



Dolby Atmos[®] for the Home Theater

August 2014

Dolby Atmos[®], the revolutionary cinema sound technology, has come to home theaters. With Dolby Atmos, content creators can precisely place and move sounds anywhere in your living room, including overhead, to make entertainment incredibly realistic and lifelike.

This white paper is designed to explain how Dolby Atmos will work in home theaters and how you can build a Dolby Atmos enabled system or upgrade your existing system to support Dolby Atmos. This paper also explains the technological components of Dolby Atmos in home theater and the tools that content creators and broadcasters will use to create and deliver Dolby Atmos content to homes.

Why replace channel-based surround sound?

Dolby Atmos is a revolutionary technology that moves beyond the paradigm of channel-based audio, which has gone as far as it can in the home.

Dolby has helped lead home theater technology since the late 1980s, when we introduced four-channel Dolby[®] Pro Logic[®]. We helped lead the development of 5.1 and then 7.1 surround sound. But as home theater expanded to 9.1 and even 11.1 systems, the problems of pursuing more and more channels became clear. Home theater content often originates from theatrical content that is mixed, at best, in 7.1 sound and, many times, in 5.1. That meant that 9.1 or 11.1 systems reached a point of diminishing returns in parsing and upmixing that limited signal to serve more and more channels.

In addition, the ability to recreate reality using channel-based audio is inherently limited. In real life, sounds move in specific and sometimes complicated ways—a hummingbird flies off a tree branch, hovers in front of a pair of blossoms, and then dives down to a fountain for a drink. Simply moving the hummingbird's sound from the left height channel to the right front channel can't possibly recreate the detail of that bird's flight. And when you lose those details, it detracts from the brain's sense that what it's watching is real.

A cinema solution

Dolby started looking for a solution to the problems of channel-based audio first in the cinema. Our goal was to free filmmakers from the limitations of audio channels by developing a system that allowed them to determine exactly where a sound should be and where it should move in three dimensions—that is, to faithfully recreate that hummingbird's flight in all its complexity.

We worked closely with filmmakers to perfect the technology. Renting out entire movie theatres to use as laboratories, Dolby engineers would sit side by side with sound mixers. These mixers would try our system and make suggestions, which the engineers would, in some cases, immediately implement into the system.

The result of that intense collaboration, Dolby Atmos, debuted in June 2012 in the movie *Brave*. Since then, all the major Hollywood movie studios have embraced the technology. In the first two years alone, studios around the world have released more than 100 feature films in Dolby Atmos.

Dolby Atmos and sound objects

Dolby Atmos is based on the concept of sound objects. In the cinema, Dolby Atmos relies on a combination of 9.1 “bed” channels and up to 118 simultaneous sound objects to deliver an enveloping sound scene. Every sound in a scene—a child yelling, a helicopter taking off, a car horn blaring—can be a separate sound object. Each of those sounds comes from a specific location in the scene, and in some cases, they move. The car careens from left to right, while the yelling child runs up a set of stairs.

Using sophisticated content creation tools that represent the sound objects in a three-dimensional space, filmmakers can isolate each of the sound objects in a scene and decide exactly where they want them to be and how they want them to move. In the final sound mix, the sound objects are combined with metadata—additional data that describes a number of parameters about the sound object, including its location and movement, if any.

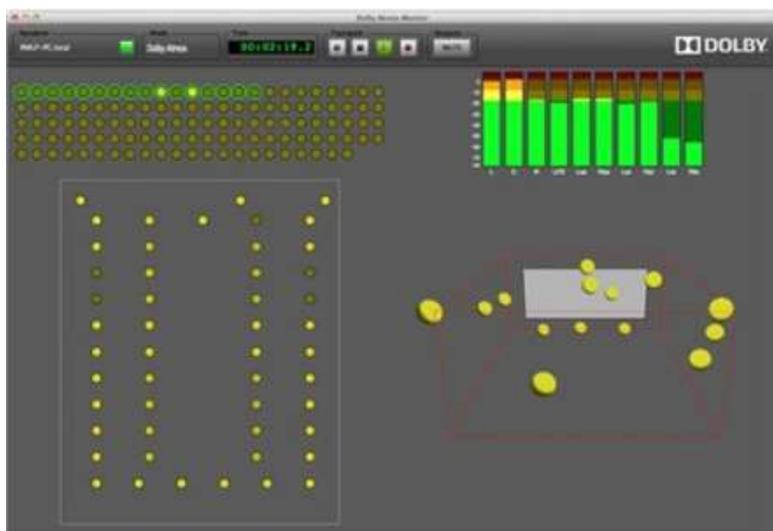


Figure 1: Filmmakers can use this tool to manipulate sound objects in a three-dimensional space.

