Dolby® Atmos™
Next-Generation Audio for Cinema

Overview

Current cinema authoring, distribution, and playback suffer from limitations that constrain the creation of truly immersing and lifelike audio. Dolby® Atmos™, the next-generation cinema sound platform, addresses these limitations and delivers an audio experience beyond anything available to date.

Dolby Atmos adds the flexibility and power of dynamic audio objects into traditional channel-based workflows. These audio objects allow moviemakers to control discrete sound elements irrespective of specific playback speaker configurations, including overhead speakers. Dolby Atmos also introduces new efficiencies to the postproduction process, allowing sound mixers to efficiently capture their creative intent and then, in real-time, monitor or automatically generate Dolby Surround 7.1 and 5.1 versions. Dolby Atmos simplifies distribution—the audio essence and artistic intent is all contained in a track file within the Digital Cinema Package (DCP), which can be faithfully played back in a broad range of theater configurations.

Content creators will welcome the new power they have to tell their stories with Dolby Atmos. Studios will appreciate the simplified distribution. Exhibitors will be able to offer audiences a new, compelling, only-in-a-theater experience. The audience will enjoy a completely new listening experience with enveloping sound that brings the stories on screen more fully to life.

Table of Contents

1 Introduction

1.1 A Brief History of Film Sound

Since the introduction of sound with film in 1927, there has been a steady evolution of technology used to capture the artistic intent of the motion picture soundtrack and to replay it in a cinema environment.

In the 1930s, sync sound on disc gave way to variable area sound on film, which was further improved in the 1940s with theatrical acoustic considerations and improved loudspeaker design, along with the introduction of multitrack recording and steerable replay (using control tones to move sounds). In the 1950s and 1960s, magnetic striping of film allowed multichannel playback in theaters, introducing surround channels and up to five screen channels in premium venues.

In the 1970s, Dolby introduced noise reduction, both in postproduction and on film, along with a cost-effective means of encoding and distributing mixes with three screen channels and a mono surround channel, as shown in Figure 1.1. The quality of cinema sound was further improved in the 1980s with Dolby SR noise reduction and certification programs such as THX®.

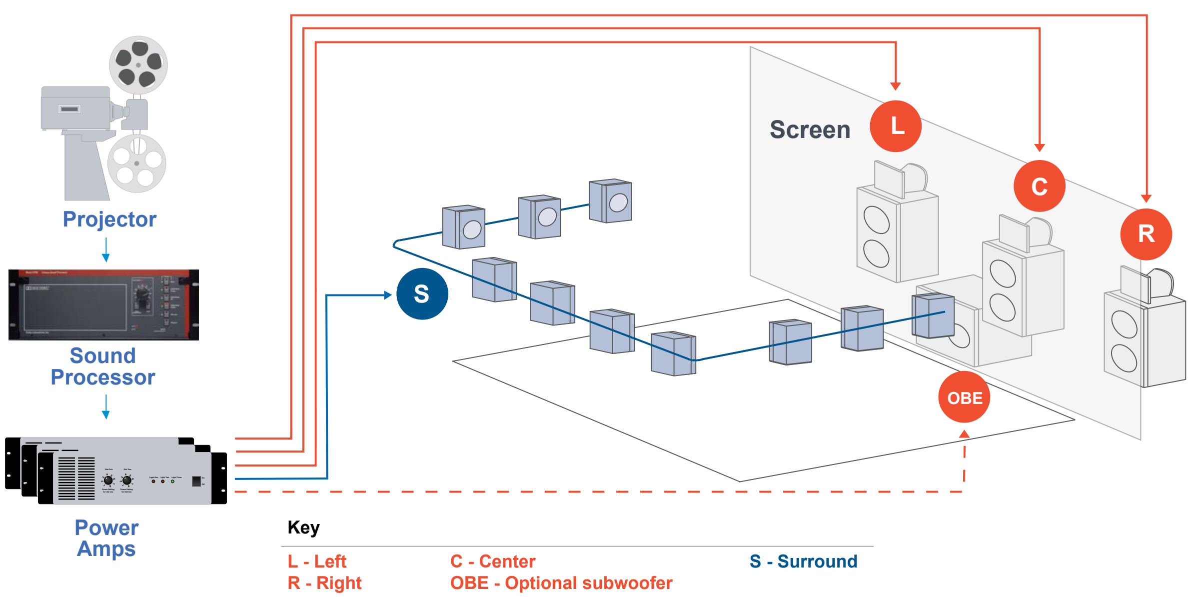

Figure 1.1 Dolby Surround

The 1990s saw the launch of digital sound to the cinema, allowing 5.1 mixing, mastering, and playback providing discrete Left, Center, and Right screen channels, Left and Right Surround arrays, and a subwoofer channel for low frequency effects, as shown in Figure 1.2. The surround channels were able to provide a wider frequency response, since the band-limiting of matrix surrounds (for prevention of "bleed" or crosstalk from the screen channels) was no longer required. The screen channels were expanded to include five screen speakers with the reintroduction of "inner left" and "inner right" channels, and were further enhanced with Dolby Digital Surround EX™, adding a Back Surround channel. All Dolby Digital film prints continue to contain a Dolby SR analog track for compatibility in all theaters (including those with only mono capabilities).

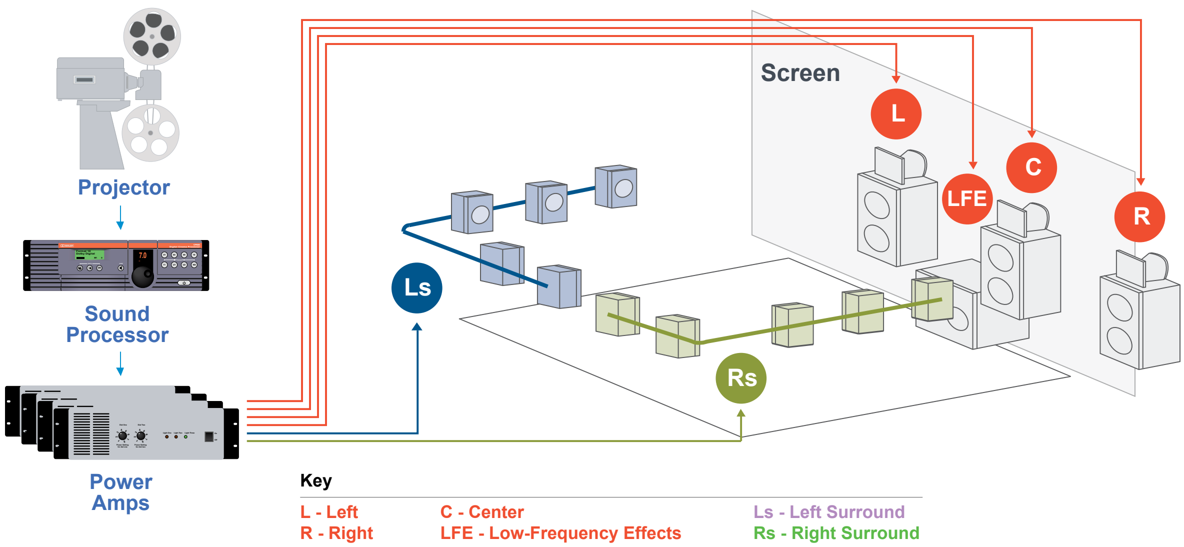

Figure 1.2 Dolby Digital

1.2 The Introduction of Digital Cinema

The introduction of digital cinema has provided the opportunity for the industry to evolve beyond the technical limitations in place with sound on film. With the creation of standards for digital cinema, 16 channels of audio have been made available within a DCP to allow for greater creativity for content creators and a more enveloping and realistic auditory experience for cinemagoers. During the advent of digital cinema, the industry has focused primarily on the development of technologies and standards relating to image and security. At the same time, the industry has enjoyed the ability to use existing 5.1-equipped dubbing theaters and cinemas for the creation and playback of soundtracks using effectively the same content for both digital cinema and 35 mm playback.

