



STRUER – CITY OF SOUND – DENMARK
2017 AUGUST 30TH – SEPTEMBER 2ND
3RD AES INTERNATIONAL CONFERENCE ON

SOUND



REINFORCEMENT

OPEN AIR VENUES

CONFERENCE REPORT

INTRODUCTION

The 3rd Audio Engineering Society Conference on Sound Reinforcement—Open Air Venues was a follow-up to the 2015 Sound Reinforcement conference in Montreal and took place in Struer, Denmark, “The City of Sound,” from August 30th to September 2nd. The conference’s focus was to bring together practitioners, manufacturers, academics, and other members of the live sound reinforcement community to discuss pressing issues and developing technologies in a friendly and constructive environment.

The conference took place at three venues across the city: the Apollon movie theater, Bang and Olufsen headquarters, and Folkets Hus (a multipurpose performance venue in the city), as well as some unique locations for evening social events.

The conference was attended by nearly 70 delegates, representing a good balance between industry and academia, with particularly strong representation from Denmark, Germany, Latvia, United States, and France and some delegates from as far away as Chile and Japan.

PRECONFERENCE ACTIVITIES

Although the conference wasn’t set to officially open until the following morning, the conference committee arranged for a preconference social event at the Apollon movie theater on the Wednesday evening. Delegates who arrived in Struer in time gathered to pick up their registration packs and stayed for din-

ner and drinks. d&b audiotechnik had a stand set up showcasing NoizCalc and SoundPlan, software focused on accurately predicting environmental noise propagation due to outdoor events. Staff from d&b and SoundPlan were on hand to give one-on-one demonstrations of the software ahead of their talks the following day. Following the reception there was a special screening of the film *The Dark Tower* in the Apollon theater equipped with a Dolby Atmos sound system.

DAY 1

Conference opening

The conference was officially opened on Thursday by conference cochair Eddy Brixen (EBB-consult, Denmark) and Peter J. Chapman (Harman, Denmark). They stressed that while we’ve come quite a way toward delivering excellent sound to audiences at outdoor events, it’s essential to consider the neighboring communities. Good sound reinforcement needs to be a compromise between the audience and the neighbors. This was a central focus of the conference, as noise pollution from outdoor events has become a major issue in sound reinforcement.

Eddy Brixen introduced the conference committee members who were present and Peter J. Chapman gave an overview of the program and emphasized the primary reason we strive for increasingly improved sound reinforcement: to make the hairs stand up on the back of the audience members’ necks.



Sponsors



Conference cochair, Eddy Brixen, left
and Peter Chapman



Keynote—Niels Werner Adelmann-Larsen

The opening remarks were immediately followed by the first keynote of the conference presented by Niels Werner Adelmann-Larsen of Flex Acoustics, Denmark. Niels' talk covered the full signal chain, from instrument to audience, with a specific focus on open air venue acoustics (or lack thereof).

Starting at the beginning of the signal chain, Niels emphasized that having great source material (players and instruments) makes the job of a mix engineer quite easy, but unfortunately this isn't always the situation we encounter.

Moving his focus to venue acoustics, Niels highlighted that while auditory masking is significant at most concerts, it is of little concern to the mix engineer (and the audience) since they are all experiencing a similar effect (which we have no control over). Instead, we must focus on what we can control. Even though everyone perceives sound in a slightly different manner (due to perceptual biases as well as physiological differences), any recommendations we make should be based on what most people find appropriate.

Of primary focus here was reverberation time. He stressed that we can't talk about acoustics with one single digit. We must use proper spectral analysis techniques. Due to an increased threshold of hearing at low frequencies, higher reverberation times are acceptable. Even with this in mind, Niels demonstrated through measurements he has taken at large venues throughout the world that low-frequency reverberation is often multiple times longer than at higher frequencies, resulting in quite poor experiences.

This problem has been solved in a number of large venues (such as those used for Euro Vision) with Flex Acoustics aQTubes, which are inflatable cylindrical low-frequency sound absorbers that are typically installed hanging from a venue's ceiling. Measurements indicate that the aQTubes are extremely effective at bringing low-frequency reverberation times down to acceptable levels.

Looking into preferred reverberation characteristics, Niels highlights an important difference: engineers prefer lower reverberation times, while musicians like to have some moderate reverberation (the most important band being around 60–300 Hz) to get a sense of the venue as well as important aural feedback from the audience. The take-away message is that it's good practice to have lower reverberation times for venues aimed at rock or pop music, but a certain level of reverberation should be maintained to ensure the musicians are in a comfortable environment, thus allowing for their best possible performance.

