S O U N D P R O J E C T S

SUB-COVERAGE
AND THE PLACEMENT OF SUB-STACKS

SOUND PROJECTS
Jonkerweg 17-19
1217 PM Hilversum
The Netherlands
Phone +31 (0)35 6213233
Fax +31 (0)35 6215455

Contents

1 PHYSICAL APPROACH TO SUB BEHAVIOUR

Since all separate sound sources interfere with each other, so do sub-sources!
If cabinets are stacked closely together, there is no problem. They will all work together coherently (will not interfere). However, when two or more stacks are separated largely enough (more than approximately 2 m) this is no longer the case. The different path lengths that now exist become of such a scale, that the emerging sound waves from the stacks can be either in phase or out of phase. This creates constructive or destructive interference in the audience, better known as "hot-spots" and "dead-spots". Because of the physical fact that low frequency sound waves have long wavelengths (80Hz-20Hz: 4,25m-17m, respectively), their interference patterns are also large and so are the "dead"- or "hot-spots". In case of low frequencies, the "dead- spots" are therefore much more pronounced than with higher sound frequencies. As we will see in the next section it's indeed in fact not really "**dead-*spots***", but more "dead-***areas***" that increase in size further away from the stacks.

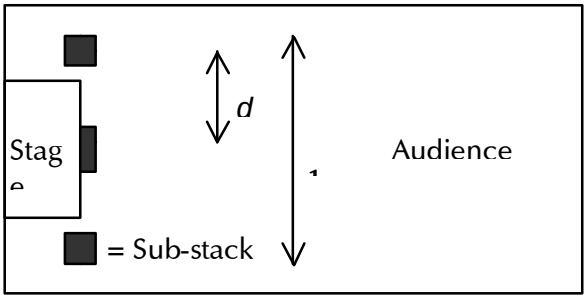

Fig.1 typical sub-stack layout (topview).

Unfortunately most venue sizes and stage orientations are of such measures, that a stereo sub set-up (two stacks beside the stage) produces rather large "dead-spots" within the audience. Mostly oriented near the middle. If such spots are present, it degrades not only the objective ***overall sound quality***, in fact it degrades the whole experience for a large part of the audience, encountering either too much or too little sub low.

There are two important parameters for horizontal sub placement. This the overall horizontal width of the sub placement (distance ***D*** in *Figure 1*.) and the horizontal separation distance between the stacks (distance ***d*** in *Figure 1*.).
If the distance between the stacks is too large (more than 2 meters for 80Hz, more than 4 meters for 40 Hz and more than 8 meters for 20 Hz) dead spots will appear in the audience.
If the overall horizontal width of the sub placement is smaller than the width of the audience area it will also create dead spots, but only oriented to the sides of the audience area.

Ideally, only uniformly horizontal spreading of the subs over the ***full width*** of the room or audience area will get rid of these "dead-spots", assuming they are placed close enough (less than 1/2 the shortest wavelength). However, such sub distribution will often be difficult to realise, since space is something, which is often not sufficiently available. Furthermore when the number of sub cabinets is limited, horizontal spreading disturbs the possibility of making the sub stacks high enough to ensure vertical narrowing of sub coverage angles. This grows to be particularly important in rooms with high ceilings or with outdoor venues (the rules for horizontal sub coverage apply in the same manner to vertical sub placement and vertical coverage).
Fortunately as it turns out, in the case of most medium size venues, a three-way set-up with a (small) sub centre cluster will often be sufficient to do the trick (as we will show below). In any case it is important to realize that the position of your subs greatly can influence sub coverage and therefore low frequency quality within the audience.

2 Examples and simulations

2.1 Two-way versus three-way setup

The interference patterns of a two-way versus a three-way sub set-up are displayed (figures 2-5), as they would appear on the ground of a venue. The light grey parts are high SPL levels the darker parts are low SPL levels. The figures represent a typical medium range venue with a width of 20 meters and a length of 40 meters (for exact reference; the plot is 18 meters wide and 45 meters long, the outer speakers are positioned 12 meters apart).
The SPL distribution simulations clearly show the large "dead-spots" (black areas) in case of a 2-way sub stack configuration[A], for frequencies from 30 Hz to 80 Hz. Whereas the set-up with a sub centre-stack[B], has a much more uniform SPL distribution throughout the whole sub frequency spectrum.