In 2010, the first step in enhancing digital cinema sound was undertaken with the introduction of Dolby Surround 7.1. The new format continues the pattern of increasing the number of surround channels by splitting the existing Left and Right Surround channels into four "zones," shown in Figure 1.3. The increased ability for sound designers and mixers to control the positioning of audio elements in the theater, along with improved panning from screen to surrounds, has made the format a success in both the continual adoption in production and the speed of conversion of theaters. With more than 60 titles and 3,600 screens equipped in less than two years since its launch, the success of Dolby Surround 7.1 has indicated a desire within the motion picture industry to embrace new audio technologies.

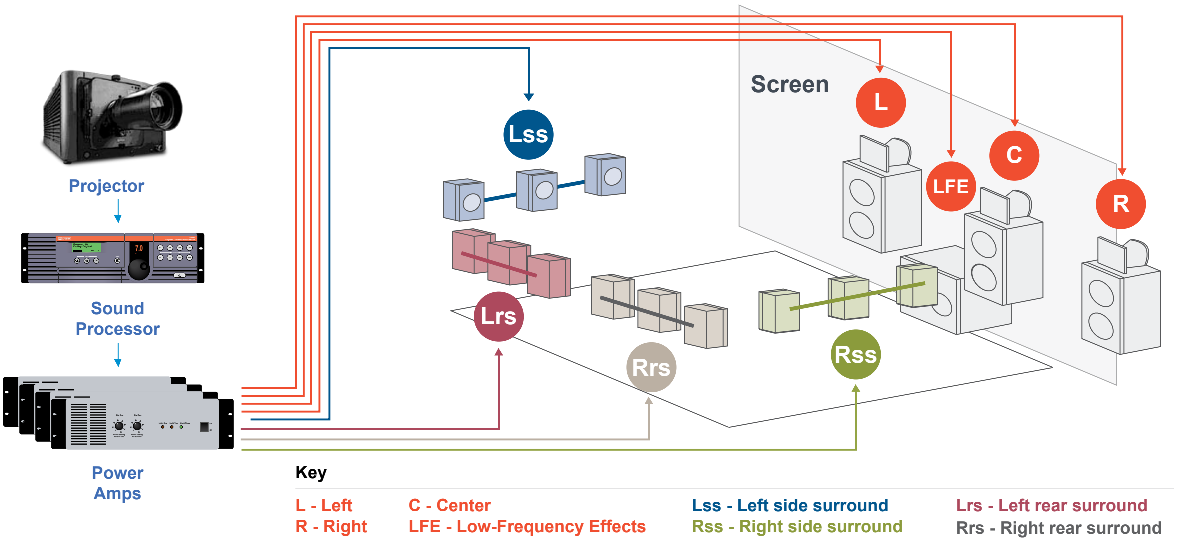

Figure 1.3 Dolby Surround 7.1

1.3 Working Toward the Next Generation of Cinema Sound

Throughout the development of Dolby Surround 7.1, Dolby continued to investigate the future of cinema sound, working toward a new audio format. Dolby equipped dubbing theaters with various speaker configurations to determine which speaker locations are compelling to a content creator. Remixed movie content was taken into different auditoria in various countries, equipped with appropriate speaker locations, to determine what is effective in theaters of varying size and shape. Finally, these tests were demonstrated to global exhibitors to gain their feedback on what would work for their customers and what they would be willing and able to install.

This cycle of research, and Dolby's current product and technology footprint, has allowed precise targeting of requirements for the next generation of digital cinema sound, in areas from sound design and editing to re-recording, mastering, packaging, distribution, and replay in theaters. For example, although many cinemas are equipped with inner left (Lc) and inner right (Rc) replay channels, these channels are rarely used because a dedicated five-screen channel mix must be created to support them. However, on larger screens, additional channels could provide both smoother pans and more accurate placement of sound to match the image. Similarly, while the use of surround arrays can arguably create a suitably ambient effect with appropriate content, the introduction of Dolby Surround 7.1 has demonstrated that significant improvement in localization of sound results from increasing the number of surround zones within the auditorium.

In parallel to research into a new audio format, Dolby has revisited critical areas of the theatrical replay environment, including the technology and standards by which dubbing theaters and cinemas are aligned and monitored. Introduction of a new audio format allows changes to be implemented without breaking compatibility, making it an ideal opportunity to revisit existing standards. In some areas the current practice is ratified, and in others it is improved upon as technology evolves.

This exhaustive research, along with lessons learned from decades of introducing new cinema sound formats, culminates in Dolby's introduction of Dolby Atmos as the next generation of sound for cinema. The Dolby Atmos platform encompasses products, services, and technologies that build on existing workflows and technologies to deliver an audio experience well beyond the best available to date.

2 Dolby Atmos Overview

Dolby Atmos achieves unprecedented levels of audience immersion and engagement by offering powerful new authoring tools to mixers. It also offers a new cinema processor featuring a flexible rendering engine that optimizes the audio quality and surround effects of the Dolby Atmos soundtrack to each room's loudspeaker layout and characteristics. In addition, Dolby Atmos has been designed from the ground up to maintain backward compatibility and minimize the impact on the current production and distribution workflows.

2.1 Audience Immersion

Two critical elements significantly improve the audience experience over 5.1 and 7.1 systems:

- Sounds originating overhead
- Sounds originating from discrete sources throughout the auditorium

2.1.1 Overhead Sound

In the real world, sounds originate from all directions, not from a single horizontal plane. An added sense of realism can be achieved if sound can be heard from overhead, from the "upper hemisphere."

The first example is of a static overhead sound, such as an insect chirping in a tree in a jungle scene. In this case, placing that sound overhead can subtly immerse the audience in the scene without distracting from the action on the screen.

Another example is a somewhat less-subtle helicopter elevating on the screen and flying off over the audience. The use of more discrete surround zones, as in Dolby Surround 7.1, helps achieve the perception of overhead movement, but adding overhead speakers prevents the brain from having to construct a phantom image of the helicopter moving overhead.

2.1.2 Improved Surround Definition and Audio/Visual Coherence

For many years, cinema has enjoyed having discrete screen channels in the form of Left, Center, Right, and occasionally inner left and inner right channels. These discrete sources have sufficient frequency response and power handling to allow sounds to be accurately placed in different areas of the screen, and to permit timbre matching as sounds are moved or panned between locations.

In a 5.1 setup, the surround zones comprise an array of loudspeakers, all of which carry the same audio information within each Left Surround or Right Surround zone. Such arrays are particularly effective with ambient or diffuse surround effects.

However, in everyday life many sounds originate from randomly placed point sources. Consider the example of being in a restaurant. In addition to ambient music apparently being played from all around, subtle but discrete sounds originate from specific points: a person chatting from one point, the clatter of a knife on a plate from another. Being able to place such sounds discretely around the auditorium can add a heightened sense of realism without being obvious.

A less subtle example is the sound of a gunshot fired from somewhere behind the audience. In this case, the intention may be to momentarily distract the viewer from the screen, as might happen if somebody were to hear such a sound in real life. Being able to pinpoint this sound could be more effective than trying to emulate it through an array of loudspeakers. The increased resolution of surround speaker configuration provided by Dolby Surround 7.1 helps add realism to such effects, but the ability to individually address surround loudspeakers in addition to the 7.1 arrays takes realism to a new level.

