DISLOCATIONS IN SOUND DESIGN FOR 3-D FILMS: SOUND DESIGN AND THE 3-D CINEMATIC EXPERIENCE

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Certificate of Authorship

I Damian Candusso,
Hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at The Australian National University or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by colleagues with whom I have collaborated on during my candidature is fully acknowledged.

I agree that the thesis be accessible for the purpose of study and research in accordance with the normal conditions established by the Australian National University.*

Signature Date

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Abstract

Since the success of James Cameron's *Avatar* (2009),[1] the feature film industry has embraced 3-D feature film technology. With 3-D films now setting a new benchmark for contemporary cinemagoers, the primary focus is directed towards these new stunning visuals. Sound is often neglected until the final filmmaking process as the visuals are taking up much of the film budget. 3-D has changed the relationship between the imagery and the accompanying soundtrack, losing aspects of the cohesive union compared with 2-D film.

Having designed sound effects on Australia's first digital animated 3-D film, *Legend of the Guardians: The Owls of Ga'Hoole* (2010),[2] and several internationally released 3-D films since, it became apparent to me that the visuals are evolving technologically and artistically at a rate far greater than the soundtrack. This is creating a dislocation between the image and the soundtrack. Although cinema sound technology companies are trialing and releasing new 'immersive' technologies, they are not necessarily addressing the spatial relationship between the images and soundtracks of 3-D digital films.

Through first hand experience, I question many of the working methodologies currently employed within the production and creation of the soundtrack for 3-D films. There is limited documentation on sound design within the 3-D feature film context, and as such, there are no rules or standards associated with this new practice. Sound designers and film sound mixers are continuing to use previous 2-D work practices in cinema sound, with limited and cautious experimentation of spatial sound design for 3-D. Although emerging technologies are capable of providing a superior and 'more immersive' soundtrack than previous formats, this does not necessarily mean that they provide an ideal solution for 3-D film. Indeed the film industry and cinema managers are showing some resistance in adopting these technologies, despite the push from technology vendors.

Through practice-led research, I propose to research and question the following:

[1] James Cameron, *Avatar*, directed by James Cameron (Century City, CA: Twentieth Century Fox Film Corporation, 2009).
[2] John Orloff and Emil Stern, *Legend of the Guardians: The Owls of Ga'Hoole*, directed by Zack Snyder, (Burbank, CA: Warner Bros., 2010).

- Does the contemporary soundtrack suit 3-D films?
- Has sound technology used in 2-D film changed with the introduction of 3-D film? If it has, is this technology an ideal solution, or are further technical developments needed to allow greater creativity and cohesiveness of 3-D film sound design?
- How might industry practices need to develop in order to accommodate the increased dimension and image depth of 3-D visuals?
- Does a language exist to describe spatial sound design in 3-D cinema?
- What is the audience awareness of emerging film technologies? And what does this mean for filmmakers and the cinema?
- Looking beyond contemporary cinema practices, is there an alternative approach to creating a soundtrack that better represents the accompanying 3-D imagery?

Terminology

Terminology relating to cinema technologies

3-D. The term '3-D' in relation to the image will refer to 3-D stereoscopy unless otherwise stated. 3-D stereoscopy refers to using two independent sets of images with each set representing our left and right eye. For the purpose of this thesis, 3-D will not refer to 3-D rendered animation/Computer Generated Imagery (CGI) unless the animation is specifically created as a 3-D stereoscopic animation.

To provide a simplistic and uniform reference to the dimensions of volumetric space I will use the common x-axis, y-axis and z-axis convention to refer to three planes that make up three-dimensional space. Figure 1 illustrates this in relation to the cinema screen. The x-axis represents left/right, the y-axis represents up/down, and the z-axis represents depth (also refer to the terms 'parallax' and z-space below).