Dolby Atmos in home theater

Dolby has now developed the technology required to translate the Dolby Atmos experience in cinema to home theaters. What happens when you play a Dolby Atmos film, whether from a Blu-ray Disc™ or a streaming video service, is quite remarkable. When you set up your Dolby Atmos enabled A/V receiver (AVR), you'll have told your receiver how many speakers you have and where they're located. Your receiver will decide—in real time—exactly which speakers it needs to use from moment to moment in order to reproduce the sounds of the car careening across the screen and the child fleeing up the stairs. That detailed, very specific movement of sound helps your brain suspend disbelief and feel as if what you're watching is real.

The flexibility of Dolby Atmos object-based sound makes it incredibly adaptable. A Dolby Atmos movie can be played back on nearly any speaker configuration. You'll be able to hear the placement and movement of sound in a Dolby Atmos movie whether you have a system with five speakers on the floor and two overhead, or 24 speakers on the floor and 10 overhead (the current maximum for a Dolby Atmos supersystem). The more speakers you have, the more precise the audio positioning becomes.

And you have lots of flexibility to upgrade your system. If you add more speakers, your AVR can use them to provide you with even more detailed, richer sound.

Delivery of Dolby Atmos movies

Major Hollywood studios are partnering with Dolby to create Dolby Atmos home video versions of current box office releases and previously released favorites. In addition to global studio partnerships, Dolby is partnering with game, music, and broadcast content creators to take advantage of Dolby Atmos technology for future home theater use.

We wanted to ensure that entertainment fans could get Dolby Atmos movies in the same ways they get movies now, on Blu-ray Disc or through streaming video services.

We invented a new, scalable algorithm as well as new extensions for our existing technologies, Dolby TrueHD, which is Dolby's lossless Blu-ray™ format, and Dolby Digital Plus™, which is used by leading streaming video providers or for secondary languages on Blu-ray Disc. Both formats now support Dolby Atmos sound, meaning that you'll be able to play Dolby Atmos movies from your Blu-ray player or streaming device.

A Blu-ray player that fully conforms to the Blu-ray specification can play a Dolby Atmos movie without a firmware update. The player will need to be connected to a Dolby Atmos capable AVR and set to audio bitstream out. Note that some Blu-ray players default to secondary audio, a playback mode in which third party content is mixed with the primary soundtrack and output as a Dolby Digital signal; be sure to turn this feature off to ensure decoding and playback of Dolby Atmos content by your AVR.

There's also no need to buy new HDMI® cables. The current HDMI spec (v1.4 and later) fully supports Dolby Atmos audio.

Dolby Atmos audio tracks (both Dolby TrueHD and Dolby Digital Plus) are backward compatible. If you play a movie mixed in Dolby Atmos on a non-Dolby Atmos system, you'll hear traditional 5.1 or 7.1 audio, depending on the type of system you have. This means content providers don't need to maintain separate Dolby Atmos and non-Dolby Atmos mixes.

Setting up your Dolby Atmos home theater

Although Dolby Atmos is a revolutionary new home theater format, it doesn't require that you start from scratch. Although you will need a new AVR, in most cases, you'll be able to keep most, if not all, of your existing speakers.

Many people now have 5.1 or 7.1 systems with a subwoofer and either five or seven speakers positioned at about ear level. Many of these speakers will work without a problem in a Dolby Atmos system.

The importance of overhead sound

In real life, sounds come from all around us, including overhead. Having the ability to recreate overhead sounds is a key element in making Dolby Atmos sound so realistic. If we see a helicopter take off onscreen and then hear its blades cutting through the air above our heads, the experience makes us feel like we're really in the scene, not just watching it.

Dolby Atmos cinemas recreate these overhead sounds with an array of speakers above the audience. Some home theater enthusiasts will also be able to install speakers in or on their ceilings, but you don't have to.

Through our knowledge of psychoacoustics and sound physics, we've developed Dolby Atmos enabled speakers that can create overhead sound even though they're only a few

feet off the floor. These speakers fire sound upward, where it reflects off the ceiling to produce an incredibly lifelike re-creation of overhead sound—you really have to hear them to believe them.

