DYNACORD

Compact Line Arrays or Horn-Loaded Loudspeakers ?

Guenter J. Krauss TELEX Communications Inc., EVI Audio GmbH

There is a never ending discussion in the sound reinforcement industry on the pros and cons of line arrays vs horn loaded loudspeakers.

As a matter of fact, line arrays have earned an exceptional acceptance for large-scale concert sound systems, so there must be some real acoustic advantages of line arrays for this type of application compared with horn-loaded loudspeakers, otherwise the ‘hype’ would already have disappeared.

Compact Line Arrays seem to violate the basic acoustic principles of line arrays but are now successfully in use worldwide. So the said violation of the acoustic principles of line arrays seems to be overcompensated by some other advantages.

Traditional horn-loaded systems are still in widespread use with great success.

Every existing sound reinforcement technology has its advocates, sometimes quite militant ones, and there is definite some uncertainty among end users what approach is best for their purposes.

This paper is focused on some acoustic and economic aspects of Compact Line Arrays vs traditional horn-loaded systems and is an attempt to rationalize the discussion and to help the end user to make the optimum decision for his application.

1 Sensitivity of Compact Line Array Components vs Horn Loaded Loudspeakers

Almost all line arrays use direct radiating cone type speakers of comparably small diameters for the low and midrange frequencies in order to keep the vertical distance between the acoustic centers of the transducers below half a wavelength at the upper end of the transmission range. The maximum sensitivity of such components is about 100dB/1W/1m. There are some exotic exceptions to this figure, but let us take the 100dB/1W/1m as a given here.

Horn loading increases on-axis sensitivity significantly, so one can expect approximately 6dB more sensitivity from a horn-loaded system. The maximum sensitivity advantage of a horn-loaded loudspeaker on axis can be up to 10dB compared with a direct radiating system but the SPL improvement depends heavily on the coverage characteristics of the respective horn.

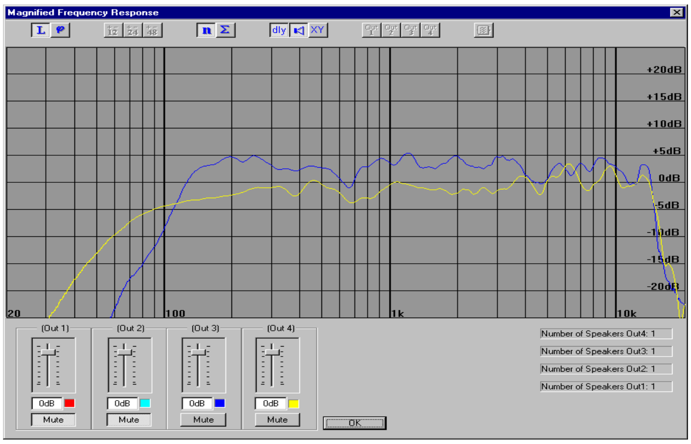

Fig. 1 On-axis SPL of a COBRA-TOP (lower curve) Compact Line Array cabinet vs a V12-60P coaxial horn-loaded cabinet

Fig. 1 shows a sensitivity comparison between a typical Compact Line Array cabinet (COBRA-TOP) and a typical coaxial horn-loaded cabinet (V12-60P).

The on-axis mid-band sensitivity of the coaxial horn-loaded cabinet is approximately 6dB higher than the sensitivity of the Compact Line Array cabinet, the coaxial horn-loaded cabinet is simply 6dB louder on axis.

In order to realize the same mid-band on-axis SPL with the Compact Line Array cabinet one has to use two vertically-stacked Compact Line Array cabinets instead of one.

As a rule of thumb, for equal on-axis sound pressure levels one has to use twice the number of line array cabinets compared with the number of horn-loaded cabinets in a traditional system.

