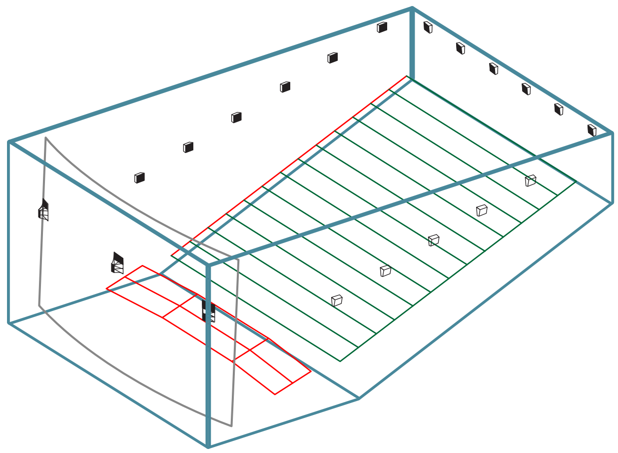
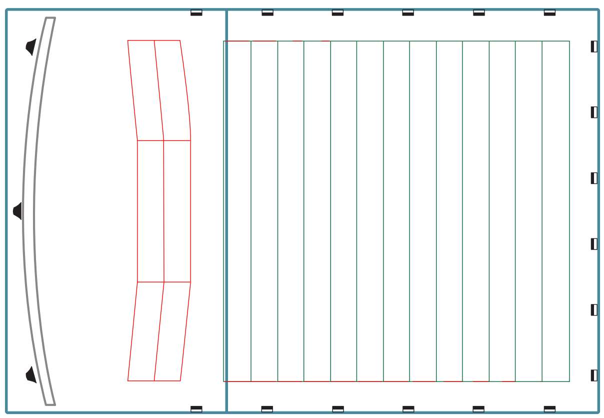
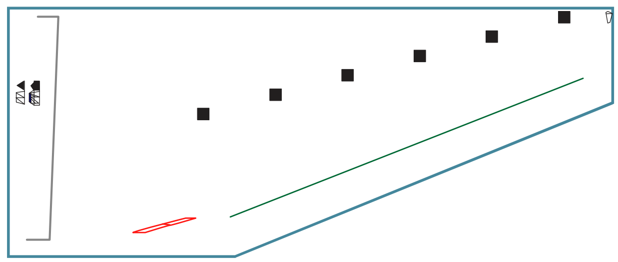
BALANCED SURROUND COVERAGE FOR PROFESSIONAL CINEMA







The importance of loudspeaker coverage in cinema is largely misunderstood. Typically just a vague reference to a specification like '90x40', the literal definition is how well the loudspeaker interfaces with the audience. The technical definition is how uniform the loudspeaker 'maps' 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 i.e. overcoming the attenuation of sound relating to distance from the loudspeaker. In cinema terms, if the loudspeakers had no envelope shape, only the first few rows would get good sound from the screen and there would be no seats with actual channel balance. The ability of a loudspeaker to present more intense energy towards the furthest 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.

Cinema surround coverage was for years, required envelope shape was for years a minor issue because they were configured in a single array evenly spaced around the perimeter of the theater. Each individual loudspeaker only needed to cover a small portion of the audience. The evolution of surround formats, however, demands a new requirement. Surrounds now must operate in much smaller groupings and even solo, which now means each surround must be able to cover the entire room (or much of it). When analyzed in this manner, surround coverage requirements are more stringent than screen channels, and the ideal coverage requirement very difficult for a single loudspeaker.

