Dolby® Atmos® Next-Generation Audio for Cinema

Issue 3

Dolby Atmos
Next-Generation Audio for Cinema

Overview

Announced in April 2012, Dolby® Atmos® is quickly becoming the de facto standard for next-generation sound in the cinema, as major studio directors, sound teams, and exhibitors adopt the solution. Because Dolby Atmos delivers an audio experience beyond anything available to date, addressing the limitations to creating truly immersing and lifelike audio that were inherent in earlier audio platforms, professionals from all disciplines within the cinema industry are embracing this technology.

Dolby Atmos introduces new features and tools to improve the mix, distribution, and playback of movies. Dolby Atmos adds the flexibility and power of dynamic audio objects, and the ability to render sounds above the listeners. As a result, moviemakers can place discrete sound elements within the soundscape, irrespective of specific playback loudspeaker configurations. Dolby Atmos also introduces new efficiencies to the postproduction process, allowing sound mixers to efficiently capture their creative intent and then, in real time, automatically generate and monitor 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 theatre configurations.

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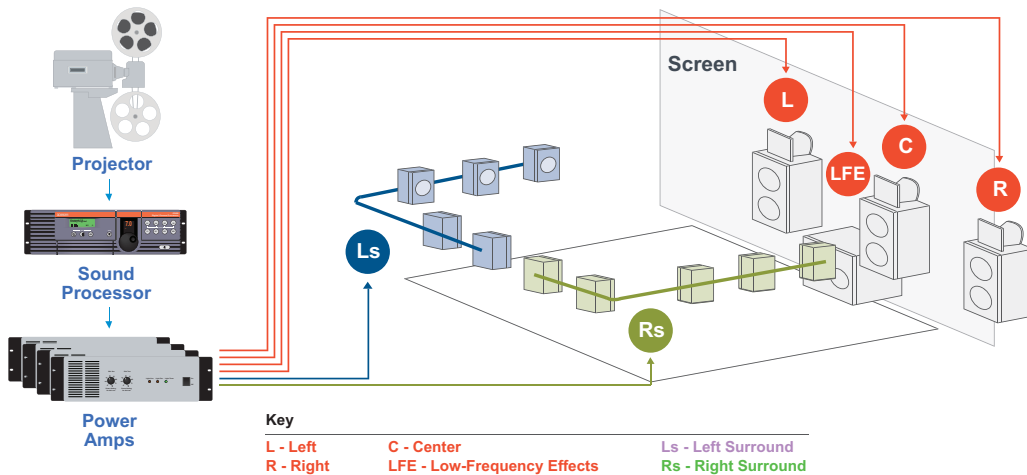
Introduction

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 theatres, 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 the following figure. The quality of cinema sound was further improved in the 1980s with Dolby SR noise reduction and certification programs such as THX®.

