



PRODUCTIONS IN AURO-3D

Professional workflow and costs

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1 INTRODUCTION

Film producers agree unanimously that sound is responsible of at least 50% of the emotional experience in a film. As such, the film industry has always been on the forefront to push the envelopes of sound reproduction: the introduction of stereo and later surround sound, the introduction of digital audio with Dolby Digital, DTS...

In 2005, four years before 3D movies became really popular in the cinema market with the release of Avatar (in 2009), Wilfried Van Baelen (founder & CEO of Galaxy Studios) developed a new **Aurophonic** audio playback system as part of his **Auro-3D Concept**, launched at the 2006 AES Conventions in Paris and San Francisco.

Auro-3D allows the addition of the **next, 3rd dimension (Height)** in sound reproduction. Indeed, there is a lot of misunderstanding concerning the term 3D-sound, because it has been frequently misused by marketing people in such a way that its definition has become unclear. Even some stereo widening algorithms for playback over stereo speakers claim to give 3D Sound. For this reason, it has to be made clear that Auro-3D is about real 'Sound in 3D' using the three orthogonal axes (x, y, z) in the speaker setup to reproduce real three-dimensional sound.

This extra 3rd dimension is an incredible tool for creative people and gives a new, extra dimension to the film watching experience.

Wilfried Van Baelen's vision was to create new three-dimensional listening formats that provide 100% compatibility with the existing standards (stereo & 5.1 Surround) for each market: the Film Industry, Gaming, Automotive, etc... The goal was to simplify the workflows for content creation in each listening format for each market without raising the costs for the content makers.

When presented with this new audio solution, theaters and post-production studios become eager to upgrade their sound systems thanks to the *practical and viable solutions* offered by the Auro-3D concept.

Apart from the incredible listening experience, the most important aspects of this concept are **audio quality** and **compatibility** on all involved levels, including the **production workflow**.

This document describes the complete workflow from recording up to the authoring for a BD and/or DCP or *movie* and *music* productions, including some suggestions on how to easily implement the new tools and apply them in an easy way to create this new dimensional experience for cinematic productions. The first focus will go to Movie productions; Music production will come as a second topic.

2 WHY USE AURO-3D IN MOVIE PRODUCTIONS?

1. Auro-3D is the best solution for the **most natural listening experience** that is far more relaxing to the brain (= less ear-fatigue), bringing the spectator in the middle of the action, whilst not detracting him/her from the story.
The best listening experience is achieved when using material recorded in the Auro-3D format, because all channels then contain 'coherent' material, enveloping the spectators in the most natural way.
2. Auro-3D is a **simple add-on** to standard surround sound productions as it builds further upon the standard ITU-recommended 5.1 speaker setups. The provided solutions also make sure that the complete existing production chain can still be used, needing only a few simple additions (see further). In the Auro-3D Concept, the maximum 3D-impact is achieved using the minimum amount of channels. The use of the monophonic overhead ceiling speakers is not a consequence of this goal, but was rather added to make the spread of the sound in a cinema theatre as homogenous as possible, creating the same localization experience for every seat in the auditorium. This cannot be achieved using a stereophonic overhead. Such a system also causes issues with the on-screen localization depending on the spectator's position in the theatre.
3. Auro-3D productions sound best when recorded **on set** with this format in mind. However, it is perfectly possible to achieve incredible results using just **sound design** and **remixing** as well.
4. Using Auro-3D allows for budget savings in production as the Aurophonic, Surround Sound and Stereo mixes can be created **simultaneously**. It is not necessary to completely remix for Auro-3D afterwards.
5. With Auro-3D, you can make you masters **future-proof** as with the Auro-3D Octopus codec multiple playback formats can be mixed into one, single PCM-stream and unmixed to the required playback format in its original quality. This means that all content can be distributed using the existing standards in the market. No changes are thus required to e.g. the SMPTE standards or DCI specifications as the full encoding and decoding processes remain in the PCM domain. As such the future standard can already be integrated into existing masters without any compromise in quality or compatibility.
6. **Single Inventory Distribution** means that the same master and delivery package (DCP or Digital Cinema Package) can be used for theaters equipped with an Auro-3D as well as a standard Surround Sound playback system. Theaters not equipped with the Auro-3D system can reproduce the Auro-encoded 5.1 surround PCM-mix, which sounds exactly as the normal 5.1 mix, over their existing equipment. Once, the theater has been upgraded with an Auro-3D Decoder, the original Auro-3D 11.1 mix will be revealed without any audible compromise. This thus effectively reduces the cost of having to create different masters and delivery packages for each playback format.
7. Auro-3D is a complete solution that has many arguments going for it. See the following **white papers** for some more details:
 - a. *Auro-3D, the most natural movie experience*, Van Baelen, W.; Claypool, B.; White Paper, 2011
 - b. *Auro-3D Octopus Codec: Principles behind a revolutionary codec*, Van Daele, B.; Van Baelen, W.; White Paper, 2011

3 'FEATURE FILM' WORKFLOW OVERVIEW

Just like any other audio project, a production for Aurophonic content consists of the following main processes.