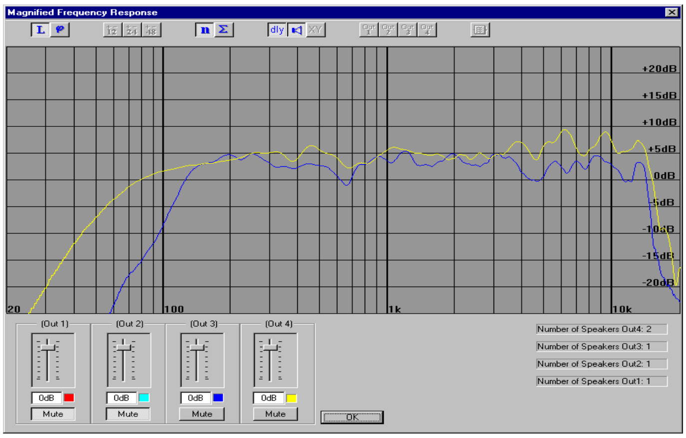

Fig. 2 On-axis SPL of two stacked COBRA-TOP Compact Line Array cabinets vs one V12-60P coaxial horn-loaded cabinet

Fig. 2 shows a sensitivity comparison of two vertically stacked COBRA-TOPs compared with a V12-60P. The mid-band on-axis sensitivities are now equal. For the low frequencies the stacked COBRA-TOPS shows a definite advantage in frequency response at low frequencies and can be used as a full-range system without additional subs.

2 Horizontal Polar Patterns

Fig. 3 shows the beamwidth (-6dB) diagram of a typical 60°*40° coaxial horn loudspeaker. The horizontal coverage is almost constant between 600Hz and 16kHz. Below 600Hz the beamwidth steadily widens up. This is due to the comparably small dimensions of the low-mid horn. Sufficient horn dimensions for constant directivity at low-mid frequencies lead to bulky cabinets and are not very popular today.

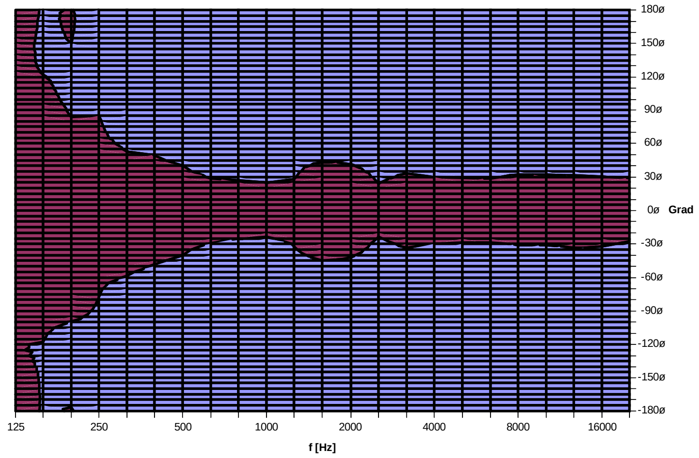

Fig. 3 Horizontal beamwidth (-6dB) of a typical coaxial horn-loaded cabinet

The horizontal beamwidth characteristics of a COBRA-TOP are shown in Fig. 4. The horizontal beamwidth is approximately 120° down to 300Hz, so the COBRA-TOP's horizontal coverage

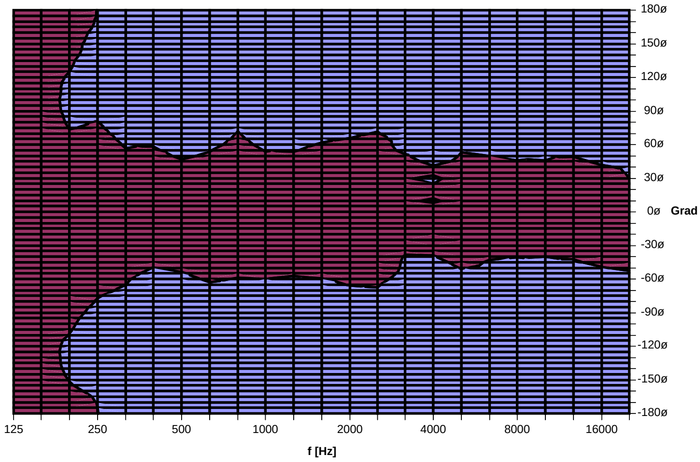

Fig. 4 Horizontal beamwidth of a COBRA-TOP Compact Line Array cabinet

is still 'constant directivity' more than an octave below the coaxial horn-loaded system of comparable size.
Therefore, even in very reverberant environments the intelligibility of the Compact Line Array cabinet can off-axis be significantly better than the more 'High-Q' horn loaded cabinet.

3 Vertical Polar Patterns

The vertical radiation characteristics of a 2*12” horn-loaded cabinet are shown in Fig. 5. The vertical beamwidth is a very consistent 40° from 400 Hz up to 16kHz. The excellent vertical characteristics at lower frequencies are a result of the vertically oriented dual 12” column, not a horn-related directional characteristic.