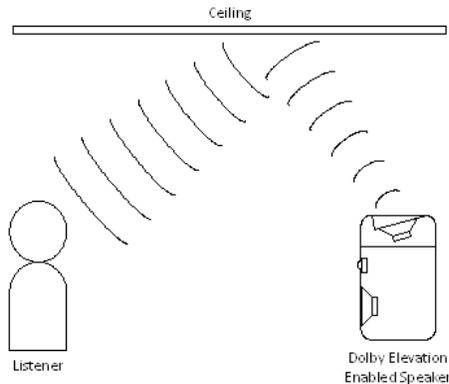


Figure 2: Dolby Atmos enabled speakers reflect sound off the ceiling to produce an incredibly lifelike re-creation of overhead sound.

You will be able to buy integrated Dolby Atmos enabled speakers that include both traditional forward-firing speakers and upward-firing speakers in one cabinet. (These speakers have two sets of posts, one for the traditional speaker and one for the upward-firing Dolby Atmos enabled speaker.)

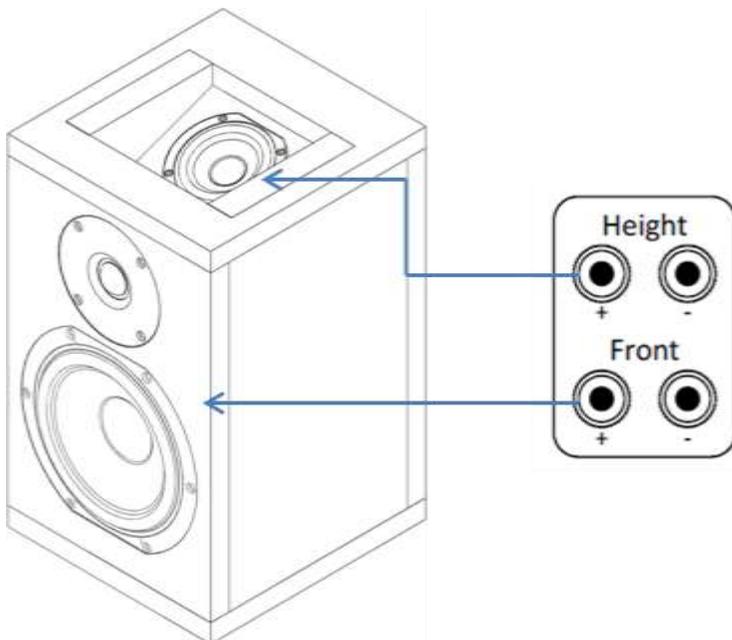


Figure 3: Integrated Dolby Atmos enabled speakers include both traditional speakers and upward-firing speakers in the same cabinet. The two sets of speakers have individual posts.

But if you already have conventional speakers you like, you can simply buy Dolby Atmos enabled add-on speaker modules. These include only the upward-firing speakers. You can place these add-on modules on top of your current speakers or on another nearby surface.

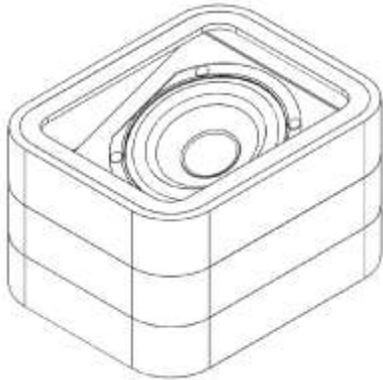


Figure 4: You can place Dolby Atmos enabled add-on speaker modules on top of or near your existing traditional speakers.

Dolby Atmos enabled speakers can produce an incredibly accurate Dolby Atmos experience in many types of rooms. You'll get the best sound if your ceiling is flat (not vaulted or angled) and made of an acoustically reflective material, such as drywall, plaster, concrete, or wood. Dolby designed the technology for rooms with ceiling heights of 8 to 9 feet (2.4 to 2.7 meters), but testing indicates that you can still hear incredible Dolby Atmos sound in rooms with ceilings as high as 14 feet (4.3 meters), though the effect may become more diffuse in rooms with higher ceilings.

Recessed lighting fixtures, chandeliers, crown molding, and heating or air conditioning vents in your ceiling do not noticeably interfere with the Dolby Atmos experience.