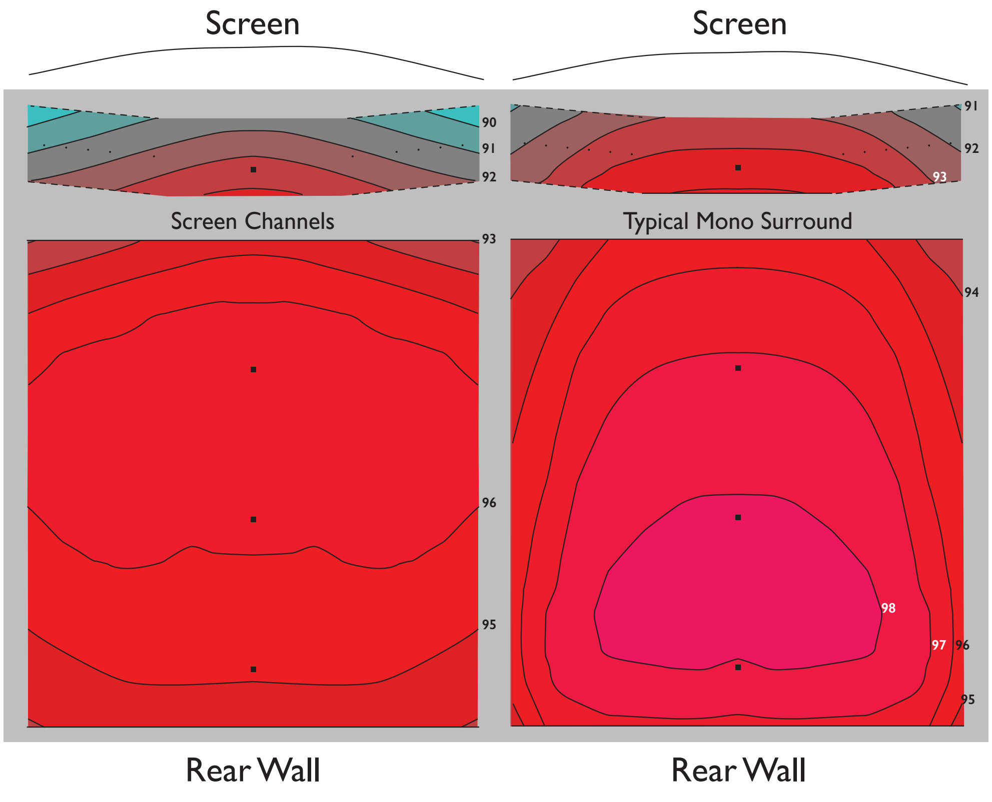
To compound the issue, different locations in the room demand a different envelope shape. A rear surround sees a very different geometry than a side surround. Add to this ceiling locations and screen locations, there are easily four distinct patterns necessary for uniform surround coverage in the immersive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

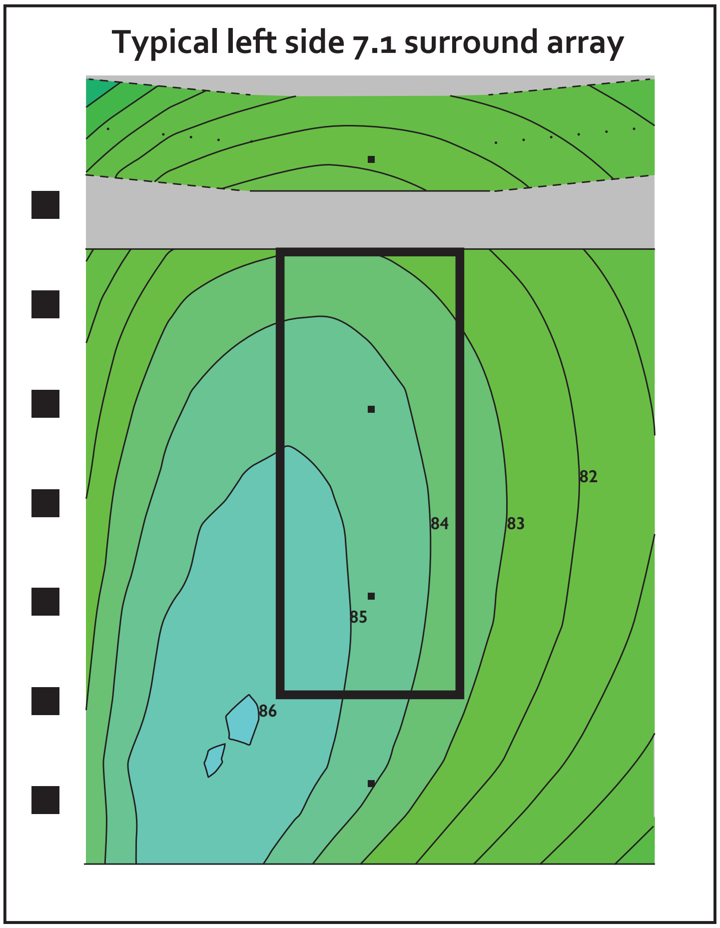
A study of loudspeaker coverage in cinema is possible with simulation using a room model as shown on the previous page. Our model is specifically a stadium seating cinema theater. Utilizing actual measured loudspeaker radiation envelopes, room coverage contour plots are calculated for each loudspeaker or group of loudspeakers. 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 one can quickly see, screen channels do a great job in the main stadium riser section and begin to fall off in the extreme front areas. The surrounds do an adequate job with a bias towards the rear of the room (where the loudspeaker density is greatest).