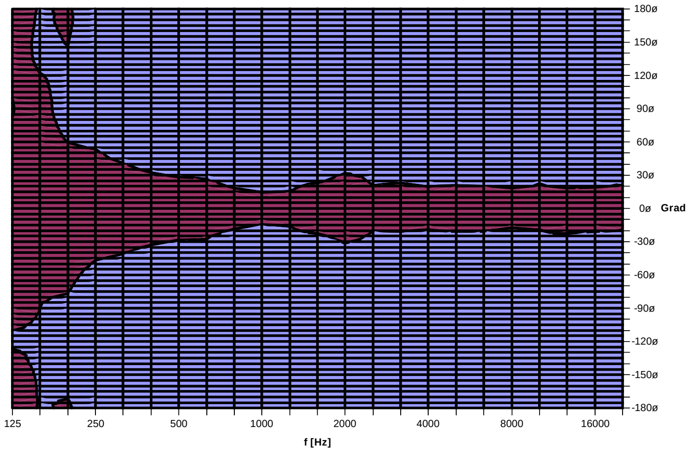

Fig. 5 Vertical beamwidth of a typical 2*12” horn-loaded cabinet (V24-60P)

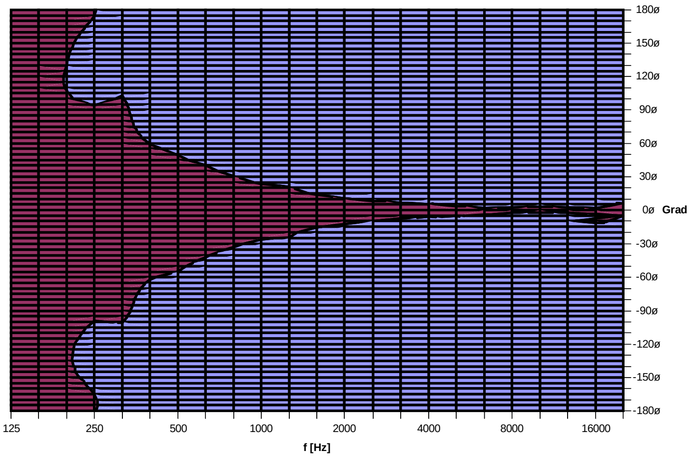

Fig. 6 Vertical beamwidth of a COBRA-4-FAR cabinet

Every ‘real’ line array component shows similar beamwidth characteristics as a COBRA-4-FAR cabinet shown in Fig. 6. The vertical beamwidth is strongly frequency dependent and reaches a small value at high frequencies. For a COBRA-4-FAR cabinet and other line-array components of similar height, the vertical beamwidth is 5° at 10kHz and applications where a large vertical coverage angle is required, e.g. high lecture rooms or theatres cannot be covered with a single cabinet or simple set-ups. For such applications a typical horn loaded system with a well-defined vertical coverage is normally the better choice.

4 Vertical Stacks

In order to realize sufficiently high sound pressure levels for larger audiences or for applications with extremely noisy patrons commonly cabinets are stacked vertically to increase the throw and the maximum available SPL. As a rule of thumb, every doubling of the number of cabinets increases the on-axis SPL in the far field by 6dB. It is now interesting to look at the resulting vertical characteristics of typical stacks of horn-loaded cabinets vs line-array components. For clearer visibility of the principal differences a point-source simulation [1] for the different technologies at a frequency of 1kHz was used in Fig. 7 and Fig. 8 respectively.

The distance between the centers of the horn-loaded cabinets in Fig. 7 is 60cm, quite typical for todays coax horn loaded mid-size cabinets. This distance is much larger than half a wavelength at 1kHz and strong vertical sidelobes exist as can be seen in Fig. 7. The stack does not only project sound to the audience but there are frequency dependent lobes towards the ceiling and the floor. The influence of the floor reflections on the perceived sound quality heavily depends on the amount of audience present.

