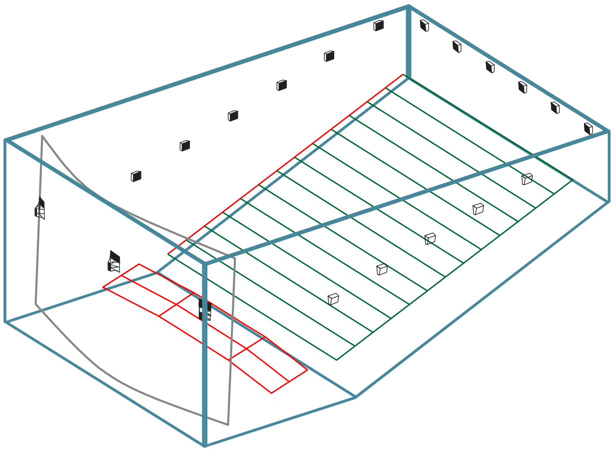
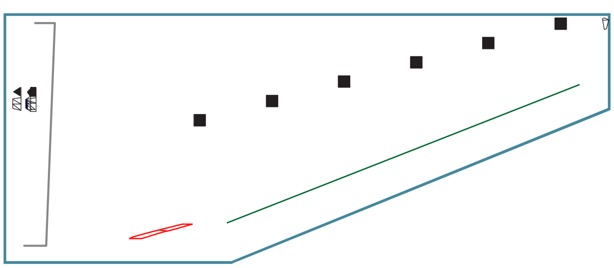
BALANCED SURROUND COVERAGE FOR PROFESSIONAL CINEMA





The importance of loudspeaker coverage in cinema is largely misunderstood. Despite often being described vaguely with specifications like “90x40,” it actually means how well loudspeakers interface or “uniformly map” with the audience.

Every loudspeaker has a unique and complex acoustical radiation envelope shape. This shape is important when trying to present uniform sound to a large area and when overcoming the attenuation of sound relating to the distance from the loudspeaker. In cinema terms, if the loudspeakers had no envelope shape, only the first few rows of seats would get good sound from the screen, and there would be no actual channel balance. The ability of a loudspeaker to reach the most distant seats is vital to uniform sound coverage. In stricter terms, the loudspeaker should present energy as the exact inverse of the energy decay created by distance and other room-related effects. The actual required shape is nearly always asymmetric and is never a simple 90x40.

For years, cinema surround coverage was distributed by a single array of speakers, evenly spaced around the perimeter of the theater. Each loudspeaker only needed to cover a small portion of the audience. The evolution of surround formats, however, requires a more sophisticated approach.

Surrounds must now operate in much smaller groups, or even solo, meaning that each surround must be able to cover much, if not all of the room. When analyzed in this manner, surround coverage requirements are more stringent than screen channels, and the ideal coverage requirement is a very difficult task for a single loudspeaker.

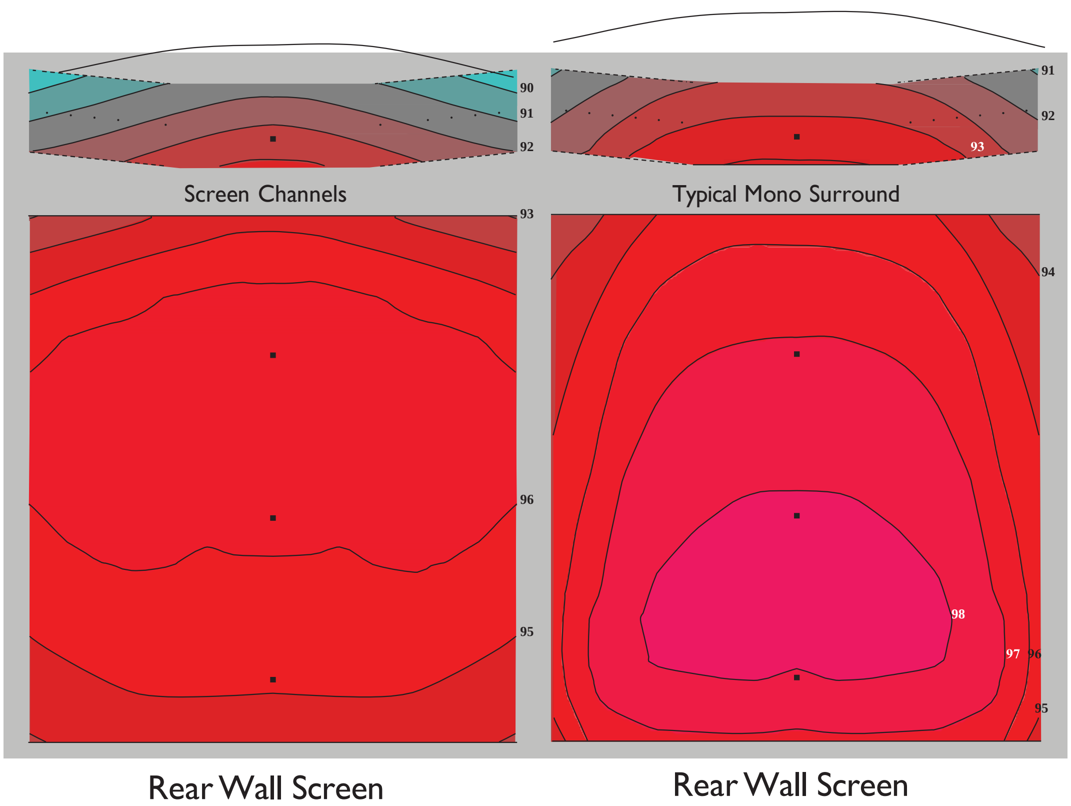
To compound the issue, different locations in the room demand a different envelope shape. A rear surround sees different room geometry than a side surround. When you include ceiling and screen locations, there are at least four distinct patterns necessary for uniform surround coverage in the immersive formats, and at least two for 7.1 or 5.1.

