Does elevating the L1™ change the line array performance? **L1® Users Forum**

This topic can be found at:
http://bose.infopop.cc/eve/forums/a/tpc/f/3976055944/m/3841041115

ST **Wed December 12 2007, 05:22 AM**

Does elevating the L1™ change the line array performance?
This is one for the Engineers-at-Bose.

From time to time we see references to elevating the L1™. Aside from any safety concerns, I wonder if doing this has any impact on the line array performance of the L1™

In a discussion comparing the MA12 and the L1™ Hilmar-at-Bose tells us that the L1™ is designed to work with a significant floor reflection.

If one were to elevate the L1™ on a platform that did not a flat surface in front of it at the same height as the Power Stand, would this have any bearing on the performance of the L1™?

Would there be impact on performance if one were to place the L1™ at the front of an elevated stage?

If yes, to either of the above, at what height would this be a significant concern?

Reference:

> quote:
>
> **The L1™ is** twice the height and also **designed to work with a significant floor reflection**. The effective height of an L1™ is roughly 3 to 4 times that of a single MA12

Source: L1™ and the Panaray MA12

This message has been edited. Last edited by: ST, Wed December 12 2007 04:41 PM

Oldghm **Wed December 12 2007, 06:33 PM**

> quote:
>
> Originally posted by ST:
> Would there be impact on performance if one were to place the L1™ at the front of an elevated stage?

Hi ST,

I recall commenting on this in a discussion a couple of years back. I have been trying to recall context to do a search but not having any luck. If I remember correctly Cliff was involved in the discussion.

O..

ST **Wed December 12 2007, 07:40 PM**

Thanks Oldghm,

I looked and looked and looked.
No luck.

Let's hope we hear from one of the engineers-at-Bose.

Ken-at-Bose **Thu December 13 2007, 07:40 AM**

My explanation will on the one hand sound nice and neat but in reality the answer is messy and fuzzy.

Caveat emptor.

A nice big hard massive floor can be thought of like a mirror with light. When you put the L1 system against the floor, the effective length doubles because of the mirror image L1 created by the floor (the mirror).

The next interesting thing is that with line source, when you double the length (i.e. add the effect of the floor) you effectively QUADRUPLE the "line-sourced-ness". So, for example, if you observe a certain "line-sourced-ness" at one distance with a line source of some length, then you will observe the same line-sourced-ness at FOUR TIMES the distance if you double its length.

Similarly, if you observe a behavior at one frequency for a line source of a particular length, then you will observe that same behavior at ONE FOURTH the frequency if you double the length of the line source.

Pretty cool.

Now, when you raise the L1 system off the floor, you create a gap between the L1 system and its mirror image equal to twice the height you raise it off the floor. Said another way, you create an array of two L1 sources separated by twice the height off the floor. At higher frequencies this will create a shadow zone in coverage -- okay if the only thing in that shadow zone are legs and knees of the listeners. The benefit is that more ears can "see" more of the L1 source.

But at least some (this is the fuzzy and messy part) of the benefit of "pure" double-length, four-times the effect, line source are diminished because of the gap.

A stage lip is of course an even messier situation. The "mirror" isn't flat but has two offset surfaces, and this creates a more complicated set of image sources. Again, some of the effectiveness of having a big flat floor plane are going to be diminished.

I hope this is of some help to the community.

(Many thanks to Chris-at-Bose who gave me years ago the most lucid explanation of line source behavior, much of which I'm drawing on here.)

Ken

L1 Wiki ::: L1 Videos

Ric **Thu December 13 2007, 10:33 AM**

I understand the shadow zone part of it, where the leg of people in front of a raised stage would not be getting much sound.

But does the rest of the post mean that a raised stage shortens how far an L1 throws? In other words an L1 coupled with a flat stage and connected flat audience floor will throw further?

SMSgt. PmP **Thu December 13 2007, 02:03 PM**

Good Afternoon,

Very interested in how this thread progresses. While I know nothing about the physics involved, I observed the following recently:

Played a gig and for the first time got negative comments on our sound using 3 L1's. Many folks complained they couldn't hear or the sound was 'muddy' in the back of a relatively small room, while the sound was 'too loud' near the stage. Just like the bad old days of my Mackie/JBL set-up.

