PERFORMANCE AUDIO + INTELLIGIBILITY + EVAC = ?? A LOUDSPEAKER MANUFACTURER'S TAKE

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1 INTRODUCTION

Entertainment, worship, and sporting venues around the world continue to grow in number and capacity. With these increases comes a demand for both high quality and highly intelligible sound reproduction for activities during and outside of the event. Also with this increase, the safe and controlled evacuation of patrons has become of equal importance to the quality of the sound, leaving operators, engineers, talent and manufacturers to find a balance together. Size isn't all that matters, however; legislation moves onward in both the European Union and the United States, requiring audio system manufacturers to not just conform but lead the way in integrating their performance sound equipment with voice alarm and annunciator systems for emergency evacuation. It's no longer just stadiums; we must reevaluate systems for even the smaller to mid-sized theatres, arenas, churches, and conference centers. Moreover, as "sports-tainment" continues to grow in popularity, operators require the highest quality sound for the patron experience, eliminating the "echo" of horn & bin systems to provide full range, accurate, if not concert quality music reproduction for the event. So what can a manufacturer of audio equipment do?

Using several case studies, L-ACOUSTICS will present working solutions to balancing high performance audio, STI requirements, and evacuation system integration through the use of line source array technology, loudspeaker monitoring, smart controller amplifiers, and network control and switching. This will serve as a launch pad for discussion of technology changes in place and in the works by performance audio manufacturers, through presentation, live equipment demonstration, and roundtable discussion within the session attendees.

2 THE ISSUE OF SOUND: "LET'S GET ROCKIN', BABY"

In our fast-paced, non-stop action world, there are few places that are not bombarded by sound, be it environmental that simply occurs around us, or targeted specifically at us to get our attention. Sporting events are no longer immune to this barrage, where the "PA" is no longer simply an announcement system, but rather the deliverer of an aural experience for the spectators and the players themselves.

Gone are the days of a tinny national anthem shrieking through a few stadium horns and echoing around the grandstand. With the continued rise in ticket prices, spectators are demanding a full on sports-tainment experience, with quality music pumping through the system before, after, and even during play. Venue operators and professional teams are scrambling to give the experience, trying to lure fans in, and keep them excited for the entire event – for value added to the high priced ticket, or to get the concessions flowing.

3 INTELLIGIBILTY & STI : "PA" VS. "THE P.A."

As discussed earlier, venues of the past had audio systems designed with one mission in mind – public address. The systems used components to maximize the throw and volume of the announcer, thereby ensuring at least most patrons knew who made that last goal/run/touchdown. Intelligibility was not always considered....

Today we use STiPA (Signal Transmission Index for Public Address) to give an absolute value to the intelligibility of a sound system. Originally developed in the 1970's as STI, STiPA gives the industry an objective standard with which to predict and measure the ability of a sound system to reproduce speech in a particular acoustic environment.

3.1 Line Source Technology & STiPA: Is STI fooling us?

The modern "line-source array" was developed by Christian Heil in 1992, revolutionizing live sound. What was termed as Wavefront Sculpture Technology® allowed the loudspeakers to provide high quality, full bandwidth, high volume audio coverage evenly from the front to rear of a venue, even a very large one. Over time, this technology has grown throughout the industry and made its way into many installed sound systems. It is common to see the "line array bananas" hanging down not simply at concerts, but also in performance venues of every type, including large athletic arenas and stadiums. The wide pattern coverage and ability to project the sound evenly from the lower to upper decks seems to be a perfect match to a stadium. However this the match is not always made in heaven...