A fundamental role of cinema sound is to support the story on the screen. Dolby Atmos supports multiple screen channels, resulting in increased definition and improved audio/visual coherence for onscreen sounds or dialogue. The ability to precisely position sources anywhere in the surround zones also improves the audio/visual transition from screen to room. If a character on the screen looks inside the room toward a sound source, the mixer has the ability to precisely position the sound so that it matches the character’s line of sight, and the effect will be consistent throughout the audience (Figure 2.1, right). In contrast, in a traditional 5.1 or Dolby Surround 7.1 mix, the effect would be dependent on a viewer’s seating position (see Figure 2.1, left). Increased surround resolution creates new opportunities to use sound in a room-centric way. This approach is an important innovation, quite distinct from the traditional approach in which content is created assuming a single listener at the “sweet spot.” Room-centric audio better supports the onscreen action.

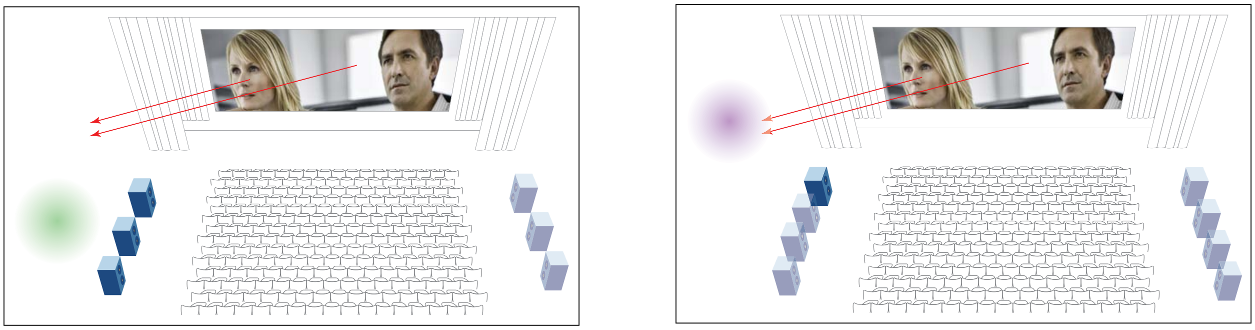

Figure 2.1 Benefits of Increased Surround Resolution for Audio/Visual Coherence

2.1.3 Improved Audio Quality and Timbre Matching

In addition to the spatial benefits, the Dolby Atmos core audio quality is an improvement over the current multichannel state-of-the-art systems.

The timbral quality of some sounds, such as steam hissing out of a broken pipe, can suffer from being reproduced by an array of loudspeakers. The ability to direct specific sounds to a single speaker gives the mixer the opportunity to eliminate the artifacts of array reproduction and deliver a more realistic experience to the audience.

Traditionally, surround speakers do not support the same full-range frequency response and level when compared to the screen channels. Historically, this has created issues for mixers, reducing their ability to freely move full-range sounds from screen to room. As a result, theater owners have not felt compelled to upgrade their surround channel configuration, creating a chicken-and-egg dilemma that has prevented the widespread adoption of higher-quality installations.

Dolby Atmos improves the audio quality in different rooms through such benefits as improved room equalization and surround bass management, so that the loudspeakers (whether on- or offscreen) can be freely addressed by the mixer without concern about timbral matching.

2.2 Author Once, Optimize Everywhere

2.2.1 Capturing the Creative Intent

In order to accurately place sounds around the auditorium, the sound designer or mixer needs more control. Providing this control involves changing how content is designed, mixed, and played back through the use of audio objects and positional data.

Audio objects can be considered as groups of sound elements that share the same physical location in the auditorium. Objects can be static or they can move. They are controlled by metadata that, among other things, details the position of the sound at a given point in time. When objects are monitored or played back in a theater, they are rendered according to the positional metadata using the speakers that are present, rather than necessarily being output to a physical channel.

Thinking about audio objects is a shift in mentality compared with how audio is currently prepared, but it aligns well with how audio workstations function. A track in a session can be an audio object, and standard panning data is analogous to positional metadata. In this way, content placed on the screen might pan in effectively the same way as with channel-based content, but content placed in the surrounds can be rendered to an individual speaker if desired.

While the use of audio objects provides desired control for discrete effects, other aspects of a movie soundtrack do work effectively in a channel-based environment. For example, many ambient effects or reverberations actually benefit from being fed to arrays of loudspeakers. Although these could be treated as objects with sufficient width to fill an array, it is beneficial to retain some channel-based functionality.

Dolby Atmos therefore supports "beds" in addition to audio objects. Beds are effectively channel-based submixes or stems. These can be delivered for final playback (rendering) either individually or combined into a single bed, depending on the desire of the content creator. These beds can be created in different channel-based configurations such as 5.1, 7.1, or even future formats such as 9.1 (including arrays of overhead loudspeakers).

Figure 2.2 Object and Bed Combination

2.2.2 Optimizing During Rendering

Dolby Atmos allows up to 128 tracks to be packaged, usually a combination of beds and objects. The renderer takes these audio tracks and processes the content according to the signal type. Beds are fed to arrays, which will potentially require different delays and equalization processing than individual objects. The process supports rendering of these beds and objects to up to 64 speaker outputs.

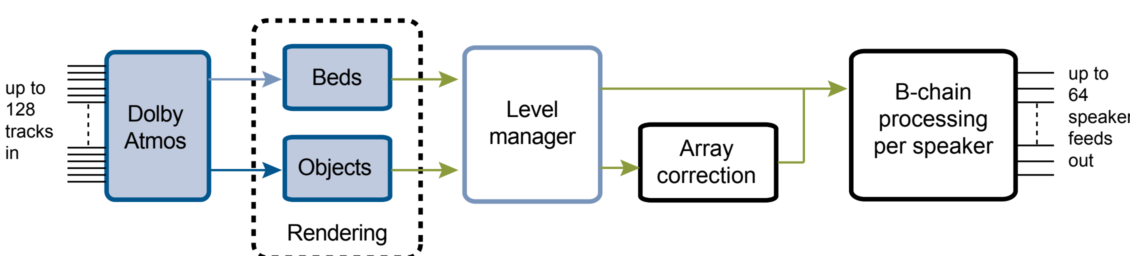

Figure 2.3 Block Diagram of Dolby Atmos Rendering

The rendering algorithm intelligently uses the surround loudspeakers in the theater to their best effect. By improving the power handling and frequency response of the surround speakers, and by keeping the same monitoring reference level for each output channel or speaker in the theater, objects being panned between screen and surround speakers can maintain their sound pressure level (SPL) and have a closer timbre match without, importantly, increasing the overall SPL in the theater.

An array of appropriately specified surround loudspeakers will have enough headroom to reproduce the maximum dynamic range available within a Dolby Surround 7.1 or 5.1 soundtrack (20 dB above reference level). However, it is unlikely that a single surround speaker will have the same headroom as a large multiway screen speaker. As a result, there will likely be instances when an object placed in the surround field will require a sound pressure greater than that attainable using a single surround speaker. In these cases, the renderer will spread the sound across an appropriate number of speakers in order to achieve the required SPL. With Dolby Atmos, improving the quality and power handling of surround speakers can provide an improvement in the faithfulness of the rendering.

Additionally, the support for bass management of the surround speakers through the installation of optional rear subwoofers allows each surround loudspeaker to achieve improved power handling and potentially use smaller cabinets.

Finally, the addition of side surround loudspeakers closer to the screen than current practice ensures that objects can smoothly transition from screen to surround. It is important to note that these additional side surround speakers are not used to replay content destined for a surround array (for instance, in Dolby Surround 7.1 rendered output, or in a 5.1 bed as part of a Dolby Atmos mix) since this will compromise the experience of using a sidewall array.

