System Integration: MX9000

While the use of multiple conventional digital signal processors can accomplish much of the necessary signal processing, EAW has developed the MX9000, a dedicated digital processing system for the KF900 Series. This powerful DSP package permits the array to deliver high fidelity sound with far greater precision, and it also enables the user to optimize every array configuration.

The MX9000 is an extraordinarily sophisticated hardware/software package with enough horsepower to provide 150 dB of internal dynamic range and over 200 million operations per second. Designed from the ground up, it applies complex proprietary predictive algorithms to previously measured performance data to forge a single coherent wavefront from multiple loudspeaker enclosures each of which contains multiple drivers.

MX9000's future capabilities include array performance optimization based on data newly measured in situ, real time performance analysis, system performance monitoring and "healing" the array should any element fail. The MX9000 comes factory-configured for various KF900 array configurations.

Combining this hardware capability with user-friendly, graphic oriented software, the MX9000 precisely steers and adjusts the KF900 loudspeaker system's directionality by internally making hundreds of adjustments at the single "click" of a computer mouse. As a result, KF900 arrays deliver much greater accuracy and exactness than ever before possible from any array.

Senior Design Engineer David Gunness working at the Athens Olympic Stadium. Fine tuning the processing brought uniformity to within ±2 dB at every seat in the stadium .

Raising The Bar

The KF900 has been refined for real world applications through an aggressive refinement process conducted over several months of 1997 on the Promise Keepers tour. Held in stadiums throughout the US, this tour provided EAW engineering with vital performance data that has resulted in a loudspeaker series proven in a variety of live applications for tens of thousands of people at each venue.

Further proof that PPST and the KF900 Series raise the performance bar for large-scale sound reinforcement has also recently been confirmed. A single KF900 Series array, installed by Alpha Sound at the Olympic Stadium in Athens, Greece prior to the World Track & Field Championships, provides coverage to the entire 85,000-plus seat venue. The 25-loudspeaker array has been measured to provide broadband uniformity, with variation of just ±2 dB at every measurement point, even at more than 500ft (151.2m). Only small areas completely masked by the upper deck balcony require supplemental reinforcement from a distributed system.

(Right) Each KF900 array used for *Promise Keepers*' 1997 events was assembled and flown by a crew of three in less than 30 minutes. (Left) Since the beams are focused vertically with DSP, KF900 arrays are always dead hung. This eliminates the need to aim the array physically.

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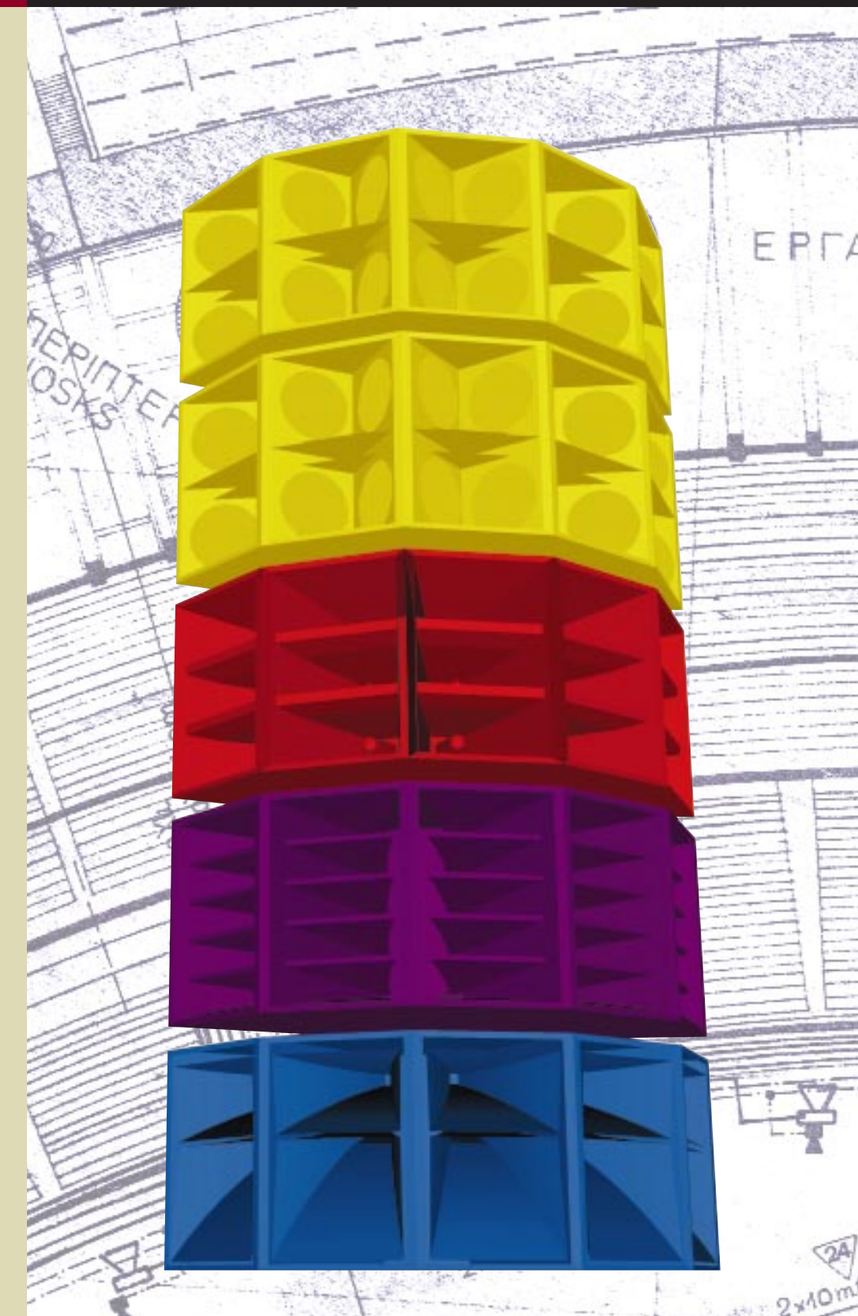
Phased PointSource™
TECHNOLOGY