Paper session (Chair – Jan Voetmann, Voetmann-Akustik, Denmark) *Perception of Low Frequency Content of Amplified Music in Arenas and Open-Air Music Festivals*

The first paper of the conference was presented by Jon Burton (touring engineer and University of York, UK) focusing on whether overall concert levels can be objectively lowered while maintaining perceived loudness across the audience.

Jon determined this by deploying a subwoofer system on a stadium tour with The Prodigy consisting of d&b B2 and J-Infra subwoofers. Various members of staff were allowed to adjust playback of various pieces of music (with and without the infra subwoofers activated) to their preferred listening level. After analyzing the



Niels Werner Adelmann-Larsen

results, Jon found that including the infra subwoofers (which extend down to around 18 Hz) results in lower preferred playback levels by up to 5 dB SPL.

These results point to an important observation: sound reinforcement doesn't necessarily need to be maximized to achieve superior low-frequency reproduction. Instead, the focus should be on bandwidth extension of the subwoofer system, as this will allow for the same effect at lower levels. Listeners prefer lower not more. This point was re-emphasized by other presenters throughout the conference.

Practical Considerations for Subwoofer Arrays and Clusters in Live Sound Reinforcement

The second paper of the session was presented by Adam Hill (University of Derby, UK and Gand Concert Sound, USA), who focused on practical aspects of achieving low-frequency directivity at large events that are sometimes overlooked when planning exclusively using software tools.

Various subwoofer clusters were tested, where source orientation, positioning, polarity, and time delay were investigated within both gradient and end-fire configurations. Adam found that in many cases, the acoustic center of a subwoofer must be taken into account in order to achieve the desired directivity. Often the forward shift in acoustic center results in physical unit spacing too great to maintain the desired polar response across the full subwoofer band.

Adam continued with an overview of points commonly overlooked in practice including: the effect of applying delay to horizontal arrays to widen/narrow the coverage pattern (he discovered when optimizing a system at a recent festival in the U.S. that this effectively increases the array spacing, resulting in decoupled behavior near the top of the subwoofer band); vertical array steering; performance stage effects on directivity; and methods of decorrelation for left/right stacks (specifically diffuse signal processing).

360° Sound System Design and Adjustment Case Study

The final paper of the session was presented by Cristian Eduardo Becerra Benitez (INACAP University, Chile), focusing on his involvement with the design of a sound reinforcement system for a recent concert in Chile, requiring 360° of coverage across the audience and the stage.

The primary objectives for this system design were to achieve consistent coverage across a nonuniformly distributed audience as well as to ensure acceptable coverage on stage for monitoring purposes by the performers. The odd audience configuration was due to a catwalk extension from the main stage, with audience surrounding it on all sides.



Jan Voetmann



Mikael Thorsen and Eliar Yousif discuss an important point.

Additionally, since the event was televised, the speakers couldn't block any sightlines for the cameras.

Cristian went through the design process he used, showing how he arrived at a solution incorporating six flown line arrays with four ground-based cardioid subwoofer clusters. Measurements were shown to indicate that even coverage had largely been achieved throughout the audience.

Panel Discussion—Are advances in sound systems improving concert experience levels?

After a break for refreshments, the conference continued with its first panel session, looking broadly into how advances in technology are impacting audience experiences. The panel was chaired by Karsten Grunnet (Danmon Systems Group, Denmark) and consisted of Jon Burton (touring engineer and University of York, UK), Scott Sugden (L-Acoustics, USA), Jörgen Allen (Bose, Sweden), and Eddy Brixen (EBB-consult, Denmark).

Jon Burton began the conversation that overall the audience has much greater expectations these days, largely due to advances in technology, the greatest (from an engineer's point of view) being system networking (with central control capabilities) and easier time-alignment of system components with digital systems. Jon questioned, though, whether these advances have resulted in corresponding increase in audience experience.

Scott Sugden picked up this point with an example that the time he spends designing systems with modern software is 100 times greater than when he was using a spreadsheet 15 years ago. Is the audience experience 100 times better? Probably not. He suggested that having networked control over every signal system component causes data overload and isn't necessarily useful. Some members of the panel disagreed with this, though.

Jörgen Allen asked the question whether software tools make systems look better on paper than they are in reality. Is perfect sound natural? He suggested that we need to keep some form of "musicality" in our systems. This point was reemphasized by other presenters over the course of the conference.

Next, the panel's focus shifted to microphones. Jon Burton commented that in his experience it took microphone manufacturers a long time before they really focused on the live sound community, even though without high-quality microphones we struggle to get good results. Scott Sugden joked that as a system designer, microphones aren't his problem. Eddy Brixen commented that microphone choice is often steered by the look of the microphone.