Key
L - Left   C - Center   S - Surround
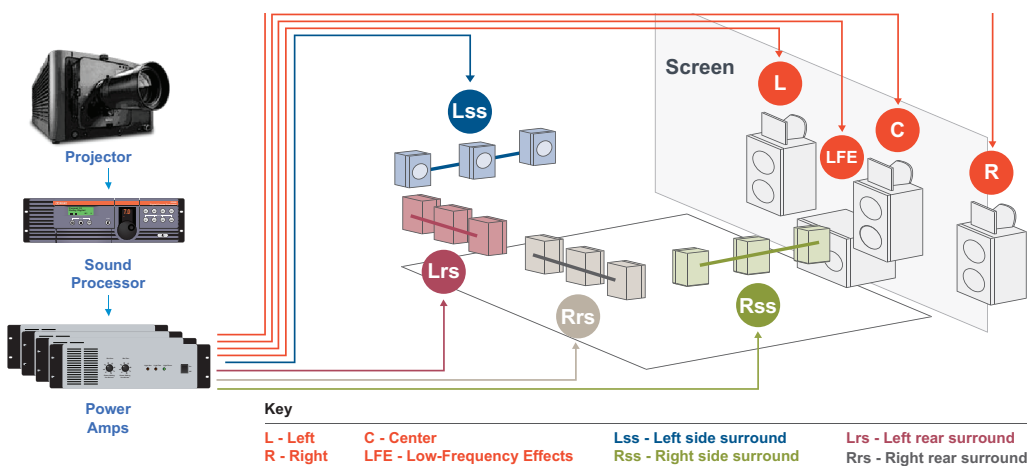R - Right   OBE - Optional subwoofer
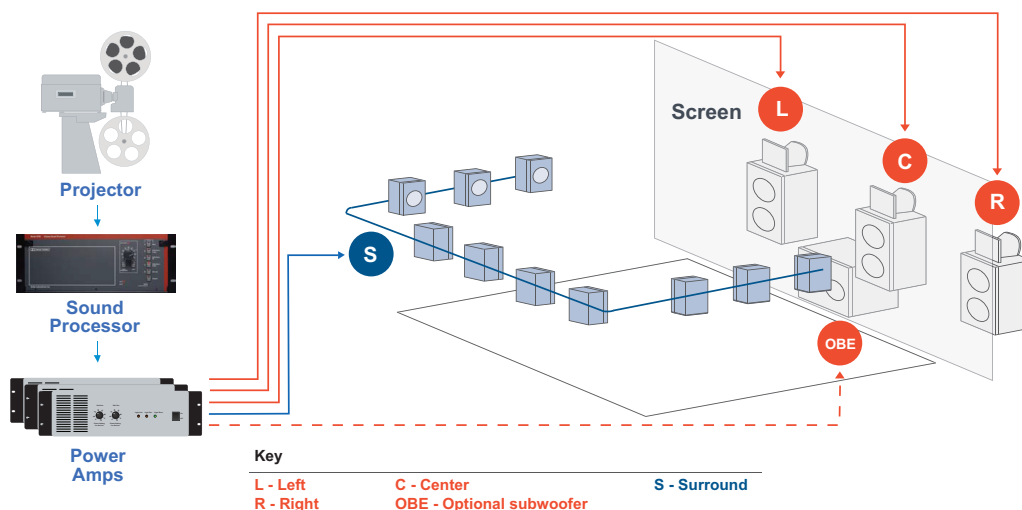
The 1990s saw the launch of digital sound to the cinema, allowing 5.1 mixing, mastering, and playback providing discrete Left, Center, and Right screen channels, Left Surround and Right Surround arrays, and a Low-Frequency Effects channel played through a subwoofer, as shown in the following figure. The surround channels were able to provide a wider frequency response, because 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 loudspeakers 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 include a Dolby SR analog track for compatibility in all theatres (including those with only mono capabilities).

Key

L - Left	C - Center	Ls - Left Surround
R - Right	LFE - Low-Frequency Effects	Rs - Right Surround

The Introduction of Digital Cinema

The introduction of digital cinema 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 were now 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 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 theatres 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. This format continues the pattern of increasing the number of surround channels by splitting the existing Left Surround and Right Surround channels into four "zones," as shown in the following figure. The increased ability for sound designers and mixers to control the positioning of audio elements in the theatre, along with improved panning from screen to surrounds, has made the format a success in both the rapid adoption by content creators and the speed of conversion of theatres. With more than 120 titles and 4,000 screens equipped in less than three 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.

Key

L - Left	C - Center	Lss - Left side surround	Lrs - Left rear surround
R - Right	LFE - Low-Frequency Effects	Rss - Right side surround	Rrs - Right rear surround

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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 theatres with various loudspeaker configurations to determine which loudspeaker locations were compelling to a content creator. Remixed movie content was taken into different auditoriums in various countries, that were equipped with appropriate loudspeaker locations, to determine what was effective in theatres 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, along with Dolby's cinema 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 rerecording, mastering, packaging, distribution, and replay in theatres. For example, although many cinemas are equipped with inner left (Left Center, or Lc) and inner right (Right Center, or 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 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 revisited critical areas of the theatrical replay environment, including the technology and standards by which dubbing theatres 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; in others, it is improved upon as technology evolves.

This exhaustive research, along with lessons learned from decades of introducing new cinema sound formats, culminated in Dolby's 2012 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.

Dolby Atmos Overview

The Dolby Atmos system includes new authoring, distribution, and playback tools. 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 the loudspeaker layout and characteristics of each room. 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.

Audience Immersion

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

- Sounds originating overhead
- Improved audio quality and timbre matching.
- Greater spatial control and resolution

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 create greater listener envelopment within the sound scene.