- Production
 - Preparation: planning and gear selection
 - Recording on set: field- or studio recording
- Post-production
 - Video Editing
 - Dialogue Editing
 - Additional Dialogue Recording
 - Foley
 - Sound Design (Ambience / FX)
 - Mixing
- Authoring (creation of DCP)
- Distribution

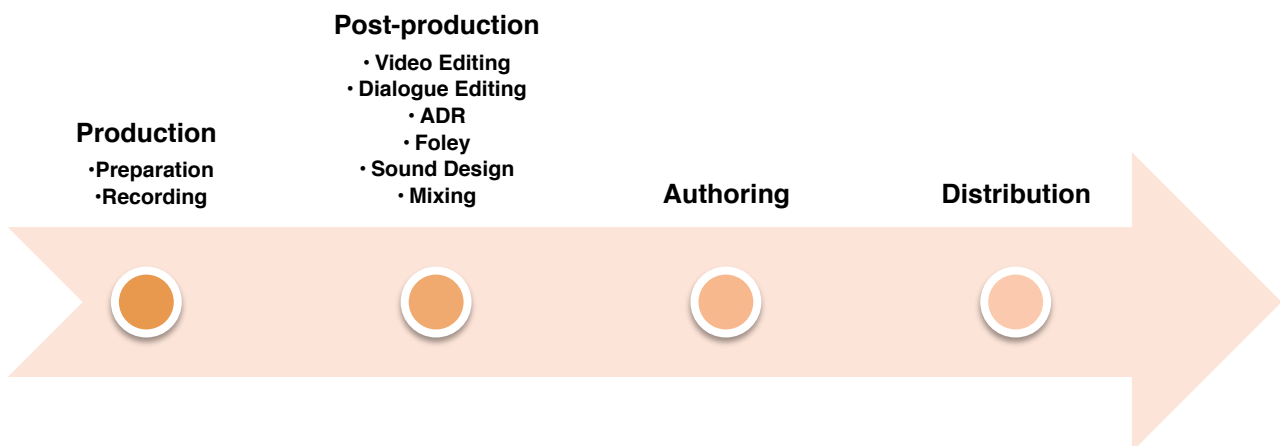


Figure 1 - High-level Professional Workflow for any Auro-3D production

In the following chapters, the influence of working in **Auro-3D** on each process will be evaluated.

3.1 Production – Preparation

When starting a production in Auro-3D, it is important to plan upfront what audio material is needed to achieve the envisioned results.

Questions that should be asked and answered are:

- What type of environment will the recording be done in?
 - Recording studio → size?
 - Location recording → inside? Outside?
- What effect should be achieved?
 - Lifelike ambient sound?
 - Effects flying around and above the listener?
 - Unusual soundscapes to emphasize the film's atmosphere even further?
 - ...
- Is an Aurophonic recording on the set necessary to achieve this effect?
 - Does the real ambience of the recording venue need to be captured?
 - Can creative panning be used? Reverbs?
 - Are sound libraries going to be used?
 - What formats are available (2.0, 5.1, 9.1, 11.1...)?
- Cost estimation
 - (One time) investment in hardware and software
 - Labour cost: there is no extra cost if 5.1 recording is already provided on the set
- ...

Once it is decided what should be recorded in Auro-3D and in what circumstances these recordings will happen, several technical choices should be made.

- Number and type of microphones
 - An Aurophonic recording typically has **8 to 12 microphones**. This is **only 4 to 6 extra microphones** compared to standard 5.1 Surround Sound recording setups.
 - The choice of microphones depends on the localization info that the engineer wants to record
- Size of microphone rig
 - Depending on the recording venue, several rig sizes can be used
 - Large (with uncorrelated sound in the lower frequencies)
 - Medium
 - Small (where lower frequencies become mono)
- Number of recording tracks
 - Ideally, all audio on set is recorded simultaneously
 - Boom-mic, clip-on mics, Auro-3D rig...
- Microphone placement at each recording venue
 - Fixed floorplan in case of static or little moving camera setups
 - Flexible floorplan with Boom-operated microphone and Auro-3D rig on scene with moving cameras
 - ...
- Recording system
 - Depending on mobility requirements
 - Depending on number of simultaneously recorded tracks

3.2 Production – Recording

As already mentioned earlier, the best listening experience can be achieved when using material **recorded** in the Auro-3D format. Because the brain (subconsciously) recognizes that all the channels contain **coherent** information, the sound completely envelops the spectators in the **most natural** way. This is actually the same in surround sound where original 5-channel recordings also give a more natural feel to the sound. It is also generally accepted that the panning of discrete sources in multi-channel sound should be avoided because the lack of a coherent sound field typically leads to a detached front-to-back experience.

Thanks to the 3-dimensional capabilities of the Auro-3D system, sounds can be reproduced in the same way as experienced in nature. It is generally known that human beings are very sensitive for this (natural) perception based on coherent information between all the channels. The impact of this coherent information on the subconscious is an extremely powerful tool to draw the spectators much closer into the story, the ultimate goal of all film directors.

Especially live, on-scene recordings have a huge impact on the listening experience, as they really have a one-to-one link with the action that can be seen on the screen, completely emerging the spectators with the real atmosphere of the scene. The human brain is very sensitive for this information and subconsciously brings us immediately much closer to the action.

In this way Auro-3D improves substantially the immersive cinematic experience.

Recording in Auro-3D is especially interesting for:

- Ambience
- FX
- Music / Scoring
- Acoustical fingerprint of the location (impulse response)
- Wild tracks (background noise of the location)
- Dialogue

In principle the on-set recording engineer already doing the boom-operated recording can continue his job as before. If an engineer is present to record 5.1 surround sound, no extra engineer is necessary to record Auro-3D on the set as this can be done by this same person. If only a boom engineer is foreseen, an extra engineer should be added to the sound crew.

While this seems to be an upcost at first, this actually helps the sound design engineers to gain time when provided with these natural recorded sounds in Auro-3D coming from the set. The impact on the listener's brain of these coherent spatial recordings cannot be reproduced during the post-production phase. However, this does not mean that it is not possible to create an impressive mix without any original Auro-3D sound; it just requires quite some more effort in later stages.

It is also a good idea to record a 'fingerprint' of each acoustical space where the film is recorded. This acoustical fingerprint can then be important in the Auro-Verb reverb engine, which allows the mixing engineer to integrate sounds from a soundbank (not recorded on set) in the right acoustical environment, enhancing the realism of the effect.

This is very useful for ADR (Additional Dialogue Recording) as well, where it always is a challenge to make the recordings sound as coming from the original space. The same is true for overdubs in foreign languages. As Dialogue is the backbone of a film, the more natural and better it sounds, the higher its emotional impact will be because it will bring us completely in the middle of the action.