This was once important to engineers, but perhaps today perfection is the primary goal. Jörgen Allen noted that the system response must be considered with open microphones as this will significantly influence the acoustic feedback of a venue.

Scott Sugden then refocused the conversation on a common mistake system designers make in that they focus on consistent SPL across a venue, where they should really be focusing on achieving a consistent tonal response. This idea was strongly supported by the rest of the panel. Jon Burton commented that he strives for democracy (or socialism) of sound (everyone gets the same sound).

The focus then turned to how we should best use the available tools for system optimization. Jon Burton discussed how he does minimal system equalization these days as modern line arrays are very well-designed. Scott Sugden suggested that a system will be judged based on worst-case performance and if a manufacturer designs a system to be acceptable using the factory defaults, then everything will always be OK.

On site, while you can't measure every seat in the venue, it's also unfair to optimize based on one or two measurement points. The best approach is to preplan/optimize with software and then fine-tune with a reasonable amount of measurements (including some during the day with the audience present—Scott does quick sweep measurements before each headliner at Coachella). Jon Burton added that he limits pink noise to 15 minutes on site. Then he tunes with pleasant music (and is sure to listen to the system with his ears, not just with a microphone).

The panel all spoke on the issue of mixing in stereo with most agreeing that stereo simply isn't

possible to deliver to a wide audience with conventional left/right systems. Jörgen Allen mentioned an experiment he conducted whereby he went back to an old sound reinforcement technique of having a small PA for each musician on stage. This was shown to give superior sound quality and imaging for the audience and musicians, although he noted that this really is only practical for jazz and folk music.

The discussion was closed with some takeaway messages. Scott Sugden stressed that we need to make sound realistic (don't try to recreate a concert hall outside). We must reconnect the visuals to the audio. From his experience, Jon Burton concluded that often we are less important than the lead singer's shoes (to the show producers and some of the audience, at least), but we still must strive to deliver an excellent audience experience. No one ever leaves a gig humming the lights.



Karsten Grunnet, left, chairs a panel discussion on advances in sound systems.



A group of delegates enjoy an outdoor tutorial after the panel discussion.

Tutorial sessions

Following the panel session, the delegates walked over to Folktets Hus (a multipurpose performance venue) for lunch and a series of afternoon tutorial sessions. There were nine tutorial sessions offered, whereby each delegate could choose three to attend.

Broadly, one track focused on noise prediction and monitoring and was delivered by Elena Shabalina, Daniel Belcher, and Nick Malgieri (d&b, Germany and USA) along with Kees Nervoort (Event Acoustics, Netherlands).

The second track focused on acoustical measurements and advanced sound system design. The three sessions were delivered by Jakup Knudsen (MAVT, Denmark), Mads Jensen (COMSOL, Denmark), and Scott Sugden (L-Acoustics, USA).

The third track took place on a small outdoor stage and focused on practical approaches to system optimization, including subwoofer systems, FOH setup, and maintaining spectral balance over varying SPLs. The sessions were delivered by Peter J. Chapman (Harman, Denmark), Jon Burton (touring engineer and University of York, UK), and Sofus Birkedal Nielsen (Aalborg University, Denmark).

Noise prediction and monitoring at open-air events

This tutorial focused on the challenges of getting sound system design software and environmental noise prediction software to work well together and was presented by Elena Shabalina (d&b, Germany). Elena began by explaining that to an audience sound is art and enjoyable but for nearby residents that sound is heard as unacceptable noise. If you fall into the latter category, it's very difficult to ignore speech or music. This observation was repeated many times throughout the conference, as it's essential to understand when trying to limit noise pollution from outdoor events.

Elena went through the two predominant standards: ISO 9613-2 and Nord2000, giving easy-to-follow example calculations for both. This allowed the audience to better understand how d&b NoizCalc software operated.

Questions from the audience focused primarily on limitations of the standards and resulting predications. The d&b team stressed that a big issue is that environmental noise professionals are typically working to the standards, while in live sound we have to deal with the reality of the situation (in the form of complaints). They emphasized that Nord2000 is much closer to reality than ISO 9613-2 (as backed up by their example simulations and calculations).



Mistakes in system setup from a FOH perspective

On the outdoor stage, Jon Burton led a tutorial on his experiences in FOH setup. One of his primary observations was that the sound up front is often forgotten even though these are the fans that lined up early to get the best spot or paid the most for tickets. He often spends a considerable amount of time ensuring this area gets good sound. One of the easiest solutions here is to avoid placing the left/right arrays too wide (a problem he encounters more and more these days).