When to avoid ceiling speakers

There are some rooms in which we don't recommend using ceiling speakers. If your ceiling is low or you have to mount your loudspeakers on overhead trusses or brackets, the overhead speakers will be closer to the listening position. The audio may be distracting because you'll hear exactly which speaker is producing the sound instead of feeling immersed in an atmosphere in which sounds occur naturally overhead.

In this environment, Dolby Atmos enabled speakers may better reproduce the Dolby Atmos sound you would hear in a movie theatre, where the overhead speakers are high in the auditorium, creating a more diffuse experience. Audio experts who have heard Dolby Atmos

enabled speakers agree that in certain rooms, the sound these speakers produce can be preferable to the sound that ceiling speakers produce.

Speaker recommendations

Dolby recommends that you use four Dolby Atmos enabled speakers when possible. Use of four speakers will make the placement of overhead sounds more accurate, and you'll get more precise, realistic sounds as an object—such as a helicopter—passes overhead in a video. Two of the speakers (whether they are integrated speakers or add-on modules) should be in the front left and front right speaker locations of your system. The other two should be positioned in the surround sound speaker locations, ideally the rear surround speakers, if you have them.

If you opt to use two Dolby Atmos enabled speakers, you'll still get a very immersive experience, with sounds moving overhead. Simply place the Dolby Atmos enabled speakers at the front left and front right speaker locations.

For the best sound, place your speakers at or slightly above the height of your ears when you're seated. Avoid placing the Dolby Atmos enabled speakers higher than one-half the height of your wall. Make sure the speakers are at least 3 feet (0.9 meter) away from you, ideally 5 feet (1.5 meters) or more. If you're using add-on modules, place them either on top of your front and surround (ideally, rear surround) speakers or within 3 feet (0.9 meter) of those speakers.

If you use ceiling speakers, Dolby recommends that you use four or more speakers when possible, though two speakers will still provide a great experience. If you use four ceiling speakers, you should place the front pair of ceiling speakers in front of the position where you'll be listening and the second pair of ceiling speakers behind you when you're seated. If you use two ceiling speakers, mount them slightly in front of where you'll be listening.

Dolby recommends ceiling speakers with wide dispersion patterns. If you use ceiling speakers with narrow dispersion (less than 90 degrees × 90 degrees) or those with aimable drivers, angle the drivers slightly toward your listening position.



Figure 5: If you use ceiling speakers, Dolby recommends using four or more.

You can also combine Dolby Atmos enabled speakers with ceiling-mounted speakers in your home theater. This can be useful if, for instance, you have two speakers already installed in your ceiling but want to add two more speakers that can produce overhead sound. You can add two Dolby Atmos enabled speakers and get detailed overhead sound without going to the trouble of installing new speakers in your ceiling. You'll hear the same overhead sounds whether you're using ceiling speakers, Dolby Atmos enabled speakers, or a combination of both.

While the arrangements recommended above will yield the best experience, a Dolby Atmos system can support many other configurations you may already have in your home. For instance, Dolby Atmos supports the standard "wide" speaker positions on the floor and the "front vertical height" positions usually found on the top of the front wall, as well as many other speaker positions.

However, before designing your room layout, refer to your AVR's documentation to ensure that it supports the combination of speakers you plan to use.

Describing your new Dolby Atmos system

With the debut of Dolby Atmos, there is a new method of referring to surround sound speaker configurations. It is based on the standard nomenclature (stereo, 5.1, and 7.1) but

adds a number at the end to specify the number of ceiling or Dolby Atmos enabled speakers you use (for example, 7.1.4).

Here are descriptions of the most common speaker layouts in a Dolby Atmos system for home theater:

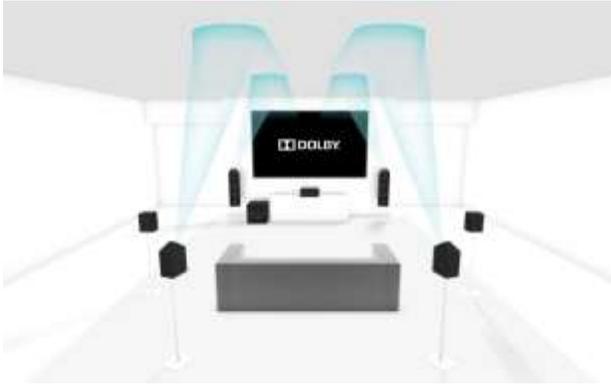


Figure 6: A traditional 7.1 speaker layout with four Dolby Atmos enabled speakers (7.1.4).