More information on speaker layout recommendations is available in Section 5, Theatrical Exhibition.

2.3 Workflow Integration

Dolby Atmos technology integrates into existing postproduction workflows without adding excessive time and cost to the process.

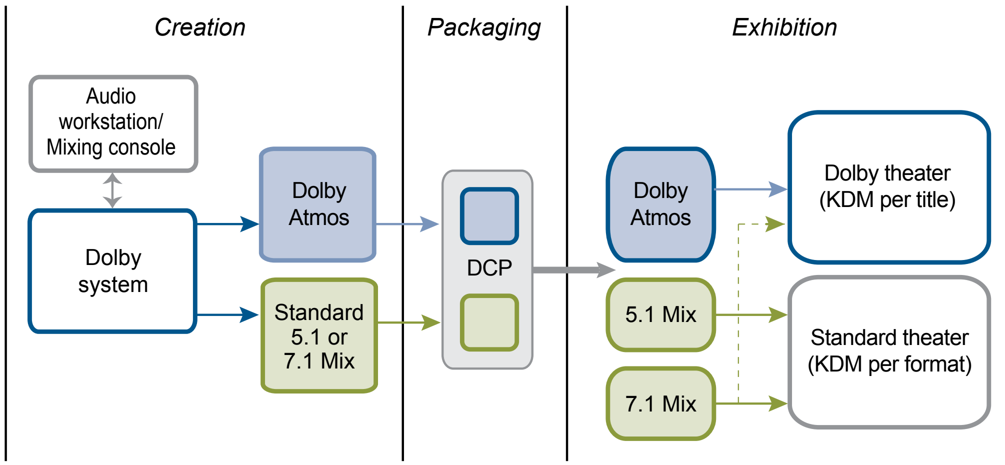

Figure 2.4 Cinema Audio Workflow

2.3.1 In the Dubbing Theater

The hybrid model of beds and objects allows most sound design, editing, premixing, and final mixing to be performed in the same manner as they are today.

Plug-in applications for digital audio workstations allow existing panning techniques within sound design and editing to remain unchanged. In this way, it is possible to lay down both beds and objects within the workstation in 5.1-equipped editing rooms.

Object audio and metadata are recorded in the session in preparation for the pre- and final-mix stages in the dubbing theater.

Metadata is integrated into the dubbing theater's console surface, allowing the channel strips' faders, panning, and audio processing to work with both beds or stems and audio objects. The metadata can be edited using either the console surface or the workstation user interface, and the sound is monitored using a Dolby Rendering and Mastering Unit (RMU).

The bed and object audio data and associated metadata are recorded during the mastering session to create a "print master," which includes a Dolby Atmos mix and any other rendered deliverables (such as a Dolby Surround 7.1 or 5.1 theatrical mix). This print master file is wrapped using industry-standard Material Exchange Format (MXF) wrapping techniques, and delivered to the digital cinema packaging facility using standard DCP techniques that allow file validation prior to packaging.

2.3.2 During Packaging

The Dolby Atmos print master files contain a Dolby Atmos mix, along with a standard, channel-based main audio mix. The main audio mix can be rendered by the RMU in the dubbing theater, or created by a separate mix pass if desired. The main audio mix forms the standard main audio track file within the DCP, and the Dolby Atmos mix will form an additional track file. Such a track file is supported by existing industry standards, and is ignored by DCI-compliant servers that cannot use it.

2.3.3 For Distribution

The Dolby Atmos packaging scheme allows delivery of a single DCP to any cinema, whether or not it is equipped to decode and play back a Dolby Atmos soundtrack. The composition contains both main audio and Dolby Atmos track files. A single key delivery message (KDM) targeted to the cinema's media block will continue to enable controlled playback of the content, and a DCI-compliant server with any cinema sound processor will be able to play the composition.

2.3.4 In the Cinema

The DCP containing a Dolby Atmos track file will be recognized by all servers as a valid package, and ingested accordingly. In theaters with Dolby Atmos, the Dolby Atmos track file will be ingested into the server and during playback will be streamed to the Dolby Atmos cinema processor for rendering. Having both Dolby Surround 7.1 (or 5.1) and Dolby Atmos audio streams available, the Dolby Atmos cinema processor can switch between them if necessary. This switching is analogous to the Dolby Digital and Dolby SR tracks on 35 mm prints, whereby a system that is equipped for Dolby Digital replay will do so from a single inventory print, but a system that cannot use the Dolby Digital track (or one that encounters a print or hardware issue) will seamlessly revert to the Dolby SR track to keep the show running.

3 Audio Postproduction and Mastering

Consider the workflow in audio postproduction—there are many steps, some of which occur in parallel, that lead to the creation of a final mix. Three main categories of sound are used in a movie mix: dialogue, music, and effects.

Effects consist of groups of sounds such as ambient noise, vehicles, or chirping birds—everything that is not dialogue or music. Sound effects can be recorded or synthesized by the sound designer or can originate from effects libraries. A subgroup of effects known as Foley, such as footsteps and door slams, are performed by Foley actors.

Dolby sound consultants work globally on all film soundtracks using Dolby technologies, and will continue to provide services in all aspects of the audio post workflow. The following sections outline initial integration of Dolby Atmos into a feature film.

3.1 Production Sound

Sound is recorded on set, and hundreds of sound files are created. Spotting sessions determine which files, including dialogue or Foley content, are of acceptable quality.

3.2 Editing and Premixing

3.2.1 Dialogue

Production dialogue that is not considered usable is rerecorded in ADR (automated dialogue replacement or additional dialogue recording) sessions. The dialogue editor uses both production dialogue and ADR, and the dialogue mixer creates dialogue premixes containing mono dialogue tracks and several channel-based beds of "loop group," such as crowd noise. At this point, dialogue that would benefit from being placed or panned throughout the auditorium is marked as an object and panned accordingly.

3.2.2 Foley and Effects

The Foley editor takes production and recorded effects to create several channel-based beds of Foley. Any Foley that would benefit from being placed precisely in the auditorium would be marked and panned as an object.

The effects editor takes designed and library sound effects to create what could be hundreds of sound effects elements and beds of ambiences. The effects mixer takes these sessions, along with the Foley content, to create effects premixes of both individual tracks and channel-based beds. Again, any suitable effects are identified and positioned as objects.

Effects may be further split into groups such as atmospheres, crowds, and movements, such as rustling cloth.

3.2.3 Music

Music is mixed by a scoring mixer and passed to the music editor and music mixer for creation of music premixes, which can again consist of tracks and channel-based beds. Music is least likely to benefit from being mixed as an object, but it certainly could be in the right circumstances.

3.3 Final Mixing

All of the music, dialogue, and effects are brought together in the dubbing theater during the final mix, and the re-recording mixer(s) use the premixes (also known as the "mix minus") along with the individual sound objects and positional data to create stems as a way of grouping, for example, dialogue, music, effects, Foley, and background. In addition to forming the final mix, the music and effects stems are used as a basis for creating dubbed foreign-language versions of the movie.

Each stem consists of a channel-based bed and several audio objects with metadata. Stems combine to form the final mix. Using object panning information from both the audio workstation and the mixing console, the RMU renders the audio to the speaker locations in the dubbing theater. This rendering allows the mixers to hear how the channel-based beds and audio objects combine, and also provides the ability to render to different configurations. The mixer can use conditional metadata, which defaults to relevant profiles, to control how the content is rendered to, for example, Dolby Surround 7.1. In this way, the mixers retain complete control of how the movie plays back in all the scalable environments that Dolby Atmos allows.

