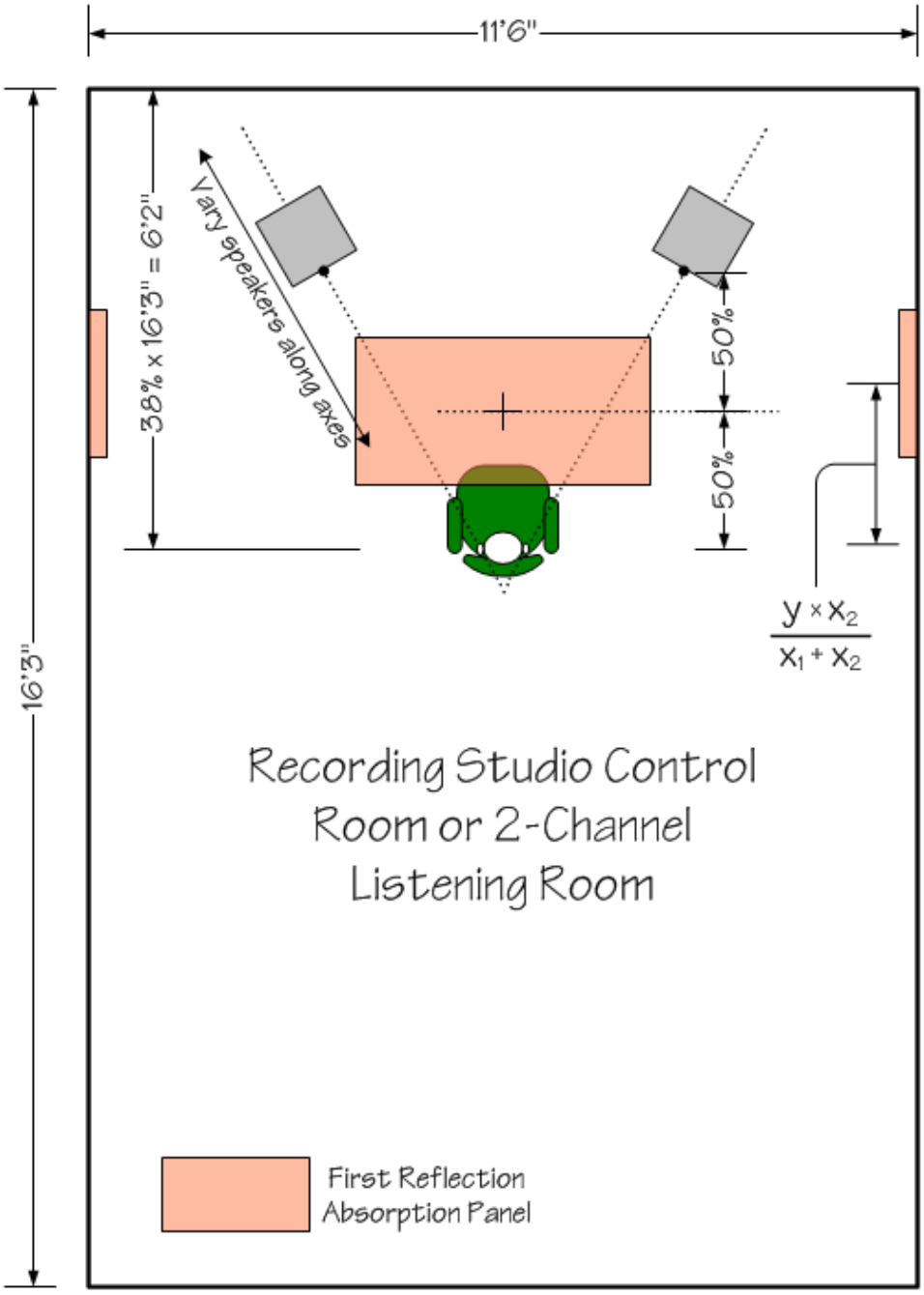

Figure 1: Proposed layout and first reflection points for a 2-Channel listening room.