Figure 7: A traditional 5.1 speaker layout with four Dolby Atmos enabled speakers (5.1.4).



Figure 8: A traditional 5.1 speaker layout with two Dolby Atmos enabled speakers (5.1.2).

There is one important consideration in expanding your system: new speakers must be added to your Dolby Atmos system in pairs. A new speaker on the right side of the room must be matched by a similar speaker on the left side of the room. This is true for speakers located on the floor as well as in the ceiling. This pairing ensures a balanced soundstage. The exceptions to this rule are when you add speakers in the center or center surround locations.

For high-end home theaters, a 7.1.4 system (a traditional 7.1-channel-based layout with four overhead or Dolby Atmos enabled speakers) will provide a great listening experience. If you're ambitious, though, Dolby Atmos can support home theater systems with up to 34 speakers in a 24.1.10 configuration: 24 speakers on the floor and 10 overhead speakers.

However, Dolby Atmos content is not tied to any specific playback configuration. Whether you have a full 7.1.4 system, a 5.1.2 system, or a 24.1.10 supersystem, your receiver will get the same content and play it back in a way that takes full advantage of your specific setup.

As a starting point, Dolby recommends that any system include speakers in the positions normally designated for a 5.1 system. This allows you to play legacy, channel-based content as well as Dolby Atmos content.

Making the right connections

Once you have your speakers set up and you've purchased a new AVR, it's time to hook up your new Dolby Atmos system. Many AVRs that support Dolby Atmos have speaker connections labeled HEIGHT. (Some AVRs do not use that label, but they allow you to assign terminals for the height channels.) Connect your Dolby Atmos enabled speakers or ceiling speakers to those outputs. If you're using four Dolby Atmos enabled speakers or ceiling speakers (or think you might in the future), you need an AVR with four height outputs.

Of course, not all the content you play on your home theater will be in Dolby Atmos. The good news is that a Dolby Atmos home theater can play any channel-based content. You can choose to have our technology automatically adapt that channel-based signal to use the full capabilities of your new system, including your overhead speakers, thus ensuring that you hear realistic and immersive sound.

If you're not able to upgrade your home theater to Dolby Atmos yet, we still recommend that you purchase the Dolby Atmos version of content whenever that is available. The Dolby Atmos format was designed to be backward compatible, so it will play on both new and existing hardware platforms. In the future, upgrading your equipment to Dolby Atmos capable products will unlock the ultimate experience from Dolby Atmos content. In the meantime, you will get a great surround experience from traditional channel-based home theaters.

The technological building blocks of Dolby Atmos

Initially, you'll be able to play Dolby Atmos content from a Blu-ray Disc or from a streaming video service. Eventually, cable, terrestrial, and digital broadcast systems as well as video game consoles will be capable of providing Dolby Atmos content.

To allow the transmission of Dolby Atmos content, we've updated and improved many of the underlying Dolby technologies already in use today, including Dolby TrueHD, Dolby Digital Plus, and Dolby Metadata-Enhanced Audio Transmission (MAT), while maintaining their full compatibility with older content formats.

The key to creating Dolby Atmos sound is the ability not only to recreate a movie's sound—such as the whine of an ambulance siren—but also to place that siren's whine in a specific place and recreate its movement through space as intended by the audio mixer. All Dolby Atmos content includes both sounds and metadata that describe how those sounds move.

The Dolby Atmos object audio renderer is the intelligence that directs the system. It determines—on the fly—how to use your speakers to place and move sounds in exactly the way the filmmakers intended.

The Dolby surround upmixer allows you, if you wish, to play channel-based content while making full use of your Dolby Atmos home theater, including the ceiling or Dolby Atmos enabled speakers.