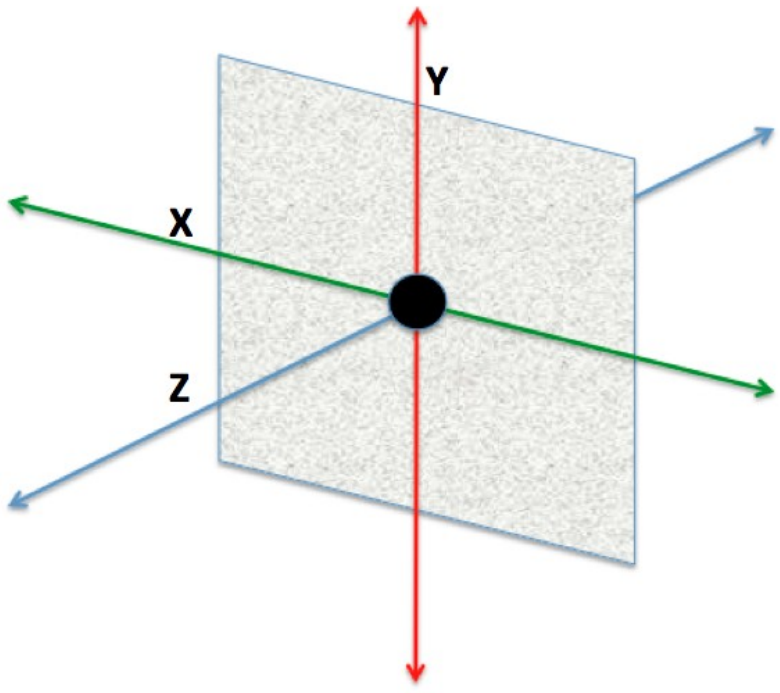

Figure 1: Three dimensions. x = left/right, y = up/down, z = depth

3-D Sound. 3-D sound is sound that is able to be replayed or generated from any point in space along all three axes as shown in Figure 1. The definition of 3-D sound will be contested later in this thesis, as there is great debate over its definition. Some state that 3-D sound is another term for surround sound, however I argue that this is not necessarily

true. My argument defines surround sound as being a means to 'project' sound in a manner that 'surrounds' an audience. I define 3-D sound as the 'placement' of sound *anywhere* within a 3-D volume or space. This is discussed in greater detail in Chapter 3.

ADR (Automated Dialogue Replacement). ADR is the process of re-recording the actor's dialogue synchronised to picture. This may be to improve the performance of an actor, alter the scripted dialogue or because the original recording may have background noise or other technical defects.

Anaglyph. A 3-D format that is encoded with filtered chromatically opposite colours for each eye. This format is inferior to the side-by-side format as the filters diminish the colour quality of the image.

Atmospheres/Ambiences. These sounds establish the environment and the set, representing the scene aurally. The sounds do not follow on-screen action and are not edited synchronised with the pictures; rather they provide a general sound foundation that establishes each onscreen location.

CGI (Computer Generated Imagery). CGI is imagery created on a computer and can be either 2-D or 3-D rendered animation. It will be presented in either 2-D or stereoscopic 3-D.

Diegetic and Non-diegetic. Diegetic refers to sounds that have a source within the film narrative. These are sounds that the character would hear, for example, cars driving past within a scene. Non-diegetic refers to sound that aids the narrative but is not heard by the characters within the film. An example may include any musical score accompanying the film. On-screen music making would be diegetic.

Film. Unless otherwise stated in this thesis, 'film' will refer to both the analogue physical medium used for traditional filmmaking and projection, and also to contemporary non-physical digital formats. As such, 'film' will refer to the product created as a result of the filmmaking process, be it physical or digital.

Although no longer a physical medium, it is important to continue to use the term 'film' to refer to the process and the working methodologies from image capture through to digital projection since these processes remain essentially unchanged with the transition to digital. Although technologies and certain employment roles have changed, the process of

capturing a series of single frame images through to editing these images and finally projecting sequenced images remains fundamental to the filmmaking process.

FPS (Frames per Second). FPS refers to the rate at which single frames of image are captured and/or projected.

HFR (High Frame Rate). HFR refers to capturing and projecting images at 48 frames per second. Conventional filming and projection is at 24 frames per second (fps).

LFE (Low Frequency Effects). Low Frequency Effects is commonly known as the sub or subwoofer track. It is a dedicated channel within the soundtrack that only allows for low frequencies and is not full frequency range. In a 5.1 system there are six channels, with five full frequency channels and one LFE channel.

LtRt (Left total, Right total). Developed by Dolby, LtRt is a matrix format allowing four channels of sound to be encoded into a stereo signal. It is also known as Dolby stereo. This format although sometimes used in home theatre, is superseded in the cinema by digital sound formats with increased speaker channels.