Another example is a 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 front to back movement, but adding overhead loudspeakers gives a much more convincing impression of the helicopter moving overhead. Finally, adding ceiling loudspeakers makes it possible to move sounds off the walls and into the room.

Improved Audio Quality and Timbre Matching

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

Traditionally, surround loudspeakers do not support the same full-range frequency response and level when compared to the screen channels. Also, the calibrated sound pressure level for surround channels in previous multichannel formats is lower than for the screen channels. As a result, any sound panned from the screen to the surrounds drops in level. Historically, this has created issues for mixers, reducing their ability to freely move full-range sounds from screen to room. As a result, theatre 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.

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 loudspeaker gives the mixer the opportunity to eliminate the artifacts of array reproduction and deliver a more realistic experience to the audience.

Dolby Atmos improves the audio quality in different rooms through such benefits as improved room equalization and surround bass management so that the mixer can make use of all the loudspeakers (whether on- or offscreen) without concern about timbre matching.

### Greater Spatial Control and Resolution

For many years, cinema benefited from 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-channel configuration, 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.

A less subtle example is the sound of a gunshot fired from somewhere off screen. Being able to pinpoint this sound opens new possibilities. The increased resolution of the Dolby Surround 7.1 configuration 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 (see the following figure, 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 the following figure, 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" (that is, the ideal listening position). Room-centric audio better supports the onscreen action.
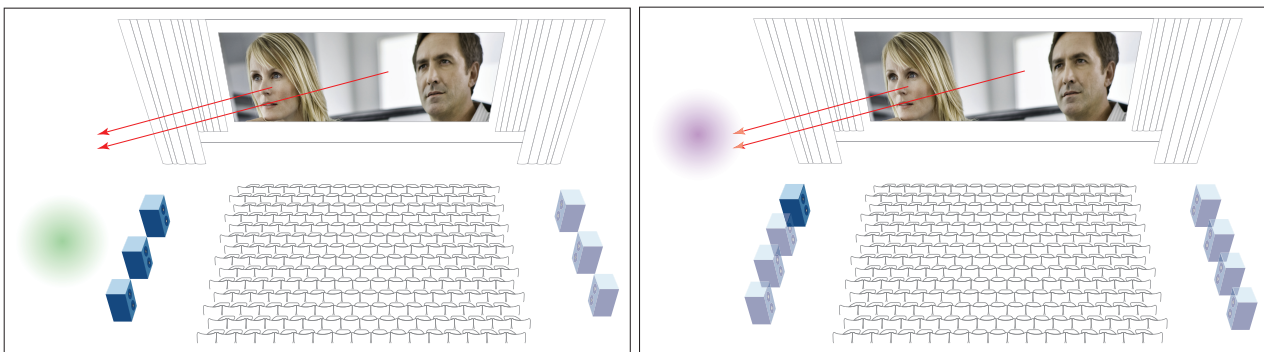
Author Once, Optimize Everywhere

Capturing the Creative Intent

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 theatre, they are rendered according to the positional metadata using the loudspeakers 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 loudspeaker if desired.

Although the use of audio objects provides desired control for discrete effects, other aspects of a movie soundtrack also 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 retained as separate bed stems through the mixing process; they are combined into a single bed as part of the print-master process. 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).

Optimizing During Rendering

Beds (Channels)   **Objects**   **Dolby Atmos**

Dolby Atmos tools allow up to 128 tracks to be packaged: a 9.1 bed plus up to 118 audio objects. The renderer takes these audio tracks and processes the content according to the signal type. Bed channels are mapped to individual loudspeakers (in the case of the screen channels) or loudspeaker arrays. Objects are positioned within the room, and rendered in real time based on the physical location of the loudspeakers. The Dolby Atmos cinema processor assigns delays and equalization to channels, objects, and loudspeakers for optimal playback quality and consistency. The Dolby Atmos cinema processor supports rendering of these beds and objects for up to 64 loudspeaker outputs.
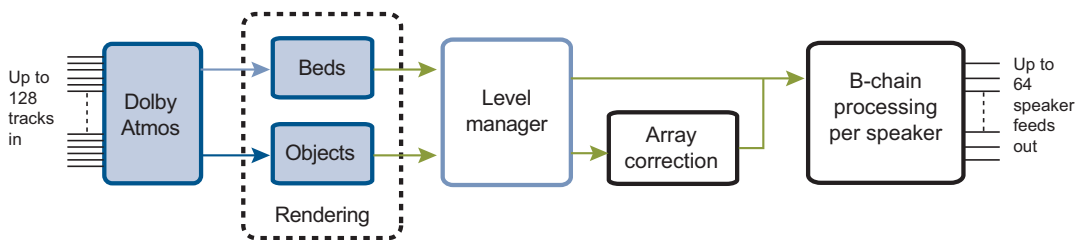

The rendering algorithm also takes into account the power handling and frequency response of the system loudspeakers.

