Sibelius Academy / University of the Arts Helsinki
Department of Music Technology
Master's Thesis
Mikko Johannes Raita, 05/2025 mikkoraita.com
This text is accompanied by a Lecture component and media in these repositories:
https://www.researchcatalogue.net/view/3676155/3676156
https://doi.org/10.5281/zenodo.15426209

Immersive Music: Mixing and Recording Strategies for Theatrical and Home Film Reproduction

Introduction:

Sound for film has been at the forefront of standardizing surround and immersive audio reproduction for the masses for the past 50 years, since the 1977 use of Dolby Stereo with its left, center, right plus matrix encoded surround channel reproduction in George Lucas' Star Wars [1]. The adoption of the current industry standard 5.1, 7.1 and Dolby Atmos formats has originated from the film sound world and spread to the home theater environment. The Dolby Atmos for Home ecosystem [2] is now expanding on that, with advances in binaural reproduction allowing millions of hand-held devices to be able to support the format [3]. The fast emerging adoption of the related Dolby Atmos Music [4] ecosystem is also expanding the popularity of the Atmos format, especially in the global pop and classical music industries. In 2022, Dolby reported that two-thirds of Billboard's top 100 artists had released music in their Atmos Music spatial audio format [5]. However, as of this writing the Finnish music production ecosystem has not yet embraced Atmos Music as widely as many larger markets, and many of the most interesting local Atmos music projects have happened in film sound. In the global film and TV industry, Atmos is the leading sound format used on many of the larger budgeted film productions, with smaller independent films and streaming productions adopting it increasingly.

I have been recording and mixing music professionally since 2001, with 5.1 music album work since 2004, and film and TV music a part of my work from the very start of my career [6]. From 2016 and onwards the larger part of my work has consisted of surround film and TV music engineering projects, with nearly 70 IMDB film and TV credits as of this writing [7]. I was the first Finnish music mixer to get work mixed in Dolby Atmos released in the 2018 feature film Happier Times, Grump (Solar Films), and have continued to work in the format since, with several Atmos film score mix and recording works but also Dolby Atmos Music album mix and recording projects released. These music albums include Lauri Porra's Matter and Time [8], Aki Rissanen's Hyperreal [9] and part of Dalia Stasevska's Dalia's Mixtape [10]. My long-time mix room at Studio Kekkonen [11] is currently equipped with an Atmos-compatible 9.1.6 [12] Dynaudio Acoustics monitoring system.

I have done classical ensemble and orchestral recording throughout my career, mostly when combining string ensembles to a pop or jazz aesthetic. My deeper dive into orchestral recording has happened in conjunction with my work in film music, both alongside other recordists as well as being the principal recordist, testing out and fine-tuning my preferred surround and immersive pickup methodology on each project. Significant learning milestones have been co-recording strings with Risto Hemmi and Daniel Hagström on *Happier Times, Grump*, co-recording Vantaa Orchestra strings with Petri Majuri on *A Reindeer's Journey* (Valdés/MRP, 2018), co-recording the Vantaa Orchestra in Atmos with Matti Heinonen on *The Nature Symphony (*MRP, 2019), recording the Kymi Sinfonietta on *Finders of the Lost Yacht* (Taavi Vartia Tuotannot, 2021) and recording the Tampere Philharmonic Orchestra on *Super Furball Saves the Future* (Yellow Film, 2022). I have also mixed many orchestral recordings done by other recordists, including mixing the BBC Symphony Orchestra, recorded by Mike Hatch at the BBC Maida Vale studios on *Dalia's Mixtape*.

The research questions for this thesis work are:
(1) What are the technical and perceptual implications of designing and using an immersive recording system for large acoustic ensembles that emphasizes hall sound capture and frontal focus via gradual surround microphone distancing, and how does this approach differ from current practices in immersive music recording?
(2) How does the use of multi-directional top/overhead acoustic pickup, reproduction, and mix choices using at minimum a 7.1.4 recording and mixing layout [13] affect the spatial sound character compared to the common use of a single stereo height pair using only a 7.1.2 Atmos Bed layout [14]?
(3) What methods can be employed to mix stereo track-based productions to spatial formats that enhance envelopment while maintaining downmix balance compatibility with lower-channel-count playback systems, including stereo?

Presentation of the Projects:
The artistic and technical examples used in this master's thesis include my work recording and mixing composer Lauri Porra's [15] Jussi award winning [16] music for the film *Stormskerry Maja* ("*Myrskyluodon Maija",* Solar Films, 2024) [17], and mixing and consulting on the music recording for director-composer Gints Zilbalodis' [18] and composer Rihards Zalupe's [19] music for the dialogueless 2025 Best Animated Feature Oscar winner [20] *Flow* (Dream Well Studios, 2024) [21]. *Flow* also won the Best Original Music Award For a Feature Film at the 2024 Annecy International Animation festival [22] and received a Special Mention from the Best Sound Creation Award from *La Semaine du Son* [23] at the 2024 Cannes Film Festival, among over 70 other notable awards worldwide. I mixed both works using the Dolby Atmos format.

In *Stormskerry Maja* I recorded, edited and mixed the full Lahti Symphony Orchestra [24] performing in Lahti's Sibelius Hall [25], utilizing a 9.1.6 bus-based mix workflow using Avid Pro Tools' integrated Dolby Atmos Renderer [26] and Pro Tools' expanded channel count internal busses [27], with an immersive mic-per-speaker main recording setup. An Atmos Music soundtrack version of the music has been released on the Platoon record label [28].