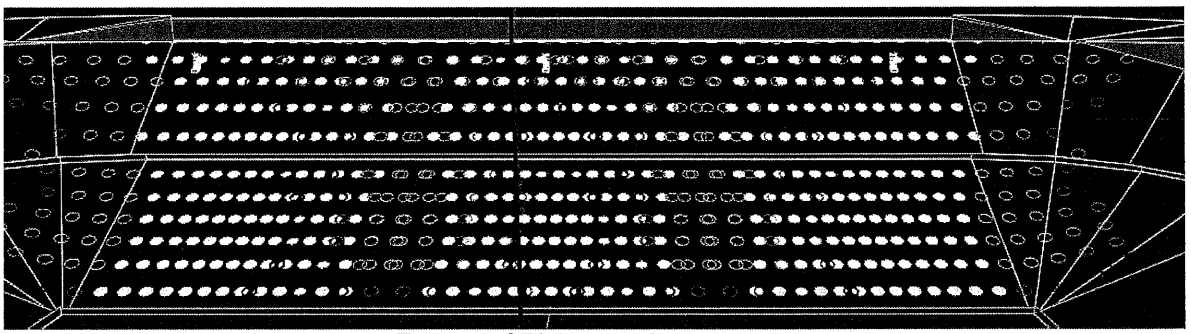

Figure 1: SPL impact, 3 arrays

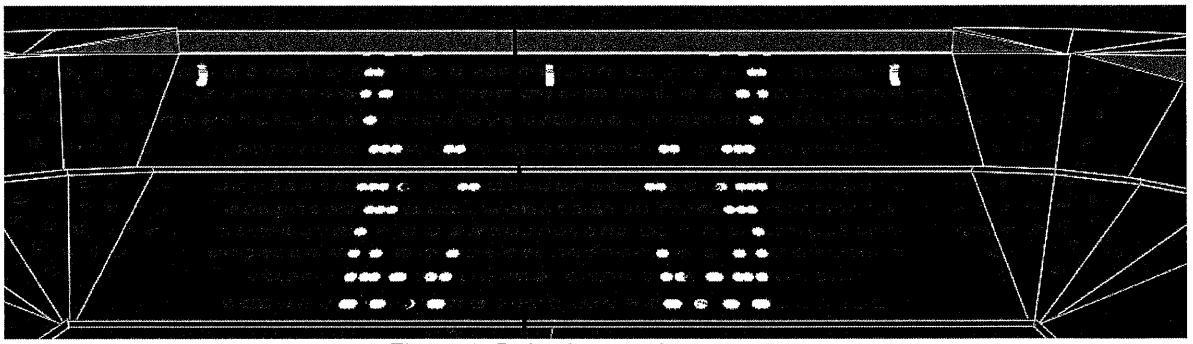

Figure 2: Delay impact, 3 arrays

In these images, we see a typical stadium side audience area being covered by three 12-element line source array systems. The dots shown in yellow on the top image indicate the sound pressure impact zones, with open circles representing a "-3db" down point for the loudspeaker. As you can see, there is a very even and consistent coverage across the seating area. The system as designed would create even SPL and an optimized STI rating based on the definitions of STI. However, when

we look at the second image, the red tells us something different. This image is showing delay impact of the sound. Areas in red are defined as having unaligned sound coverage based on criteria ignoring sound pressure levels 10db down from a primary source, and more than 30ms in delay away from the primary source. This image reveals a large problem with the "less is more" philosophy that maximizes STI, for it also is maximizing the echo/delay problems. A person seated between arrays would officially have a good STI rating, however the actual sound would have intelligibility issues due to the distance from each source. The echo and delays caused by the sound propagation of each array would render the announcer difficult to understand, and bring to mind an "old stadium" sound, complete with the long echo.

This problem concerning fewer sources vs. echo/delay issue is not new; the most common answer is to add loudspeaker system elements, thereby creating a more distributed system that will further optimize SPL while reducing the echo caused by distance between loudspeakers. The images below show a similar venue, this time with five 12-element line source array systems.