For system tuning in general, the focus must be on intelligibility. If an audience can hear the words to a song, they're generally happy. On this point, Jon described Big Mick's approach to sound check, where he starts with the vocal microphones and builds the mix around that (an approach Jon strongly advocates).

In terms of system testing, Jon suggested using a mono signal to test left/right as this will easily reveal differences between the two sides (which seems to be a big problem with many systems, for whatever reason). For soundcheck, you need to be efficient, don't rely on endless amounts of effects/plugin-ins. You can get those up and running during the show. Don't waste the little time you have. Make sure the core instruments are patched and acceptable (especially at festivals). It's best to get your vocals set first. Anything

remaining can be dialed in during the first song.

Ultimately, Jon repeated what he discussed earlier in the panel session: it's of central importance to get good sound everywhere. Don't just focus on the FOH riser.



Immersive hyper-realistic sound reinforcement

Back inside, Scott Sugden's tutorial focused on the L-ISA system from L-Acoustics. Since simply hearing the show is no longer a big challenge in live sound, we should focus on audio-visual fusion and sound separation in order to give the audience a more realistic listening experience.

L-Acoustics approach is to distribute multiple wide-pattern line arrays and point sources in front of (and in many cases, to the side and above) the audience in order to deliver good spatial performance to all listeners. When implemented correctly, this will give the audience natural spatial cues, resulting in improved localization and immersion. For the engineer, they'll not have to apply as much EQ or dynamics, and will be able to pan sources without the worry of negatively impacting the listening experience of part of the audience.

In terms of practical considerations, this sort of system requires a reevaluation of the importance of audio at concerts. At present, it's often seen as a side-issue. This often results in compromised loudspeaker placement, hence poor listening experiences. If we strive

to make audio important again, systems of this sort could move us beyond our usual left/right configurations (with their associated restrictions).

Mayor's reception dinner and live jazz

Following the tutorial session, the conference moved to Struer Museum. After the delegates enjoyed a buffet dinner, the mayor of Struer, Mads Jakobsen, thanked everyone for coming to Struer and gave a brief overview of the city's history and very close link to the audio community. As a musician, he understood very well the importance of good sound and urged us to keep working hard in everything that we do. He concluded that good music can be ruined by bad sound and thanked us all for our hard work to avoid this.

The remainder of the evening was spent enjoying music from Danish jazz group The Martin Fabricius Trio, and delegates were allowed to peruse the museum which included a significant section on the history of Bang and Olufsen (which was founded in Struer over 90 years ago).

DAY 2

Invited paper—David Scheirman

Friday began at Bang and Olufsen headquarters with the first invited paper of the conference, from AES president-elect David Scheirman (Bose, USA). David's paper was entitled "Back to the Future, a Technology Project Review: Outdoor Sound Reinforcement of Symphony and Opera for Extremely Large Audiences."

In his talk, David gave an overview of the challenges and issues faced by the sound system designers responsible for outdoor performances by the New York Philharmonic and the Metropolitan Opera. David was brought in after numerous issues arose with the sound reinforcement.

The system was a distributed system, with no main left/right arrays/stacks required, since the audience closest to the stage would receive sufficient acoustic coverage from the stage. The system needed to be quick to setup and calibrate, since it had to be deployed entirely during the morning of the concert.

One issue that David addressed when he joined the project was the accurate placement of the towers. Instead of using the existing system of a measured piece of string, he brought in digital surveying equipment for precise placement. Everything was then time-aligned, taking the conductor's position as "time-zero."

The speakers themselves were of a three-way design with a downward facing woofer. In addition, there were two drive units that were rear-facing to simulate the rear wall reflections you'd experience in a concert hall. The loudspeakers were battery-operated with signals fed to them wirelessly from the mix position. They were spaced

at 10° intervals moving outward, resulting in lower energy levels further from the stage, which is in line with the natural acoustics of a concert hall.

Other than the technical design of the



Committee members Morten Lydolf (left) and Eddy Brixen (center) meeting with delegates outside Struer's Kulturcenter.

system, David highlighted how to best work with the local crews and how to communicate well with the conductor (don't talk about sound, ask about the score).

Overall, with David's help the system was brought up to expectations and the concerts received the best reviews an audio engineer could hope for in this situation—there was no mention of the sound.

Workshops

The delegates were split into three groups for the workshop sessions, rotating every 70 minutes with a hot-dog lunch after the second session (expertly served by Morten Lydolf from Harmon, Denmark).

Beolab 90

The first workshop was conducted by Jakob Dyrbye (Bang and Olufsen, Denmark), one of the acoustic engineers who worked on Bang and Olufsen's new Beolab 90.

