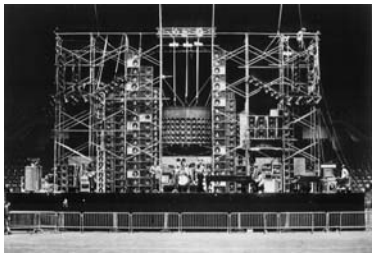
The line array in theory & praxis

Line arrays have dominated the sound transmission in modern entertainment technology of music festivals and international sports events for more than ten years now. These sound reinforcement systems can easily be identified by their slightly bent shape which is a reason why they are sometimes called „bananas“ in colloquial speech. More and more, line arrays can be found at smaller venues like medium-sized concerts and political events. This opens the market for more compact systems with easy handling and modest costs in order to operate in a profitable way.

In retrospect:
More than 50 years ago, the American engineer Harry F. Olson developed the theoretical basis for line arrays in his standard work „Acoustical Engineering“. Unfortunately, his insights were only realized in column speakers which can be seen in churches and other venues fighting with reverberation. In these column speakers, several loudspeakers ranging from 3 to 5 inches are vertically aligned for transmitting speech between 200 Hz and 4 kHz. These speakers are not perfectly suited for transmitting music. Another example is a hi-fi system designed by Rudy Bozak in the fifties and sixties with up to 12 vertically aligned tweeters.

In parallel, a radical change in requirements for voice and instrument amplification could be noted from the fifties and the upcoming of rock music. While jazz was performed mostly without any electric equipment way into the sixties, the success of rock and beat music was from the very beginning based on the volume presented at concerts. With amplifiers and voice amplification in the medium two-digit watt range, this volume could only be realized in dark and small basements in Hamburg or Liverpool where popular bands like the Beatles performed. A very important aspect why the
Beatles did not play any major concert after 1966 was the simple reason that the reinforcement systems available at that time, were not at all suitable for large sports arenas and for reinforcing the more and more complex music of the Fab Four.



In the United States, especially the band Grateful Dead tried to solve this problem via a gigantic piling up of loudspeakers. The „Wall of Sound“ was developed and optimized by the band‘s sound engineers for years and it included up to 641 individual loudspeakers with a total RMS power of 26.4 kW. In miniature, a similar concept was adopted by Udo Klempt-Gießing for the cult band Grobschnitt from Hagen, Germany.

It was not before 1983 that Joseph D‘Appolito suggested simultaneously using hi and mid speakers in several vertically aligned, but horizontally guided cabinets. It would take another decade until Christian Heil presented the first line array in its current definition to the market. Ever since, the triumphant success of line arrays could not have been stopped anymore.

The PSSO CLA (Compact Line Array system):
The Compact Line Array system by PSSO is the answer to the industry‘s tendency towards line arrays and against conventional amplification systems.

While most available line array systems on the market are not profitable for small to medium-sized venues, the PSSO CLA system was especially designed for this purpose. The innovative reinforcement system unites several core characteristics which make it very attractive for installation and hire:
The weight of the mid/high column is amazingly low, due to special plastic components for the cabinet and modern neodymium technology for the speakers. Its modern design makes this system also adequate for mere voice amplification and gala performances.

By combining the tops with the matching 15“ subwoofer and 18“ subwoofer, the system can be upgraded to a full power line array system. And as the efficiency is more than convincing it provides enough sound for large halls and open-air events. The compact size is no obstacle.

What makes the compact line array unrivaled is its sophisticated and safe flying hardware. Only two technicians are needed to comfortably set up the entire system. All security-relevant parts are regularly tested by an accredited testing institute. A fact which sets the PSSO CLA apart from other manufactures in this price segment.

With the CLA system, PSSO offers a flexible tool for all kinds of different tasks in the sound reinforcement business. The
system is an economical line array fulfilling all safety requirements, which can be easily installed and convinces by its sound, according to the slogan „I love Sound!“.

This second part of our line array series deals with the physical aspects of such sound systems. Quite a complex subject yet we have tried to give you a comprehensible access.

The basic problem of every sound reinforcement system for large venues is the fact that an individual speaker cabinet cannot supply the complete audience with the required sound pressure level. Even if the audible transmission range between 20 Hz and 20 kHz is separated into five or more different speaker sizes, the necessary characteristics required for audiences with thousands or even a hundred thousands of people cannot be produced – even with the latest technology.

Furthermore, destructive interference occurs even when using only two speakers at once. Interference occurs when sound waves from two different sources overlap and lead to undesired amplification or elimination of parts of the frequency range. The aim of every sound reinforcement system is to minimize destructive interference and to provide the desired signal level at every position in the audience are.