The one most notable difference between this room and others we've played (where the L1's performed brilliantly, even if we didn't!) was this room had a very tall elevated stage, probably 3-1/2 to 4 feet above the main floor of the room. I suspected having that large, hollow space beneath the L1's was a problem, but have no idea how to address it. We did tilt the L1's downward in an attempt to improve coverage, but the quality/tone of our sound never improved. Everyone in the band could hear the difference and, obviously, our audience could hear it, too.

Am I correct in assuming that the elevated stage was the culprit? Also, what suggestions do folks have to improve the sound in these situations? We are supposed to play the venue again in Feb08, and we're beginning to dread the thought of how we'll sound there.

Chris-at-Bose **Thu December 13 2007, 03:56 PM**

It's hard to untangle this question, because we are talking about four factors that affect throw: having a big flat floor under an L1 (as opposed to no floor at all), the obstruction caused by a lot of people, raising the L1 above the floor, and "lowering the floor only out where the audience is" to make an elevated stage. What is confusing is that the answer about throw distance depends on which combinations of these effects we mean to include. I think there is a way to step through this in a sequence that will give a useful answer for all the combinations encountered in practice.

Start with an L1 suspended in mid-air. Call its throw distance the "bare L1 throw". (I know, we don't encounter this, but it's a reference condition.)

Now put the L1 on a big, flat, hard, empty floor. As Ken said, the new throw distance will be four times the bare L1 throw.

Now add a dense mass of people on the floor. (Popular, aren't you! They must love you and your Bose sound.) They block virtually all the sound reflected from the floor (taking the floor effect out of the picture) AND they block some of the direct radiation from the L1. So the real throw distance now becomes less than the bare L1 throw, possibly far less. Call this the "obstructed throw". Most of us have experienced this at one time or another, unless you're never popular.

Now raise the L1 above the floor. The actual throw distance improves as the L1 gets above the obstruction of all those people. If you hypothetically raised the L1 'way up in the air, you would get

back to the bare L1 throw, but you won't actually raise it that high because the "sound layer" would go over everyone's heads and they would all hear muffled sound. So the throw you get by raising the L1 is farther than the obstructed throw, but not as far as the bare L1 throw. Notice that the floor effect is not a factor in your decision, because all those people are obstructing the floor anyway.

Now, with the L1 elevated, take away the people. What throw do you get? Who cares--put that L1 down, you no longer have a reason to elevate it. (Gotcha!) This trick allows me to avoid having to admit, "I don't exactly know". (Oh, I just did, didn't I. Never mind.)

Let's go back to the case where the L1 is elevated and you are so popular that the place is packed with people. Remember that the throw distance was between the obstructed throw (short) and the bare L1 throw (medium). Now quick, imagine a stage that elevates you up to where the L1 is. People see you better, but do they hear any difference? Basically, no. (I'll explain why in the next paragraph.) So you get the same throw as when only the L1 was elevated, some distance between the obstructed throw and the bare L1 throw. For the audience's ears, the elevated stage is the same as the elevated L1. But they do see you better.

So, why doesn't the stage sound different from just elevating the L1s? Well, as Ken said, you have to imagine the floor as a mirror. If the stage floor were a mirror, how much of the L1 image could the audience see in the floor of the stage? Typically very little. Most of the image is cut off by the edge of the stage. Since they can't see most of the L1 image, that image has little effect on the sound they hear. So, if the stage could be magically removed, leaving the L1s and performers floating, those in the audience would hear very little difference in the sound of the L1. (The bass would change, but we're not talking about that.)

I think that covers the bases. In summary, the only time you really get the 4x longer throw from the floor reflection is when the floor within 50 feet or so of the L1 is hard, flat, and sparsely populated, as it is in some extensive outdoor events. And you need the extra throw for sprawling events like that. When the floor is densely packed, elevating the L1s improves the throw, whether the means of elevation also raises the performers (i.e., a stage) or not.