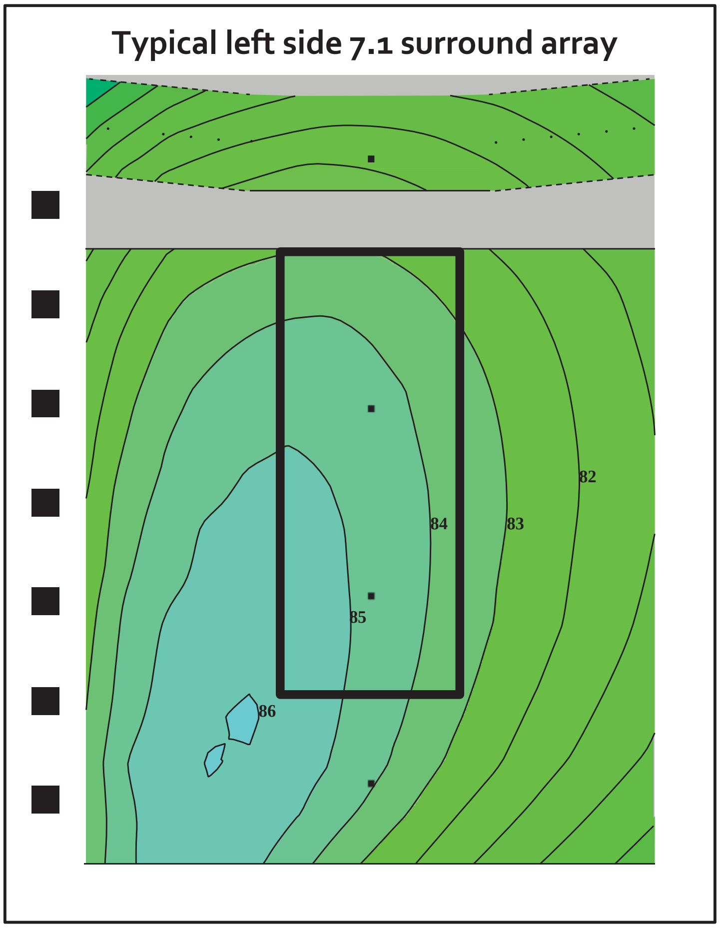
A study of loudspeaker coverage in cinema is possible with a simulation using a room model as shown on the previous page. The model we are using is a stadium seating cinema theater. Room coverage contour plots are calculated for each loudspeaker or group utilizing actual measured loudspeaker radiation envelopes. Two important mapping references are shown below: premium quality screen channels and a traditional monaural surround array. Each contour line on a plot represents a 1dB change in SPL level. As seen in the illustrations, screen channels do a great job in the main stadium riser section but begin to fall off in the very front areas. The surrounds do an adequate job with a bias towards the rear of the room (where the loudspeaker density is greatest).