Jakob took the group through the design process for the speaker, highlighting various design challenges and how the team overcame them. The design is roughly a three-way system (with crossover points at 300 Hz and 3 kHz), although the set of active drive units is frequency dependent. For instance, above approximately 5 kHz, only one tweeter is active (to avoid lobing errors), while below this all three tweeters are active (since they're close enough to couple in this range). A similar approach is used for the woofers.

Overall, the speaker consists of 18 independently-controllable drive units and is designed to be placed wherever a user deems fit. A proprietary calibration procedure is included to optimize the speaker for its environment, with an additional feature allowing for specific tuning to an individual sweet spot, if needed.

After going through the design process, Jakob took the group to a listening room (with acoustics corresponding to a typical living room). A set of two Beolab 90s were set up and demonstrated in narrow, wide, and omni coverage modes. Opinions on the best setting varied between the group, but regardless of what setting was preferred it was an enjoyable listening experience.

FOH sound system set-up and optimization

The next workshop was held on a large temporary stage set up outside for a concert taking place on the following evening. The system consisted of d&b J-Series line arrays and subwoofers, driven by DiGiCO SD10 consoles with Lake processing.

The workshop was led by Peter Jørgensen (Audio Consulting,



David Scheirman goes Back to the Future

Denmark) with assistance from Nick Malgieri (d&b, USA). Peter and Nick walked the group through importing a system design from d&b ArrayCalc software into d&b R1 remote control software. They demonstrated various optimization methods, such as the new Array Processing feature, which allows users to define various presets to deal with changing crowd size throughout the day (turn off unnecessary sections of the array while maintaining desired audio characteristics) or shifting temperature/humidity.

The software communicates directly with the networked amplifiers and has test routines to detect connected loudspeakers and to determine if there are any system faults. Peter and Nick demonstrated this live with the provided system.

Microphone choices and techniques

The final workshop took place on stage outdoors and was led by Rune Slot (DPA, Denmark). Rune began the workshop with a quick overview of the theory behind microphone construction and deployment, dispelling some myths surrounding large versus small diaphragm microphones.

Rune described how it's advantageous to use linear microphones with consistent frequency responses off-axis. In the context of microphone choice for drums, this is especially important as there will be significant bleed from other sources, therefore the bleed signals need to have the same frequency response as their source.

Following this, Rune went through microphone choice and placement for a typical drum kit, beginning with choice and location for area mics (primarily useful for IEM mixes), kick drum (in and out), snare (top and bottom), hi-hat, toms, and overheads. Time alignment to the snare drum was emphasized, with live recordings made and played back to demonstrate the detractive effects of poor alignment.

Rune used a useful wine glass analogy to explain performance of microphones. The glass stem is the noise floor (it's always there and of little use), the portion of the glass filled with wine is our usable dynamic range, and the unfilled top portion of the glass is the area where we could operate the microphone, but where THD and other nonlinearities become significant.

Invited paper—Akira Mochimaru and Jörgen Allen

The second invited paper of the conference was written by Akira Mochimaru (Bose, USA) and presented by Jörgen Allen (Bose, Sweden). The paper, titled "Progressive Directivity Array: Technology Overview and Performance Advantages for Sound Reinforcement

Systems," details an approach that Bose has been adopting in recent years.

Typical line array boxes are restricted to fixed horizontal and vertical directivities. In a progressive directivity array, the directivity patterns can be defined for each box individually. This should allow for consistent tonality across an audience due to the precise coverage pattern control.

Jörgen emphasized that practicality needed to be kept in mind during the design of such a system. It would be unreasonable to manufacture a different box for every possible directivity. Instead, Bose has designed a loudspeaker that can be adjusted by the user to achieve the desired coverage angle (limited to a few options for horizontal and vertical).

The general design procedure for such a system involves dividing the audience area into sections of equal surface area from front to back. From the spatial layout of each section, users can reverse engineer the required vertical directivity required for each box. The more boxes in the array, the higher SPL which is achievable and the better control of tonality in the coverage area. Directivity control was shown to be accurate down to 500 Hz.

Jörgen highlighted the potential for such a system (which generally has similar coverage ambitions as L-Acoustic's L-ISA system, albeit approaching the challenge in a different manner), but indicated that at present it's better suited as a fixed installation, rather than as a touring system.