On *Flow,* a similar main and surrounds recording setup was used per my instruction by recordist Normunds Sne [29], for a live string orchestra recording of Sinfonietta Riga Strings [30], which was a late addition to the score that otherwise used synthetic elements and individual instrument performances [31], with me again utilizing a 9.1.6-based mix workflow. *Flow* was only released in the 7.1 Theatrical sound format using a downmixed music mix version, but my original Atmos music mix was used during the production to facilitate remote binaural reference listening for the composers, via the Dolby Binaural and Apple Spatial Audio formats as explained in my promotional interview with Liquidsonics [30]. An Atmos Music soundtrack album release of the original mix version is also in consideration at the moment of this writing, but the soundtrack album is currently released only as stereo on Milan Records [32].

Methodology:
(1) During these productions I have employed an immersive orchestral recording setup that I prefer for cinematic and theatrical reproduction, as opposed to the currently often cited near-spaced immersive recording array setups, where microphones are positioned relatively closely in a tree-style cubical or spherical array. These types of closely spaced setups are often suggested in Dolby Atmos and classical engineering themed professional discussion forums and even contemporary research [33, 34], like the 3D-MARCo [35] and the ECHO-Project database unveiled just at the time of this writing [36]. My preferred setup is more similar to how stereo productions have traditionally employed distanced ambience mic pairs and also how 5.1 surround recordings have been commonly made with a direct/ambient approach [37], but expanded to 3-dimensional immersive reproduction. In my findings, the more distanced surround microphones minimize smearing of main microphone spatial cues and decorrelate low frequencies. I also find the setup can highlight a good concert hall acoustic more favourably than closely spaced tree-style arrays, as it combines the closer-than-realistic main pickup

above the conductor with surround and height channels positioned gradually towards the audience area. This approach is especially suitable for film music production, as the soundstage is more similar to that of a concert listening experience. The soundfield is also anchored towards the screen, helping the audience in keeping focus on the visual storytelling, due to less distractingly direct musical material present in the surround field.

In the setups I have regularly seen suggested in contemporary research and discussions, the situation is often different, in twofold ways. First and especially prominent in contemporary published texts, the surround hall sound is picked up very close to the frontal mics, which, while possibly wonderfully immersive sounding, could be very different to what one would hear in the audience, and could introduce perceptually coloured and confusing spatial cues. Second, a very distinctly separated "ambience array" is sometimes suggested to be combined with closer main pickup, as Hamasaki explained an use case for his classic Hamasaki Square array in a 2023 conference workshop [38]. This setup is philosophically closer to my own proposal, but Mr. Hamasaki pointed out especially that the setup presented was not intended for a 7.1 or above ear-level base channel count, so it was not mic-per-speaker-channel, but the 4-mic square array was intended for summing to the stereo surround channels of a 5.1 ear-level base. Engineer Justin Gray has proposed similar setups with separate close and far-field immersive arrays in his 2025 Youtube videos [39].

My suggested recording setup, optimized with 9.1.6 speaker reproduction and especially Atmos theatrical reproduction in mind, is a mic-per-speaker-channel system expanded from the traditional Decca tree mic setup, as described in the book *Classical Recording, a practical guide to the Decca Tradition* [40], with the suggested approximately 1,3m L-R main mic distance, 0,65m center mic forward spacing and approximately 2,8-3m of height. I typically use omni mics with APE [41] balls for the main LCR mics, for the added high frequency directionality or "reach" that they provide, while maintaining the full far field bass response of the omnidirectional pickup. Wide outrigger omni mics are positioned 3m to both sides of the L-R pair. I have used the same basic system for several prior orchestral recording situations, as well as variations of it for immersive recordings in smaller spaces with smaller ensembles. I have found that I prefer the natural mic-per-speaker main LCR pickup for LCR-based reproduction, as opposed to using a main stereo pair only. My 3D panner positions for the 3 main LCR omni mics in the Decca tree are normally 100% in the respective main speaker channels, except possibly using a center % control for the C channel, to bleed some of the signal to the L-R channels, as often requested by film final mixers to leave room for the dialogue and other sounds of the film. The outrigger mics are panned to the Screen Wide speakers, which are physically positioned closest to the screen on the side wall of an Atmos film theatre [41], as suggested by score mixer Alan Meyerson [43].

On the suggested setup, I utilize widely spaced 2m AB omni mic pairs in the hall audience area for the Side and Rear ear-level speaker channels, with actual distances dependent on the hall size and careful critical listening in various points in the hall. The top Front, Mid and Rear pairs are positioned on top of the ear level surround mics. For *Stormskerry Maja*, I employed 1m extra elevation for the top channels over the approximately 2,5m height of the ear level surround mics, as I was using cardioid mics aimed upwards when combining with the ear level omni mics. If I had had access to high quality hypercardioid mics for the top mics, a smaller elevation could have been appropriate. As the Sibelius Hall is moderately large and has very pleasing natural reverberation, I distanced the side ear-level and top pairs significantly, positioned at roughly 7m from the main LCR mics, while the rear channels were spaced at roughly 10,3m from the main mics, with the mics pointing in their respective speaker channel directions, as seen in Fig. 1, with the directional height mics aimed upwards but slightly towards their respective wall-ceiling junctions.