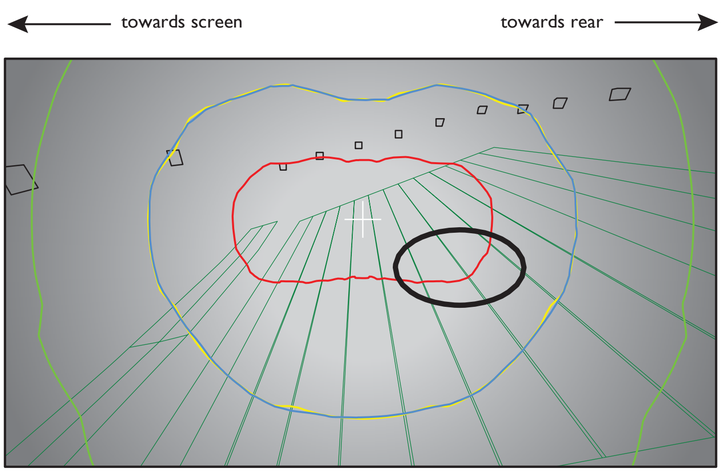
The result is that there are two distinct seating areas from an audio balance standpoint: the front 2/3 of the room and the remaining 1/3 at the back. The front 2/3 seating area is within +/-1dB channel balance. The rear 1/3 of the room has a different balance with the surrounds up and the screens down in level. Therefore, the rear 1/3 of the theater is at least 2dB out of calibration, and this is typical of almost every stadium cinema room, using the monaural array model.

We use the monaural array model to help describe a critical design factor in cinema audio—uniformity and channel balance. The ideal goal is perfect coverage, which in these plots would be shown as all one color with no contour lines. This defines perfect uniformity. How each loudspeaker plot compares to the other defines channel balance. If all loudspeakers had perfect uniformity, they would also have perfect balance. As we deal with real devices, however, imperfections in uniformity impose demands on balance. In designing real devices, it is important to design the audio experience to track with the visual experience. In layman's terms, the best visual seats should also be the best audio seats. The screen channel plot above is an example of this. Coupled with the fact that screen channel content is of greatest importance, the screen channel plot can easily be regarded as the reference target for the surround plots as we begin looking at the newer formats.

While the 2dB channel imbalance shown above is not perfect, it is significantly better than any of the newer formats. A distributed array of loudspeakers will have significantly better distribution of energy than a single loudspeaker. The perimeter array, however, does not have the ability to localize an audio event. This, coupled with the fact that typical surrounds have a different sonic character and dynamic compared to the screen channels is why the newer formats have emerged.