Big band concert

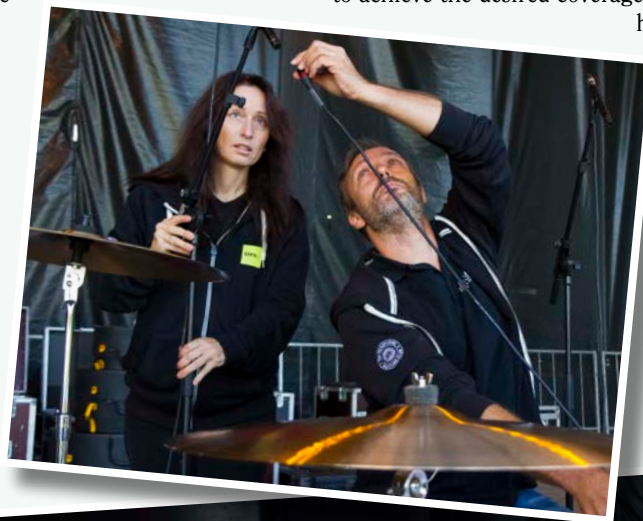
The daytime events were concluded on

the outdoor stage with an hour-long performance by Denmark's own Katrine Windfeld Big Band. The performance was attended by the conference delegates as well as B&O employees. The concert was mixed using the sound system and microphones demonstrated in the workshops.

Evening social event

In the evening, the delegates were taken by bus to The Hayloft, a local concert venue located on the island of Thyholm, which was described to the delegates as "pretty much in the middle of nowhere."

At the Hayloft, the delegates were each personally welcomed by owner, Bent Hargaard, and his wife, and were treated to a tapas dinner prepared by the local butcher and wine that Bent imports from France and other countries.



After a very enjoyable meal, the delegates were treated to a performance by a well-known Danish band, The Nice Little Penguins. The show was mixed by conference cochair Peter J. Chapman (Harmon, Denmark). The entertainment provided was great and there were no complaints about the sound (a miracle, considering the audience). Everyone had a good chuckle, though, when the guitarist accidentally unplugged himself during a guitar solo.

DAY 3

Paper session (Chair—Morten Lydolf, Harman, Denmark)

Adaptive, data-driven sound field control strategy for outdoor concerts
Saturday began with the final paper session of the conference.

The first paper was presented by PhD students Franz Heuchel and Diego Caviedes Nozal (Technical University of Denmark).

Franz and Diego described the system they're working on with their colleagues with the aim of limiting noise pollution to areas outside a defined audience area (bright zone vs. dark zone). This is achieved with a distributed system around the audience using a combination of microphones and computational models for system optimization. The system is designed to constantly update itself by use of a machine learning algorithm, taking in the live measurements and using them to update the computational model.

As present, the system has been validated in simulations only, but these results give good indication of the effectiveness of the approach. Areas in which the delegates were eager for the group to look into involved the limitations of the control area as well as the overall system efficiency after application of the sound field control.



The Nice Little Penguins perform at the Hayloft.



Committee member Peter Petersen (right) with Dirk-Jan Broekhen

Adjoint-Based Time Domain Sound Reinforcement

The second paper of the session was delivered by Mathias Lemke (Technical University of Berlin, Germany). His paper describes a slightly different approach to sound field control that may be new to many in the fields of audio and acoustics. The work shares the goals from the first paper of this session but goes about the solution in a very different manner.

The work was inspired by the fact that the selection of line array element positions and angles are typically an ill-posed inverse problem. Instead of starting with known loudspeaker locations, the

desired sound field is defined. From this, an optimization function is applied (using an adjoint-based approach) to determine the ideal loudspeaker positions and angles. An advantage of this approach is that a best-fit solution can be found for any number of loudspeakers.

Mathias went through the theory behind the approach, where electroacoustic sources were modeled as fluid dynamic sources. With the governing model defined, he presented a number of simple simulations illustrating how the process works and emphasized that it is entirely based in the time domain.

The chair thanked Mathias for introducing the audience to what was likely a new topic for most of the delegates.

Large-scale sound reinforcement in extreme atmospheric conditions

The paper session was concluded with a presentation by Etienne Corteel (L-Acoustics, France). The presentation focused on challenges for system designers when faced with widely varying atmospheric conditions over the course of an event. Two examples were highlighted here: the Hollywood Bowl and Coachella Valley Music and Arts Festival

(both experiencing large differences in temperature and/or humidity from day to night).

Etienne explained that in drier conditions (such as in the desert with Coachella) there will be greater variation in high-frequency propagation due to temperature. In extreme cases, propagation loss over the audience can go from only 10 dB to upward of 40 dB.

Due to this wide variation in performance, Etienne proposed a very practical system for determining how to correct for these effects (split into three grades): small propagation loss (< 6 dB)—correction with EQ; moderate propagation loss

(6–12 dB)—partial correction with EQ (no more than 12 dB boost, to avoid compromised headroom); severe propagation loss (> 12 dB)—delay towers required

While the assumption may be that the solution to this issue would be to apply EQ to the required individual elements in a line array, Etienne demonstrated that there is a serious efficiency issue if targeting individual elements, due to high element overlap at long distances. Instead, his approach advocates applying EQ to groups of line array elements to maintain efficiency. This removes the restriction of having one amplifier channel (with DSP) per element.