Additionally, the support for bass management of the surround loudspeakers 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 has been the practice for previous formats ensures that objects can smoothly transition from screen to surround. It is important to note that these additional side surround loudspeakers 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), because this would compromise the experience of using a sidewall array.

More information on loudspeaker layout recommendations is available in "Theatrical Exhibition" on page 12.

Workflow Integration

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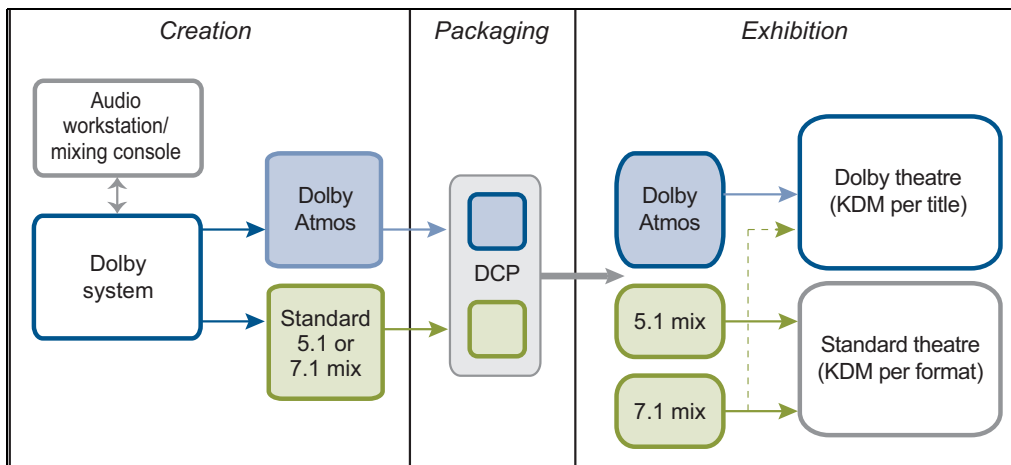
In the Dubbing Theatre

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 have been in previous formats.

Plug-in applications for digital audio workstations, along with software updates for most of the major large-format film mixing consoles, 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 premix and final-mix stages in the dubbing theatre.

Metadata is integrated into the dubbing theatre 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 Dolby Atmos 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.

During Packaging

Dolby Atmos print-master files contain a Dolby Atmos mix. The main audio mix can be rendered by the RMU in the dubbing theatre, 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 forms an additional track file. Such a track file is supported by existing industry standards, and is ignored by Digital Cinema Initiatives (DCI)–compliant servers that cannot use it.

For Distribution

The Dolby Atmos packaging scheme allows delivery of a single SMPTE-standard DCP to the cinema, which contains both main audio and Dolby Atmos track files. A single key delivery message (KDM) targeted to the cinema's media block enables controlled playback of the content, and a DCI-compliant server with appropriate software can play the composition.

In the Cinema

A DCP containing a Dolby Atmos track file is recognized by all servers (with appropriate software) as a valid package, and ingested accordingly. In theatres with Dolby Atmos installed, the Dolby Atmos track file is ingested into the server and, during playback, is 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.

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 continue to provide services in all aspects of the audio postproduction workflow. The following sections outline initial integration of Dolby Atmos into a feature film.

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.

Editing and Premixing

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.

Foley and Effects

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

The effects editor uses designed and library sound effects to create what could be hundreds of sound effects elements and beds of ambiences. The effects mixer uses 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.

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. The use of full-range surround loudspeakers allows mixers to move music offscreen to the surround zones and maintain the same timbre and fidelity as the screen loudspeakers.