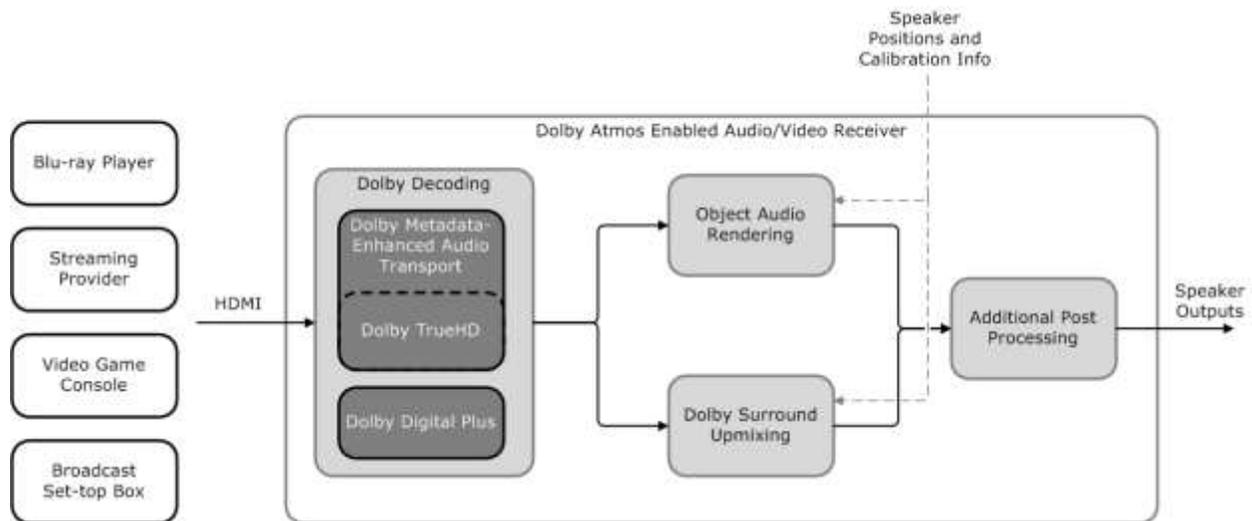


Figure 9: This diagram represents the workflow for translating cinematic Dolby Atmos content to home theaters.

Dolby Atmos in Dolby TrueHD

Dolby has extended the Dolby TrueHD format, used in Blu-ray discs, to allow the format to carry Dolby Atmos content. Before Dolby Atmos, Dolby TrueHD included lossless support for channel-based audio, such as 5.1 and 7.1. We have added a fourth substream for Dolby Atmos sound. This substream represents a losslessly encoded fully object-based mix.

Dolby Atmos in Dolby TrueHD can be transmitted from a Blu-ray player to your AVR in the same way it is accomplished today. If your AVR supports Dolby Atmos, when the Dolby TrueHD signal is decoded, the object-based audio and object audio metadata will be decoded for further processing.

Dolby Atmos audio can be encoded with Dolby TrueHD at multiple sampling rates (including 48 and 96 kHz) and bit depths (16- and 24-bit). Dolby Atmos enabled receivers will also support legacy Dolby TrueHD bitstreams at multiple sampling rates (including 48, 96, and 192 kHz) and bit depths (16-, 20-, and 24-bit) to provide full backward compatibility with legacy Blu-ray Disc media and Dolby TrueHD music files.

Dolby Atmos in Dolby Digital Plus

The updated Dolby Digital Plus has a new decoder capable of processing Dolby Atmos content. This module utilizes new bitstream metadata to extract Dolby Atmos object audio and outputs this information for further processing. The sampling rate for Dolby Atmos content is 48 kHz, the same sample rate for Dolby Digital Plus content.

Dolby Atmos in Dolby MAT

In the past, the Dolby MAT encoder existed in a Blu-ray player to pack the variable bitrate Dolby TrueHD bitstreams for transmission over the fixed bitrate HDMI. A MAT decoder is subsequently used in an AVR to unpack the Dolby TrueHD bitstreams. With the introduction of Dolby Atmos, we have expanded this technology to support encoding of Dolby Atmos content as lossless pulse-code modulation (PCM) audio.

A key benefit of Dolby MAT 2.0 is that Dolby Atmos object audio can be live encoded and transmitted from a source device with limited latency and processing complexity. Among the possible sources are broadcast set-top boxes and game consoles. The Dolby MAT 2.0 decoder in an AVR outputs the object-based audio and object audio metadata for further processing. The Dolby MAT 2.0 container is scalable and leverages the full potential of the HDMI audio pipeline.

Dolby Atmos object audio renderer

The Dolby Atmos object audio renderer is essentially the brain of a Dolby Atmos home theater. Dolby Atmos content consists of both sound objects and metadata that include information about where those sounds should be placed and how they should move, along with other data such as the type of object represented. The Dolby Atmos object audio renderer knows the speakers available in your system (you'll supply this information by following the setup instructions provided by the company that makes your receiver) and determines which speakers to use from moment to moment to recreate the sound the filmmakers intended.