Basic mixing of the recordings was straightforward, as the recording system had 3D panner positions designed for all main and surround mics, and relatively small EQ adjustments were necessary for a pleasing and coherent soundstage. The Sibelius Hall features a mechanical variable acoustics system, which was used at a moderately reverberant setting suggested by the orchestra organization, similar to what has been used on previous recordings done in the hall. To optimize the

Atmos delivery to the primary theatrical reproduction system, the 9.1.6 mix bus outputs were routed to the Atmos Renderer's 7.1.2 Atmos Bed inputs, with 3 added stereo pairs of audio objects with static panning metadata. In an Atmos cinema, the Atmos Bed channels are played back from speaker array rows placed across the walls and ceiling, so the whole left side wall will reproduce the left side Bed content, while the left half of the ceiling reproduces the left height Bed content, and the left half of the rear wall reproduces the left rear Bed content. Room size-dependent additional delay is added to all of the Bed Surround channels in theatrical playback [44], just like in traditional theatrical 5.1 and 7.1 reproduction [45]. In addition to these Bed channels, I employed statically panned object pairs for the Screen Wide speakers [42] and front and rear top channels. In this system, the static top objects are panned to the extremes of the ceiling, so they will be reproduced from the corner speakers in the cinema ceiling.

I find this arrangement between arrayed surrounds-based bed channels and single-speaker pinpoint objects a good compromise between very realistic and immersive spatial reproduction in the central sweet spot in the cinema theater, but also covering the less optimally located seats adequately via the bed array channels. This setup also translates well to an Atmos Home environment with up to 9.1.6 monitoring, in the case of a domestic Blu-ray or Atmos streaming release. To compensate for the fact that objects do not get extra delays in any playback scenarios but are always synced to the LCR screen channels, I added 10ms of manual extra delay to the top rear object channels, on top of the natural time of arrival delay captured in the recording stage. In hindsight, this delay could have been larger for the largest cinemas, but there is also the question of Atmos home reproduction where the Bed channels are not delayed, and the 5.1 downmix version of the film, where the rear-positioned objects will be summed to the surround channels where they will inherit the additional cinema surround playback delay. As far as downmix colouration, the additional delay did not pose issues, as the delayed signal was already from the diffuse natural reverberation field of the hall, from the distanced backwards pointing top cardioid mics.

The *Stormskerry Maja* recordings also included conventional spot mics for instrument sections and individual instruments, which were used sparingly in the mix, but highlighted for soloist material or ensemble balancing reasons. The total channel count for the recording was 62 simultaneous mics on the musical cues with piano playing with the full orchestra. The full mic setup used is listed in the pre-planned microphone setup chart in Fig. 2. In the mix, I employed decorrelated algorithmic 9.1.6-width reverb with Liquidsonics' Cinematic Rooms Pro [46] on the comparatively dry spot mics, to help them blend better to the overall mix when highlighted. I also employed true 9.1.6 reverb with a setting without interchannel room propagation, essentially in a multi-mono configuration, on the main and surround mics, to extend the hall reverberation slightly. There were also some overdubs and solo pieces recorded in the hall in addition to the tutti orchestra, namely additional orchestral percussion, piano and harp. All main and room mics were recorded for all individual overdubs, for a coherent soundstage when combined with the tutti recordings. The score also employed some later-recorded string quartet and solo cello elements, but those are left outside of the scope of this thesis presentation.

(2) Related to the 9.1.6-based mix and delivery method, I want to point out the importance of having directional overhead information in all Atmos mixes, especially from the point of view of Atmos Home reproduction, and will prepare demonstrative audio excerpts for my thesis defence presentation. The issue with using only the 7.1.2 Atmos Bed is that in any .4 playback scenario, like the minimum suggested Atmos mixing setup of 7.1.4 [12], the stereo only overhead information will be played back from both the front and rear overhead speaker pairs [14], resulting in a "pressure cooker" effect according to mixer Alan Sallabank [47] for the listener as well as audible phasing if the listener would move their head in time to the music. This is not a significant issue in theatrical Atmos reproduction and the arrayed overhead playback, possibly due to the larger distance to the overhead speakers and therefore smaller relative distance difference between speakers, but in Atmos home reproduction, which all Atmos mixes should account for, the effect can be quite noticeable and even distracting.

This single-directional versus multi-directional overhead disparity is lessened in .6 and up home playback like on a 9.1.6 speaker system, as the bed overhead information will get reproduced from the middle overhead speaker pair only, as is the case in Dolby Binaural headphone reproduction (But not in Apple Spatial Audio reproduction, which uses a simulated 7.1.4 room for playback as of this writing). Nevertheless, even in these situations without the detrimental artifacts of dual mono height reproduction, a true .4 or .6 overhead employing mix will sound more immersive and convincing than delivering only stereo overhead material, according to my findings.

I would like to emphasize that for myself, discovering this issue has been a process of years of working on several Atmos mix projects. My first Atmos mixes were for film, and done primarily on a 7.1.2 or 9.1.2 monitoring system without employing these static directional overhead object pairs, instead delivering just an Atmos Bed mix with possible additional moving objects. The projects were all final mixed in theatrical Atmos mix facilities with arrayed Bed surrounds playback, so I was oblivious to the effect for my first several years of working on the format. I did not become fully aware of the issue until 2021, when I expanded my mix room to its current 9.1.6 speaker setup and added Blu-ray and streaming Atmos Home playback capabilities. With these updated facilities I started analyzing various released Atmos productions, both my own and those done by others in 9.1.6 and 7.1.4 speaker reproduction, and started noticing the problems in the overheads with the Bed-only using productions.

(3) The *Flow* string orchestra recordings employed a similar mic setup as *Stormskerry Maja*, but the surround mic distances were smaller due to the relatively smaller size of the former church used for the recordings. The orchestra recordings were mixed similarly to *Stormskerry Maja*, but they played a smaller role in the overall music, so the mixing of the other musical elements was of greater importance. The other musical material was heavily synthesizer-based, with live woodwind soloists and percussion tracks recorded by Zalupe in a relatively small studio space, and often combined with virtual instrument material of the same instruments. One problem with traditional panning of stereo and mono tracks in a 3-dimensional immersive soundfield is the fact that in normal automatic format downconversion scenarios such as employed in consumer equipment like TV's, the surround and height channels are lowered in volume in the resultant downmix, which might affect musical balances significantly.