Mixers have also found that assigning music tracks as objects and moving the objects offscreen will change the perception of the music size and can enhance the audience's sense of envelopment. Additionally, moving music offscreen frees up the screen loudspeakers for audio effects and can help clarify dialogue tracks.

Final Mixing

All of the music, dialogue, and effects are brought together in the dubbing theatre during the final mix, and the rerecording mixers use the premixes 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 loudspeaker locations in the dubbing theatre. 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. In this way, the mixers retain complete control of how the movie plays back in each of the scalable environments supported by Dolby Atmos.

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 theatre and is carried through to exhibition in the cinema.

The RMU can render the necessary channel-based mixes, thereby eliminating the need for 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 theatre is equipped and calibrated by Dolby sound consultants in exactly the same manner as the playback theatres 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.

→		5.1/7.1/9.1 Beds/Stems
→		Objects
→		Dolby Atmos rendered mix
→		Channel-based mix
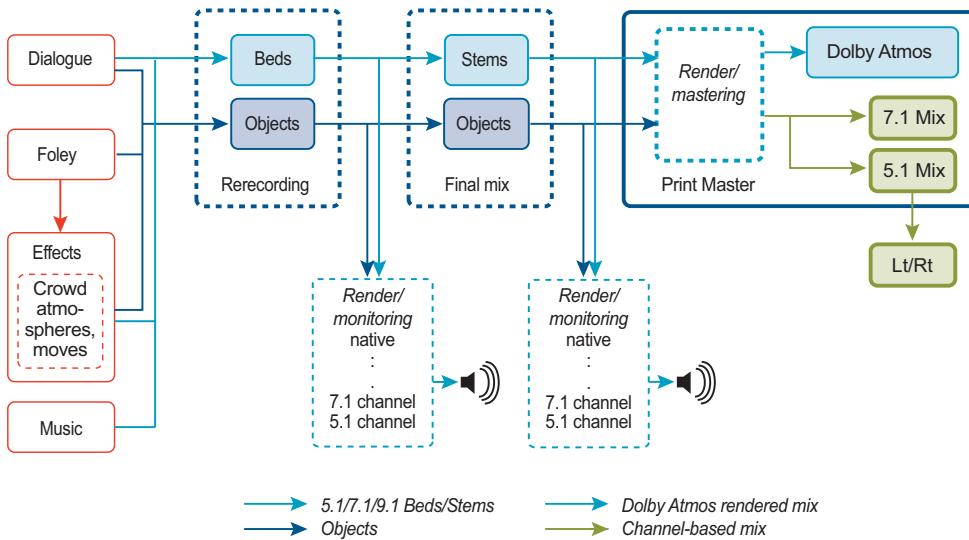
Digital Cinema Packaging and Distribution Audio File Delivery

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 was signed off in the dubbing theatre. The packaging system can 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 theatre.

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 file is packaged as an auxiliary track file, and is optionally encrypted using a symmetric content key per the SMPTE specification.
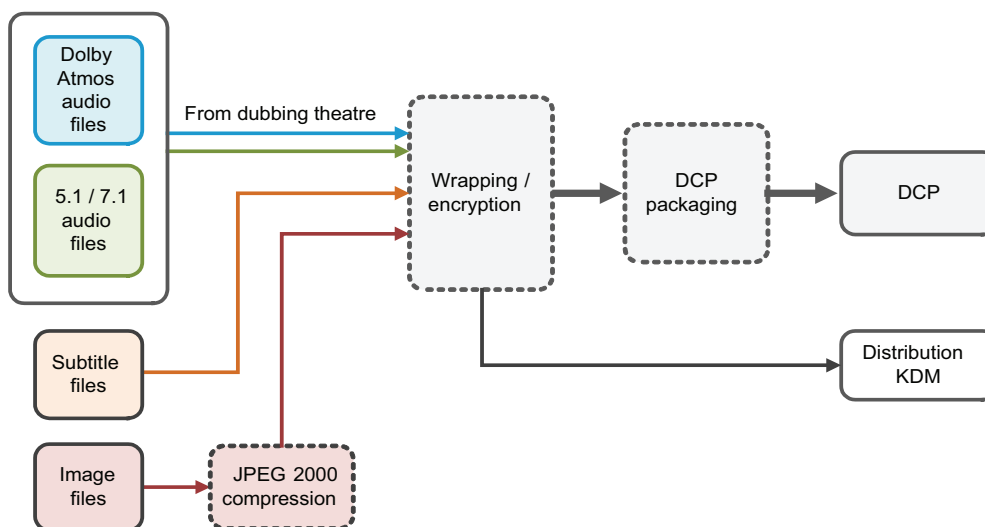
Digital Cinema Package Distribution