3.2.1 Microphone setups

Several microphone set-ups have been developed and used to make Aurophonic recordings under varying circumstances. The basic idea, however, is always the same: a regular (5-channel) surround sound microphone setup is used as the basis, completed with only **four** (or preferably **five**) additional (Height) microphones placed above the main microphones and **one** microphone to record the “Voice of God”-channel. Only using these 3 layers (Lower, height and top) the reproduction of a natural space can be achieved with a minimum of 10 speakers, while also providing compatibility with the 5.1 surround sound standard.



Just like for surround sound recordings, the microphone types and their exact placement depends on many factors:

- recording venue (inside/outside; room size; room acoustics...)
- envisioned effect (diffuse ambient sound / loud direct reflections / real sources from above...)
- creative ideas
- camera angles/movements
- ...

Note: The additional **room microphones** to record Auro-3D are often already available in every orchestral scoring session to capture the reflections inside the room. They can thus be used for Auro-3D by simply re-routing their signals to different channels to create a much better, richer and more natural sound compared to standard surround sound productions.

The following setups have been used to great effect for Aurophonic recordings. However, many different variations are possible, depending on the requirements already mentioned above.

3.2.1.1 Scoring with large orchestra

For a large orchestra, in a good, large hall, a standard surround sound setup can be used based on a Decca Tree (wide-spaced AB-pair with Center microphone), combined with a wide-spaced AB-pair for the surrounds. Above the main microphones (L, R, LS, RS), the height microphones are added at about half the distance between the main L/R-microphones. In a good hall these microphones can be omnidirectional, but when less room acoustics are wanted, cardioid microphones can be used as well, directed downwards towards the orchestra.



3.2.1.2 Scoring with small (chamber) orchestra, grand piano solo

For these occasions, smaller setups are likely to be more appropriate. Good results have been obtained using an ORTF LCR-setup, with a medium-spaced AB-pair for the surround-channels. These are then augmented with height microphones placed above the ORTF-setup and above the AB-pair. For the choice of microphones and their specific placement the same rules apply as for the large setup.

3.2.1.3 Medium-sized mobile rig for (outside) location recording

A mobile medium-sized rig is interesting when doing outside recordings as well as for music events (concerts), live broadcast (e.g. sport events) or nature documentaries.

3.2.1.4 Small-sized mobile setup as boom for on-set recording

This setup is ideal for use on-set of film recordings to record the three-dimensional ambience of the scene while remaining mobile and invisible to the camera(s).

It is also of particular use in very small places such as cars, trains, bathrooms, etc..., or in situations where high mobility is necessary (documentaries...).

3.2.2 Other recording equipment

Apart from the microphones, some additional equipment is needed to enable the recording of these extra microphones:

- microphone amplifiers
- recording unit with sufficient recording channels and storage

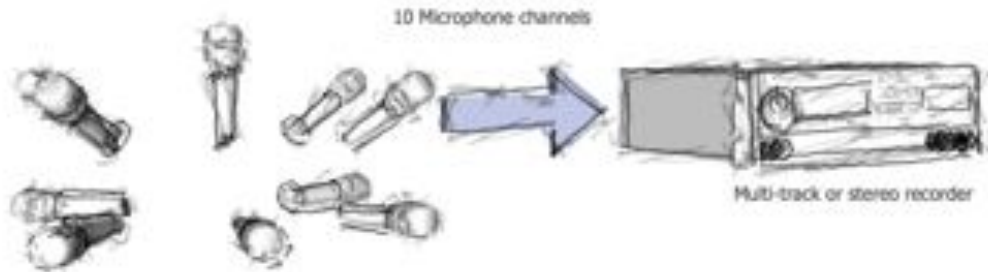


Figure 1 - Discrete multi-channel recording of 10-channel Aurophonic setup

3.2.2.1 On-scene Auro-encoding

If it is difficult to use a multi-channel recording rig, or the recording rig does not have enough channels, an **Auro-3D encoder** (hardware version under development) can be used to encode the record the Aurophonic multi-channel audio onto 5 channels, or even on only 2 channels (using the upcoming unique *Auro-3D StereoMagic* mode) on any stereo PCM-recorder. During mixing a decoder can then be used to decode the original channels without audio compromises for further mixing.

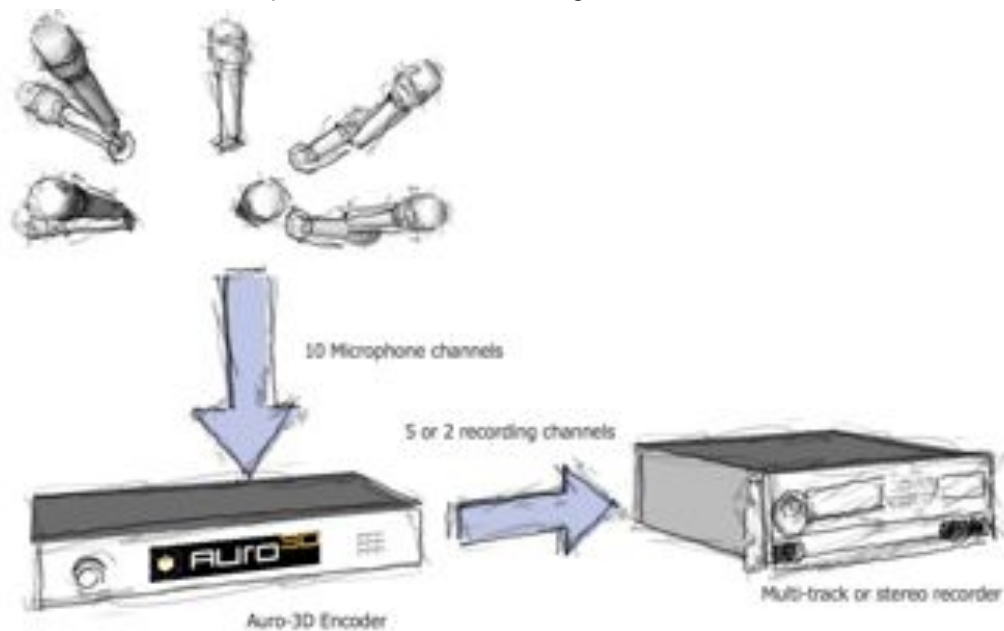


Figure 2 - Auro-3D Encoded recording of 10-channel Aurophonic setup to 5 or 2 recording channels

Another advantage of this approach is that this will also result in less data that needs to be stored, and therefore in a lower production cost.