Depending on the receiver configurations, the Dolby Atmos object audio renderer can support as many as 34 speakers—24 traditional floor speakers and 10 ceiling or Dolby Atmos enabled speakers—along with one or more subwoofer. The renderer also supports smaller configurations, making it fully scalable and adaptable to a variety of home theaters.

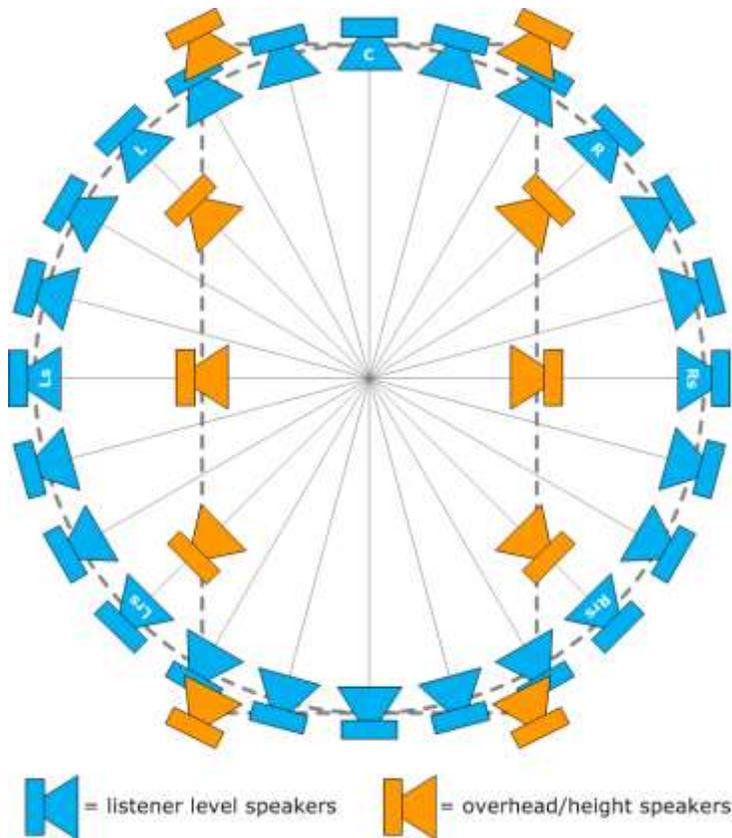


Figure 10: Dolby Atmos for home theaters supports as many as 24 speakers on the floor and 10 speakers producing overhead sound.

Dolby surround upmixer

If you invest in building a Dolby Atmos home theater, you want to get full use of it, even if the content you're playing isn't mixed in Dolby Atmos. That's where the Dolby surround upmixer comes in.

If you choose to enable it, the Dolby surround upmixer expands the audio of legacy channel-based content so that it takes advantage of your entire system, including the ceiling or Dolby Atmos enabled speakers. Dolby surround upmixer expands the audio while still honoring and maintaining the artists' intent for the mix. The Dolby surround upmixer employs the original signal to create a highly accurate rendering of the environment in the movie.

Unlike previous wideband upmixing technologies, the Dolby surround upmixer operates on multiple perceptually spaced frequency bands for a fine-grained analysis of the source signal. Dolby surround upmixer can individually steer frequency bands, producing surround

sound with precisely located audio elements and a spacious ambience. Dolby surround upmixer replaces the Dolby Pro Logic II family of upmixers, offering greater flexibility and superior audio performance.

The Dolby surround upmixer will provide audio to, at maximum, the same set of 24 speakers on the floor and 10 Dolby Atmos enabled or ceiling speakers. To maintain the frontal audio image, the upmixer will not send upmixed audio to speakers that are located between the Left, Center, and Right speakers.

Translating cinematic Dolby Atmos content to the home

As we've said, Dolby Atmos allows each sound in a movie scene to be represented as a separate audio object. And each of these objects has its own metadata describing precisely where it should originate and how it should move, among other data. This approach produces incredibly lifelike sound, but for a scene with lots of action, it also produces a lot of data. Getting all that data to your living room through the limited bandwidth available is a challenge. We've met that challenge with a technology called spatial audio coding.

Spatial audio coding takes into account the spatial information, along with other information, about the sound objects to efficiently encode them in Dolby TrueHD and Dolby Digital Plus. This spatial coding is not a channel-based, matrix-encoding system like Dolby Pro Logic II or Dolby Pro Logic IIz. Instead, it is a fundamentally new coding technique that allows all of the original cinema audio objects to be sent to your home theater.