My mix workflow to combat this phenomenon on *Flow* included the use of upmixing tools, namely the Nugen Audio Halo Upmix 3D [48] plugin with context-dependent and variable settings on multiple upmix processing busses, to convert the mostly stereo source material into an immersive sound field in the plugins' maximum output width of 7.1.4, with stereo-to-7.1.4 plugin instances. I would situationally use other similar upmixing tools like Perfectsurround's Penteo Pro [49] and the recently released INU by Sam Hocking [50], but they were not used on the *Flow* mix. I would avoid relying on manual upmixing techniques or older upmixing tools, which often use conventional delays or similar processing to divert signal to the surround channels, as these could exhibit significant colouration of sound on further downmix of the material.

The advantage of using Halo Upmix over conventional 3D panner positioning was the decorrelated multichannel output of the plugin that does not localize heavily to the surrounds except on more extreme settings, and the fact that it delivers an uncoloured bit-perfect downmix to stereo when downmixed using widely used downmix coefficients like those described in ITU-R BS.775-4 [51] and Dolby Atmos' default downmix settings. A downmix would otherwise lower the balance of musical elements panned to the surrounds by -3dB or more, especially in the case of Atmos height information. I have found this downmix-friendliness a significant help in film and TV music mixing, as nearly all projects will eventually be played back on home stereo equipment. Having less changes in musical balances for rear-panned elements in these situations is definitely desirable. According to Riionheimo & Lokki, coloured or improper downmixing can also reduce perceived clarity and proximity of the surround sound image [52], which could affect a downmix situation from Atmos to 5.1 especially, if not using care in upmixing tool and workflow selection. It is also worth noting that these upmixers are useful tools for spilling part of the central components of a stereo signal to the center speaker without reducing stereo width, which can help anchor the soundstage more towards the center of the screen when listening in non-centered seats in a theater, without narrowing the soundstage in the central seats.

In addition to the Halo Upmix workflow, I again employed Cinematic Rooms Pro [30] and also Fabfilter's 9.1.6-compatible Pro-R2 [53] reverb on the *Flow* mix, also employing the plane editing features on Cinematic Rooms Pro to add more realistic-sounding room properties to the reverb signal, via adding a slightly longer reverb and pre-delay times to the rear channels and raising the comparative level of the rear and overhead channels. The reverb-based immersive enhancement was also combined with Halo Upmix on mild settings or a small amount of conventional panning to the surround field, especially on elements like percussion, where heavier upmixing would have created unwanted colouration of transients in the upmixed signal.

Reflection on outcomes:

My aim for this thesis work has been to demonstrate my current working methodology on immersive music for film work, and to bring my immersive orchestral recording concepts into discussion, as well as to emphasize the importance of directional overhead reproduction in immersive music production. In my view, these music production and engineering works exhibit the current state of my personal journey as a music mixer and recordist for surround and immersive reproduction well, both projects using a combination of techniques I have practised and researched upon since my earliest surround sound works. I am generally very happy with the way these productions turned out, combining the composers' intentions with my own mix aesthetics and spatial thinking, with very favourable critical and audience receptions internationally.

The Dolby Atmos workflows employed in both projects are robust and well suited for downmix delivery in other formats, highlighted by the fact that the *Flow* Atmos music mix translated to the 7.1 format used in the final film mix without other changes than using static and uniform downmix coefficients. In general, I have found that for material like this, where pin-point localisation in the immersive space is not necessary for any singular elements, but instead an enveloping immersive sound field is desired, 7.1 reproduction can retain the intent of a wider Atmos music mix very well and the two-directional surround field can be a significant upgrade over 5.1 reproduction.

The orchestral recording strategy presented in these projects (1) exhibits an enveloping and immersive soundstage while retaining spatial focus in the frontal screen direction, making it particularly well suited for cinematic music when recorded in suitably sized halls. Covering the described distance-spread array setup in this thesis work could help highlight an apparent research gap in the contemporary field. Further comparative research using similar recording setups along more closely spaced tree-style setups could be suggested, especially for film sound applications.

The described multi-directional overhead pickup in immersive recording (2) can be heard in the thesis demonstration material and is suggested to enhance spatial realism, and as a way to avoid the artifacts of stereo only height reproduction. The exhibited upmixer-based immersive mix workflow for stereo source material (3) has proven effective in creating an enveloping and immersive soundstage, while maintaining musical balances even for heavily surround-mixed elements and avoiding colouration in all downmix scenarios, especially critical for film and TV sound applications.

Musical references

[8] Lauri Porra. 2024. "Matter and Time." https://platoon.lnk.to/matterandtime.
[9] Aki Rissanen. 2023. "Hyperreal." https://tidal.com/browse/album/296781978/u.
[10] Dalia Stasevska. 2024. "Dalia's Mixtape." https://tidal.com/browse/album/378269835?u.
[28] Lauri Porra. 2024. "Stormskerry Maja (OST)." https://platoon.lnk.to/stormskerry-maja.
[32] Gints Zilbalodis, Rihards Zalupe. 2024. "Flow (Original Motion Picture Soundtrack)." https://soundtracks.lnk.to/flow.