Is A Seamless Horizontal Array Possible?

Can An Array's Vertical Pattern Work At Both 600 Feet And 25 Feet?



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Athens Olympic Stadium, Greece

KF900 SERIES: *Witness Evolution*

KF900 Series And PPST: An Introduction

The requirements of large scale sound reinforcement present the sound system designer with a conundrum of the first order. On one hand, covering the entire audience area with the necessary sound pressure levels (SPL's) requires many drivers and/or multiway loudspeaker systems. On the other hand, creating a coherent wavefront providing intelligibility and musicality dictates that the number of transducers be kept as low as possible.

Experiments in the 1970's, such as the Grateful Dead's "Wall of Sound," yielded poor results but pointed the way toward the array-optimized loudspeakers that held sway from the 1980's to the present. Yet even the best integrated arrays project only a few hundred feet and are plagued by high frequency attenuation and dubious intelligibility.

The largest applications go beyond the scope of conventional single-source arrays. For football and soccer stadiums, often 600ft (181.8m) or more end-to-end, sound system designers have been forced to use a more complex and expensive distributed approach. Single source arrays produce either inadequate coverage at the far end of the stadium and/or excessive SPL's under the array. Similarly, music events held in stadiums require the use of delay systems to supplement the primary arrays, another costly necessity. (Apparently, these events can never be too loud.)

This small array consisting of just 25 KF900 modules fills the 85,000 seat Athens Olympic Stadium. Except in areas masked by overhung balconies, no additional loudspeakers were required.

A loudspeaker technology producing a coherent impulse that sounds both intelligible and musical at 600ft (181.8m) has become a sort of Holy Grail for high-end professional loudspeaker manufacturers. Unfortunately, they seem to have enjoyed about as much success in the quest as the Knights of the Round Table did in theirs.

Despite the considerable difficulty of the task, Eastern Acoustic Works (EAW) set out to create a full range loudspeaker array that could provide a highly intelligible yet musical wavefront, with the necessary sound pressure levels and minimal high frequency attenuation at 600 ft (181.8m) – and at 50 ft (15.2m).

The Entire Equation

By approaching the total problem, EAW engineers have developed a total solution. Rather than simply creating a specialized tool to achieve extreme long throw with existing arrays, our approach instead solves the true problem: incoherent sound wave propagation from multiple drivers.

First, we optimized the well-documented electro-acoustic elements that would apply to the loudspeaker array. Transducers would need to be very efficient and capable of very high output. Waveguides would need large mouths and long throats to achieve the high "Q" required.

Next came vigorous pursuit and refinement of new or overlooked concepts such as high frequency pre-emphasis to combat air absorption, and the benefits of vertical versus horizontal audience segmentation.