AVOIDING NULLS

In all rectangular rooms the bass response is most lacking at the halfway points - halfway between the front and rear walls, halfway between the left and right sides, and halfway between the floor and ceiling. Therefore, the worst place to sit is exactly halfway back in the room, with your ears halfway between the floor and ceiling, or halfway between the left and right walls. You shouldn't put loudspeakers in those places either.

Loudspeaker tweeters should be at ear level, but you should raise or lower them a few inches if needed to avoid having the woofer exactly halfway between the floor and ceiling. Likewise, while left-right symmetry is important for proper imaging, you could optionally offset your listening position a few inches to either side to avoid being exactly halfway between the left and right side walls.

THE 38 PERCENT RULE

The placement method used here is based on the "38 percent rule" which theorizes that the best listening position is 38 percent into the length of the room, when measured from either the front or rear wall. This offers the best compromise of peaks versus nulls for any given room size. For 2-channel listening you'll get the flattest low frequency response by sitting 38 percent of the way back from the front wall. However, this is not practical in many home theaters, especially those with large screens, because that puts you too close to the screen. Fortunately, you can get the same benefit by sitting 38 percent of the room length when measured from the rear wall.

Please understand that 38% is one *theoretical* best location to begin measurements, but it may not end up the best place to sit due to other factors - wall properties, speaker location, speaker type, furnishings in the room, and a host of other conditions that can affect frequency response. The *only* way to know which location really is most flat is to measure the low frequency response at high resolution using software such as **ETF**, **FuzzMeasure**, or **Room EQ Wizard**.

Once you know the ideal listening position from the front or rear wall, the next step is to place the loudspeakers. The speakers and listening position should be at the points of an equilateral triangle, as shown in Figures 1 and 2. Note that the theoretical point of the triangle is just behind your head, with the axis lines grazing your ears.

If you have the **ETF** program or **REALTRAPS Test Tone CD**, or another way to accurately measure your room's low frequency response, you can experiment with different speaker distances by sliding both speakers along each axis while you measure the response. Otherwise, put them along the axis at a distance that is convenient and makes sense for the size and layout of your room. Too often people obsess over minute details that matter only a little, while ignoring ergonomic concerns that matter much more.

FIRST REFLECTIONS: CEILING AND FLOOR

Now let's look at treating the first reflection points. The concept of first reflections - also called early reflections - is explained in the article **Creating a Reflection-Free Zone**. The method shown here is simpler because it avoids needing a mirror and second person, but you'll probably want to keep a calculator handy.

I recommend treating *all* of the first reflection points, not just those at the side walls. Finding the ceiling and floor reflection points is easy. Assuming your ears are at the same height as the tweeters, which they should be, the reflection points are exactly halfway between you and the loudspeakers. So if the speakers are six feet in front of you, the center of the ceiling absorber will be three feet in front of your head, as shown in Figure 1. If your floor is reflective I recommend placing a small throw rug directly under the absorbing panel on the ceiling. For larger rooms, or when the speakers are farther away or farther apart, you'll want two overhead panels (and two throw rugs). This is shown in Figure 2.