3.3 Post-production – Video Editing, Dialogue Editing, ADR, Foley

Auro-3D recordings are multi-channel PCM-recordings, just like any other recording at its source; the editing processes remain exactly the same as before.

3.3.1 Video Editing

As long as the Auro-3D recordings, which are multi-channel PCM-files, are correctly aligned to the picture, the video editing remains the same as before.

3.3.2 Dialogue Editing

The sounds recorded on set need to be synchronized in the same way as the editor is currently doing; the only difference is the addition of the extra Height channel tracks.

Several tools are available on the market that allow to automate this process. By simply grouping the tracks, the editor can further operate in the same way as he is used to when editing surround tracks. Naturally, the first productions will require some initial extra effort to set up personalized templates etc., but in the end, the addition of the the Auro-3D content should not bring additional effort to the dialogue editing process.

3.3.3 Additional Dialogue Recording (ADR)

Additional Dialogue Recording (ADR) normally does not require Auro-3D recordings since they will never have the same acoustical reflections as the original recording location. In fact, sometimes on set dialogue recordings do not even exist due to circumstances not allowing the crew to record the actors. The use of three-dimensional reverbs, such as Auro-Verb, will help to recreate the acoustical reflections as present on the set. If acoustical fingerprints of the stage are not available, Auro-Verb naturally has a library of different acoustical spaces that can be used instead.

3.3.4 Foley

Many softer background noises, such as movements of clothing, do not require an Auro-3D treatment. Louder sounds, on the other hand, create a clear reflection pattern in a room and as such will benefit from being recorded in Auro-3D. But for most of these sounds, also the Auro-Verb treatment will give very believable results, keeping the workflow as efficient as possible.

3.3.5 Conclusion

Most post-production stages can be performed in almost exactly the same way as in the currently used processes.

3.4 Post-production – Sound Design

Just like the recordings on the set, the Sound Design process can be easily adapted to Auro-3D to enhance the film's atmosphere even further. As already mentioned before, the creation of a coherent sound field in Auro-3D is possible but it will be much easier to have the ability to use sounds recorded on the set. Depending on the situation, Auro-3D recorded wild tracks can be more useful than a full Auro-3D recording in sync with picture. The wild ambiance track can then be used as a carpet to which certain specific sounds can be added enriched with extra reflections from the set by using the Auro-Verb and/or Auro-Matic.

Several tools enable this easy transition.

- The acoustical footprint recorded on the set can be integrated in several effects
 - **Auro-Matic Pro** upmixing (plug-in, under development): create the 9.1 or 11.1 version of audio-material originally recorded in 5.1 or stereo and bring it in the 3D-environment of the scene (see White Paper)
 - **Auro-Verb** (plug-in, under development): use the acoustical fingerprint recorded on location in the special Aurophonics reverb unit to recreate the exact room acoustics of the scene for ADR and Foley.
- Cost estimation:
 - (One time) investment in software tools (Auro-Matic Pro, Auro-Verb...)
 - Labour cost – Sound Design I probably the only stage in the production workflow where working in Auro-3D will require some extra work and attention.

3.5 Post-production – (Final) Mixing

The mixing stage is where all the Auro-3D magic comes together to create the complete 3-dimensional cinematic experience. At this stage all material (on-set recordings, ADR, sound design, etc...) comes together to form the final mix.

As a preparation, it is important that all this material is organized to match the track layout on the mixing desk.

3.5.1 Auro-3D Source material

- Auro-3D multi-channel recordings from the set (dialogue, ambience) and orchestral scoring stage
 - Complete multi-tracks can be used immediately
 - Auro-encoded material should be decoded first using the **Auro-3D Decoder** (hardware unit or decoder plug-in), before entering the final mix.
- Existing 5.0 (surround sound) multichannel or stereo recordings (e.g. from sound libraries), upmixed to Auro-3D 9.1 or 11.1 with the **Auro-Matic Pro** plug-in
- Dialogue from the set or ADR and FX can be processed with the **Auro-Verb** plug-in to recreate the exact room acoustics of the scene

3.5.2 Auro-3D Mixing

3.5.2.1 Auro-3D Mixing Concept

As part of the complete **Auro-3D Concept** a mixing template has been developed that allows for the **simultaneous** mixing to Auro-3D 11.1 and 5.1 Surround Sound, using the Auro Encoder plug-in that is inserted in the final stem.

When creating separate mixes for two formats (e.g. stereo and surround), many mixing engineers have proven that both formats gain in quality by checking and switching between those formats on a regular basis. To avoid confusion this has to be visually communicated to the client, but in the end it is in his interest that both formats sound at their best.

The Auro-3D Encoder plug-in allows dynamically mixing (with automation) the height channels into the lower channels during the mixing process. This means that the engineer always hears the final result of the surround mix while listening through the Auro-3D plug-in (except when the plug-in is disabled). This way the optimal 5.1 surround mix will be created while mixing the Auro-3D 11.1 mix. The bulk of the extra mixing time will be limited to optimizing all phase and level relationships between the two output formats.

Naturally, this process requires some exercise but each engineer (or post-production studio) capable of delivering the 5.1 surround AND Auro-3D 11.1 mix for almost the same budget will have a big advantage against competitors without this experience.