This single DCP can be delivered to any DCI-compliant server with suitable software. Any installations that are not equipped with Dolby Atmos playback will ignore the additional track file containing the Dolby Atmos soundtrack and use the existing main audio track file for standard playback. Those installations equipped with a Dolby Atmos Cinema Processor CP850 can ingest and replay the Dolby Atmos soundtrack where applicable, reverting to the standard audio track as necessary.

Theatrical Exhibition

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

Equipment Considerations

Dolby Atmos Cinema Processor CP850

Dolby Atmos and the Dolby Atmos Cinema Processor CP850 change how theatre loudspeakers are installed, calibrated, and maintained. With the introduction of many more potential loudspeaker outputs, each individually equalized and balanced, there is a need for an intelligent and time-efficient room equalization process. Automated room calibration, coupled with the ability to review and adjust all derived EQ and level settings enables quick installation and complete control when fine-tuning a theatre.

In addition to the implementation of reliable automatic equalization, Dolby Atmos uses a sophisticated 1/12-octave (rather than the standard 1/3-octave) band equalization engine derived from the highly acclaimed Dolby Lake® processor. Up to 64 outputs can be processed to more accurately balance the sound in a theatre.

Integration with Cinema Servers

The Dolby Atmos Cinema Processor CP850 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 reverts back to Dolby Surround 7.1 or 5.1 PCM audio.
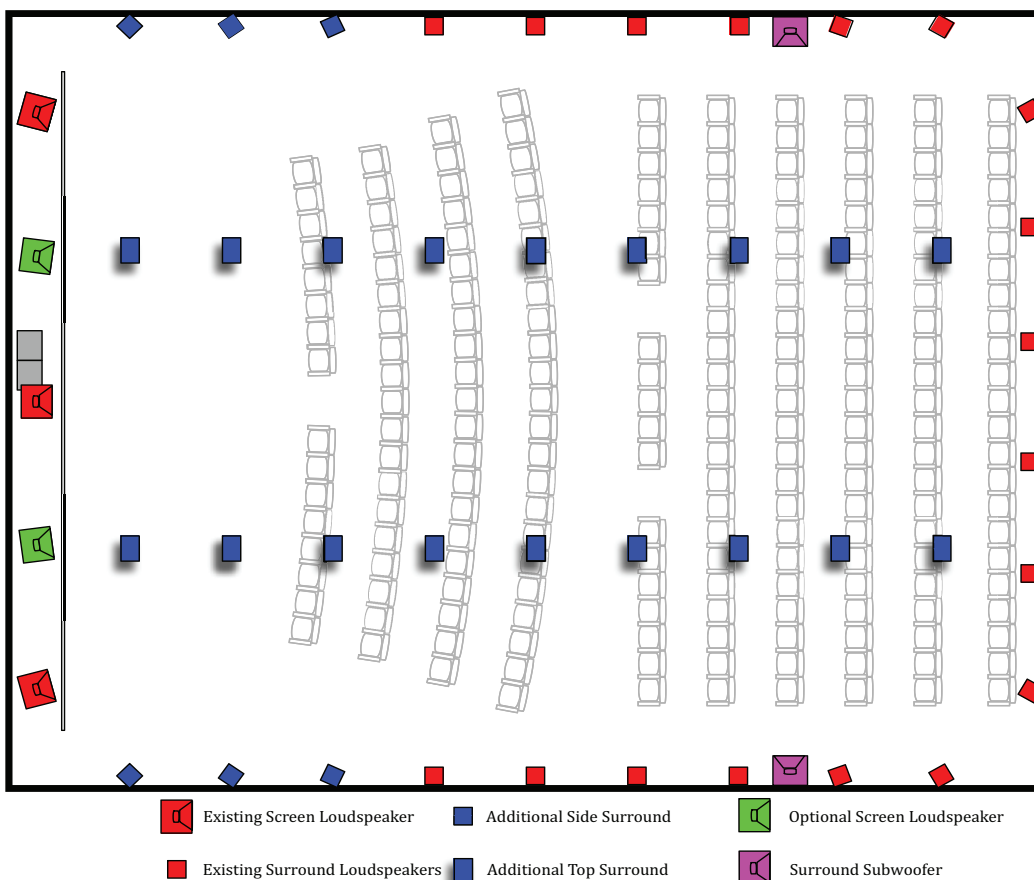
Auditorium Considerations