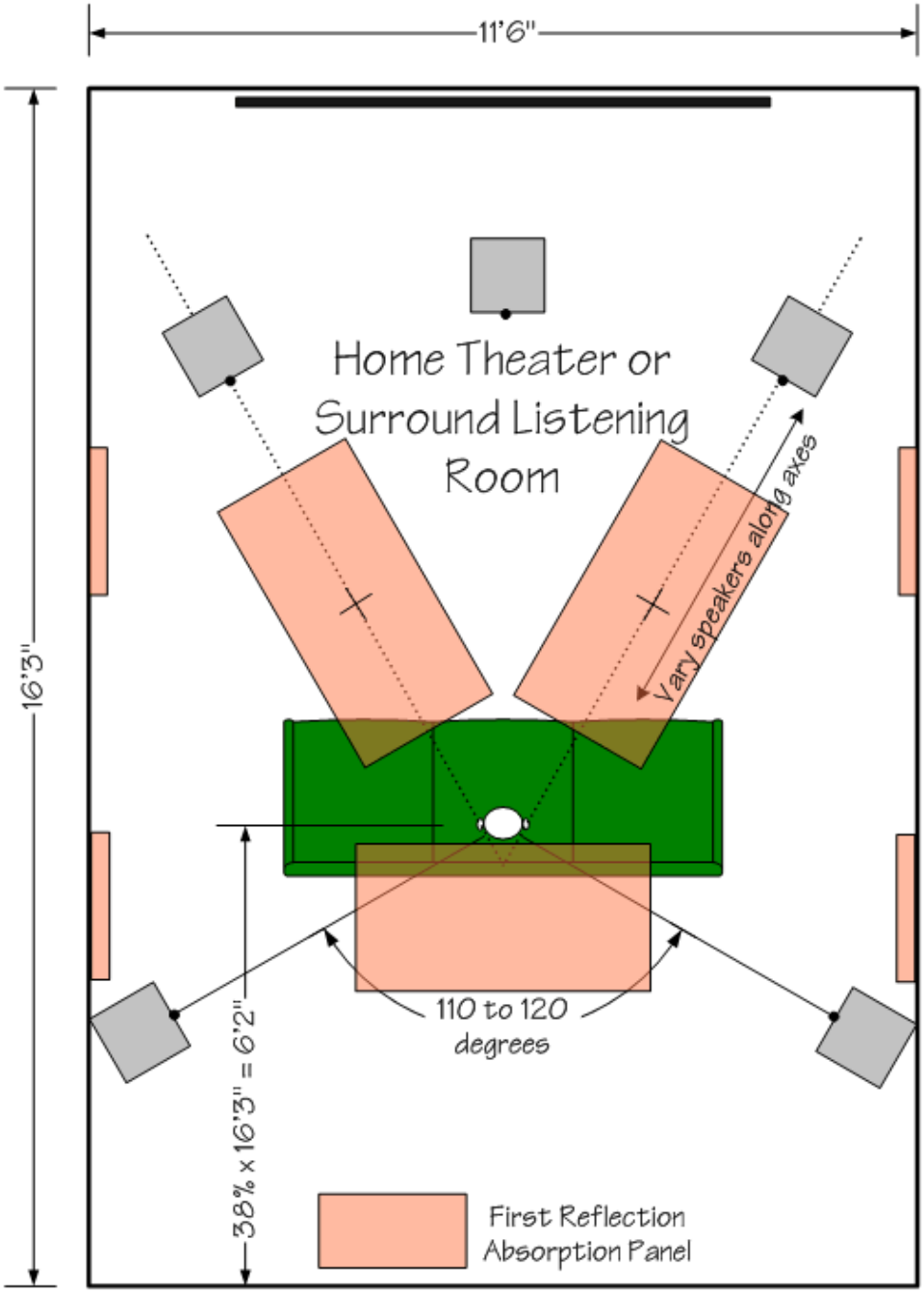

Figure 2: Proposed layout and first reflection points for a multi-channel listening room.

Note that the main and center speakers should form an arc. This puts the center speaker slightly farther forward in the room than the mains, though they remain at the same distance from you. (The surrounds should be that same distance too.) If you'd like you can average the distances between the mains and center speaker. Or else you could calculate each distance separately and verify that the panels are large enough to cover both reflection points.

This brings up a related issue, because the notion of a single point is valid for only a single listening position. If you have more than one seat you should determine all of the reflection points, and be sure your panels are placed to handle them all. In smaller rooms a single 2x4 foot panel is probably adequate, but larger rooms will require two panels, or even more if you have a second row of seats.