If I don't mention it, someone will ask about the intermediate case where the density of people is moderate. As always, let your ears be your guide. If it sounds muffled in back, you have an obstruction problem and elevation will usually help. But I must remind you that safety has to come before sound quality. When you say you "killed the audience", we don't want that to be literally true. Be careful.

Hope this is useful.
Chris

ST **Thu December 13 2007, 04:24 PM**

Hi Ken and Chris.

Thank you for this wonderful food for thought.

One more question for now.

Do you think it helps if we can move those wonderful people back from the stage a little. That is, do you think we can regain some of benefit of the mirrored, unobstructed throw by getting more clear space in front of the L1™.

In a larger room, I have always wanted a deeper stage. Not only because we would like to get out in front of the L1™s, but also to get more of that reflection off the floor. Does that fit?

Ooops - here comes another question. Do you think it matters if we have carpeting on the floor in front of the L1™ ?

ST **Thu December 13 2007, 04:40 PM**

Another thought.

I imagine our 24 pistons as firing parallel to the floor. The behaviour must be more complicated than this, otherwise there were be no reflection. But if the effective output is parallel to the floor, how does elevating the Cylindrical Radiator® help when there is an obstruction? Let's say we have elevated the L1™ so we have three feet of Cylindrical Radiator® above the obstruction (people). Wouldn't most of the sound from that top three feet continue parallel to the floor and out over the heads and ears of the people?

Or is it more, that if the ears are below the top of the Cylindrical Radiator® and they can "see" the Cylindrical Radiator®, then they can probably hear the Cylindrical Radiator®.

Chris-at-Bose **Thu December 13 2007, 05:51 PM**

Hi ST,
I'm stuck here at work in a snowstorm--commuter traffic at a standstill throughout the area. Might as well keep posting. I'll take your questions in order of ease.

How does the sound from an elevated L1 get over the heads of the front rows and yet hit the heads in the back rows. This is pretty technical. When sound travels glancingly over an absorptive surface, the sound wave loses energy at its bottom edge into the absorber. That energy must flow downward out of the wave, so the real direction of the sound in a thin layer above an absorptive surface is mostly forward, but slightly downward. The wave above "feels" this small loss of sound below it and also moves downward toward the weaker area. So, gradually the sound is diffracted downward onto the absorbing surface. So even with a perfectly vertical L1, sound over an audience spreads gradually down onto the heads of the people in back. How far back will it go before the whole beam has been absorbed? I don't know, but I'm guessing it takes more than 50 feet if the aiming is optimized.

Carpet. Now think of a very short audience, no higher than carpet.  The sound will very, very gradually get lost into the carpet over long distances. But it must not be a very strong effect, as we know that the sound of the L1 carries long distances outdoors over say, grass, which is also absorptive. For people near the L1, the floor reflection is very slightly weakened compared to a bare floor, maybe not audibly. The biggest effect of carpet is to absorb the reverberation better than a bare floor would.

Clearing a space in front of the L1. I'm not sure about this one. I can think of arguments that the throw would improve, and other arguments that it would not. My intuition is that a clear space would lead to improved sound for the audience on average, because the biggest "damage" seems to be done by the packed people nearby. When you create a clear space in the center by moving people back, the last rows don't move back much, so they don't suffer. In the limit, you could move everyone back to create a semicircle one person deep and there would be no obstruction. But this intuition is a vague notion. I wouldn't get in a car where decisions were made on arguments like that. 

Well, the Mountain Road is clear of traffic, so I'm off to sweep the car and venture home. Think warm thoughts my way.
Chris

Chris-at-Bose **Thu December 13 2007, 07:44 PM**

Made it. Only took five times as long as usual. Flagged down a plow to clear the driveway and paid cash. We've got nearly a foot and it's still coming down. All Boston is a traffic mess. "Miller time."
C

Oldghm **Thu December 13 2007, 08:59 PM**

If my brain was as well developed and organized as Chris', I wouldn't have to ask, but my comprehension is lacking so.....

In most instances we are shown and told that the L1 performs in a pie like slice of space in front of the speaker, suggesting something like a 7 foot tall 170 degree wide laser beam. In this discussion we talk about the reflection or mirrow image as if the L1 projects as a more normal source of light.