Filmmakers frequently remix a film to sound its best in home theaters (a process known as the near-field mix). Spatial audio coding is a tool available during the near-field mix so that the filmmakers can hear exactly how the film will sound when it is encoded to Dolby Digital Plus for streaming or encoded losslessly in Dolby TrueHD for Blu-ray.

Creating Dolby Atmos soundtracks

The first Dolby Atmos content for home theaters will be delivered via Blu-ray Disc and streaming video or over-the-top (OTT) services. For Blu-ray, studios will employ lossless Dolby TrueHD for the primary soundtrack and Dolby Digital Plus for secondary languages. In the future, Dolby Atmos content will be delivered via video on demand (VOD), broadcast (terrestrial and digital), and cable services that use multichannel Dolby Digital Plus in their core architecture.

Production houses creating Dolby Atmos content for home theaters will use a tool called Dolby Media Producer, along with its suite of professional encoding, decoding, and media-related tools.

Before using Dolby Media Producer, though, production houses have the option to perform several preliminary steps, including a near-field remix and remastering of the cinematic master file. In this stage of the process, the audio mixer may make small adjustments to the mix to ensure that it sounds as they intended in Dolby Atmos enabled home theaters.

Dolby Digital Plus elementary bitstreams from Dolby Media Producer may be used for streaming media and broadcast delivery. Dolby TrueHD bitstreams are used to create Blu-ray Disc versions.

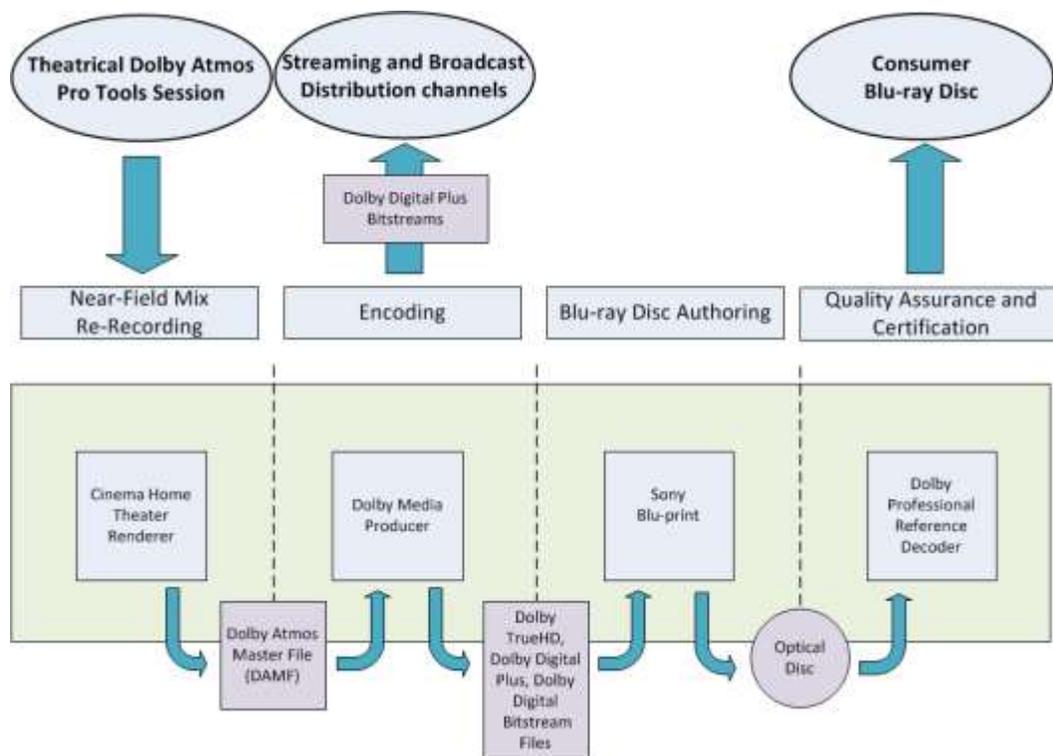


Figure 11: The content creation workflow for Dolby Atmos home content.

Conclusion

Dolby has invested years of engineering and research work into accurately translating the Dolby Atmos experience from the cinema to home theaters. Today we can bring a Dolby Atmos experience to the home through established delivery methods while maintaining

backward compatibility. The result is nothing short of the most realistic and immersive entertainment experience ever available for home theaters.