3.5.2.2 Auro-3D Stem Layout

Since most mixing consoles have Stems with a bus-width limited to 8 channels, a workaround is needed to create the possibility to mix Auro-3D content. This workaround is based on three items:

- a. The Auro-3D Encoder plug-in that mixes the Height and Lower layers in a dynamic, artistically controlled way.
- b. A Stem layout that provides easy routing in Auro-3D as well as compatibility with surround sound formats. (As an example, the AMS-Neve DFC console with Encore II already has all the necessary feature on-board, including Auro-3D panning.)
- c. For mixing consoles without the Auro-3D panning system, a special tool can be used to this panning in-the-box.

The amount of channels per Stem depends on the kind of content being mixed and the mixing engineer's artistic vision for the spatial experience. The following chapters can help as a guide in creating the templates for Auro-3D mixing.

To work as efficiently as possible, ALL pre-mixes should be delivered using the same Stem layout as described below. This way, the mixing engineer responsible for the final mix, can rely on the pre-mixes following the same Auro-3D Stem layout. It is therefore important that the supervising mixing engineer decides on the Stem layout before the pre-mixes are created, following the same procedure currently used for the simultaneous mixing of 5.1 and 7.1 surround.

	Lower layer			Height Layer		Comment
	Stem	Width		Stem	Width	
Dialogue	A	5.0	+	G	4.0	In case no dialogue in Height Top (HT/VoG) is needed
		5.0			5.0	Auro-3D 10.1: Quad Height + HT
		5.0			6.0	Auro-3D 11.1: 5.0 Height (incl. Height Center) + HT
PS: Typically, the most important channels for Dialogue are L, C and R. The other channels are normally only used to create spatial reflections.						
Ambiances	B	5.1	+	H	4.0	Minimum configuration: Auro-3D 9.1
		5.1			5.0	Auro-3D 10.1: Quad height + HT
		5.1			6.0	Auro-3D 11.1: 5.0 Height (incl. Height Center) + HT
		6.1			6.0	Auro-3D 12.1: incl. Center Surround Channel
		6.1			7.0	Auro-3D 13.1: + HT
		7.1			6.0	When a 7.1 surround mix is needed
		7.1			7.0	7.1 surround + Back height center (for mixing Auro-3D 13.1 content with compatibility with 7.1)
FX	C	5.1	+	I	6.0	Minimum configuration: Auro-3D 11.1
		6.1			6.0	Auro-3D 12.1: incl. Center Surround Channel
		7.1			6.0	When a 7.1 surround mix is needed
		7.1			7.0	7.1 surround + Back height center (for mixing Auro-3D 13.1 content with compatibility with 7.1)
Music	D	5.1	+	J	4.0	Minimum configuration: Auro-3D 9.1
		5.1			5.0	Auro-3D 10.1: Quad height + HT
		5.1			6.0	Auro-3D 11.1: 5.0 Height (incl. Height Center) + HT
PS: As the basic standard for music recording is 5.1 surround, most music will be recorded and mixed in Auro-3D 9.1. However, in some occasions the music channels are also used to create certain effects, making it useful to also provide the HC and HT channels for such situations.						
Spare	E		+	K		
PS: The AMS-Neve Gemini II console with Encore 2 automation provides 12 stems, providing two extra stems to create an extra Lower and Height layer when needed.						
SUM	F	5.1	+	L	6.0	Final Mix in Auro-3D 11.1
		6.1			6.0	Final Mix in Auro-3D 12.1
		6.1			7.0	Final Mix in Auro-3D 13.1
		7.1			7.0	Final Mix in Auro-3D 13.1 with 7.1 surround compatibility

3.5.2.3 Monitoring

The minimum 9.1 setup in an Auro-3D compatible mixing room, requires a standard 5.1 setup at about ear-level, augmented with 4 monitors placed above the corner monitors at 30° elevation.

The smallest Auro-3D setup for cinematic use, however, is actually based on the existing 5.1 surround configuration with the addition of 5 speakers in the Height layer as well as one speaker on a third layer, referred to as the Height Top speaker. To avoid confusion with certain systems that use the term 'Top' for the Height layer, this speaker in the third layer is often referred to as the 'Voice of God' (VoG).

Documentation is available describing the speaker setup guidelines and the requirements for Auro-3D Certification of a mixing room. This certification program is especially important to guarantee correct compatibility between installations in mixing studios and movie theaters, so that content makers can be reassured that the spectators will receive the correct experience.

Figure 3 shows a discrete 11.1 setup. The rear and top channels in a cinematic setup are actually using speaker arrays (multiple speakers reproducing the same signal) to create a better spread of the sound in the theater, but the diagram, clearly shows the different channels and their placement.

As can be seen, an Auro-3D 11.1 setup uses a 3-layer configuration:

1. The lower layer with the standard 5.1 setup at about ear-level
2. The Height layer in a 5.0 configuration, placed above the lower monitors at 30° elevation
3. The Top layer or Voice of God (VoG)