Micro-diegetic. An original term coined by the author to describe an amplified sound that would otherwise not normally be heard by a character. An example may include a light filament or small insect wings that under normal circumstances would not be heard, however if the shot is in close-up, the amplified sound informs the narrative.

MPSE (Motion Picture Sound Editors). Founded in 1953, the Motion Picture Sound Editors (MPSE) is an honorary society of motion picture sound editors. The society's goals are to educate others about and increase recognition of sound editors, show the artistic merit of soundtracks, and improve the professional relationships of its members.

Pan. Pan is commonly used in both aural and visual contexts. In this thesis pan refers to the placement or movement of sound across specific or various sound channels or speakers. Pan in the visual context refers to a camera in a fixed location that rotates from a single pivot point along the horizontal plane. The term is discussed in further detail in Chapter 3 (page 57).

Parallax. Parallax identifies where an object appears in 3-D space relative to the screen (see Figure 2, page xvi).

Positive Parallax – objects appear to be behind the screen, further away from the viewer.
Negative Parallax – objects appear to be in front of the screen, closer to the viewer. Also see z-space below.
Zero Parallax System (ZPS) – objects appear to be flat with the screen.

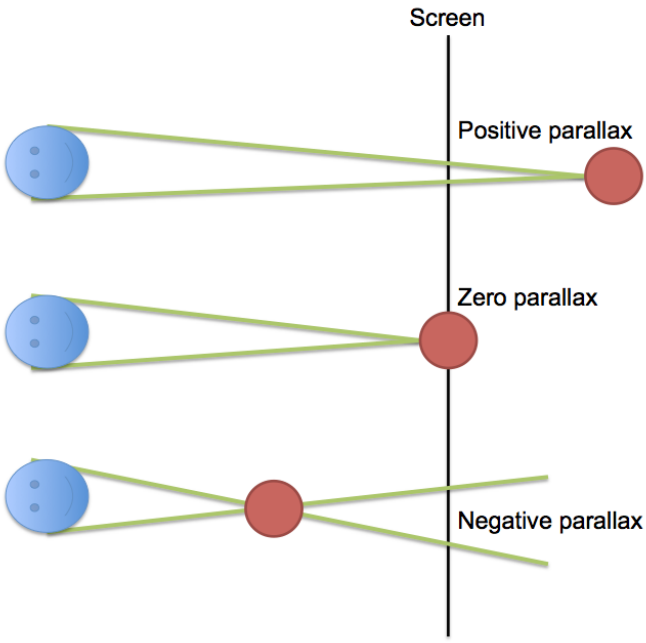

Figure 2: Parallax views

Positional Data. An original term coined by the author during this investigation. It identifies the 3-D spatial positioning assigned to the various elements of the soundtrack during the editing and mixing process (input).

Positional Rendering. An original term coined by the author during this investigation. It identifies the spatial position of the various elements of the soundtrack within a 3-D space during exhibition (output).

Side-By-Side. A 3-D format that is used with 3-D television. Each frame consists of two halves, with the entire frame for the left eye scaled down horizontally to fit the left-half of the frame, and the entire frame for the right eye scaled down horizontally to fit the right side of the frame.

Stereo Sound. Stereo sound is a sound format that contains two or more channels. In the context of this thesis it will refer to a sound format with only two channels.

Surround Sound. Surround sound exists in several forms and is installed to some extent in almost every cinema in the western world. Although the first true known stereo recording

can be traced back to 1932, it was in 1940 when RCA and Disney released *Fantasia* (1940) in Fantasound that sound was used to truly 'surround' an audience. Throughout this thesis I will refer to surround sound as any sound format that uses speaker channels additional to the screen channels.

Sync. (Synchronisation). Sound and image for film are mostly recorded as independent media. At various stages throughout the filmmaking process the two media are synchronised, especially during exhibition.

Z-Space. In the context of this thesis the z-space will relate to negative parallax and the space within the cinema auditorium. It will also relate to the positioning of sound off the screen.

Terminology relating to the various roles within a film sound crew

ADR Editor. On completion of the ADR recording, the ADR editor edits the recordings in sync with the images, without compromising performance.