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. Prior to the introduction of Dolby Atmos and continuing today, we have seen 5.1 cinema sound transition to Dolby Surround 7.1, and other exhibitors have installed even more channel-based loudspeaker systems, including 9.1, 11.1, 13.1, and beyond.

We provide recommendations on loudspeaker layout for use with Dolby Atmos soundtracks, as described 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 will be rendered in different playback loudspeaker configurations, and an exhibitor can decide how much of an investment to make in a given theatre in order to optimize the experience within a budget. The ideal number of loudspeaker output channels used will vary according to room size. The first-generation Dolby Atmos Cinema Processor CP850 can support up to 64 outputs. Although 61.3 channels may seem excessive when compared with typical existing configurations, currently available multichannel amplifiers can individually amplify a large number of speakers (for example, 11 surrounds on each side wall in a large theatre, each amplified on its own channel).

The recommended layout of loudspeakers for Dolby Atmos remains compatible with previous 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 loudspeaker locations. In contrast to using all 64 output channels available, the Dolby Atmos format can be accurately rendered in the cinema to other loudspeaker configurations such as Dolby Surround 7.1, allowing the format (and associated benefits) to be used in existing theatres with no change to amplifiers or loudspeakers.

Optimized Playback

The audio playback equipment present in dubbing theatres and cinemas can vary widely with room size, and shape. It can also vary based on a cinema owner's desire to differentiate their theatre. A primary benefit of Dolby Atmos is its ability to optimally render a soundtrack based on the available loudspeakers and loudspeaker positions. To ensure consistent playback of the cinema soundtrack, detailed guidelines for system design are provided in the *Dolby Atmos Specifications* document. This section provides a highlight of some of the unique features of a Dolby Atmos equipped room. The following figure shows a diagram of suggested loudspeaker locations in a typical auditorium.

Existing Screen Loudspeaker   Additional Side Surround   Optional Screen Loudspeaker
Existing Surround Loudspeakers   Additional Top Surround   Surround Subwoofer