References

[1] Ioan Allen. 1977. "The Dolby Sound System for Recording Star Wars." American Cinematographer, 07 01, 1977, 709. https://theasc.com/magazine/starwars/articles/starwars/dolby/.
[2] "Dolby Atmos for the Home." n.d. Dolby Professional. Accessed May 3, 2025. https://professional.dolby.com/tv/home/dolby-atmos/.
[3] "Dolby Atmos for Mobile Devices." n.d. Dolby Professional. Accessed May 3, 2025. https://professional.dolby.com/categories/mobile/dolby-atmos-for-mobile-devices/how-it-works.
[4] "Music Like Never Before - Dolby Atmos Music." n.d. Dolby. Accessed May 3, 2025. https://www.dolby.com/music/.
[5] Dolby Laboratories, Inc. n.d. "Dolby Laboratories (DLB) Q3 2022 Earnings Call Transcript," Accessed May 4, 2025. https://www.fool.com/earnings/call-transcripts/2022/08/09/dolby-laboratories-dlb-q3-2022-earnings-call-trans/
[6] Mikko Raita. 2025. "Mikko Raita CV / discography and filmography." http://www.studiokekkonen.com/documents/MikkoRaitaDiscography.pdf.
[7] "Mikko Raita." n.d. IMDb. Accessed May 3, 2025. https://www.imdb.com/name/nm2889397/.
[11] "Studio Kekkonen / Mikko Raita." n.d. Accessed May 3, 2025. http://www.studiokekkonen.com/mikko/index.html.
[12] "Dolby Atmos Home Entertainment + Music Studio Technical Guidelines." 2025. Dolby Professional Support. https://professionalsupport.dolby.com/s/article/Dolby-Atmos-Home-Entertainment-Studio-Technical-Guidelines?language=en_US.
[13] "Why doesn't the Renderer have 7.1.4 or larger beds?" 2025. Dolby Professional Support. https://professionalsupport.dolby.com/s/article/Why-doesn-t-the-Renderer-have-7-1-4-or-larger-beds?language=en_US.
[14] "What's the difference between beds and objects?" 2021. Dolby Professional Support. https://professionalsupport.dolby.com/s/article/What-s-the-difference-between-beds-and-objects?language=en_US.
[15] Lauri Porra. n.d. "Lauri Porra." Accessed May 3, 2025. https://lauriporra.wordpress.com/.
[16] "Jussi-palkitut." n.d. Suomalainen elokuvapalkinto vuodesta 1944 — Jussi-gaala. Accessed May 3, 2025. https://www.jussit.fi/jussipalkitut.
[17] "MYRSKYLUODON MAIJA." n.d. Solar Films. Accessed May 3, 2025. https://solarfilms.com/portfolio-posts/myrskyluodon-maija/.
[18] "Gints Zilbalodis." n.d. Wikipedia. Accessed May 3, 2025. https://en.wikipedia.org/wiki/Gints_Zilbalodis.
[19] Rihards Zalupe. n.d. "Rihards Zalupe." Accessed May 3, 2025. https://www.rihardszalupe.net/.
[20] "The 97th Academy Awards | 2025." 2025. Oscars.org. https://www.oscars.org/oscars/ceremonies/2025.
[21] "Flow." n.d. FLOW – Dream Well Studio. Accessed May 3, 2025. https://flow.movie/.

[22] “About > Archives > Award winners.” n.d. Annecy Festival. Accessed May 4, 2025. https://www.annecyfestival.com/about/archives/2024/award-winners.
[23] “6ème Prix de la Meilleure Création Sonore.” 2024. La Semaine Du Son. https://www.lasemaineduson.org/portfolio/6eme-edition-du-prix-de-la-meilleure-creation-sonore/.
[24] “The Lahti Symphony Orchestra.” n.d. Sinfonia Lahti. Accessed 5 5, 2025. https://sinfonialahti.fi/en/lahti-symphony-orchestra/.
[25] “Sibelius Hall.” n.d. Sibeliustalo. Accessed May 5, 2025. https://www.sibeliustalo.fi/sibelius-hall/?lang=en.
[26] “Pro Tools Dolby Atmos Renderer.” 2023. Avid. https://www.avid.com/resource-center/dolby-atmos-renderer.
[27] “Pro Tools 2023.6 delivers track markers, expanded track widths, more.” 2023. Avid. https://www.avid.com/resource-center/whats-new-in-pro-tools-20236.
[29] Normunds Šnē. n.d. “Normunds Šnē.” Accessed May 5, 2025. https://sne.lv/index.html.
[30] “Mikko Raita on Mixing The Cinematic Score of Oscar Winning “Flow.”” 2025. Liquidsonics. https://www.liquidsonics.com/2025/03/09/mikko-raita-on-mixing-the-cinematic-score-of-oscar-winning-flow/.
[31] Joe Schmidt and Jake Weisman. 2025. ““It’s About Animals As Emotions”: ‘Flow’ Composer Rihards Zalupe on His Score for Oscar-Nominated Film.” Collider. https://collider.com/flow-composer-rihards-zalupe/.
[33] Hyunkook Lee. 2021. Multichannel 3D Microphone Arrays: A Review. Journal of the Audio Engineering Society. Audio Engineering Society. 69. 5-26. 10.17743/jaes.2020.0069.
[34] Francis Rumsey and Kim Sungyoung. 2018. Immersive Sound: The Art and Science of Binaural and Multi-channel Audio. Edited by Agnieszka Roginska and Paul Geluso. N.p.: Routledge. 202-214, 233-240. https://www.routledge.com/Immersive-Sound-The-Art-and-Science-of-Binaural-and-Multi-Channel-Audio/Roginska-Geluso/p/book/9781138900004.
[35] Hyunkook Lee. (Creator) and Dale Johnson. (Contributor) Oct 6, 2019. 3D Microphone Array Comparison (3D-MARCo). Centre for Audio and Psychoacoustic Engineering (CAPE) - University of Huddersfield. 10.5281/zenodo.3474285
[36] “ECHO Project - APL.” 2025. Applied Psychoacoustics Lab. https://apl-hud.com/echo/.
[37] Tomlinson Holman. 2008. Surround sound : up and running, 2nd ed. 91-92: Elsevier/Focal Press. https://www.sciencedirect.com/book/9780240808291/surround-sound.
[38] Kimio Hamasaki. 2023. “Kimio Hamasaki: Enveloping Masterclass.” AES Europe 2023. https://aeseurope2023.sched.com/event/1Ko9Q/kimio-hamasaki-enveloping-masterclass.
[39] Justin Gray. 2025. “Inside an Immersive Recording Session With Schmaltz & Pepper | Humber College.” Youtube. https://www.youtube.com/watch?v=7Ta2X7wOiiM.
[40] Caroline Haigh, John Dunkerley and Mark Rogers. 2021. Classical Recording: A Practical Guide in the Decca Tradition. Edited by Audio Engineering Society. 128-131: Routledge. https://www.routledge.com/Classical-Recording-A-Practical-Guide-in-the-Decca-Tradition/Haigh-Dunkerley-Rogers-Haigh-Dunkerley-Rogers/p/book/9780367312800.
[41] Eddy B.Brixen. “Acoustic modification accessories.” n.d. DPA Microphones. Accessed May 5, 2025. https://www.dpamicrophones.com/mic-university/technology/acoustic-modification-accessories/.
[42] “Dolby Atmos Specifications.” n.d. 6 Dolby Professional. Accessed May 5, 2025. https://professional.dolby.com/siteassets/cinema-products---documents/dolby-atmos-specifications.pdf.
[43] Sreejesh Nair. 2016. “Film Score mixing with Alan Meyerson.” Film-mixing. https://film-mixing.com/2016/07/28/film-score-mixing-with-alan-meyerson/.