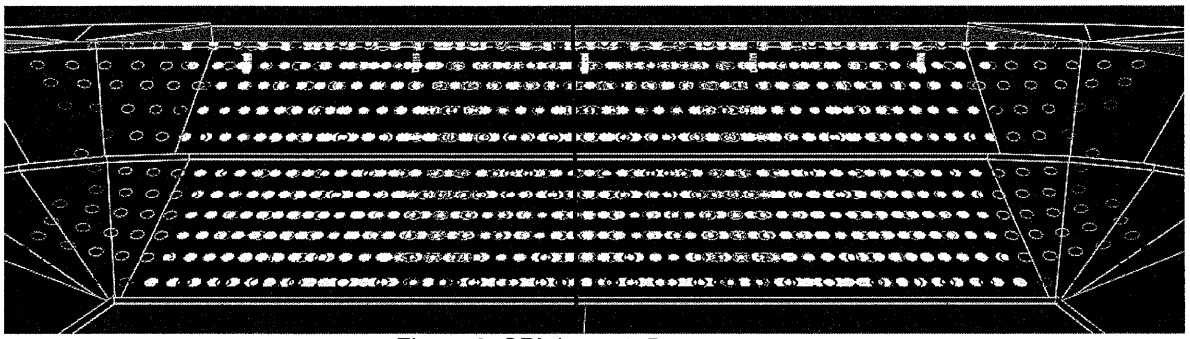

Figure 3: SPL impact, 5 arrays

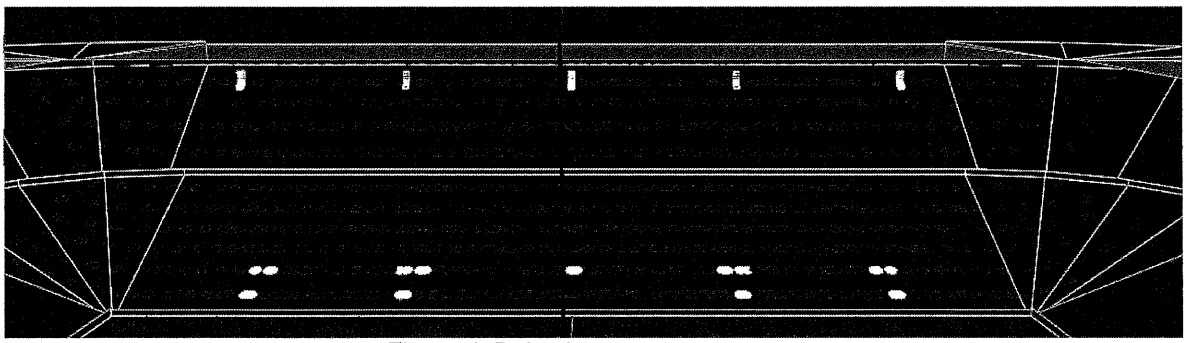

Figure 4: Delay impact, 5 arrays

As you can see, the top image shows even better sound coverage than before, with more overlapping and SPL optimization. In fact, to the man sitting between the loudspeakers, this system would be more intelligible and easier to listen to. However the second image shows us even more red zones, reflecting substantial delay mismatches from the now five audio sources above the audience. Based on STI prediction, this solution would score quite poorly, despite being the more intelligible audio solution.

Are line-sources a poor choice for large venues then? Does the width, overlap and even coverage simply not work when it comes to proper STI and intelligibility? As shown, the overlap is the problem – as each array propagates into the venue, the audience in being hit from many directions and multiple sources, creating either the echo problem (example 1), or delay/STI problems (example 2). So what is the solution?

The science behind a line-source array tells us that as each element is added to the line, the overall control of the vertical sound directivity is tightened and improved. Even in the images above, we can see that the sound propagation ends at the top and bottom of the audience area quite sharply. Previously we identified that having the dispersion width of a line-source array can create echo and delay problems. The solution therefore could be to use the line-source array in the horizontal field instead.