3.4 Mastering

During the mastering session, the stems, objects, and metadata are brought together in a Dolby Atmos package that is signed off in the dubbing theater and will remain untouched through to exhibition in the cinema. The Dolby Atmos package will also contain the backward-compatible Dolby Surround 7.1 or 5.1 theatrical mix. The RMU can render this output if desired, thereby eliminating the need for any additional workflow steps in generating existing channel-based deliverables. The audio files are packaged using industry-standard MXF wrapping techniques to minimize the risk of changes, and delivered to the digital cinema packaging facility.

As has been standard practice for several decades, the dubbing theater is equipped and calibrated by Dolby sound consultants in exactly the same manner as the playback theaters to ensure complete confidence that what is created in the studio will translate predictably to the cinema.

In addition to rendering channel-based theatrical deliverables, the Dolby Atmos master file can be used to generate other deliverables such as consumer multichannel or stereo mixes. Again, intelligent profiles and conditional metadata in Dolby Atmos allow controlled renderings that could significantly reduce the time required to create such mixes.

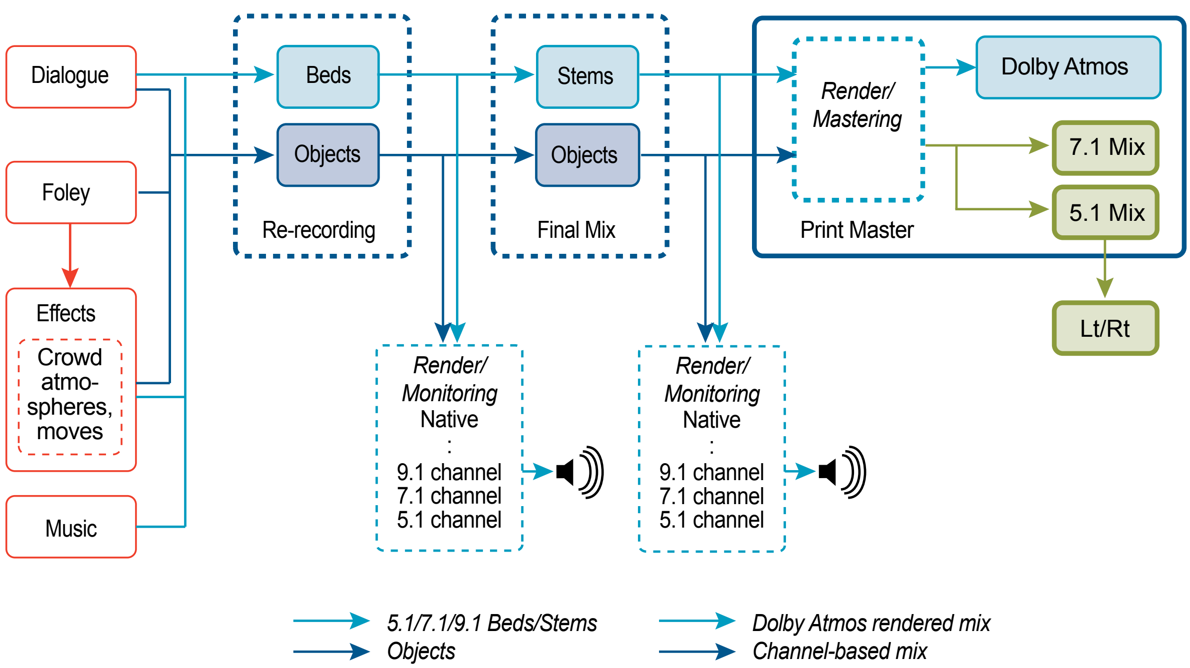

Figure 3.1 Dolby Atmos Audio Post Workflow

4 Digital Cinema Packaging and Distribution

4.1 Audio File Delivery

The Dolby Atmos audio files delivered to the packaging facility can be imported into an appropriate digital cinema packaging system, such as the Dolby Secure Content Creator (SCC2000), to create a DCP. The audio track files may be locked together to help prevent synchronization errors with the Dolby Atmos track file that has been signed off in the dubbing theater. The SCC2000 may also respond to data in the print master file, such as first frame and last frame of action, to ensure accurate synchronization of sound to picture as was signed off in the dubbing theater.

Upon importing, the MXF audio files (both Dolby Atmos and main audio) are checked to confirm that there is no corruption or tampering. If an error is reported, the operator will be alerted to take appropriate action. This workflow is similar to successful current practice used in Dolby Digital mastering for theatrical releases, whereby the Dolby Digital and Dolby SR tracks are physically associated and also coded to prevent unauthorized tampering.

4.2 Appending Audio Tracks

Certain territories require the addition of track files during the packaging phase, such as the addition of hearing-impaired (HI) or visually impaired narration (VI-N) tracks to the main audio track file. The SCC2000 will continue to allow the addition of tracks to the main audio track file where required by the industry.

4.3 Track File Encryption

Upon creation of the DCP, the main audio MXF file (with appropriate additional tracks appended) is encrypted using SMPTE specifications in accordance with existing practice. The Dolby Atmos MXF is packaged as an auxiliary track file, and is optionally encrypted using a symmetric content key per the SMPTE specification.

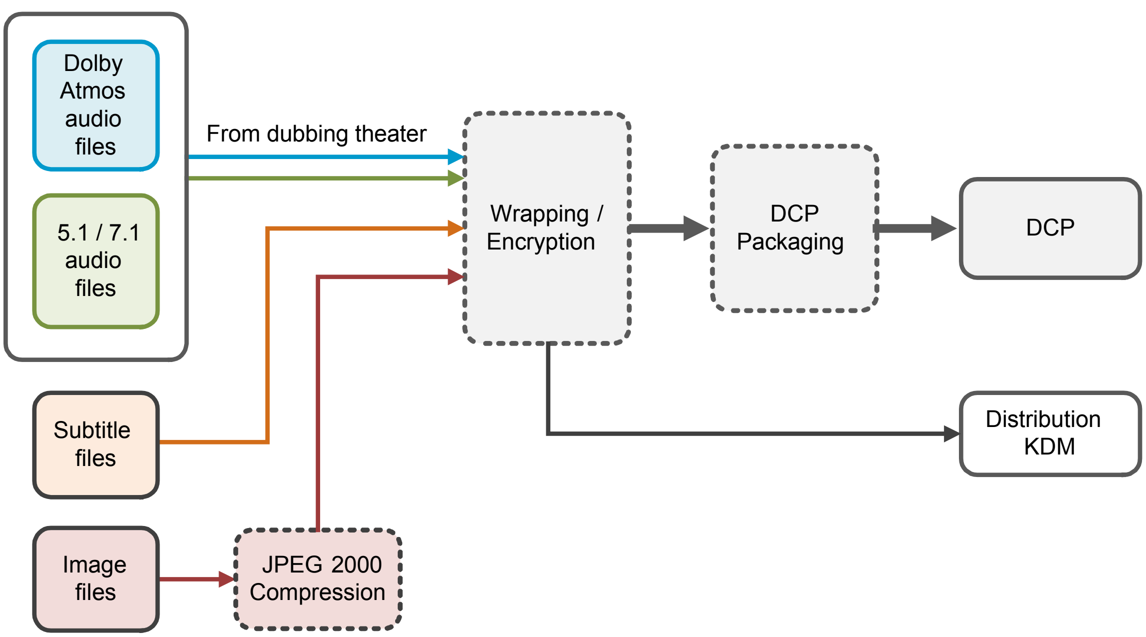

Figure 4.1 Digital Cinema Packaging Workflow

4.4 Digital Cinema Package Distribution

This single DCP can then be delivered to any DCI-compliant server. Any installations that are not suitably equipped will simply ignore the additional track file containing the Dolby Atmos soundtrack and will use the existing main audio track file for standard playback. Those installations equipped with a Dolby Atmos cinema processor will be able to ingest and replay the Dolby Atmos soundtrack where applicable, reverting to the standard audio track as necessary.