[44] "Dolby Cinema Processor CP950 and Dolby Atmos Cinema Processor CP950A Manual." n.d. 67-69: Dolby Professional. Accessed May 5, 2025. https://professional.dolby.com/siteassets/products/cp950a/dolby_cp950-cp950a_manual_issue_11.pdf.
[45] "Dolby Model CP500 Digital Cinema Sound Processor." n.d. 8.1: Film-Tech. Accessed May 5, 2025. https://www.film-tech.com/warehouse/manuals/DOLBYCP500.pdf.
[46] "Cinematic Rooms." n.d. Liquidsonics. Accessed May 5, 2025. https://www.liquidsonics.com/software/cinematic-rooms/.
[47] Allan Sallabank. 2020. "Dolby Atmos - Using Upmixers, 3D Reverbs With Objects - Free Expert Tutorial Part 5." Production Expert. Accessed May 4, 2025. https://www.production-expert.com/home-page/2020/2/25/dolby-atmos-tutorial-part5-using-upmixers-3d-reverbs-and-objects.
[48] "Halo Upmix." n.d. NUGEN Audio. Accessed May 5, 2025. https://nugenaudio.com/haloupmix/.
[49] "Penteo - Creative Audio Reversioning." n.d. Perfectsurround. Accessed May 5, 2025. https://www.perfectsurround.com/.
[50] "INU." n.d. Demix.me. Accessed May 5, 2025. https://demix.me/inu.
[51] "BS.775 : Multichannel stereophonic sound system with and without accompanying picture." 2022. ITU. https://www.itu.int/rec/R-REC-BS.775/en.
[52] Janne Riionheimo and Tapio Lokki. 2024. Spatial Sound, Part 2: Exploring the Impact of Listening Room on Sound Character. Journal of the Audio Engineering Society, 72(12), 930–944. https://doi.org/10.17743/jaes.2022.0175
[53] "FabFilter Pro-R 2 - Reverb Plug-In." n.d. FabFilter. Accessed May 5, 2025. https://www.fabfilter.com/products/pro-r-2-reverb-plug-in.

Figures

Fig. 1. The *Stormskerry Maja* mic setup in the Sibelius Hall, approximate locations & angles using the curved stage extension (rectangle = 1x1m). Used with permission from Eventum Lahti Oy.