Screen Loudspeakers

Based on investigations into the perception of onscreen auditory images, we have found that two additional loudspeakers behind the screen—Left Center (Lc) and Right Center (Rc) screen loudspeakers (as used in the 70 mm six-track magnetic format)—can be beneficial in creating smoother pans across large screens. Consequently, we recommend installation of these additional loudspeakers, particularly in an auditorium with a screen greater than 12 m (40 feet) wide. All screen loudspeakers 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. The following figure shows a diagram of suggested loudspeaker locations at the screen.
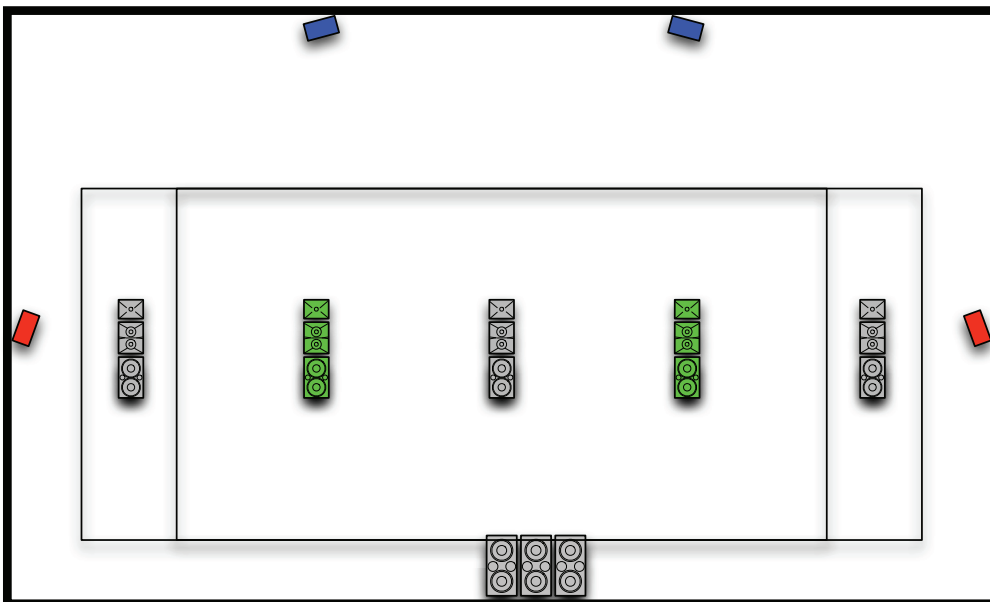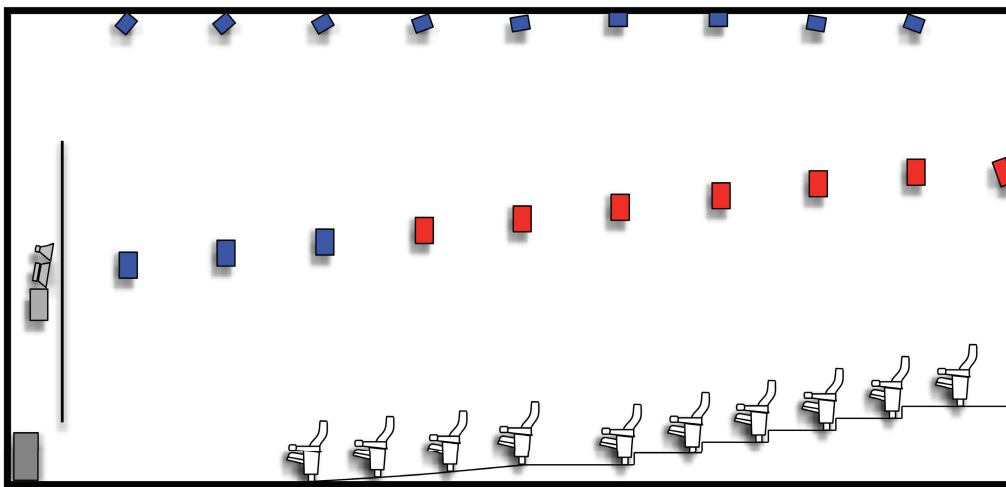

Surround Loudspeakers

The surround loudspeakers should be individually wired back to the amplifier rack, and be individually amplified with a dedicated channel of power amplification matching the power handling of the loudspeaker in accordance with the manufacturer's specifications. Ideally, surround loudspeakers should be specified to handle an increased SPL for each individual loudspeaker, a wider frequency response, and uniform coverage throughout the seating area. Most cinema surround loudspeakers are not capable of producing high levels of low-frequency energy. To address this, the Dolby Atmos Cinema Processor CP850 supports surround sound bass management; the low-frequency component of surround signals are optionally routed to dedicated outputs to drive surround subwoofers placed as left/right pairs within the auditorium. For details on the proper number, spacing, and aiming of surround loudspeakers, see the *Dolby Atmos Specifications* document.

Side Surround Loudspeakers

To enable smooth transition of sound from and to the screen, surround loudspeakers should be placed along the length of the side walls, extending all the way to the screen, as shown in the following figure. The additional side surround loudspeakers (those closer to the screen than the recommended practice for previous formats) are not used as side surrounds during playback of Dolby Surround 7.1 or 5.1 soundtracks. To provide uniform coverage for each loudspeaker over the seating area, the side surround loudspeakers toward the front and rear of the auditorium should be aimed toward the reference position in the theatre.

Rear Surround Loudspeakers

The back wall loudspeakers will typically have a similar count and linear spacing as in a well-designed Dolby Surround 7.1 theatre. In contrast to current practice, the back surround loudspeakers near the side walls should be aimed toward the reference position in the theatre in order to provide optimum coverage for each loudspeaker over the seating area.

Top Surround Loudspeakers

Overhead loudspeakers should use two arrays from the screen to the back wall. The arrays should be positioned in alignment with, or slightly wider than, the Lc and Rc screen channels of a typical auditorium. They should always be placed symmetrically with respect to the center of the screen. 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. As with the side surround loudspeakers, the top surround loudspeakers toward the front and rear of the auditorium should be aimed toward the reference position in the theatre.

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