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# THE PRACTICAL REALITIES OF IMMERSIVE AUDIO

What to watch for when considering the latest in sound technology

by Mark Mayfield

■ In real life, our experience of sound is omnidirectional; it comes from all around us. Unlike our visual sense, we perceive sounds that happen anywhere within an imaginary sphere around our heads, whether our head is turned in the direction of the source or not. Other factors—such as the physical shape of our ears, the time arrival of the sound to each of our two ears, and cognitive processing—help determine the actual direction of the sound source. This is what we call “localization.”

With movies, our sense of localization is simulated and then re-created using loudspeakers and signal processing. In the earliest days of sound in cinema, the front of the screen acted as the only source of sound. Any sense of sound localization came from room acoustics and reflections from surfaces in the room coming in at random. There was no chance of re-creating an acoustical environment that matched the one seen on the screen. This all changed in the 1940s and '50s, when loudspeakers started appearing on the walls

around the audience, in what was eventually dubbed “surround sound.”

Surround sound, the experience of sound in multi-dimensions with realistic localization, has made great strides since then, but let's face it: just as a computer is still no match for the human brain, approximating our natural hearing mechanism with technology still has a long way to go before the experience feels completely realistic. The most recent leap in this effort is immersive audio.

## WHAT IS IMMERSIVE AUDIO, REALLY?

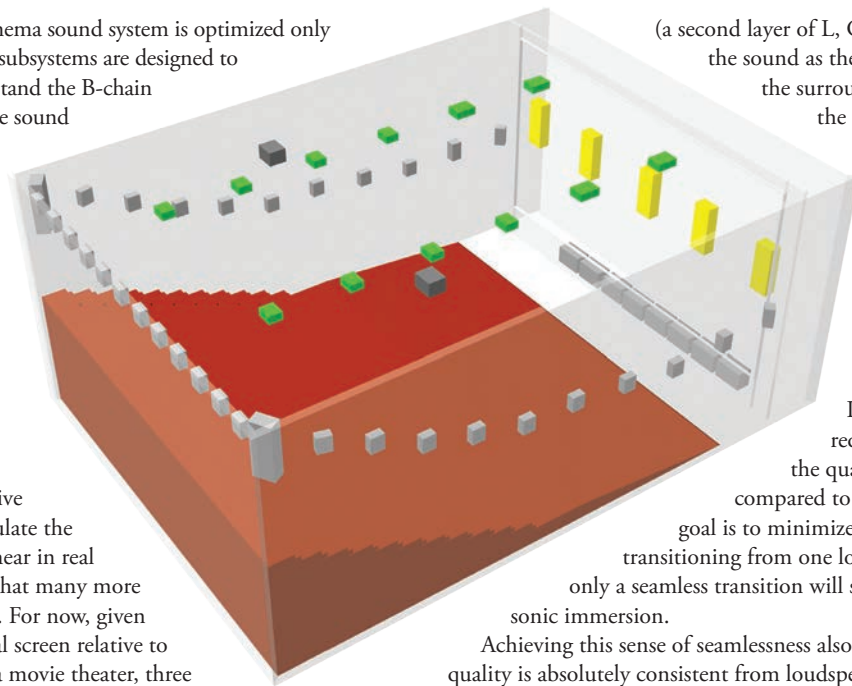
Achieving a true immersive experience in a movie theater is not a trivial matter. At its most basic level, it's a two-stage process. First, the sonic reality is simulated and stored during the creation of the film in the post-production process. Then that simulation is reproduced in an acoustically neutral movie theater. Today, there is no single standard for accomplishing either of these stages, but one thing is certain: it takes a lot of sound sources to simulate any single acoustic scene, let alone the dozens of environments dictated by many changing scenes in a typical movie.

Today's immersive audio processes are either channel-based (5.1, 7.1, 11.1), object-based (each sound is a discrete digital object that is directed to one or more loudspeakers via “metadata” stored on the DCP), or a combination of both. All of these methods have a significant impact on the digital cinema B-chain.

Like any system, a cinema sound system is optimized only when all components or subsystems are designed to work together. To understand the B-chain implications of immersive sound in cinema, it's helpful to break the system down to its three main sections: signal processing, amplification, and loudspeakers. For practical purposes, let's look at each of these sections in reverse order.

### IMPLICATIONS FOR LOUSPEAKERS

Since a truly immersive experience needs to simulate the seamless experience we hear in real environments, it's clear that many more loudspeakers are needed. For now, given the small area of a typical screen relative to the other three walls in a movie theater, three screen channel loudspeakers positioned at Left, Center, and Right seem to provide an adequate sense of localization for the action on an average-sized screen. In some cases, five (including Left-extra and Right-extra) or six



For most immersive formats, many more surround loudspeakers are mounted around the perimeter and sometimes ceiling of the typical cinema.

(a second layer of L, C, R) are used to simulate the sound as the filmmaker intended. For the surround loudspeakers lining the other three walls, the immersive experience requires many more loudspeakers that are more closely spaced, since a sound may be required to originate in just one loudspeaker or potentially all of them simultaneously. In some cases this may require two to three times the quantity of loudspeakers compared to 5.1/7.1 systems. The goal is to minimize any perception of sound transitioning from one loudspeaker to the next; only a seamless transition will sustain the sense of total sonic immersion.