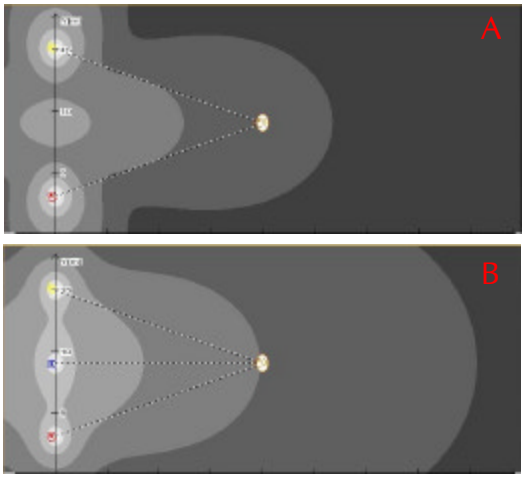

Fig. 2 frequency 20Hz
A: 2-way set-up, B: 3-way set-up.

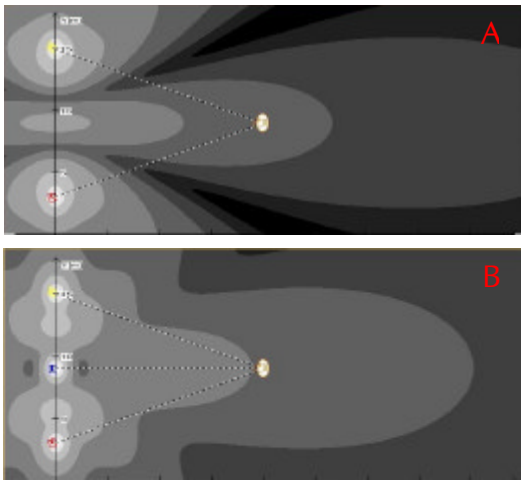

Fig. 3 frequency 40Hz
A: 2-way set-up, B: 3-way set-up.

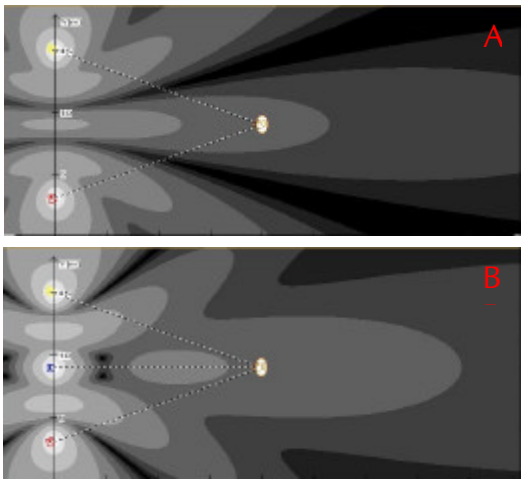

Fig. 4 frequency 60Hz
A: 2-way set-up, B: 3-way set-up.

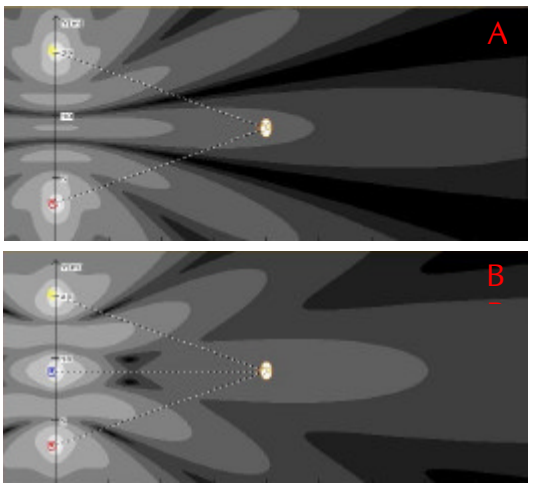

Fig. 5 frequency 80Hz
A:2-way set-up, B:3-way set-up.

In figures 7-9 the sub-frequency response is compared between the 2-way sub-stack set-up and the 3-way sub-stack set-up, for the positions indicated in figure 6. The plots represent the sub-frequency response as perceived by the listeners in the audience standing at those positions.

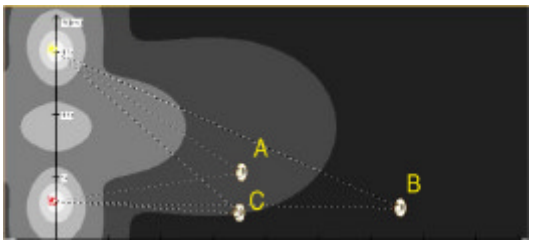

Fig. 6 positions for which the frequency response is plotted in figure 7-9.

In case of the 2-way set-up, the listeners at positions ***A*** or ***B*** will not hear any frequencies between 60Hz-100Hz, while listeners at position ***C*** will not hear any frequencies between 10Hz-40Hz. The advantage of a 3-way sub-stack set-up is clearly shown by the plots. The sub-frequency response is much more uniform for all three positions.

