

# Before the Immersive Audio Show — Pre-Production

By David Kennedy

For a moment, let's turn our attention away from the current pandemic. It took the last three months to present just the first half of the first chapter from John Eargle's classic *Audio Engineering for Sound Reinforcement*.

The astute *FRONT of HOUSE* reader will recall my three-page article in the Oct. 2019 issue that chronicled the 80-year evolution of the many types of multi-channel arrays and surround sound formats — including immersive sound. In November, we focused on Q&A topics on immersive sound technology with Avid, Astro Spatial, d&b, Martin Audio, Meyer Sound, L-Acoustics and Out Board. In the Dec. 2019 issue, we covered how turn-key immersive, L/C/R (Left, Center, Right) and stereo live-sound systems differ in cost, with graphic examples of immersive sound coverage and maximum sound levels.

The January "Tech Feature" discussed how — at this point in the evolution of immersive live-sound systems — there are many different types and methods of sourcing such a system. In it, I proposed 12 categories for various immersive products and system bundling solutions. Summarizing Dr. Terence Caulkins from last winter: "Until recently, live immersive playback has been a relatively niche occurrence — as such, most DIY (PC and Mac) solutions have yet to be extensively road tested for large-scale live sound applications. In a large venue context, all the rules of typical system design apply, including loudspeaker selection, room

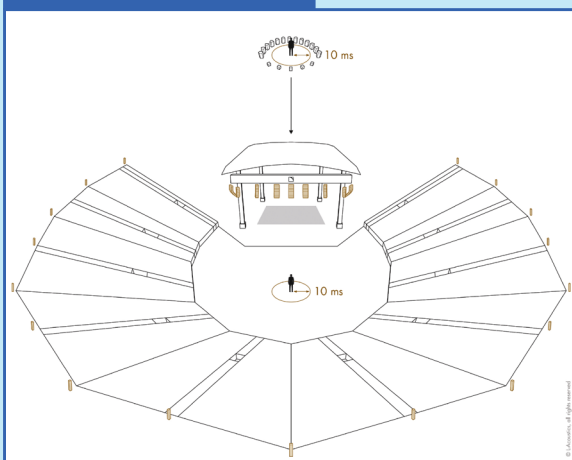
acoustic design and system calibration. A key issue lies in the transcoding of content from one immersive audio system to another, which could be facilitated by adopting the MPEG-H 3D format." We also sought input on the topic from Astro Spatial, EAW, Flux Audio and Out Board.

The February issue presented some graphic examples of how the realism of audio imaging can be improved with the greater number of immersive arrays across a stage/proscenium. Some live immersive software now lets production professionals create surround sound imaging in the studio and then scale it up automatically to large venues as needed (as shown in **Fig. 1**). As many have already said in this article series, audiences will be increasingly more demanding that venues and tours become equipped with immersive technology.

Welcome back to the sixth article in my coverage of the latest in immersive live-sound systems. After months of searching and manufacturer inquiries turned up no published documents on how to set up a recording studio for pre-production of live-sound immersive programs, I will defer most of this page to Dr. Terence Caulkins of leading design/engineering firm Arup, NYC to tutor us on immersive pre-production — his expert comments follow.

Next month, I will report on the replies to my inquiries on immersive pre-production and the latest in immersive live-sound from several leading manufacturers. **FOH**

Figure 1



Scaling up L-ISA studio to large venue by L-Acoustics

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Figure 2



Exploring virtual architecture in Arup's NY SoundLab

## Thoughts on Pre-Production Systems for Immersive Sound

By Terence Caulkins, PhD

The design process for immersive sound pre-production systems is complex and requires careful consideration of multiple dimensions. Here are some guidelines to help you along the way.

If your pre-production system is dedicated to a single venue and/or live playback configuration, the problem is somewhat simplified. Budget allowing, one can take the "one-to-one" approach of scaling down the large venue system layout to fit inside the mixing studio, keeping with an equal quantity of loudspeaker locations and identical relative angle of each loudspeaker with respect to the mix position. Individual delays and EQ should be employed to simulate the large venue signal chain delay plus acoustic propagation from each loudspeaker to the mix position, especially if you are mixing live content through the immersive system.