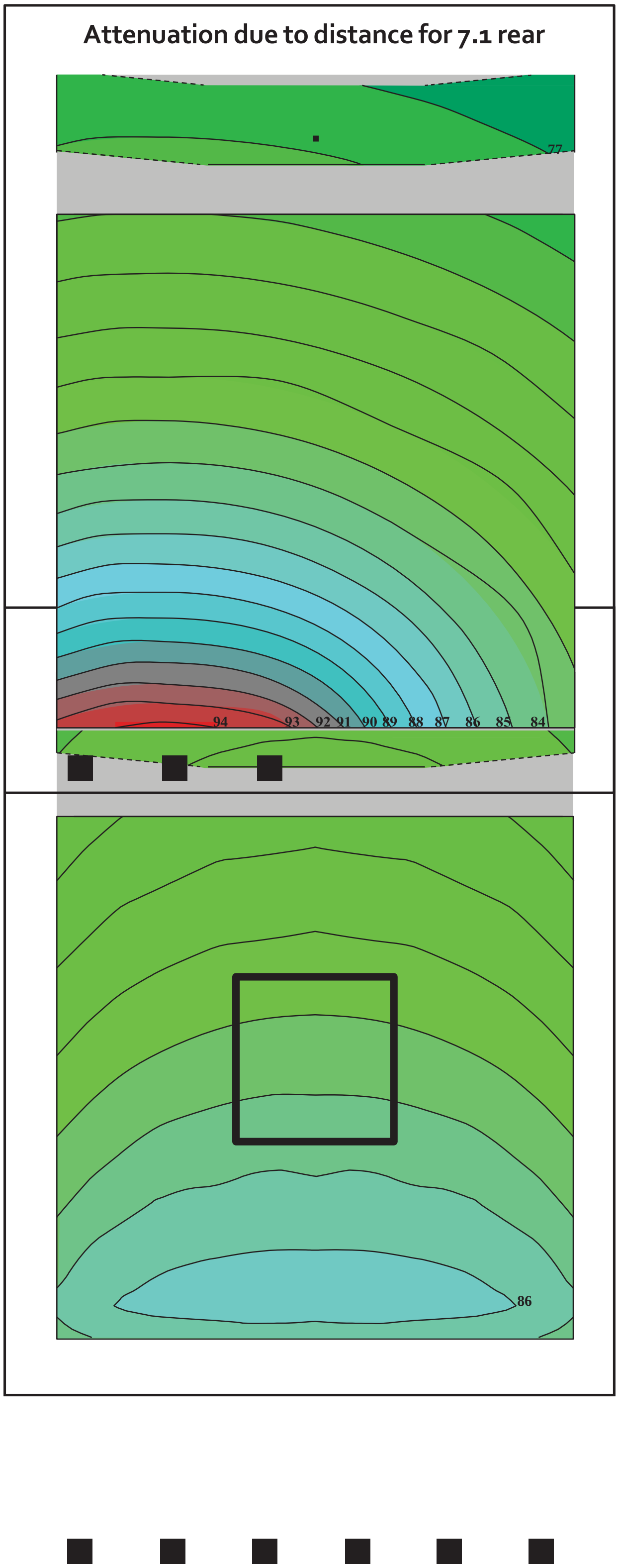


How a side surround 'sees' the audience. The red, blue, and green lines represent the 3,6,9dB pattern lines of the loudspeaker. Stadium seating creates a 'hot' spot—shown by the ellipse—where the loudspeaker energy is strong, and the audience is close.

An evaluation of the newer formats reveals a more stringent requirement. In a 7.1 layout, the locations are the same as monaural, but the array is divided into 4 channels. The contour map below shows coverage of the 7.1 left side surrounds, with seven loudspeakers in this model. One can immediately see a strong bias towards the rear. Knowing this format is intended to be operated in left/right pairs, an important part of the evaluation deals with the balance between the left and right. Noting the right side mapping will be a mirror image of the left, a box is drawn in the area where the surrounds are in left/right balance, and also in balance with the screen channels (referenced on the previous page).

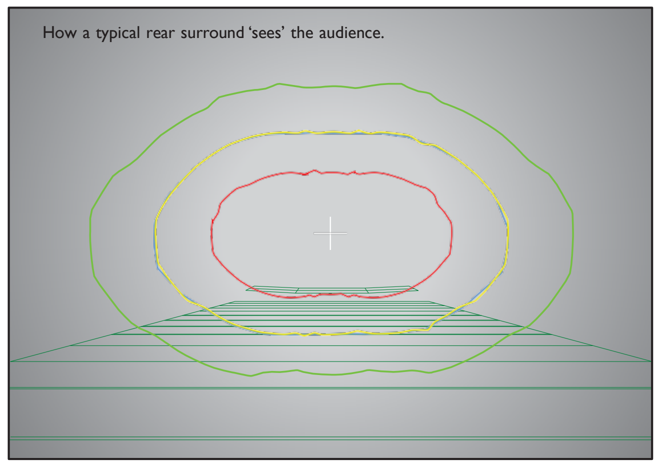
The channel balance area which includes the screen channels and the 7.1 side surrounds covers approximately 25% of the audience, assuming premium loudspeakers. It should be noted that 5.1 performs worse because half of the rear loudspeakers are grouped with their associated side arrays, making the rear bias even stronger and collapsing the balance area even further. Meticulous level adjustments with the loudspeakers can improve this slightly, but two fundamental issues remain: incorrect loudspeaker pattern and improper orientation in relation to the seating plane.

Seating plane orientation is best described by the graphic below, which shows loudspeaker pattern orientation from a side surround position to the audience. The goal is for the intense (red contour) energy to be directed to the most distant seats. With horizontally oriented loudspeakers presenting to an angled seating plane, there is a natural 'hot' spot created on the rear side of the pattern where the seating plane approaches the height of the loudspeaker. Explained a different way—audience distance from the rear side of the red contour is much closer than the audience on the forward side of the red contour. Since all of the loudspeakers experience this phenomenon, a rear bias is created in the coverage.



All channels +/-1dB balance only within the rectangle

Analysis of 7.1 rear surrounds reveals a more difficult coverage requirement. The primary room-related parameter a cinema loudspeaker must compensate for is attenuation due to distance. The contour map below shows this for a 7.1 left rear array and demonstrates the 16dB difference between front and rear rows. To further complicate the issue, this happens in a fairly small angle from the loudspeakers' perspective. The graphic below shows how a typical loudspeaker coverage pattern presents in this arrangement. The audience does not experience the most intense energy, so it stands to reason that it's not the correct pattern for this application.