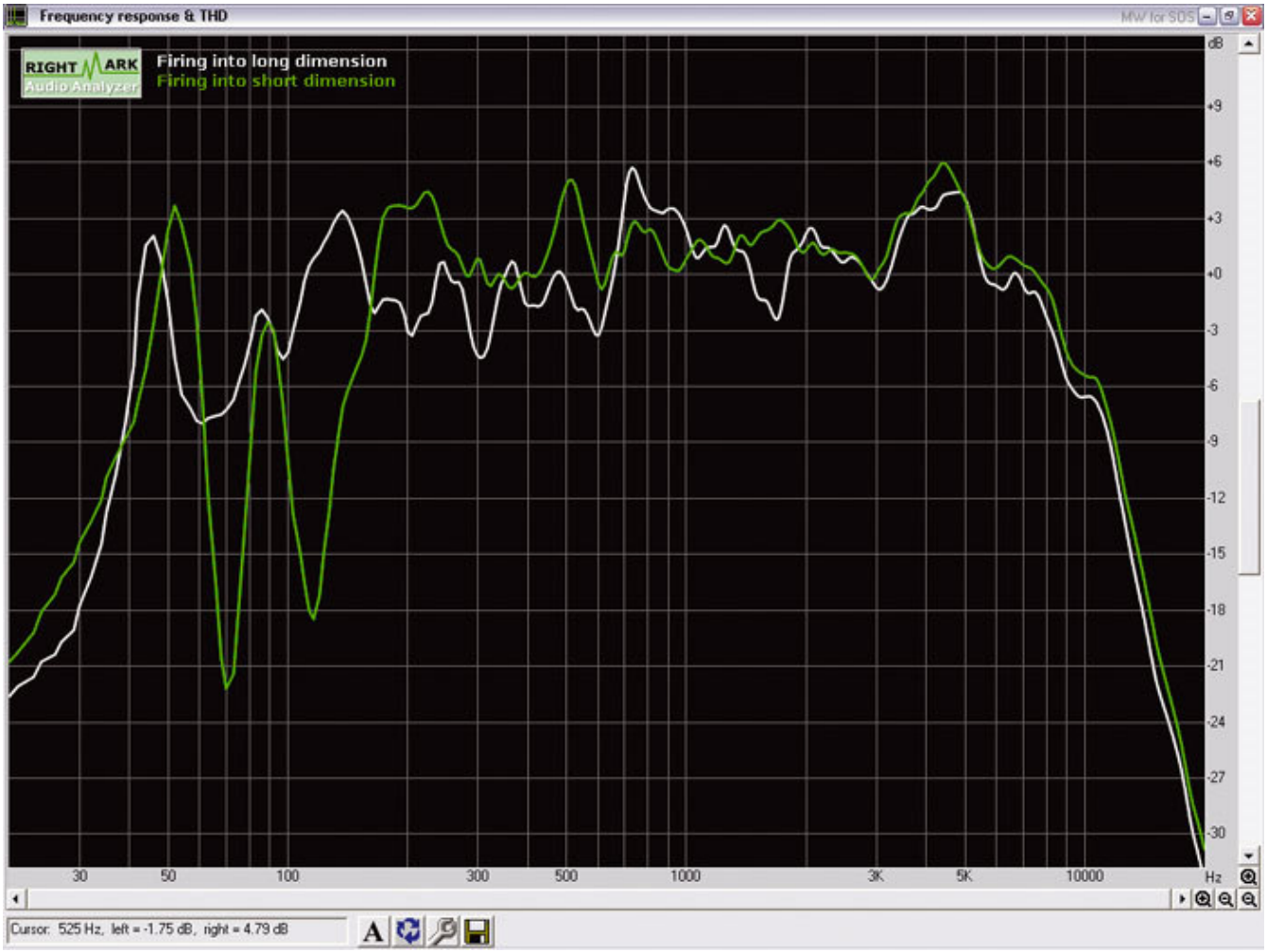

Figure 3: This graph compares the response with the loudspeakers firing down the longer versus shorter dimensions of a room. Image courtesy of Sound On Sound magazine from their MiniTraps review.

FIRST REFLECTIONS: SIDE WALLS

The side wall panels will go slightly forward of the halfway point, and the exact distance is determined using the formula shown below. The panels are centered vertically on the tweeter height, which should be ear height as well.