For reaching this aim, speaker clusters were used for a long period of time where several technically identical speaker systems are horizontally and vertically grouped together. Due to sophisticated cabinet constructions and the use of horns in front of the individual drivers, the efficiency, i.e. the realistic electric power converted into sound pressure level, could be increased while reducing the interference areas within the crossover areas between the individual speaker systems to an acceptable level and thus getting closer to a physically ideal point source.

The sound pressure level is reduced by 6 dB for every doubling of the distance from the speaker system, although this only applies to ball waves, i.e. undirected sound sources. Especially in closed rooms, a point is very fast reached where the diffuse sound, i.e. the sound reflecting from the walls and ceiling, reaches the same level as the direct sound from the speaker system. From this point on, the destructive interference is so strong that the acoustic performance can only be recognized in a strongly falsified manner. This distance is referred to as critical distance. One solution is applying delay lines where the transmitted signal is “refreshed” before the critical distance, thus enabling a large or longer audience area at large venues. Nevertheless, the delay speakers must reproduce the signal with a delay as the speed difference between acoustic and electric signal transmission is already audible from only 20 meters away. This is where the name “delay line” comes from.

Another disadvantage of this procedure is the significant sound level loss even among the first meters of the audience area. According to the already cited formula, the sound pressure level at eight meters distance is only one eighth of the level in one meter distance from the speaker system clusters. Often, this problem was solved by more volume which is not only a health hazard in the stage area, but may also have a negative effect on the sound quality and sound level on the stage and which can no longer be recommended with today’s emission guidelines.

Überlappungsbereiche bei der konventionellen Cluster-Bildung

(Quelle: „Mysterium Line-Array" von Volker Holtmeyer)

Line arrays are the next logical step in this chain of cause and consequence. With line arrays, it is possible to minimize the basic problems of conventional cluster systems. With line arrays, it is possible to minimize interference between the vertically aligned speaker systems by a vertical dispersion of less than 15°, to increase the coverage and to keep the sound pressure level constant for the maximum number of people in the audience by curving the system, i.e. setting the individual components at a specified inclination angle. Furthermore, line arrays can realize a larger horizontal dispersion angle than horn systems.
In order to realize this, some physical problems need to be solved. While the vertical alignment of several low speakers or mid speakers is easy and already applied in the column speakers as described above, more problems occur with higher frequencies. Thus it is not possible to realize the necessary, very low distance between high speakers via standard horn speakers or cone speakers. This distance between the speakers and the number of signal sources in vertical alignment and the curving angle is very important for the acoustic aim of the line array technology: the production of a coherent wave front.

In order to reach this aim nevertheless, so-called wave guides are used. They enlarge the output of the individual sound source which makes a very low distance between several vertically aligned sound sources possible. Additionally, these wave guides modify the delays of the sound waves in the transmission area of the hi speaker in a way that building a coherent wave front is possible.

With an ideal line array, a sound pressure level loss of only 3 dB for doubling the distance could be realized, in reality and depending on the system and the number of elements used, this value lies somewhere between the ideal 3 dB and the 6 dB of a cluster system. Thus using delay lines is still necessary especially for larger venues, but within a higher distance to the main PA. The reason is the improved directivity of the systems in comparison to conventional horn speakers.

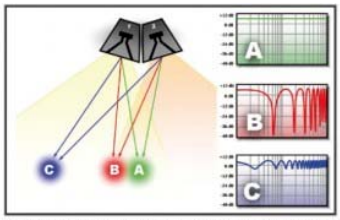


Abb. 3-1 Interferenzerscheinung durch Clusterbildung von Lautsprechern

(Quelle: Diplomarbeit von Benjamin Lampert)

Introducing line arrays led to a reduction of individual speakers up to one quarter which provided additional resources for lighting and video technology. With the introduction of the DMX protocol in 1990, it was especially the concurrent digitization of the lighting technology that considerably benefited from the smaller and lighter sound reinforcement systems.

Sources and further reading:

- Harry F. Olson: Acoustical Engineering (1957)
- Joseph D'Appolito: A Geometric Approach to Eliminating Lobing Error in Multiway Loudspeakers (1983)
- Anselm Goertz: Theoretische Grundlagen und die praktische Anwendung von Line-Arrays in der Beschallungstechnik und ihre Berücksichtigung in Simulationsprogrammen (2002)
- Volker Holtmeyer, Dieter Michel: Computersimulation von Line-Array-Lautsprechersystemen (2003)
- Volker Holtmeyer: Mysterium Line-Array - Mode oder Trend? (2003)
- Volker Holtmeyer: Line-Arrays – The Hype Goes On (2006)
- Benjamin Lampert: Praxisnahe Simulation von Line-Array- Lautsprechersystemen mittels
Directivity-Balloons (2006)