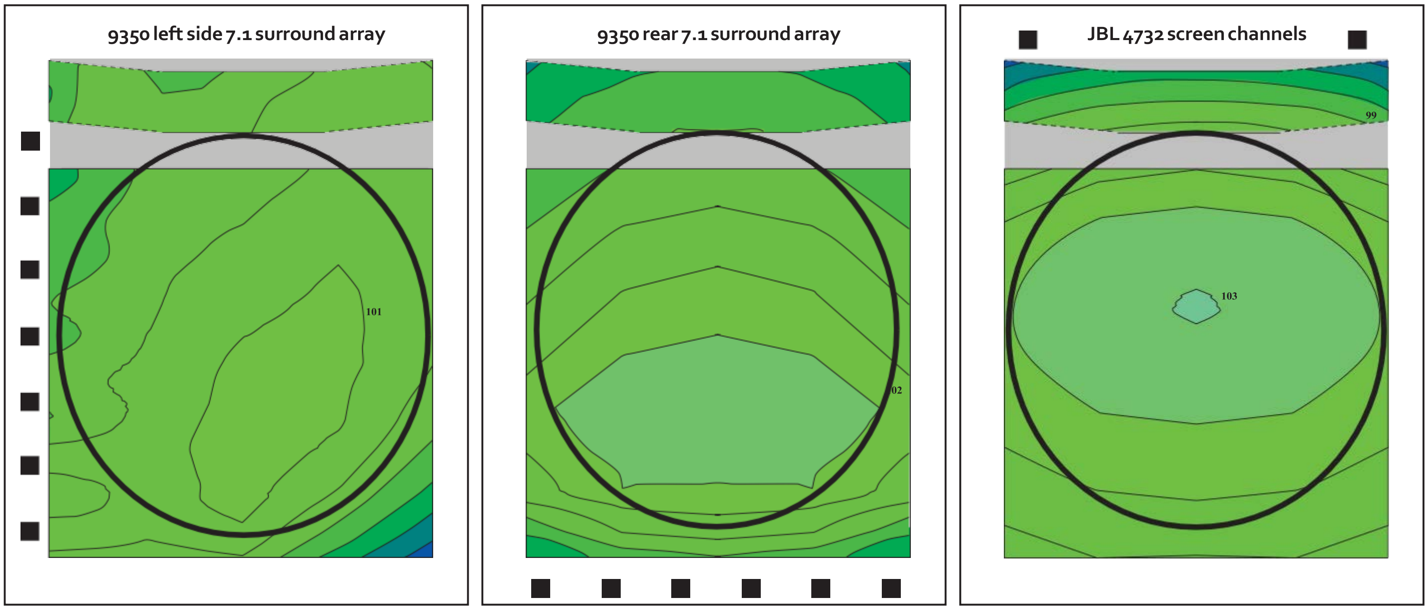
The resulting coverage map of a 7.1 rear surround array is shown on the bottom left. It has a severe rearward bias and a 7dB differential between the front seats and rear seats. In this example, the front half of the theater receives no intelligible rear content. Also, there is a 4dB differential between the rear row and calibration row. Evaluating the +/-1dB channel balance for all loudspeakers is now restricted to the box shown, which represents approximately a mere 7% of the audience!

JBL's legendary engineering team embarked on an exhaustive research and development journey to combat this issue, and the result is the 9350.

The 9350 is a configurable pattern loudspeaker, featuring multiple patent-pending technologies that deliver unprecedented performance, far surpassing any other product in this market. Using a unique combination of waveguide and line array techniques named Dual Dissimilar Arraying, two distinctly different waveguides are used in tandem to sculpt a combination pattern to match the requirements of the room's geometry. By utilizing electronic filtering, the coverage pattern possibilities are virtually infinite. The standard 9350 features both a side surround and rear surround pattern. This may sound like it would require sophisticated DSP, multiple amplifiers, and an extreme price tag, but the 9350 is a passive loudspeaker with one amplifier connection and a simple selector switch at the input terminals to configure the coverage pattern. In other words, it's efficient and affordable.

In more specific terms, the 9350 is a dual HF two-way with a waveguide 15" woofer. The unique 'acoustic divider' waveguide (patent pending) on the woofer provides directivity and crossover performance closer to a 3-way system, and the powerful 15" neodymium woofer uses legendary JBL differential drive technology for an impactful low-frequency extension. The 9350 rivals screen channels in sonic performance and dynamics.

The improvement in performance when using the 9350 is nothing short of spectacular. Coverage mapping with the 9350 in all surround positions, and using JBL 4732s as screen channels is shown below. The ellipse now highlights the notably large +/- 1dB coverage area. This is excellent channel balance with left/right balance in 80% of all seating and 100% of primary usage seating! This degree of audience coverage is unprecedented in cinema and only possible employing JBL's newly developed technologies.



All channels +/-1dB balance within the ellipse includes 100% of primary usage seating!

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