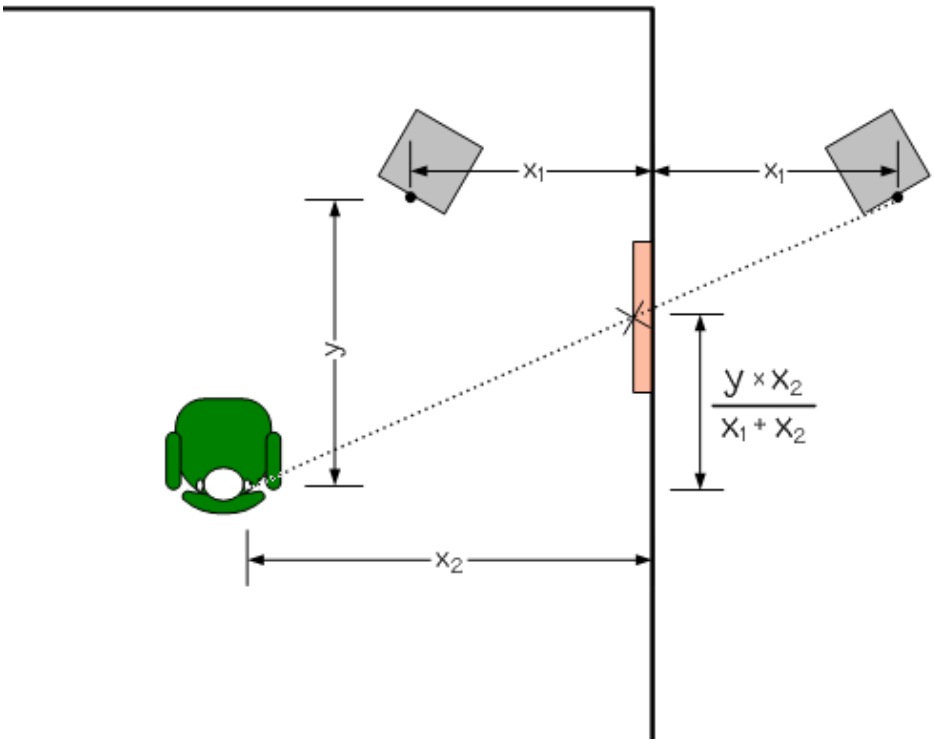

Figure 4: The math behind the placement.

Looking at Figure 4, this simple formula shows how to find the reflection point based on the distances from the side wall to the tweeter, and from the side wall to the listener. You may recognize this as being equivalent to a bank shot in pool. Only the right speaker is shown, but the distances will be identical for the left side too. (I'll explain the phantom speaker shown to the right outside the room in a moment.)

Let's say the speaker is 2 feet from the side wall (x1), and you're 6 feet from that same wall (x2), and the loudspeaker's tweeter is 5 feet in front of you (y). The distance between the wall opposite your head and the center of the panel is solved as follows:

$$\text{Distance} = \frac{y \times X_2}{X_1 + X_2} = \frac{5 \times 6}{2 + 6} = \frac{30}{8} = 3.75 \text{ feet} = 3'9''$$

Another way to look at this is to pretend you have a mirror image of the room on the other side of the wall. This is the extra loudspeaker shown in Figure 4. If you draw a line from the phantom speaker to the listening position, that line will pass through the wall at the reflection point.

With special thanks to Bill Eppler for providing the first reflection calculations, and to acoustics guru Wes Lachot. The following is from a newsgroup post where Wes explained his logic behind the 38 percent rule.

As my article on bass waves illustrates, every bass frequency has a corresponding place or places in the room where there is a null due to destructive interference. The most deadly places to listen are those where the natural modal frequencies of the room are being cancelled, because then you are hearing something completely different from what others in the room are hearing.

For instance, a 14 foot long room would have a large boost generally at 40 Hz due to modes, but at 7 feet from the front wall there would be a serious null at that frequency due to destructive interference. If the listening position were placed at this half-way point, you'd hear very little at 40 Hz while those at the back of the room would hear a boost because 40 Hz is a modal frequency.

Similarly, the second harmonic of 40 Hz (80 Hz) will exhibit a null at the point one quarter of the distance from the back wall. If you listen at this point the same problem is present, where the bass you hear is radically different from that heard at other

points in the room.

If you draw a graph carrying this out to the first 5 or 6 harmonics, you'll notice that the point in the room that is least affected is 38 percent from the front of the room. Coincidentally, this is also the Golden Mean point.

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