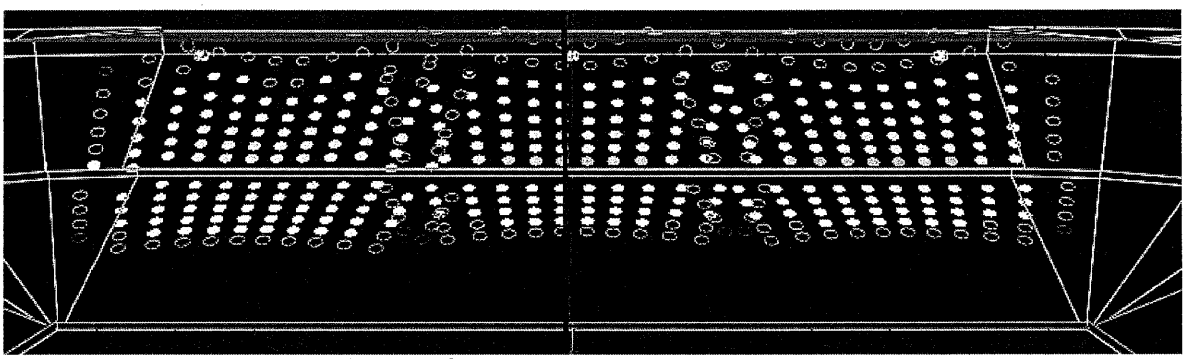

Figure 5: SPL impact: 3 horizontal arrays

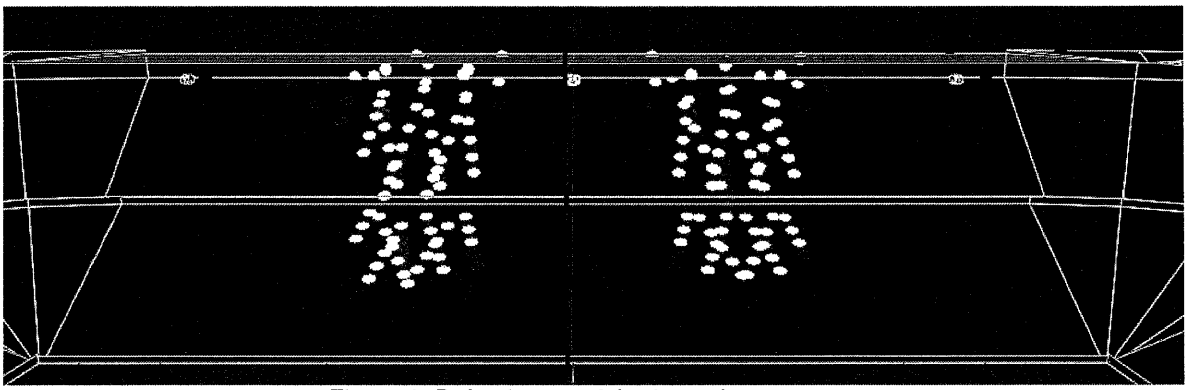

Figure 6: Delay impact: 3 horizontal arrays

In the images above, we see three loudspeaker arrays consisting of ARCS loudspeaker elements. These cabinets are using the line-source array in a horizontal plane. The SPL impact image shows how there is less overlapping, while maintaining horizontal directivity control. The results of this control are revealed in the delay impact image, showing far less echoing and delay effects, thereby increasing both the overall intelligibility and the STI rating. For this particular example, an additional field fill system would be required to maximize the overall SPL for high intensity performances.

4 LIFE SAFETY AND PERFORMANCE AUDIO

In recent times of larger and larger venues, timely, controlled evacuation of those facilities has become of paramount importance. As life safety systems improved from blaring horns to speakers and strobes, audience movements during moments of crisis have become more controllable and thus safer to all. However, rooms keep getting larger, and as we noticed earlier, having more loudspeakers (ie: many fire alarm speakers on the wall) is not conducive to intelligibility. The solution has turned to using the performance audio system as part of the life safety / evacuation system, though a connection to the fire panel annunciator/VACIE or building management network. With this solution (most notably in new EN 54 and NFPA 72 regulations) comes great changes for loudspeaker manufacturers who are installing into large venues, be it facilities for sport, performing arts, or even worship. What begins as a simple change – another input to the system – turns very

complex with the addition of specific STI, active loudspeaker monitoring, and uninterrupted power requirements.

4.1 The performance audio system: get out of the way, or lead the way?

For many years, particularly in performing arts centers, life safety was thought about only in terms of how fast to "get out of the way". This was usually in the form of a normally closed contact to the primary DSP or control frame/matrix of the performance audio system that, in the event of activation, would be released by the fire panel, forcing the performance audio system to mute, allowing any announcements or sirens to be heard. Within larger venues this becomes problematic, as the sheer number of life safety system speaker elements required would dwarf all other wall treatments. This has led to changes in performance audio systems for large venues, and how to best integrate the life safety system with the audio.

The obvious reason for this change in life safety technique stems from a basic question: "why add all these little screaming speakers when we can use those big things hanging there already?" In this way, the life safety annunciator & VACIE panel can take over the audio system in the case of an emergency, allowing building managers/security/life safety personnel to make announcements to the venue. The performance audio system will thus lead the charge for announcements to the venue, requiring high fidelity, volume, intelligibility and STI. As legislation changes, these requirements of using the "house PA" for such life safety requirements will increase to smaller and smaller spaces, not simply the 30K seat arena.

There are issues that must be addressed by manufacturers however. First is power, as legislation for life safety requires battery backup for 30 minutes full power and 24 hours of standby. Manufacturers must now be mindful of the overall power consumption and efficiency of their amplifiers to help designers accurately design battery networks for the performance audio system. System monitoring is also vitally important, requiring the audio network to be aware of the status of every component all the way to the loudspeakers themselves. If there is a fault, it must be found and reported to the immediately to the users/front panels, and subsequently communicate the issue to the Building Management System.

4.2 Case Study: Olympiahalle, DE

At the Olympiahalle Arena in Germany, the sound system was to be high performance line arrays, with the ability for the annunciator panel to take control and make life safety announcements, while being fully redundant in the case of amplifier failure. This project was designed and installed to meet EN 60849 requirements.