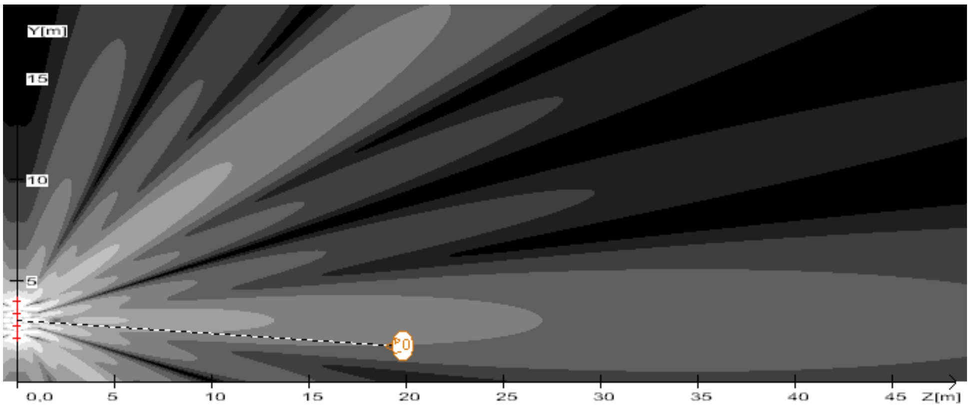

Fig. 7 Vertical plane SPL distribution of a typical four unit stack of horn-loaded cabinets at 1kHz

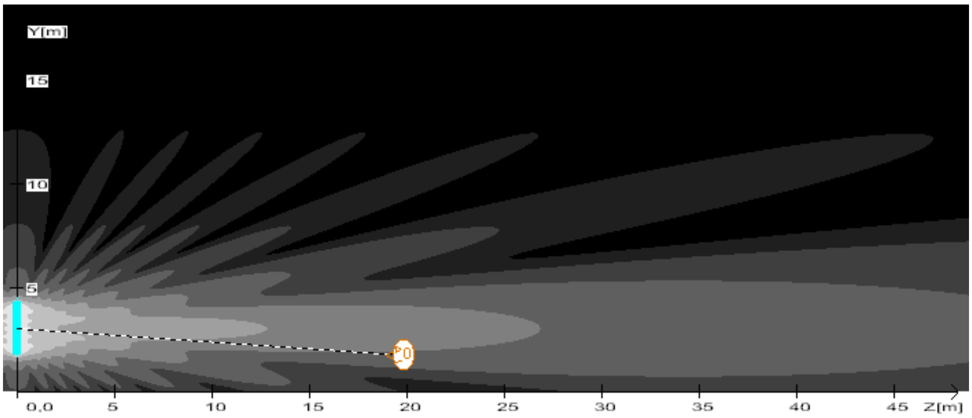

Fig. 8 Vertical plane SPL distribution of a typical four unit stack of Compact Line Array cabinets at 1kHz

For comparison purposes Fig. 8 shows the level distribution for a Compact Line Array stack with four cabinets. Here the sidelobes are significantly less pronounced and the projection to the floor and the ceiling is much better controlled than in a typical stack of horn-loaded coax cabinets. Hence the perceived acoustics are less sensitive to the presence or absence of an audience.

An interesting detail can be seen from Fig. 8. In a plain audience area, the patrons walk ‘along the edge’ of the constant SPL balloon and the SPL does not change according to inverse square law but remains quite constant. In our example the SPL difference between 4m and 40m is only 11dB but this has nothing to do with ‘cylindrical wave propagation’ but is the result of the directional characteristics of a Compact Line Array.

5 Midrange Distortion

Almost all line arrays use direct radiating cone type speakers of comparably small diameters for the low and midrange frequencies. Cone type direct radiators have an order of magnitude lower distortion figures than regular compression driver-horn systems due to several reasons, so most line array cabinets show a ‘cleaner’ sound quality in the vocal range. Nevertheless, some customers prefer the ‘bite’ and the ‘vocals-in-the-face characteristic’ of a classical horn-loaded system and there is nothing to argue against personal preferences.

6 Conclusion

So what is better, Compact Line Array Systems or horn-loaded coaxes?

One could do a MT matrix and weight the pros and cons but the weighting and the results still would heavily depend on personal preferences.

From a purely economic point of view I would say that coaxial horn-loaded loudspeakers are the preferred choice for systems where high on-axis SPLs are most important at moderate cost and for applications where a large, well defined vertical coverage angle is required .

Compact Line Arrays are more expensive for the same on-axis SPL but have the advantage of better horizontal coverage of almost plain audience areas, predictable acoustic parameters in varying stack sizes and inherently lower distortion figures.

7 Literature

[1] Beranek, Leo L., Acoustics, Mc-Graw-Hill, 1954