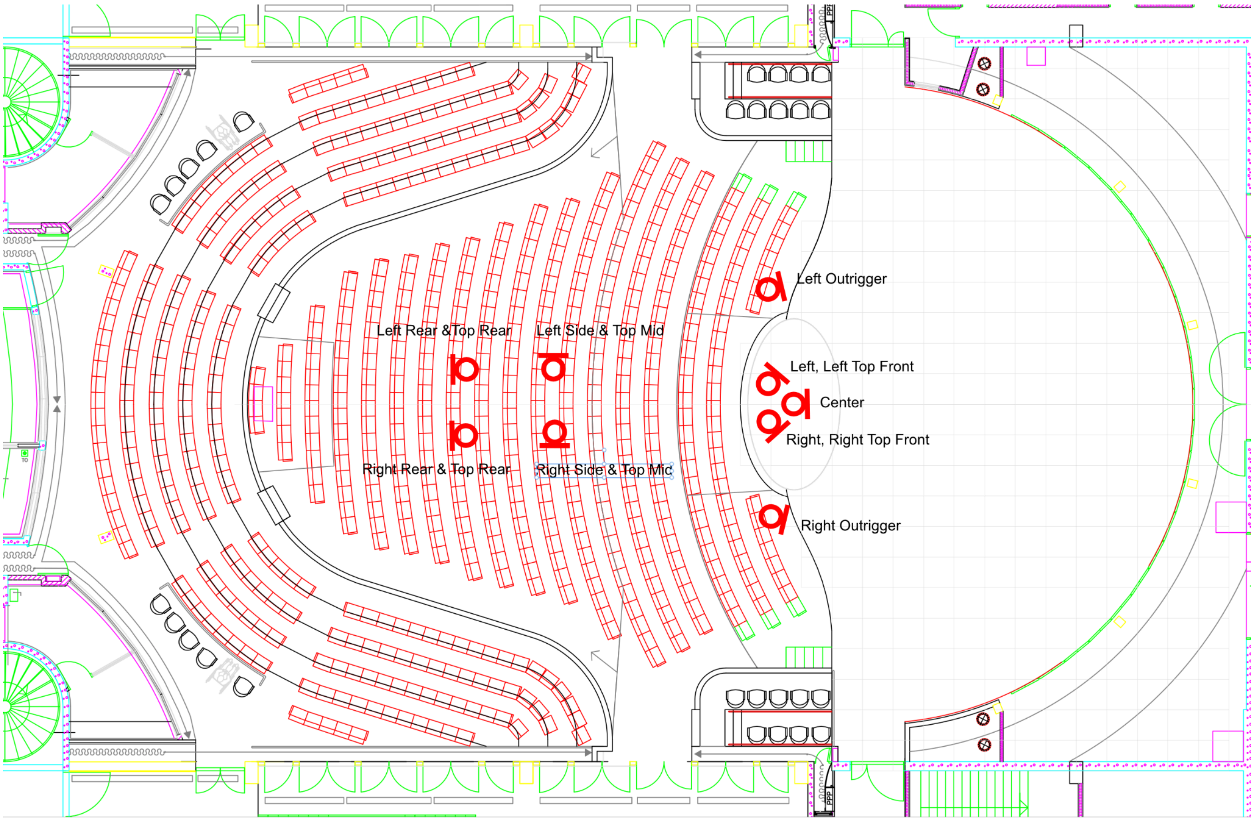

Fig. 2. The pre-planned *Stormskerry Maja* microphone setup.