Committee member Thomas Lund, left, leads a panel discussion on neighbor annoyance.

In the case of Coachella, the propagation loss was measured to be in excess of 12 dB at high frequency, therefore delay towers were implemented. For the Hollywood Bowl, delay towers weren't possible, so the system had EQ applied to give the best results at night time (when the concerts are typically held).

Questions from the audience focused on the possibility of automation of this process, but Etienne stressed that we need to be cautious about too much automation, as this isn't required for all systems and it could cause serious detrimental effects if something goes wrong.

Panel discussion—Environmental considerations and neighbor annoyance – Creating a win-win situation

The final panel discussion of the conference was chaired by Thomas Lund (Genelec, Finland) and consisted of Lars Frederiksen (Alfa Audio, Denmark), Finn T. Agerkvist (Technical University of Denmark), Jan Voetmann (Voetmann Akustik, Denmark) and later by Bob McCarthy (Meyer Sound, USA), arriving straight from Copenhagen where he was coordinating the final preparations for the first show of Metallica's European tour.

The effect of outdoor (and sometimes indoor) concerts on neighbors was an ongoing concern at the conference, and the panel drew from their experience to give a good state of affairs surrounding this area.

The session began with an interesting case study presented by Lars Frederiksen. In this example, the noise disturbances were being caused by an indoor concert venue in close proximity to a residential area (the issues were below 100 Hz, with peaks around 30–40 Hz).

Following the regulations, they determined that the SPL at FOH would have to be limited to around 82 dBA using the current sound system, which is unacceptable for a typical concert. While this could have been solved with improvements to the structure of the building or by purchasing an entirely new sound system, a more efficient approach was chosen. The subwoofer system was updated to exhibit cardioid behavior, which resulted in 5–10 dB reduction in noise levels for the neighbors.

This was certainly a step in the right direction, but various delegates pointed out that the new subwoofer system measurement's highlighted that the low-frequency didn't extend as low as with the original system, so perhaps some of the improvement needs to be attributed to band limitation. In some cases (depending on the performance type) this reduction in very low-frequency extension could be deemed problematic.

After the case study, the full panel was invited to comment

on the current challenges of noise pollution due to live events. An engaging conversation followed, initiated by Jan Voetmann, where he stated that the technological issues for this area are already well-known. What we need to look at closer are the regulations. Certain regulations can result in too low a level in the audience. How can we find a solution for both the audience and neighbors?

Ultimately, the panel and the audience concluded that regulations and metrics vary

considerably in their use throughout the world. We really need to develop better metrics that are in line with perception of music. Additionally, Finn Agerkvist suggested that we need a method for monitoring noise that can identify the source. In some cases the source of the offending noise may not even be the outdoor event. He later shared that from his experience, often noise measurements in neighborhoods are above regulation limits without the concert. This led the panel to begin to discuss what the correct approach to measurement should be and what the current issues are.

Bob McCarthy stated what many in the audio community already understand, which is that there is a long-standing issue with the use of A-weighting scale for loud events (it doesn't correspond to perception, since it largely ignores low frequencies). He continued to make clear that low frequency isn't going away. Rather, the use of the infrasound band is likely to become increasingly common (Meyer Sound's new subwoofers used with Metallica operate flat down to around 11 Hz). Thomas Lund suggested that the A-weighting scale has stuck in practice due to the fact that medical studies have almost exclusively used it since the 1940s.

Jan Voetmann provided the insight that musical signals carry information (as opposed to information-less noise signals). Human perception is tuned to try to pick out information from noise, therefore music from nearby concerts/events could be annoying even if the levels are below the limits set for broadband noise. With this in mind, regulations can't be based solely on sound energy. We must consider the information carried in the signals. Members of the audience alerted the panel to the fact that in Germany noise laws do indeed account for the content of the noise.

A lively discussion ensued between the panel and the audience. One point was made that the acoustics within nearby households must be taken into account. If the offending noise is centered in frequency around a room-mode in someone's living room, then a very low (and legal) level outside could easily cause issues indoors.

With all this in mind, Bob McCarthy reminded the delegates that concert promoters don't choose sites based on audio and acoustics. They want to maximize their profits, hence the central locations of most events. We need to do our best to solve the noise problems, since this isn't likely to change.