Achieving this sense of seamlessness also requires that the sound quality is absolutely consistent from loudspeaker to loudspeaker.

This depends on manufacturing processes of the loudspeaker itself, as well as intelligent application of signal processing that is specific to that loudspeaker model, as determined in a well-controlled laboratory environment. And



since each loudspeaker might receive a different sound channel or object, each loudspeaker must be individually wired.

Recognizing that we also hear sounds above our heads in nature, some immersive systems use loudspeakers suspended from the ceiling. While this might raise concerns of patron safety for some theater operators, safely suspending loudspeakers overhead is about as complicated as suspending large light fixtures. Some of the keys to safe overhead mounting include:

- First, consult a mechanical or structural engineer to determine mounting points capable of supporting the load with an appropriate safety factor.

- Be sure the loudspeaker enclosure itself is structurally capable of supporting its own weight with an appropriate safety factor. Multi-density fiber enclosures are great for side-wall and behind-screen loudspeakers, but overhead mounting calls for a well-built enclosure of multiple-layer plywood.
- Always use a secondary means of support, such as a safety cable attached to the loudspeaker and the mounting structure.

Conventional installation practice for behind-screen loudspeaker mounting involves placing them on a platform. This practice works well for any immersive sound installation, except when the format requires a second layer of Left, Center, and Right for “height” channels behind the screen. In this case, consider suspending the top layer; some manufacturers provide their most popular screen channel loudspeaker models in versions that are purpose-built for suspension from safe “hang points” in the ceiling. Again, this requires the input from a structural or mechanical engineer.

#### IMPLICATIONS FOR POWER AMPLIFIERS AND SIGNAL PROCESSING

Immersive audio also places greater demands on your power amplifier and signal processing decisions. Realizing that the number of surround loudspeakers could be double (or more) compared to traditional 5.1/7.1, and that each loudspeaker may need to deliver a discrete full-bandwidth sound source, it's obvious that each loudspeaker also requires its own channel of amplification. This means more individual power amplifiers, which also increases the amount of “rackspace” in an already shrinking projection booth. There may also be increased AC mains power requirements and cooling for these electronic devices.

Fortunately, power amplifier technology has advanced significantly in recent years, and there are some elegant ways of addressing these demands. Amplifier efficiency (the amount of power from the wall that's actually converted into power to make sound) has dramatically increased with new breed “class D” power amplifiers with switching power supplies. This translates into lower power requirements to the building, saving energy costs and infrastructure. Since they don't require large power transformers, these more efficient amplifiers can also be much smaller (which equals less rackspace) and produce far less heat (equals less cooling) compared to conventional amplifiers. These new designs also allow more channels to be packed into the physical chassis, enabling amplifier models to be built with four or even eight channels in a single chassis.

It's a fact of physics: to make bass, you need to move a lot of air. The most effective way is to use larger loudspeakers. For behind-screen loudspeakers, this is no problem since they can be hidden behind the screen. But to avoid breaking the sense of “immersion”



in the action happening on-screen, surround loudspeakers need to be as unobtrusive as possible. Fortunately, we can use the psychoacoustics of human hearing to our advantage; bass frequencies are naturally less “localizable”—it’s hard to tell where they’re coming from. The loudspeakers for bass frequencies can be physically located apart from the main surround loudspeakers. In fact, bass frequency content from multiple wall-mounted surround loudspeakers can be combined and produced by a smaller number of low-frequency loudspeakers mounted in less visually obvious locations. This is the main idea behind bass management, which is accomplished through the system’s signal processing.

Getting the sound source from the DCP to the listener through an immersive system with up to 64 or more loudspeaker locations is a complicated feat of networking. Signal routing for most immersive formats requires sophisticated digital signal processing and significant processing power. Remember that each sound object may be delivered to any single loudspeaker or group of loudspeakers—or all of them simultaneously. Since we are still in the early days of immersive audio, there exists no single standard, and any system investment must consider future-proofing to the extent possible with today’s products. Make sure that your system’s signal processing supports any currently available immersive audio format and will be capable of supporting any future offerings.

Besides signal routing capabilities, achieving a seamless sound field objective also requires that the system’s digital signal processing is able to correctly shape the sound to each specific loudspeaker model, using laboratory pre-sets. “In-situ” or automatic equalization that attempts to correct for room acoustic anomalies is simply no substitute for a well-designed loudspeaker that is lab-corrected for any performance anomalies and intrinsically delivers consistent power response into that room.

## THE FUTURE OF IMMERSIVE AUDIO IN THE THEATER

Despite all of these new considerations, immersive audio has the potential to become the next big differentiator of the in-theater experience. The biggest obstacles at the moment are the lack of a commonly accepted industry-wide standard and the cost of implementation. Technology providers are working on the cost equation, and industry groups such as SMPTE are working to develop and promote standards. The two issues are related and the success or failure of any new cinema format depends on the support of filmmakers and studios to create great content that audiences want to experience in the movie theater. ■

Mark Mayfield is an experienced cinema audio expert and has worked with and consulted for many leading audio manufacturers including Bose, JBL Professional, and Eastern Acoustic Works. He is currently director of global marketing for Cinema at QSC, LLC.