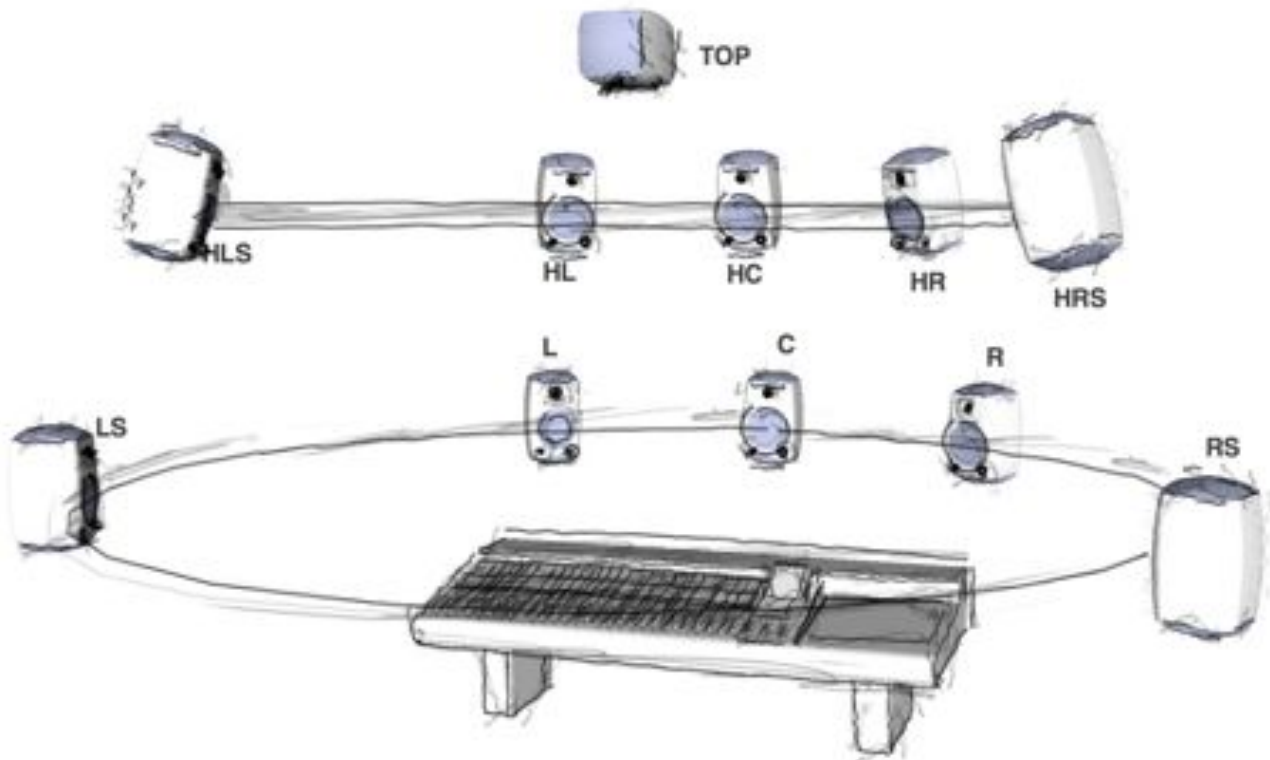


Figure 3 - 11.1 Auro-3D Monitoring setup

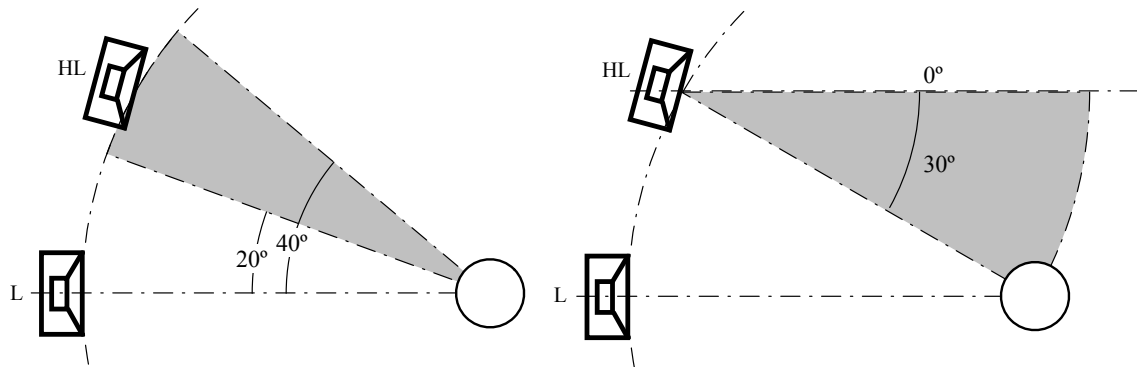
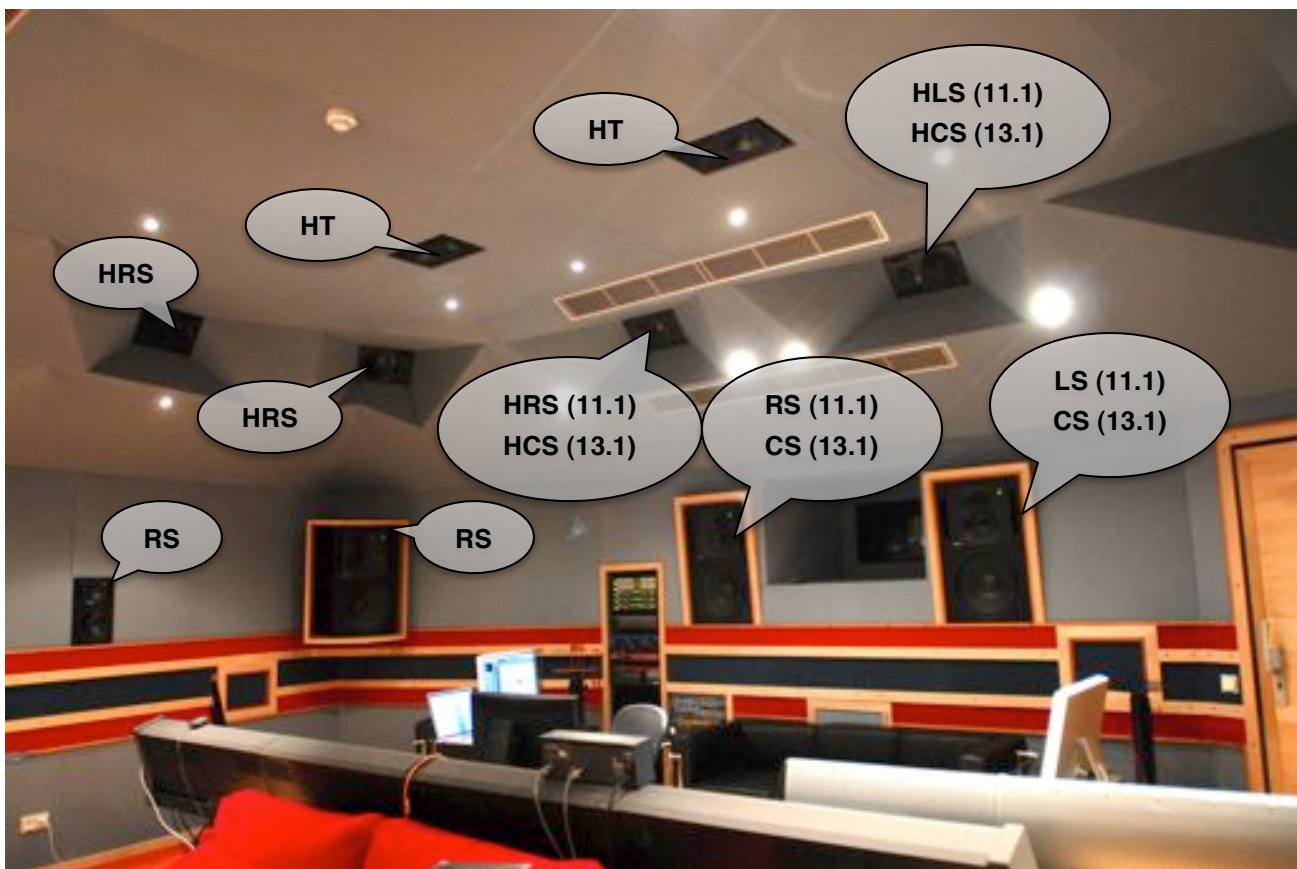
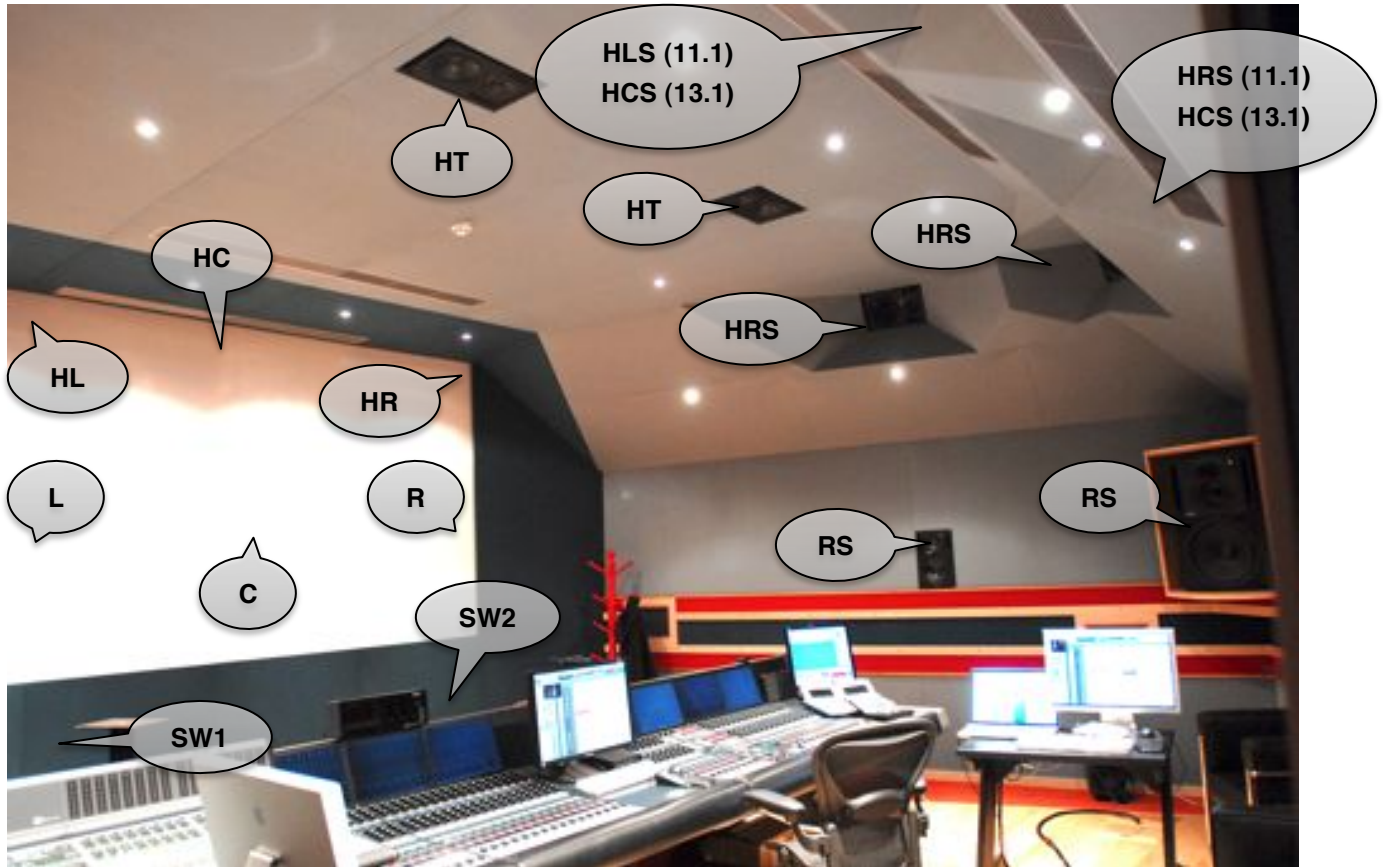


Figure 4 – Elevation and inclination angles of the Height monitors above the main monitors

In an Auro-3D 12.1 configuration, a Center Surround channel is added, and in Auro-3D 13.1 this is completed with the Height Center Surround channel.





The pictures above show the Galaxy Studios' Auro-3D compatible pre-dubbing stage with up to 18.2 playback channels and *AMS-Neve DFC with Encore II automation* capable of Auro-3D compatible mixing for all surround formats (5.1, 6.1, 7.1) and Auro-3D formats (8.0 up to 13.1).