Thankfully I'm not so popular as to be experiencing any problems, but still would like to better understand what seems to be diverse information.

Specs could never be this interesting.

O..

Mike in Texas **Fri December 14 2007, 11:13 AM**

Curious - did you guys ever consider the line arrays / speaker columns being placed elevated and PARALLEL, above the band? 6 or 7 years ago I saw the newly reformed Eagles in concert in Dallas, shortly after Heck Freezes Over. The system they used was very different at the time. It was Infinity I'm pretty sure, and they had arrays above the band, nothing to the side. This inspired me to do most of a year researching an alternative to the triple, first closing in on Panaray 802's, and then, thank goodness, the P.A.S. came out! Hooray ever since!

Chris-at-Bose **Fri December 14 2007, 01:09 PM**

Hi O,
Actually, your brain must be in fine shape, as you are right that the mental model of the L1 radiating a pie-wedge of sound is incompatible with the mental model of a "mirrored" floor reflection affecting the throw. I was wondering when this question would come up.

What is useful about the pie-wedge idea is that it defines boundaries where people's heads should and shouldn't be, in order that they hear good sound from the L1. It's a simple idea that works really well for all of us. But we know that some sound does escape from the "layer". Let's explore that. If you don't have a foot of snow on the ground outside, you could check what I'm about to say yourself and see if you agree.

Imagine setting up a single L1 outdoors in a large flat area. It's more obvious if you don't use a B1, and it doesn't really matter for this experiment whether you have a Model I or II. Bring a stepladder and some canned music to play through the L1. Set the ladder up about 3m (10 ft) in front of the L1 and start the music. As you climb the ladder step by step, the sound suddenly gets very dull when your eyes get above the top of the L1. It's a sharp and startling effect at this distance. But you still hear the low register from the L1. Clearly the lows are "escaping from the layer" even at this distance.

Now drag the ladder out to 10m (~30 ft) and repeat. The effect in losing the highs is still very sharp, but now you can hear some more midrange above the layer than you had at at 3m. And you still hear the lows above the layer. At this distance, the lows and mids are escaping from the layer.

Now take the ladder out to 30m (100 ft). Here the whole effect is gentle. You may have to get quite high on the ladder to notice the loss of high frequencies. Even the highs are beginning to escape the layer at this distance. The layer is beginning to dissipate by spreading vertically.

Okay let's go inside for some hot chocolate and think about this.

So, a good mental model that goes one step beyond the pie-wedge idea is the idea of a layer, where the lows spread out first, then later the mids, then later the highs. So this is the sound that actually gets reflected from the "mirror" floor.

Now, the "leakage" off the bottom of the layer reflects from the "mirror" and "folds back into the layer" and is now leaking slowly upward within the layer. It's not very strong compared to the layer itself, so

we have a hard time hearing that it is there, but it is. Detailed measurements or predictions can see it.

Now comes the coolest part of all: when the reflected lower leakage reaches the top of the layer, it mostly CANCELS with the original upper leakage! Cancels, not adds. And this happens all along the top of the layer at all distances! So adding a floor below an L1 actually decreases the amount of leakage ABOVE the L1 layer. That's where the extra 4x throw distance comes from--a reduction of leakage by partial cancellation. Is that amazing or what?

Sounds like magic, doesn't it. But it's simple; the extra travel distance that the reflected lower leakage took makes it become out of phase with the upper leakage, which went straight to that point. It's "phase cancellation" doing something good for a change. For every frequency, this partial cancellation effectively "postpones" that frequency's escape from the layer until farther away from the L1. Hence, longer throw.

QED

Chris

Col. Andy **Fri December 14 2007, 01:38 PM**

HI Chris. What a cool explanation. Even I understood it.

Respect

BabyBlueEyes **Fri December 14 2007, 02:14 PM**

Time and again we read about low ceiling set-ups, or what-to-do-in-case-of types of settings. If the hard, smooth, flat floor (ideally perpendicular to the perfectly plumb radiator) is in play as much as it is, why not a comparably close ceiling (disregard materials for the question)? If the ceiling is as close to the top of the loudspeaker as the limiting length of the bayonet (which is close enough to the height of the power stand), what now?