Myrskyluodon Maija Lahti setup v0.5 09.09.2023									
							Hi = 8-10x 3-5m stands, Me = 10 normal 2,5m, Lo= short max 1,5m		
Mi	Preamp	Mic Nr.	Cable	Source	Mic	P48	PT Track Name	Stand height	STAND MODEL
	Grace 1	1		Decca L	DPA 4006 +APE40	x	DecLR	Hi	k&m 26007+26703 110-315cm (no boom) 1 1
	Grace 2	2		Decca R	DPA 4006 +APE40	x	DecLR	Hi	Manfrotto 1004, 124-366cm (no boom) 6 6
	Grace 3	3		Decca C	DPA 4006 +APE40	x	DecCnt	Hi	Manfrotto 1004, 124-366cm (no boom) 6 6
	Grace 4	4		Cond Speak	AT AE3000 (Card)	x	Cond Spk	Me	K&M Normal
	Grace 5	5		Outrigger L	Schoeps MK2S (Omni)	x	DecOut	Hi	manfrotto 5001b 49-199cm (no boom) 2 2
	Grace 6	6		Outrigger R	Schoeps MK2S (Omni)	x	DecOut	Hi	manfrotto 5001b 49-199cm (no boom) 2 2
	Grace 7	7		SurSide L	DPA 4006 (Omni)	x	SurSide	Hi	vielä kaksi pitkää, jotka unohdin katsoa tänään
	Grace 8	8		SurSide R	DPA 4006 (Omni)	x	SurSide	Hi	vielä kaksi pitkää, jotka unohdin katsoa tänään
	Grace 9	9		SurBack L	DPA 4041 (Omni)	x	SurBack	Hi	k&m 20800, 135-310cm (no boom) 3 3
	Grace 10	10		SurBack R	DPA 4041 (Omni)	x	SurBack	Hi	k&m 20800, 135-310cm (no boom) 3 3
	Grace 11	11		SurTopF L	DPA 4022 (Card)	x	SurTopF	4-5m	Athletic mic10, 152-317cm + 235cm boom 2 2
	Grace 12	12		SurTopF R	DPA 4022 (Card)	x	SurTopF	4-5m	Athletic mic10, 152-317cm + 235cm boom 2 2
	Grace 13	13		SurTopM L	DPA 4011 (Card)	x	SurTopM	4-5m	Manfrotto 1004, 124-366cm (no boom) 6 6
	Grace 14	14		SurTopM R	DPA 4011 (Card)	x	SurTopM	4-5m	Manfrotto 1004, 124-366cm (no boom) 6 6
	Grace 15	15		SurTopB L	DPA 4011 (Card)	x	SurTopB	4-5m	Manfrotto 1004, 124-366cm (no boom) 6 6
	Grace 16	16		SurTopB R	DPA 4011 (Card)	x	SurTopB	4-5m	Manfrotto 1004, 124-366cm (no boom) 6 6
	MTRX 1	17		1vl 1	Schoeps MK4 (Card)	x	1vl1	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 2	18		1vl 2	Schoeps MK21 (WCard)	x	1vl2	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 3	19		1vl 3	Schoeps MK21 (WCard)	x	1vl3	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 4	20		2vl 1	Schoeps MK4 (Card)	x	2vl1	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 5	21		2vl 2	Schoeps MK4 (Card) Sib	x	2vl2	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 6	22		2vl 3	Schoeps MK21 (Wide) Sib		2vl3	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 7	23		Vc 1	AKG 414 XLS Kek (Card)	x	Vc1	Lo/Me	K&M Normal
	MTRX 8	24		Vc 2	AKG 414 XLS Kek (Card)	x	Vc2	Lo/Me	K&M Normal
	MTRX 9	25		Vc 3	AKG 414 XL2 (Card)	x	Vc2	Lo/Me	K&M Normal
	MTRX 10	26		Vla 1	Schoeps MK4 (Card) Sib	x	Vla1	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 11	27		Vla 2	Schoeps MK21 (Wide) Sib	x	Vla2	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 12	28		CB 1	DPA 4006 (Omni)	x	CB1	Lo	k&m 25950 short tripod + boom 4 4
	MTRX 13	29		CB 2	Neumann U47fet (Card)	x	CB2	Lo	k&m 25950 short tripod + boom 4 4
	MTRX 14	30		CB 3	AKG 414 XL2 (Card)	x	CB3	Lo	k&m 25950 short tripod + boom 4 4
	MTRX 15	31		Fl 32 /Picc/Alto	AT 4081 (Fig8)	x	Fl32	Me	K&M Normal
	MTRX 16	32		Fl 21 /Alto/	AT 4081 (Fig8)	x	Fl21	Me	K&M Normal
	MTRX 17	33		Ob 12	AT 4081 (Fig8)	x	Ob12	Lo/Me	K&M Normal
	MTRX 18	34		Ob 23 /CorAng	AT 4081 (Fig8)	x	Ob23	Lo/Me	K&M Normal
	MTRX 19	35		Cl 32 /BassCl	AT 4081 (Fig8)	x	Cl32	Lo/Me	K&M Normal
	MTRX 20	36		Cl 21	AT 4081 (Fig8)	x	Cl21	Lo/Me	K&M Normal
	MTRX 21	37		Bsn 12	Schoeps MK22 (OCard)	x	Bsn12	Lo/Me	K&M Low
	MTRX 22	38		Bsn 23 /ContBs	Schoeps MK22 (OCard)	x	Bsn23	Lo/Me	K&M Low
	MTRX 23	39		HrpL	Sennheiser MKH40 (Card)	x	Hrp	Lo/Me	k&m 210/9 black, normal tripod + boom 4 4
	MTRX 24	40		HrpR	Sennheiser MKH40 (Card)	x	Hrp	Lo/Me	k&m 210/9 black, normal tripod + boom 4 4
	MTRX 25	41		Hrn L 43	DPA 4015 (WCard)	x	Hrn43	Me/Hi	k&m 210/9 black, normal tripod + boom 4 4
	MTRX 26	42		Hrn R 21	DPA 4015 (WCard)	x	Hrn21	Me/Hi	k&m 210/9 black, normal tripod + boom 4 4
	MTRX 27	43		TrpL 32	Coles 4038 (Fig8)		Trp32	Me	K&M Normal
	MTRX 28	44		TrpR 21	Coles 4038 (Fig8)		Trp21	Me	K&M Normal
	MTRX 29	45		TbnL 12	AT 4081 (Fig8)	x	Tbn12	Hi	K&M Normal
	MTRX 30	46		TbnR 23	AT 4081 (Fig8)	x	Tbn23	Hi	K&M Normal
	MTRX 31	47		Tuba	AKG 414 (Card)	x	Tuba	Me	Mafrotto 1051, 67-210cm + k&m 211/1- boom 9 9
	MTRX 32	48		GC	DPA 4055 (Kick Mic)	x	GC	Lo/Me	K&M Low
	MTRX 33	49		Timp L	Sennheiser MKH40 (Card)	x	TimpL	Hi	K&M Normal
	MTRX 34	50		Timp R	Sennheiser MKH40 (Card)	x	TimpR	Hi	K&M Normal
	MTRX 35	51		Perc Oh L (TT/Cym)	Sennheiser 8040 (Card)	x	PercOh	Me	K&M Normal
	MTRX 36	52		Perc Oh R	Sennheiser 8040 (Card)	x	PercOh	Me	K&M Normal
	MTRX 37	53		Vibes L	AKG 414 XLS (Card)	x	Vibes	Me	K&M Normal
	MTRX 38	54		Vibes R	AKG 414 XLS (Card)	x	Vibes	Me	K&M Normal
	MTRX 39	55		Sd?	Neumann KM184 (Card)	x			K&M Normal
	MTRX 40	56		Sd?	Neumann KM184 (Card)	x			K&M Normal
	RME 1	57	B1	PnoC L	Oktava MK012 (Omni/card)	x	PnoC	Me/Hi	K&M Normal
	RME 2	58	B2	PnoC R	Oktava MK012 (Omni/card)	x	PnoC	Me/Hi	K&M Normal
	RME 3	59	B3	PnoD L	SM57		PnoD	Me/Hi	K&M Normal
	RME 4	60	B4	PnoD R	SM57		PnoD	Me/Hi	K&M Normal
	RME 5	61	B5	PnoR L	AT 4081 (Fig8)	x	PnoR	Me/Hi	K&M Normal
	RME 6	62	B6	PnoR R	AT 4081 (Fig8)	x	PnoR	Me/Hi	K&M Normal
	RME 7	63	B7	PnoCnt	AT 4081 (Fig8)	x	PnoCnt	Me/Hi	K&M Normal
	x	64	x	TB	x		TB	x	
	NONE/RME 5		B5	Mari.L	AT 4080 (Fig8)	x			K&M Normal
	NONE/RME 6		B6	Mari.R	AT 4080 (Fig8)	x			K&M Normal
	NONE/RME 7		B7	Glock	Beyer M160 (Supercard)	x			K&M Normal