3.5.2.4 Mixing Consoles

To mix Auro-3D compatible material, the mixing console should be able to use multi-channel buses of up to 14 channels. Using two special panning joysticks, the sound can then be panned anywhere within the 3-dimensional sound-field of the Auro-3D system.

Currently, *AMS-Neve* already produces Auro-3D compatible digital mixing consoles (88D and DFC), as shown above. Other large-format manufacturers will do this as well in the near future.

3.5.2.5 In-the-box mixing

Most Digital Audio Workstations (DAWs) such as Pro Tools, Nuendo... are capable of working with (groups of) buses that have a sufficient amount of channels to do in-the-box mixing in the Auro-3D format. The **Auro-Panner** can then be used to position any source in the Auro-3D sound field.

Additional processing can be done using all the usual tools, including the **Auro-Verb** 3-dimensional reverb.

Auro-3D PCM Master

The last stage before the release of Auro-3D audio material is the creation of the Auro-3D Encoded 5.1 PCM Master. This stage consists of the following three main steps:

- Encoding of the Cinematic 11.1 Auro-3D and 5.1 surround sound versions into one 5.1 Auro-encoded PCM-file for Digital Cinema (X-Curve based mix for DCP)
- Bouncing of the Consumer 9.1 Auro-3D and 5.1 surround sound versions into one 5.1 Auro-encoded PCM-file for BD and DVD (Linear mix)
- Encryption of the files (copy protection)

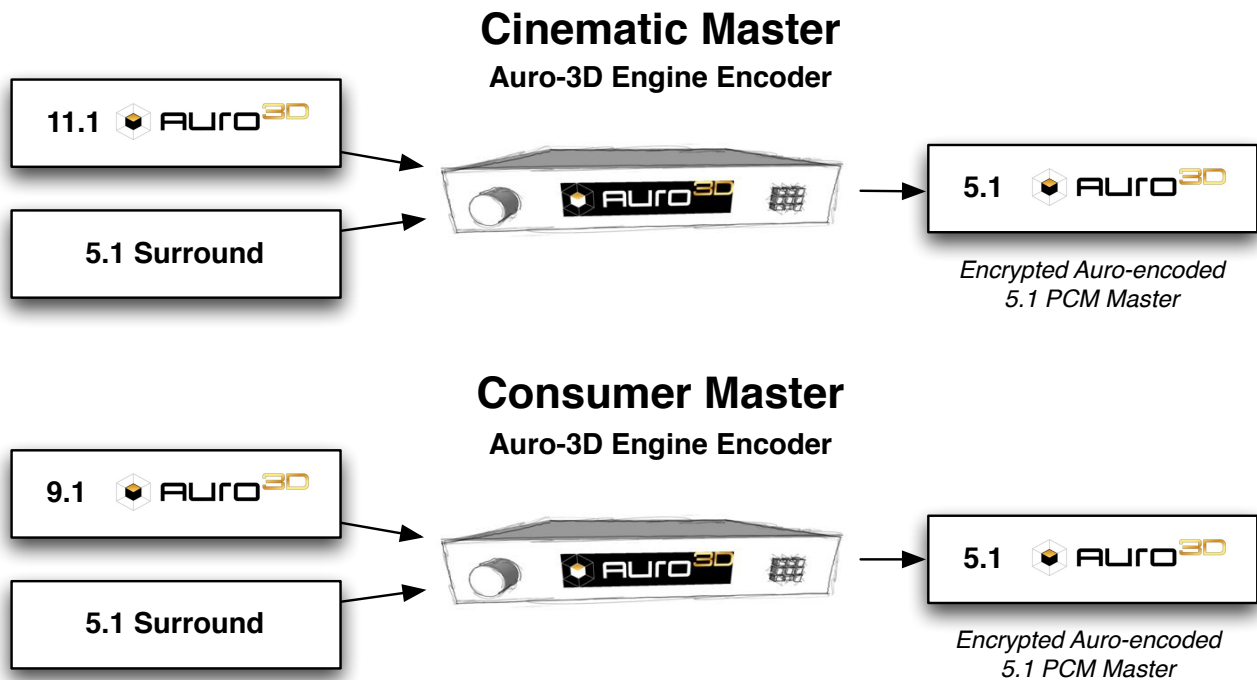


Figure 5 - Auro-3D Encoding with the Auro-3D Engine Hardware encoder or plug-in

The main advantage of the Auro-encoded PCM-files is that the same DCP can be used by theaters equipped with an Auro-3D Decoder and those without, effectively providing the **highest compatibility** between both groups as well as being **future-proof**.



Figure 6 - Auro-encoded 5.1 PCM stream with and without decoding

3.6 Authoring

The authoring process is now simplified as there is only one audio-stream to be taken into account. Moreover, since this is a 5.1 PCM-stream, no further encoding process is necessary anymore.

However, in case the audio-stream takes more bandwidth than originally budgeted, the Auro-encoded PCM-stream can still be further compressed using the currently available *lossless* audio codecs. This will then further reduce the stream by up to 40%.

3.7 Single Inventory Distribution

As already mentioned earlier, one of the strongest points of the **Auro-3D** codec, is the fact that it guarantees maximum compatibility with all existing standards. The final carrier format for distribution is **one** single standard multi-channel (5.1) PCM-stream, in which the other formats (11.1 or 9.1) are encoded.

The same master can thus be sent to cinema theaters with or without an Auro-3D setup. Theaters not yet equipped for Auro-3D will then simply play the audio-stream as a standard 5.1 mix, while those that have the Auro-3D decoder and playback system will be able to play back the full 11.1 listening format.

For playback at the homes from a BD, the same way of working is possible: one single master can be played back as 5.1 surround sound for those that do not own an Auro-3D decoder, while the consumers that do own an Auro-3D equipped home theater system will be able to enjoy the full 9.1 Auro-3D version of the movie.