In this system, program audio (AES/EBU) and life safety send (analog) was distributed to each amplifier. The outputs of the amplifiers ran through a networked loudspeaker switch-over device, allowing backup amplifiers to be routed to the line array elements within the arena. The amplifiers, switch-over, and program systems all ran to a Control System (AMX/Crestron) that monitored the behavior of all equipment at all times. During normal operation, program audio ran freely over digital AES to each amplifier, feeding the program sound to the room. Meanwhile, the amplifiers and switch-over were monitoring the integrity of the system, and would alert the user to errors and faults through the touch panel interface. The user could then diagnose issues and re-patch loudspeakers and amplifiers as necessary. In the event of an emergency, life safety personnel would activate the annunciator/VACIE panel and take control of the system, switching all of the amplifiers to their analogue inputs. The switch could also be made directly by the user through a touch panel interface. This complex switch-over system has allowed Olympiahalle to maintain important safety and redundancy standards while providing very high quality sound to the audience. Image 7 below gives a simplified schematic of this audio switch-over system.

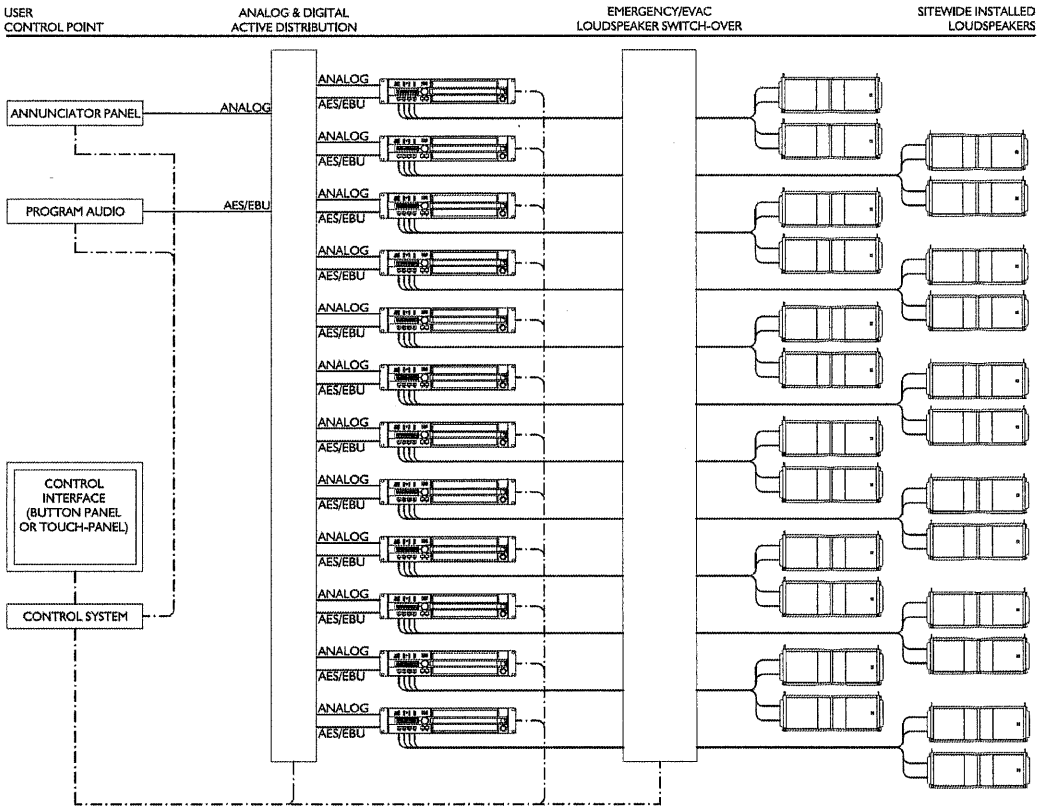

Image 7: Olympiahalle life safety switchover schematic

5 CONCLUSION

As shown, the future will hold many challenges for sound systems in large, public venues. With the rise of size and quantity of performance/sport facilities as well as an increased demand for high quality sound reproduction by patrons and operators, manufacturers must be at the cutting edge, balancing these needs for high performance with the necessities of life safety systems. By incorporating the regulations within the feature set of the equipment, there can be an easier transition, and more incentive for designers to choose a high performance audio system, while knowing that life safety and patron evacuation is still a priority. The future will see these new facilities, providing the ultimate in sonic quality and audience experience, while keeping each and every patron safe and sound.

6 REFERENCES

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