An audience member asked about active noise-cancellation arrays (which we see popping up at various events). Bob McCarthy spoke of his experience with these systems, stating that such a system did reduce the noise problems in line with the secondary array, but such a solution becomes difficult when neighboring areas aren't only in a straight line from the venue. The other panel members voiced their agreement with this feeling.

Bob McCarthy concluded the session by reminding the delegates that there's no such thing as free lunch (although a member of the audience observed that in the case of this conference, there was free lunch directly following this session).

Keynote—Bob McCarthy

After the free lunch, there was the final keynote of the conference given by Bob McCarthy (Meyer Sound, USA). Bob's talk focused on system optimization. He observed that over his 30+ years of experience, we can often lose sight of what we're shooting for, searching for "unicornic freepass filters." Essentially, with our ever-improving technology, we have a solution and are searching for a problem.

Bob began by giving a short overview of what we should be targeting in system optimization. The goal should be maximum uniformity (while maintaining maximum SPL capabilities)—a point supported by a number of presenters throughout the conference. The challenges we face are location, location, location, as well as crossover management (both spatial and spectral) and design factor (working in venues not designed for modern sound reinforcement or designed with over-use of technology). Additionally, he stressed that stupidity removal remains a big part of optimization.

Going through the history of optimization tools, Bob stressed that RTAs are of little use to us since they only inspect magnitude (where we need magnitude and phase information). He went on to describe the development of the Sound-Independent Measurement system (SIM) in the 1980s. In Bob's opinion, this is the point where we really started to learn about sound system optimization.

Instead of going through general approaches to optimization, Bob walked the delegates through his design and optimization of Metallica's current sound system for their European Tour (which was beginning in Copenhagen that evening).

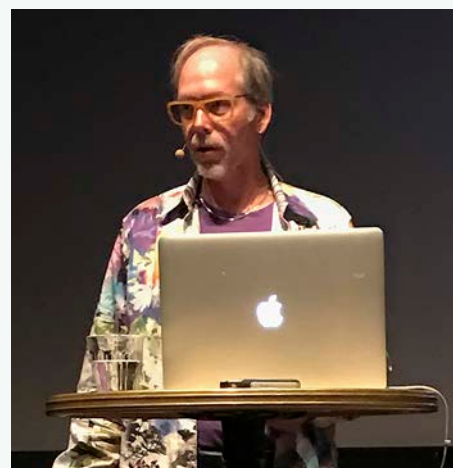
He described a serious design challenge which he termed "lightzilla." This was a lighting/video system that was suspended directly above the stage (the concert setup was in the round). Due to the size and weight of this system, the closest the loudspeaker arrays could be hung was 12 m away from the stage, providing an interesting challenge of ensuring adequate sound coverage to the front of the audience while maintaining an accurate sound image.

To solve this, Bob described his solution that has arrays pointing almost straight down close to the stage, with front fills used to correctly direct the sound image.

The rear of the audience was covered by more traditionally-configured line arrays. The subwoofer system was a three-deep end-fire configuration, 15 m from the stage, configured to direct the sound toward the audience. A happy advantage to this configuration was that the subwoofers were very close to the main arrays, thus requiring less overall system delay (as compared to everything needing to be delayed up to 30 ms with the old central TM subwoofer array).

Bob included a second case study, on a more traditional concert setup at a stadium in Mexico City. Due to the stage geometry, he used two different end-fire arrays of subwoofers per side of the stage: one standard and one infra (extending to 11 Hz). To achieve directionality, the arrays needed to be around 15 m long (providing the infra array with 3 m between each element).

Questions from the audience included one on how to deal with measurements in empty stadiums. Bob clarified that the ground is the worst reflection in this case, so you can place your measurement microphone on the ground (watching out for any fork lifts in the area) to avoid any issues. Late reflections aren't as much of an issue. In his experience, wind is the biggest problem, where it takes make repetitions of measurements to get a good reading. Bob advocated against measurement averaging, since that could give a skewed view of reality.



Bob McCarthy during his keynote

CONFERENCE CLOSING

The conference was closed by cochair Eddy Brixen (EBB-consult, Denmark), thanking everyone for attending and detailing the final logistics for those wishing to take part in the "Run to the Beat" race that afternoon or attend the after-party concert at Bang and Olufsen headquarters that evening. It didn't appear that any delegates planned to do any running, but a number seemed interested in the concert.

The delegates gave an enthusiastic round of applause for the organizing committee for delivering a very enjoyable and well-balanced conference.

Editor's note: the papers from this conference can be downloaded from the AES E-Library at <http://www.aes.org/publications/conferences/?confNum=ID-168>. AES members get free access to the E-Library.



Conference delegates socialize after a long day.