5 Theatrical Exhibition

This section provides information on installation of Dolby Atmos systems in theaters.

5.1 Equipment Considerations

5.1.1 Dolby Atmos Cinema Processor

The introduction of Dolby Atmos and a new cinema processor changes how theater speakers are installed, calibrated, and maintained. With the introduction of many more potential speaker outputs, each individually equalized and balanced, there is a need for intelligent and time-efficient automatic room equalization. Coupled with the ability to manually adjust any automated room equalization, it is critical that the qualified installer know exactly what processing is being applied to a given speaker channel in order to make educated decisions when fine-tuning a theater.

In addition to the implementation of reliable automatic equalization, Dolby Atmos uses an optimized 1⁄12-octave band equalization engine derived from the successful Dolby Lake® processor. Up to 64 outputs can be processed to more accurately balance the sound in theater. The system also allows scheduled monitoring of the individual speaker outputs, from cinema processor output right through to the sound reproduced in the auditorium. Local or network alerts can be created to ensure that appropriate action is taken. In the meantime, the flexible rendering system may automatically remove a damaged speaker or amplifier from the replay chain and render around it, allowing the show to continue.

5.1.2 Integration with Cinema Servers

The Dolby Atmos cinema processor is connected to the digital cinema server with the existing 8 × AES main audio connection and an Ethernet connection for streaming Dolby Atmos audio data. Playback of Dolby Surround 7.1 or 5.1 content uses the existing AES audio connection. Dolby Atmos audio data is streamed over Ethernet to the cinema processor for decoding and rendering, and communication between the server and the cinema processor allows the audio to be identified and synchronized. In the event of any issue with the Dolby Atmos track playback, sound is reverted back to Dolby Surround 7.1 or 5.1 PCM audio.

5.2 Auditorium Considerations

While flexibility to simplify the introduction of new technology is a critical factor in the release of a new audio format, this same flexibility must be used to allow the system to scale and evolve with the industry. We have already seen 5.1 cinema sound transition to Dolby Surround 7.1, and exhibitors have started to install even more channel-based speaker systems including 9.1, 11.1, 13.1, and beyond.

Dolby provides recommendations on speaker layout for use with Dolby Atmos soundtracks, as detailed in this document, but the Dolby Atmos system is designed to allow both content creators and exhibitors to decide how they want to use it. A mixer can listen to and determine how content is going to be rendered in different playback speaker configurations, and an exhibitor can decide how much of an investment to make in a given theater in order to optimize the experience within a budget. The ideal number of speaker output channels used will vary according to room size. The first-generation Dolby Atmos cinema processor can support up to 64 outputs. Although 61.3 channels may sound excessive when compared with configurations available today, multichannel amplifiers that are currently available make individually addressing each of, for example, 11 surrounds on each sidewall in a large theater a reasonable proposition.

The recommended layout of speakers for Dolby Atmos remains compatible with existing cinema systems, which is hugely important so as not to compromise the playback of existing 5.1 and 7.1 channel-based formats. In the same way that the intent of the content creator must be preserved with the introduction of Dolby Atmos, the intent of mixers of Dolby Surround 7.1 and 5.1 content must equally be respected. This includes not changing the positions of existing screen channels in an effort to heighten or accentuate the introduction of new speaker locations. In contrast to using all 64 output channels available, the Dolby Atmos format is capable of being accurately rendered in the cinema to speaker configurations such as 7.1, allowing the format (and associated benefits) to be used in existing theaters with no change to amplifiers or loudspeakers.

5.2.1 Optimized Playback

Different speaker locations can differ in effectiveness depending on the theater design, and therefore the industry appears to agree that there is not an ideal number or placement of channels. As a result, Dolby Atmos is adaptable and able to play back accurately in a variety of auditoria, whether they have a limited number of playback channels or many channels with highly flexible configurations.

Figure 5.1 shows a diagram of suggested speaker locations in a typical auditorium; specific details about these speaker locations are described in subsequent sections.

The reference position referred to in the document corresponds to a position two-thirds of the distance back from the screen to the rear wall, on the center line of the screen.

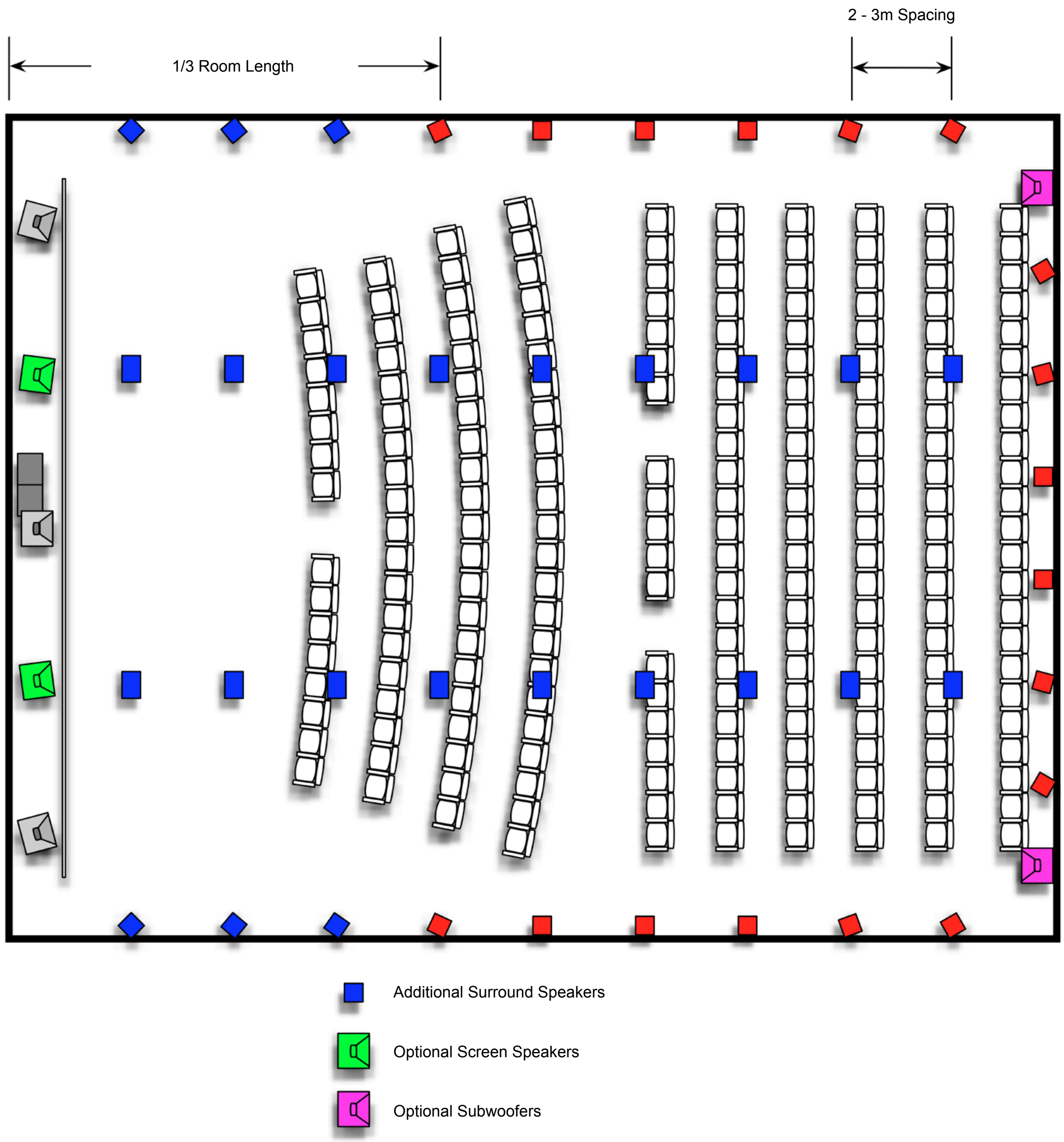

Figure 5.1 Recommended Speaker Locations

5.2.2 Screen Speakers

As we have studied the perception of elevation in the screen plane, we have found that additional speakers behind the screen, such as Left Center (Lc) and Right Center (Rc) screen speakers (in the locations of Left Extra and Right Extra channels in 70 mm film formats), can be beneficial in creating smoother pans across the screen. Consequently, we recommend installation of these additional speakers, particularly in auditoria with screens greater than 12 m (40 ft) wide. All screen speakers should be angled such that they are aimed toward the reference position.