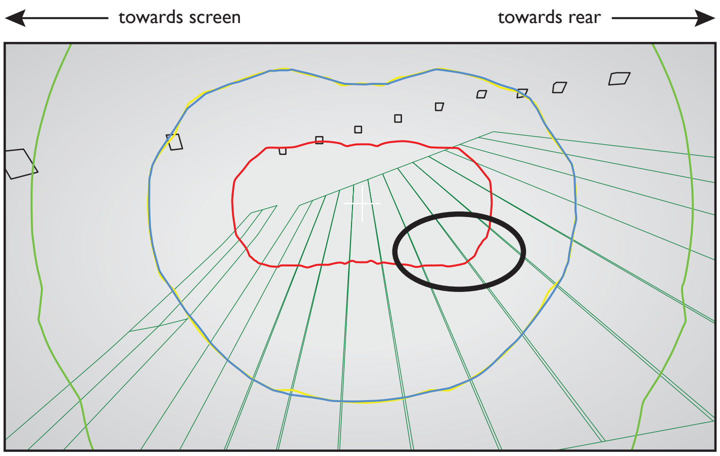
One can deduce from this there are two distinct seating areas from an audio balance standpoint –the front 2/3 of the room and the rearmost 1/3 of the room. The front 2/3 seating area is within +/-1dB channel balance. The rear most 1/3 of the room has a different balance with the surrounds up and the screens down in level. Therefore, the rear 1/3 of the theater is at least 2dB out of calibration. This is typical of almost every stadium cinema room and this is still based on 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 for there to be perfect coverage which in these plots would be 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 i.e. the best visual seats should also be the best audio seats. The screen channel plot above fits this requirement. 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 ideal, it is significantly better than any of the newer formats. A distributed array of loudspeakers will easily have better distribution of energy than a single loudspeaker. The perimeter array, however, looses all ability to localize an audio event. Couple this with the fact a typical surround having a very different sonic character and dynamic as compared to the screen channels is why the newer formats have emerged.







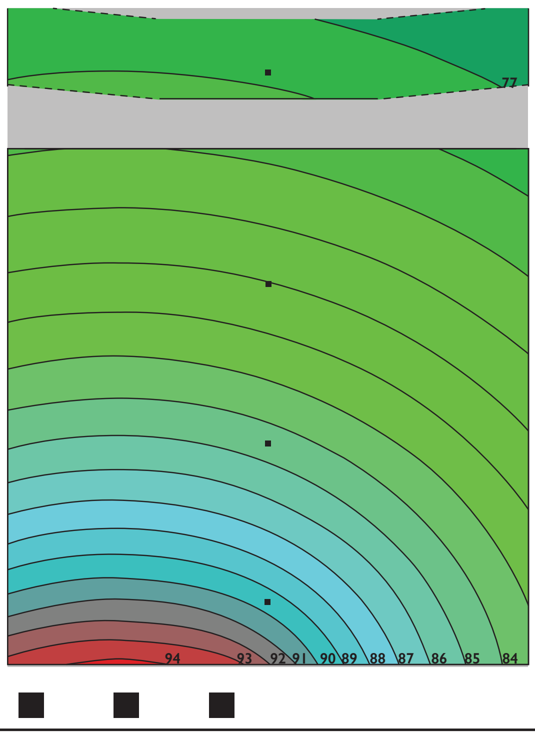
How a side surround 'sees' the audience. The red, blue, and green lines represent the 3,6,9dB pattern lines of the loudspeaker. Stadium seating creates a 'hot' spot—shown by the ellipse—where the loudspeaker energy is strong and the audience is close.