N

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Jazzman888 **Fri December 14 2007, 03:07 PM**

Hello Chris,

I take it that the word "throw" as you use it is not synonymous with "sound pressure level", "volume", or "how loud the sound appears to the ear", since anytime there is phase cancellation, there is a net reduction in sound pressure level. I think you mean that "throw" is the distance that a cylindrical wave maintains its unique properties. It would clarify things if you could verify this.

Also, at 100 ft., if you can hear the highs when you are near the top of the ladder, then the "throw" must be less than 100 ft., since at that point, because you can hear the highs, the wave is losing its cylindrical properties. Does this mean that without the benefit of reflections from a floor, which would be the case with a raised stage situation, that the "throw" is 25 ft. or so?

W.A.

Chris-at-Bose **Fri December 14 2007, 04:07 PM**

Hi Nathan,
The "mirror" analogy will serve us well here. Imagine a mirrored floor below the L1 and a mirrored ceiling just above the top cap. (Since it's imagination, we don't have to leave room for the bayonet during assembly.) What would you see when you looked at the L1 and its images from the audience

area? An infinite number of images both above and below the real L1. It would look almost like a continuous line source going on forever above and below. A true cylindrical radiator, radiating a true two-dimensional sound field, falling off at 3 dB per doubling of distance for as far as the floor and ceiling extend.

It is hard to believe that many discrete images with overlapping "imperfect" sound fields can add up to a continuous, simple, smooth sound field, but that is what happens mathematically. Two short ideal line sources stuck together end-to-end are identical to a single longer line source, so the sum of the sound fields of the two short sources has to be identical with the field of the longer source. If you apply the same principle again to the longer source, the same thing happens again. And again. And again. So the sound field radiated by an infinite number of little line sources stuck end-to-end is mathematically the same as the radiation pattern of a single infinitely tall line source. Again, verrrry cool how that works.

Although L1s are not ideal line sources, and floors and ceilings are not perfect reflectors, and the geometry is never square and plumb, and there are little gaps at the floor and ceiling, all these small effects aren't enough to invalidate the mental model of all those images adding up to a very tall line source, so that the field would really be very close to cylindrical.

That said, my intuition is that most low-ceilinged spaces aren't very acoustically friendly to the ear, no matter what the source is. I'm not sure why that is, though. Mysteries remain.
Chris

Chris-at-Bose **Fri December 14 2007, 05:38 PM**

Hi Jazzman,
Good to "see" you.

> quote:
>
> anytime there is phase cancellation, there is a net reduction in sound pressure level. I think you mean that "throw" is the distance that a cylindrical wave maintains its unique properties. It would clarify things if you could verify this.

I was about to agree, but then I thought more carefully.

There is increased level of anywhere from 0 to +6 dB within the near field layer when the floor is added. It has to be exactly +6 dB at the floor where the direct and reflected are the same magnitude and phase. The interference is constructive there, not a cancellation. As you move up from the floor at any distance, the reflection magnitude is decreasing and its phase is shifting slowly, so eventually you go from constructive to destructive interference and it works out nicely that this happens at the top of the layer. But there is not a pronounced volume increase at ear height at normal distances, I think. (I've never made the floor come and go with an A/B switch, so I have some uncertainty on this.)

However if you were really in the far field of a geometrically perfect L1 system (a long way away), then adding the floor would narrow the polar pattern by a factor of 2 and add +6 dB throughout the new main beam of that pattern. All speakers get this +6 db in their far fields, if they are right on the floor and you stand far from them, but on that floor.

So, now that you bring it up, I guess I'm going to say that the sound pressure level really does increase in general when the floor is added. So "throw" increases in both senses. But I wasn't referring to the level effect when I wrote about throw above. I was referring to the shape of the near field.

I'm still working on your second point. More later.
Chris

Drumr **Sat December 15 2007, 10:17 AM**

Chris,
I'm thankful for the snow in Boston, it's given you lots of time to think & type. I am enjoying the read.
It's snowing here right now...4" so far, I have a gig tonight on top of a high hill.