Finally, the issue of achieving true coherency from multiple sound sources across a large listening area was addressed using scientific methods applied with a commitment to obtaining genuine, useful results.

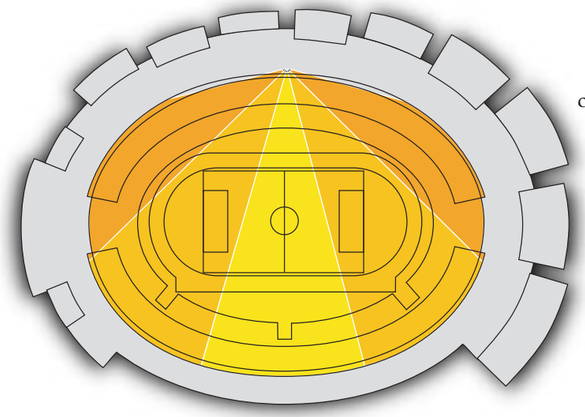

figure 1: Athens Olympic Stadium, Greece (plan view)

Consistent horizontal directivity from 300 Hz to 20 kHz lets us give each column of this 5 column array its own distinct processing fine-tuned to its coverage area. Minimal interaction between the columns means that each horizontal coverage zone only receives sound from its assigned column. (Note: The symmetrical nature of this stadium let complimentary columns use the same processing.)

A KF900 array can be comprised of a variety of modules, each optimized for a particular need.

These modules include:

- **KF910 longthrow HF module**
- **KF911 downfill HF module**
- **KF913 medium throw/downfill HF module**
- **KF920 longthrow/ downfill MF module**
- **KF930 PPST LF module**

A modest KF900 array produces 151 dB SPL average (163 dB SPL peak) at 1m (equivalent) with flat on-axis frequency response at more than 600 ft (181.8m). Attenuation is 15-20 dB at 60° below vertical, with flat frequency response. Most impressive: the acoustical quality is studio-like, with impulsive high frequencies, excellent intelligibility and a distinct absence of the mid-bass "growl" typical of large arrays.

Enter PPST

Phased Point Source Technology (PPST), and the KF900 Series, leverage the ever-increasing power digital processing to create a unified source sound impulse at all points within the coverage area.

Frequency-specific KF900 loudspeaker modules use newly engineered mid- and high-frequency drivers packed into the smallest possible space and loaded on new SimplePhase™ horns, optimized to accommodate the PPST process.

PPST itself builds on EAW's previous use of phase and frequency "shading" techniques to manipulate beamwidths and to blend vertically dissimilar subsystems. PPST seamlessly integrates both the various horn "cells" as well as the various loudspeaker modules into a single acoustical element the beamwidth of which can be adjusted and even steered in the vertical plane.

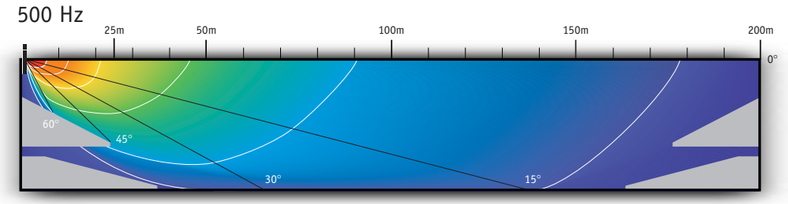

figure 2: Athens Olympic Stadium, Greece (section view)

First we focused a highly directed beam of sound on the horizontal axis. Then we used sophisticated digital signal processing based on advanced predictive algorithms to align the arrivals and smooth the off-axis frequency response, providing an even level of musical, intelligible sound at all points below the array.

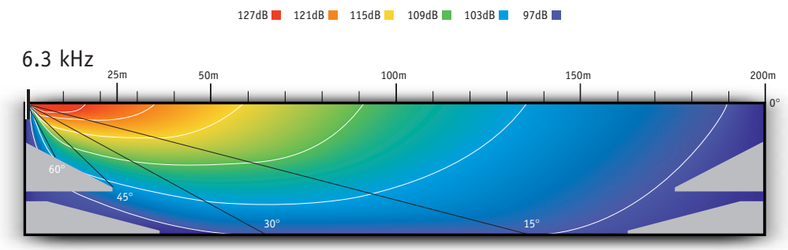

figure 3: Athens Olympic Stadium, Greece (section view)

Using a technique we call high frequency pre-emphasis, we overcame the phenomenon of air loss to achieve high frequency level perception at distances in excess of 600 ft.