The recommended placement of the subwoofer behind the screen remains unchanged, including maintaining asymmetric cabinet placement, with respect to the center of the room, to prevent stimulation of standing waves. Figure 5.2 shows a diagram of suggested speaker locations at the screen.

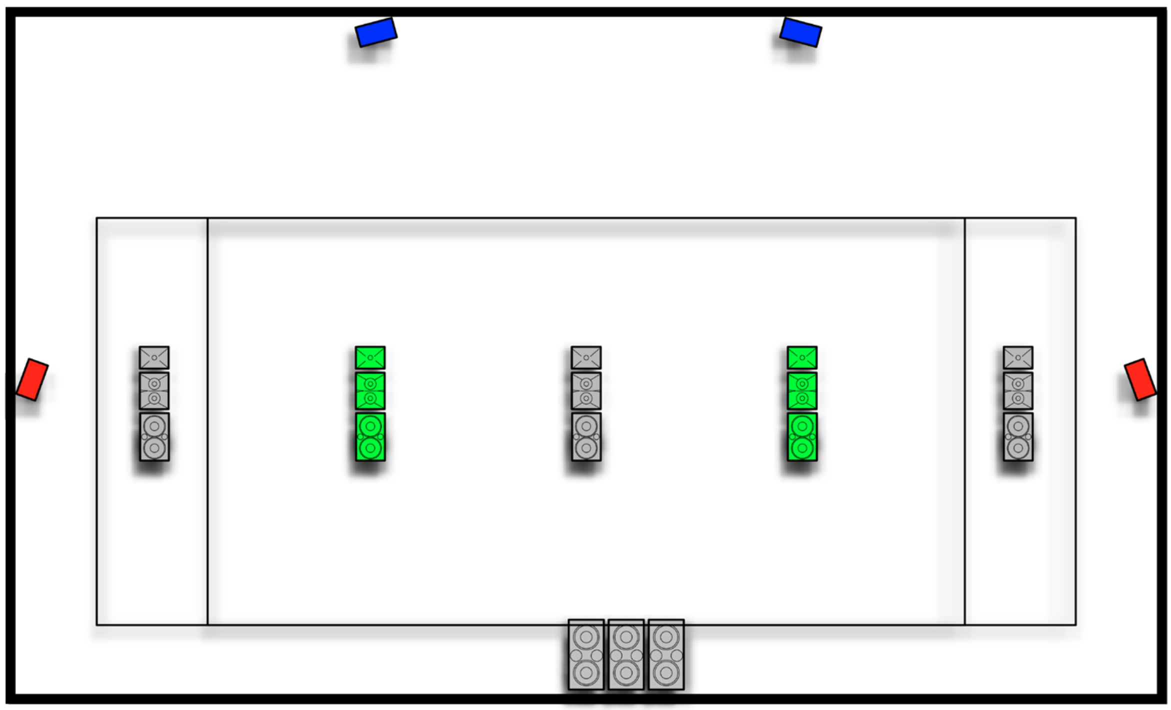

Figure 5.2 Recommended Speaker Locations (Screen, Side Surrounds, and Top Surrounds)

5.2.3 Surround Speakers

Surround speakers should be individually wired back to the amplifier rack, and be individually amplified where possible with a dedicated channel of power amplification matching the power handling of the speaker in accordance with the manufacturer's specifications. Ideally, surround speakers should be specified to handle an increased SPL for each individual speaker, and also with wider frequency response and providing uniform coverage throughout the seating area where possible.

As a rule of thumb for an average-sized theater, the spacing of surround speakers should be between 2 and 3 m (6′6″ and 9′9″), with Left and Right Surround speakers placed symmetrically. However, the spacing of surround speakers is most effectively considered as angles subtended from a given listener between adjacent speakers, as opposed to using absolute distances between speakers.

For optimal playback throughout the auditorium, the angular distance between adjacent speakers should be 30 degrees or less, referenced from each of the four corners of the prime listening area. Good results can be achieved with spacing up to 50 degrees. For each surround zone, the speakers should maintain equal linear spacing adjacent to the seating area where possible. The linear spacing beyond the listening area, such as between the front row and the screen, can be slightly larger.

Side Surrounds

Additional side surround speakers should be mounted closer to the screen than the currently recommended practice of starting approximately one-third of the distance to the back of the auditorium. These speakers are not used as side surrounds during playback of Dolby Surround 7.1 or 5.1 soundtracks, but will enable smooth transition and improved timbre matching when panning objects from the screen speakers to the surround zones.

To maximize the impression of space, the surround arrays should be placed as low as is practical, subject to the following constraints: the vertical placement of surround speakers at the front of the array should be reasonably close to the height of screen-speaker acoustic center, and high enough to maintain good coverage across the seating area according to the directivity of the speaker. The vertical placement of the surround speakers should be such that they form a straight line from front to back, and (typically) slanted upward so the relative elevation of surround speakers above the listeners is maintained toward the back of the cinema as the seating elevation increases, as shown in Figure 5.3. In practice, this can be achieved most simply by choosing the elevation for the front-most and rear-most side surround speakers, and placing the remaining speakers in a line between these points.

The distance between side surround speakers should be determined based on the guidelines at the start of this section.

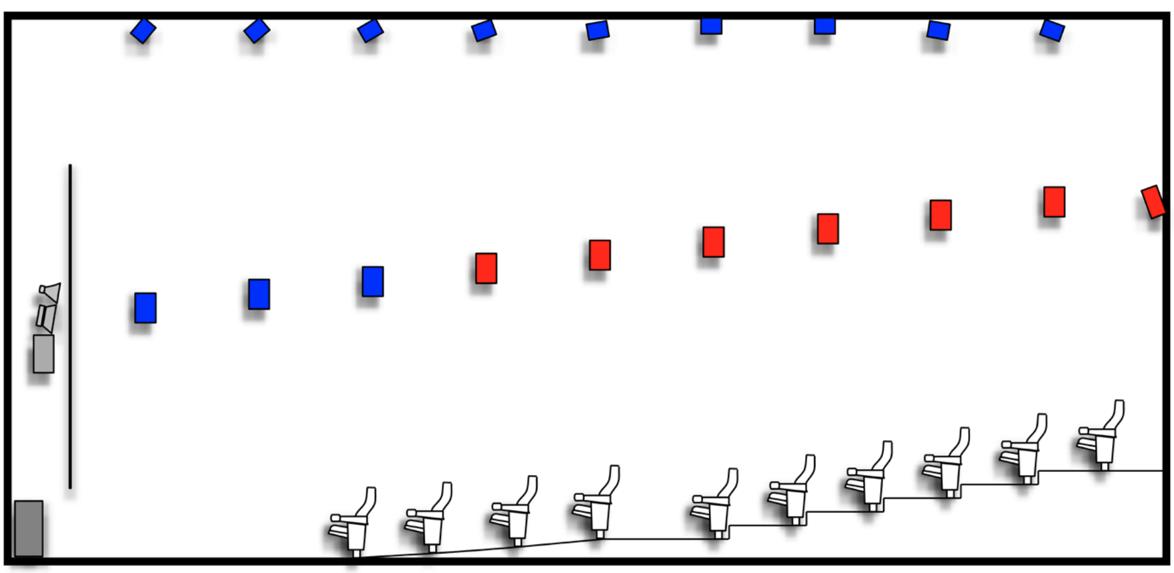

Figure 5.3 Recommended Side Wall and Ceiling Speaker Locations

In order to provide optimum coverage for each speaker over the seating area, the side surround speakers should be aimed toward the reference position in the theater, under the following guidelines:

- Side surrounds should be angled vertically to the seats on the opposite side of the auditorium (typically aiming 20 degrees downward).
- Side surrounds should be angled horizontally toward the reference position. Taking 0 degrees as aiming directly across the room:

    - No speaker angle should exceed 45 degrees.
    - Speakers adjacent to the seating area should not exceed 30 degrees.
    - Speakers in the prime listening area should be left at 0 degrees.

Rear Surrounds

The number of rear surround speakers, and the distance between them, should be determined based on the guidelines at the start of this section. The back wall speakers should have approximately the same linear spacing as the side surrounds adjacent to the seating area, although it may be necessary to slightly increase the density of back surrounds in order to meet the angular requirements. Such an increase in density can also be an advantage for power handling of the left and right rear surround zones, which are typically half the length of the side surround zones.

In order to provide optimum coverage for each speaker over the seating area, the back surround speakers should be aimed toward the reference position in the theater, under the following guidelines:

- Back surrounds should be angled vertically to the front row seats in the auditorium (typically aiming 20 degrees downward).
- Back surrounds should be angled horizontally toward the center line of the auditorium. Taking 0 degrees as aiming directly toward the screen:
    - No speaker angle should exceed 30 degrees.
    - Speakers in the prime listening area should be left at 0 degrees.

Top Surrounds

Overhead speakers should be in two arrays from the screen to the back wall, nominally in alignment with the Lc and Rc screen channels of a typical auditorium, where the screen width is effectively the width of the theater and the screen top is near the ceiling. They should always be placed symmetrically with respect to the center of the screen. The top surrounds should have the same design characteristics as the side surrounds to maintain timbre matching.

The number and spacing of the top surround speakers should be based on the position of side surround speakers as determined using the guidelines at the start of this section. However, the spacing of top surround speakers is less critical than for side surrounds, and so it is acceptable for the number and front-back position to vary relative to the side surrounds if necessary. The top surround array should also extend to the screen in the same manner as the side surrounds, but it should not obstruct the path of the projection light.

The lateral position of the arrays should be chosen to optimize spatial immersion and uniformity across the listening area. As stated earlier, placing the top surround speaker arrays in alignment with Lc and Rc screen channels will generally give good results. For rooms where the seating area is significantly wider than the screen, or the top surrounds are mounted significantly higher than the level of the top of the screen, it is desirable to have the overhead arrays more widely spaced.

The minimum width is the Lc and Rc spacing. The maximum width should be determined based on elevation angles as follows:

Let E be the elevation angle of the nearest side surround, measured from a reference position in the middle of the seating area (typically 15 to 25 degrees). The elevation angle of the corresponding top surround array should be greater than or equal to 45 degrees plus half of angle E as shown in Figure 5.4. For example, if E is 20 degrees, then the elevation angle of the top surround array should be greater than or equal to 55 degrees.

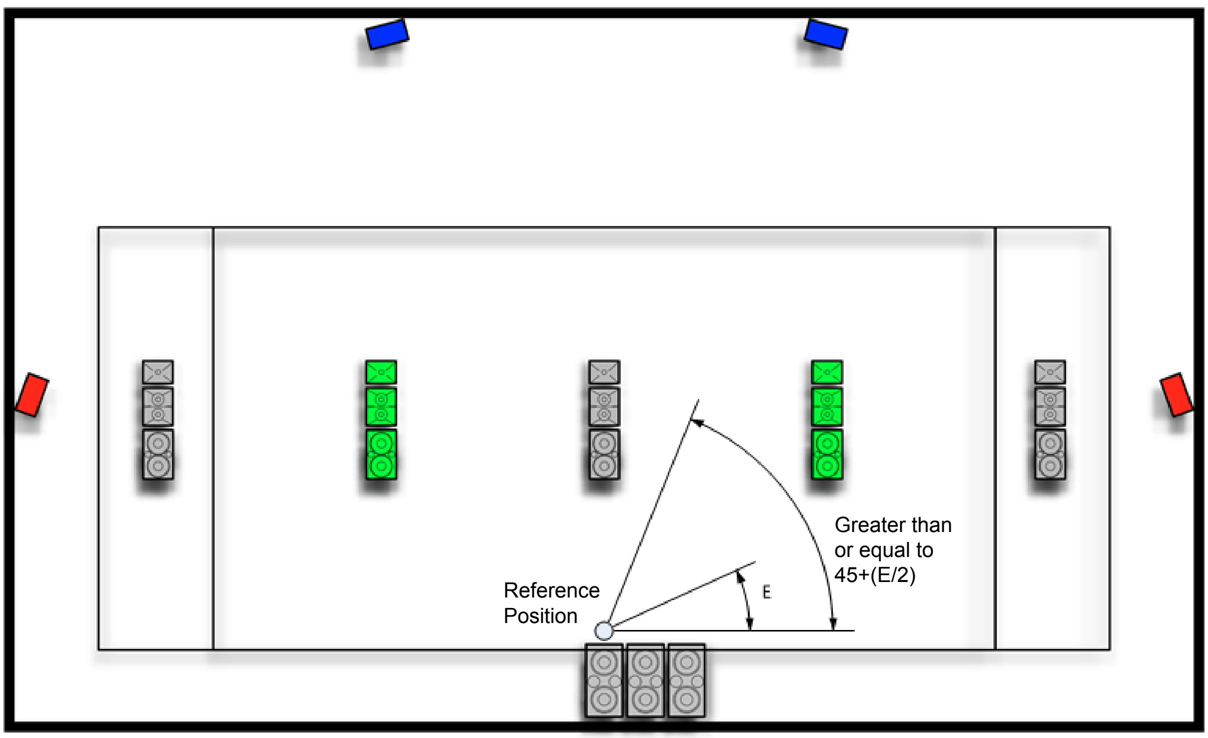

Figure 5.4 Example of Top Surround Lateral Position

In order to provide optimum coverage for each speaker over the seating area, the top surround speakers should be aimed toward the reference position in the theater, under the following guidelines:

- Top surrounds should be angled laterally (across the auditorium) to a position that is halfway between the overhead's lateral position and the center line of the auditorium (typically aiming between 10 and 20 degrees toward the center line).
- Top surrounds should be angled longitudinally (along the length of the auditorium) toward the reference position in the same manner as the side surrounds. Taking 0 degrees as aiming vertically downward:
  - No speaker angle should exceed 45 degrees.
  - Speakers adjacent to the seating area should not exceed 30 degrees.
  - Speakers in the prime listening area should be left at 0 degrees.

Finally, surround speakers over the audience area must be mounted in compliance with manufacturer requirements and local safety codes.

Dolby Laboratories, Inc.
100 Potrero Avenue, San Francisco, CA 94103-4813 USA T 415-558-0200 F 415-645-4000
dolby.com