ADR Recordist/Mixer. The ADR recordist re-records the actor as they perform to the images of the scene. It is important to capture the performance whilst best matching the tonality of the ADR with the original location dialogue. This is important if the actor is recording a line of ADR amongst surrounding lines of location or production dialogue. It is common for the ADR recordist to record using similar or the same microphones used on location. 'The energy and realism of ADR work can be judged in the final film by the performance, pitch, tempo, and emotional intensity synchronous with the image and original track.'[1]

Atmosphere Editor. Creating the aural environment for each scene is the responsibility of the atmosphere editor. Aural environmental ambient locations situate the character within the scene. The sounds may be actual recordings of locations or they may be fabricated, depending on the context of the film. It is general practice that the atmosphere

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[1] David Sonnenschein, *Sound Design: The Expressive Power of Music, Voice and Sound Effects in Cinema* (Studio City, CA: Michael Wiese Productions, 2002), 159.

editor will utilise all of the speaker channels available. This includes creating atmospheres that are in 5.1 or 7.1 formats depending on the film specifications. In regards to spatial sound design, the atmosphere editor can create an ambience as wide as their imagination allows.

Boom Swinger(s). Working alongside and generally under supervision from the location sound recordist, the boom swinger manually positions the boom microphone in the best position possible to capture the dialogue from each character. They 'swing' the boom from one character to another, seeking to obtain the cleanest and best possible recording, whilst keeping the microphone out of shot.

Dialogue Editor. Once the picture edit has commenced, the dialogue editor begins the task of assessing the dialogue recordings as edited by the picture editor. With the selected audio takes often chosen based on the onscreen performance, the sound quality may not be of usable quality. The dialogue editor will listen to all takes, find suitable alternative takes and then edit these as best as possible in sync with the visual, whilst trying to maintain the original performance of the character. The dialogue editor endeavours to create a 'clean' dialogue edit, free from extraneous noises. If a line of dialogue is unusable despite all efforts to edit a fabricated line from alternative takes, then the line may be re-recorded as ADR. This process takes place in a studio with the actor performing to the onscreen visuals.[2]

Foley Artist. When a soundtrack is created, the entire soundtrack is built from the ground up. This includes all diegetic sounds that are made by the characters. With the location recordist focusing on dialogue, all other character sounds are recreated. This includes walking, scratching, clothes rustling, hand grabs and any other sounds that the characters would make in real life. The foley artist has the job of recreating all sounds of the characters. Animation is another example where foley is able to bring characters to life. Foley is not limited to reproducing sound effects for humans, with an example being the use of two empty halves of coconuts to perform the sound of horse hooves.

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[2] See definition of ADR above in Terminology (page xiv)

Foley Editor. Using the tracks supplied by the foley recordist, the foley editor's primary role is to ensure that the recordings are synchronised with the pictures. It is not uncommon for the foley recordist and foley editor to be the same person. Good track layout is also expected from the foley editor to enable the re-recording mixer easy access to each sound.

Foley Recordist/Mixer. Working alongside the foley artist, the foley recordist records the performance. The recordings are recorded to many individual tracks, thus allowing greater flexibility in the final sound mix.

Location Sound Recordist/Mixer. The location recordist is primarily responsible for capturing the dialogue performance of the characters during the shoot. This includes using various microphones - generally a hidden lapel microphone per main character recorded on individual audio tracks on the location audio recorder, and a boom microphone as an additional track. The recordist endeavours to record the dialogues with minimal background noise as having a clean, separated dialogue recording of each character is essential in the workflow, especially for editing and mixing.

If time and budget permit, the location recordist will also record any additional sounds of interest or uniqueness. This may include location ambiences and atmospheres, vehicles, unique on-set props and any other sounds that may be difficult to capture or recreate once the film has progressed to the post-production stage.

Music Editor. The music editor is responsible for all music cues, editing these to the various picture edits and timings. Often also working with the multitrack recordings supplied by the music recordist and composer, the music editor has creative licence to create additional music cues if required.

Music Mixer. The music mixer collaborates with the music editor and mixes the music cues appropriately to the film. This includes mixing the musical score, underscore or source music. Music mixers balance the various instruments within the multitrack recordings, adding reverberation and other effects where necessary, and they are responsible for positioning the music within the cinema space.

Music Recordist/Engineer. Often working with the composer, the music recordist is responsible for capturing the live musical performances of the composed musical cues.

This may include orchestral recordings, band recordings and any other score, song or music requirements.