The acoustics of the studio should be controlled using appropriately distributed sound absorbing and diffusing treatment and active architecture (spatial reverberation) may help better simulate the large venue condition for the mix engineer. With the right adjustments in place, in a "one-to-one" pre-production system, the mix engineer can count on experiencing a relatively accurate translation of the spatial sound trajectories and overall spatial balance of the content experienced in the live venue. This is an ideal setup for pre-production, and should be employed whenever project conditions allow it.

The design of a more "generalist" pre-production system that is agnostic of the final venue condition is a more complex task. Depending on the target venue, the system may be asked to handle one or more audio spatialization formats, from mono, stereo, 5.1, through vector-based amplitude panning, Higher-Order Ambisonics, all the way to Wave Field Synthesis — a high spatial resolution methodology that typically requires dense loudspeaker layouts<sup>1</sup>.

Using object-based media encoding, you can efficiently "transcode" content between different loudspeaker layouts. However, this should be done carefully. If you are working with a high spatial resolution pre-production system, you will generally be able to find a subset of loudspeakers to closely match the setup of a venue that has fewer loudspeakers, and get a sonic result that closely matches. In simulating a high-resolution system with fewer loudspeakers, it is possible to employ "virtual loudspeakers" panned between the available loudspeaker locations in your pre-production system. This, however is a *non-ideal* approach and will require *in-situ* adjustment in the large venue. Any wave-based effects — such as focusing or plane wave propagation produced with WFS — will be lost in the transcoding from a high spatial resolution system to a low-resolution system.

### » Key Considerations

Additional factors to consider in the design of an immersive pre-production system include:

- **Architectural Constraints:** Consider ceiling height, flexibility of your loudspeaker mounting solution, accessibility, maintenance, furniture, ergonomics and coordination with other architectural elements such lighting, HVAC, security systems, sound isolation, etc.
- **Loudspeaker Selection and Size:** Smaller loudspeakers can be spaced more densely to achieve higher spatial resolution but may lack in SPL capability and timbral fidelity.
- **Hardware:** Make sure your designed system CPU, bandwidth, and channel counts are sufficient to meet the needs of current and future productions you will need to handle.
- **Setup time:** If you are setting up a temporary pre-production studio, depending on your production schedule, it could be preferable to utilize a lower channel count system, especially if this will give your 3D audio mixer and/or composer more time to develop the content.
- **Spatial Regularity of the Layout:** A regular<sup>2</sup> layout will allow you to create smoother spatial trajectories and better sound field quality when playing back ambisonic content.
- **Perceptual Considerations:** Our localization capabilities tend to be much better in the horizontal plane and in front, and less precise behind, above and below us, so it can be a good idea to densify loudspeakers where our perceptual acuity is best. This should however be balanced out with the overall regularity of the spatial layout of loudspeakers around the listener.

We have applied and optimized these considerations on many iterations of the Arup SoundLab (**Fig. 2**), which we have used as a pre-production and architectural simulation space to inform the design of some of the world's best arts and culture venues. Imagine being able to hear at the design stage what a project will sound like when complete. This is what our SoundLab enables users to do.

Today, SoundLab technology in Arup offices around the world is helping clients achieve better outcomes for a wide range of projects. Because SoundLab's auralizations are matched to real-world conditions, clients and design teams can be sure they're focusing on finding real solutions. The constructive dialogue this enables increases trust between designers, engineers, clients and the general public. We have taken things further of late by introducing visualization and virtual reality into our practice. In the film *Seeing is Believing*, my colleague Joseph Digerness and I explore how immersive experiences can transform the design process.

### » Footnotes

<sup>1</sup> — The original rule of thumb proposed by Delft University for loudspeaker spacing in WFS systems was 15cm spacing in order to ensure accurate wave front control up to 1,500Hz.

<sup>2</sup> — See Jerome Daniel's PhD Thesis for what constitutes a "regular" layout from an ambisonic perspective (available at [gyronymo.free.fr/audio3D/download\\_Thesis\\_PwPt.html#PDFThesis](http://gyronymo.free.fr/audio3D/download_Thesis_PwPt.html#PDFThesis), or [plsn.me/FOH-JD-Thesis](http://plsn.me/FOH-JD-Thesis)).