An evaluation of the newer formats reveals a more stringent requirement. Starting with the 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—7 loudspeakers in this model. One can immediately see a strong bias towards the rear which is explained later and a bias towards the loudspeakers. 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 in balance with the screen channels (referenced on the previous page).

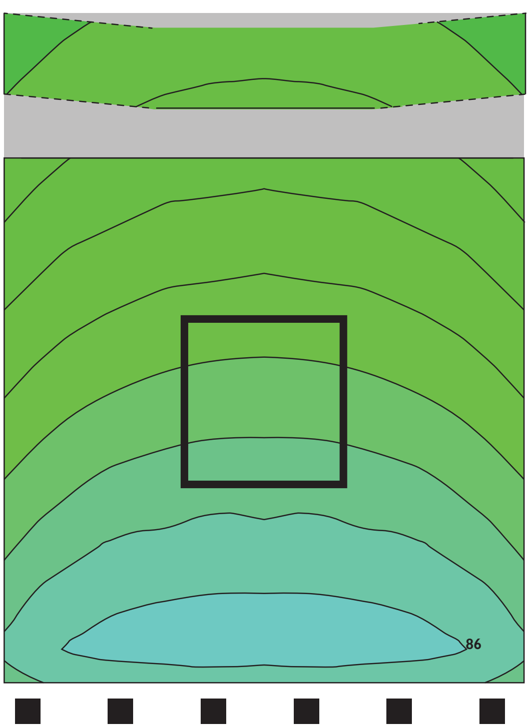
The channel balance area which includes the screen channels and the 7.1 side surrounds is 25% of the audience. This assumes premium quality loudspeakers! It should be noted here that 5.1 is actually worse because 1/2 of the rear loudspeakers are grouped with their associated side arrays making the rear 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 to the seating plane are not fixed with level.

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

Attenuation due to distance for 7.1 rear

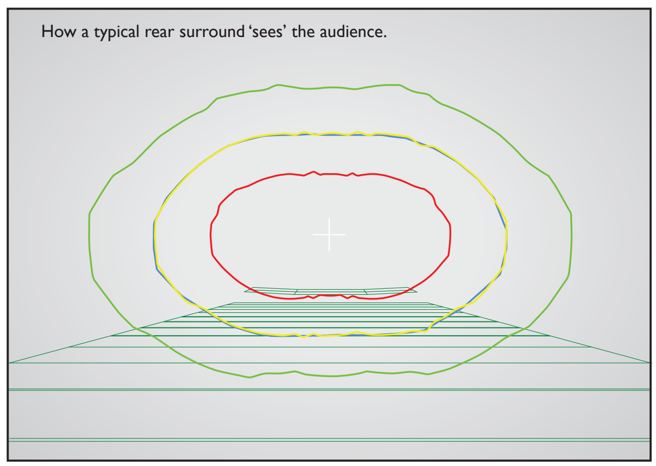


Attenuation due to distance for 7.1 rear



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

Analysis of 7.1 rear surrounds reveals a more difficult coverage requirement so much so that several graphics are offered as explanation. 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 shows the 16dB difference between front row and rear row. To make this more difficult, this happens in a fairly small angle from the loudspeakers perspective. The graphic right shows how a typical loudspeaker coverage pattern fits in this arrangement. The most intense energy is actually not directed at audience so the transition area of the pattern can align with the audience to achieve the best overall uniformity. Needless to say, this is the wrong pattern for this application.