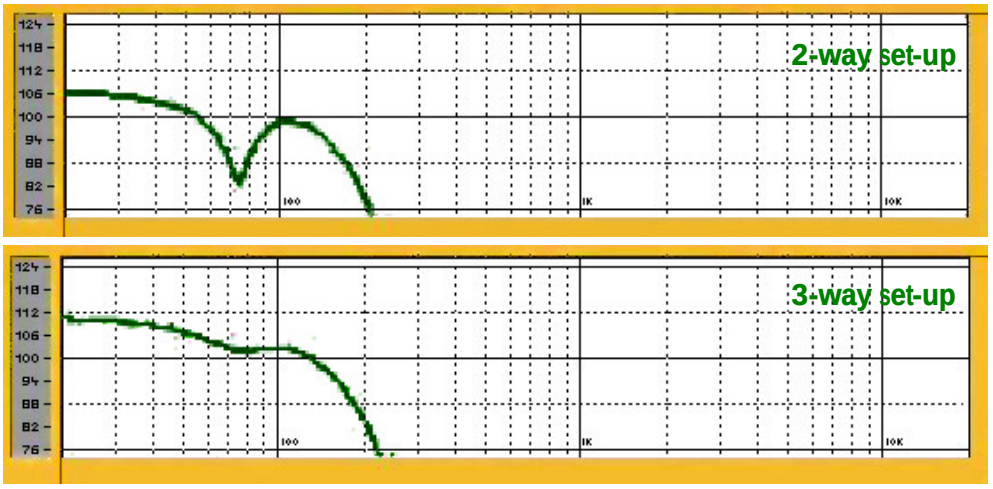

Fig. 7 frequency response at position *A*.

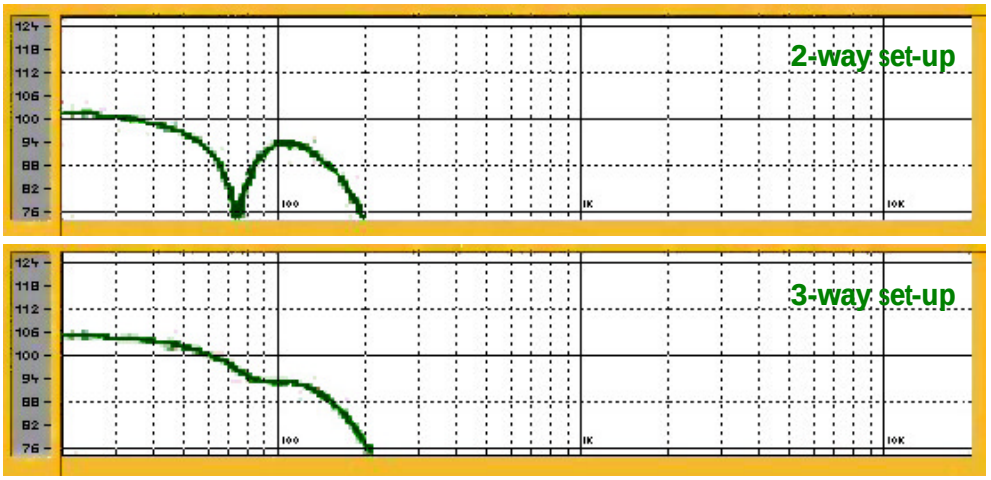

Fig. 8 frequency response at position *B*.

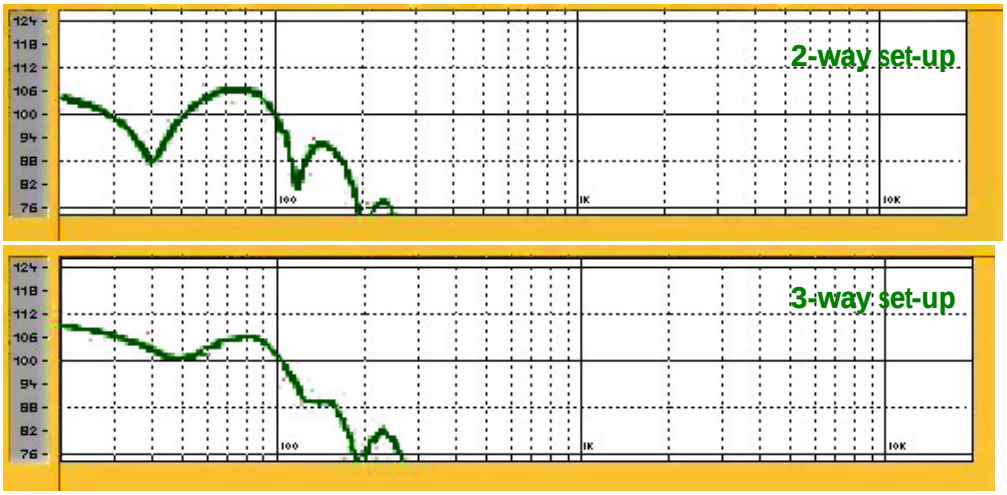

Fig. 9 frequency response at position *C*.