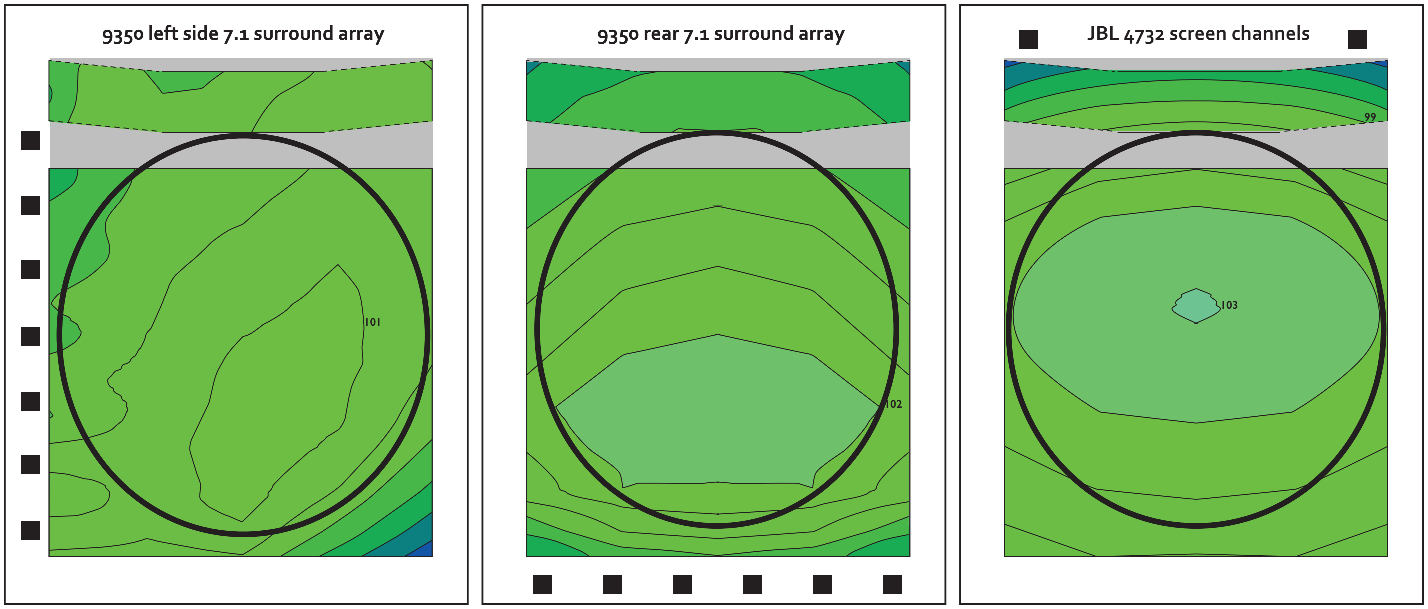
The resulting coverage map of a 7.1 rear surround array is shown bottom left. It has a severe rearward bias and a 7dB differential between front seats and rear seats i.e. the front 1/2 of the theater receives no intelligible rear content. In addition, there is a 4dB differential between the rear row and calibration row. Evaluating the +/-1dB channel balance for all loudspeakers is now restricted to the box shown or 7% of the audience!

Having identified the problem, JBL engineers embarked on extensive research and development which has culminated in the 9350 a comprehensive development which has now culminated into the 9350. The resulting loudspeaker design is unique. With three patent pending technologies emerging from the development, the 9350 delivers unprecedented performance surpassing anything else available.

The 9350 is a configurable pattern loudspeaker. 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 room requirement. With electronic filtering, coverage is manipulated in almost infinite pattern possibilities. The standard 9350, therefore, has a side surround pattern and a rear surround pattern. This sounds a lot like sophisticated DSP, multiple amplifiers, and an extreme price tag fortunately, 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 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 the legendary JBL differential drive technology for impactful low end. This surround speaker rivals screen channels in sonic performance and dynamics.

The difference in performance is nothing short of spectacular. Evaluating the 9350 in all 7.1 surround positions and using JBL 4732 as screen channels, coverage mapping is shown below. The notably large +/- 1dB coverage area is now highlighted by the ellipse. 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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