Re-recording Mixer. The final collaborative process of the creation of the film soundtrack is the final mix, bringing all of the various elements of the soundtrack together. The re-recording mixer collaborates with the director, supervising sound editor, sound designer, music mixer and any other relevant sound editors. The re-recording mixer is responsible for the completed final soundtrack including the relevant volumes, tonality, reverberations and final spatial positioning of all sound elements. Often this process makes the entire soundtrack available to the director for first time.

Sound Designer. This is undoubtedly one of the most debated definitions within the film sound community. Weis acknowledges the dual definitions associated with the title, noting that the term can refer to someone brought onto a film to create one kind of effect, or to someone who is brought onto a film during the planning stages, along with the set and costume designers, and who does their own mixing.[3] This is discussed in greater detail in Chapter 3 (page 69).

Sound Effects Editor. Regarded as a creative role, the sound effects editor records, creates and edits sound effects that may be diegetic or non-diegetic. This may include anything from an alarm clock to vehicles, weaponry, animals and creature sounds. Generally, any onscreen sound not made by a character (foley) is a sound effect.

Supervising Sound Editor. Depending on which country the sound team is based within, the supervising sound editor's role also has several definitions. In some countries, including the United States of America, it describes the person responsible for all dialogues within the film, including dialogue editing and ADR. In other countries, including Australia, the term can mean the person responsible for the overall soundtrack of the film, including the supervision of the dialogues, sound effects, foley and the final mixing process.

The supervisor will often be the conduit between the director and the editing and mixing teams. In Australia the supervising sound editor is also responsible for the film's sound

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[3] Elisabeth Weis, "Sync Tanks," *Cineaste* 21, no. 1/2 (January 1995): 56.

budget, including editing facilities, recording facilities, mixing facilities, staffing and any other outsourcing that may be required. In this thesis I use the term in reference to the persons job title, unless otherwise stated.

Accompanying Blu-ray and DVD Track Listings

The practice-led research components accompany this thesis in the form of a Blu-ray and DVD. Both the Blu-ray and DVD essentially have the same content however it is preferable to use the Blu-ray version where possible as it provides a far superior representation of the work. The Blu-ray contains the work in the Side-by-Side 3-D format, whereas the DVD is in the inferior anaglyph (red/cyan) format. For Side-by-Side to be viewed, a 3-D compatible projector, television or computer screen is needed. You may also need to switch your screen to side-by side mode from the menu. Anaglyph can be seen on any colour screen, however the colour and resolution are limited. You will also need a 5.1 compatible sound system and stereo headphones to listen to all formats.

Below is the track listing of both the Blu-ray and the DVD.

***Carwash* 3-D (2013)**

All mixes are original creations by the author.

- Stereo
- Binaural (headphone)
- Auro (headphone)
- 5.1 Surround

***Foxed!* (2013)**

As *Foxed!* was released prior to this PhD I have included the original mix as a reference only. The original 5.1 and stereo mixes are not the author's work. The additional mixes were created by the author.

- **Original 5.1 (please note this is the original release mix – reference only)
- **Original Stereo (please note this is the original release mix – reference only)
- 5.1 Surround
- Binaural (headphone)
- Stereo

Legend of the Guardians: The Owls of Ga'Hoole (2010)

As *Legend of the Guardians: The Owls of Ga'Hoole* had a theatrical release, the original mixes have been included for reference only. The theatrical release is not the author's original mix. The author is credited as a Sound Effects Editor for the original release. The

additional mixes however were created by the author. The three scenes *Fleck Field, Its a Trap* and *Legendary Lyze of Kiel* all have the following mixes created.

- 5.1 Surround
- 5.1 Surround (no music)
- Auro Headphone
- Auro Headphone (no music)
- **Original 5.1 (please note this is the original theatrical mix – reference only)

Additional Mixes

This menu contains the binaural mixes for all clips used in Chapter 6 combined with an additional LFE track. The audio for this is a 3-track configuration inside a 5.1 track. To listen to these you will require a 5.1 decoder that is capable of splitting Channels 1+3 to a set of headphones and Channel 6 to a sub woofer.

Chapter 1: Introduction and Overview of the Research Framework

Introduction to the research

To date, the majority of discussions on 3-D film production and the viability of the medium have focused on the imagery. With so much attention directed towards the 'look' of 3-D cinema, the accompanying soundtrack has been overshadowed. Could this be because people deem surround sound the same as 3-D sound? In an interview with Randy Thom, he argues that cinema sound has been in 3-D for 50 years, since the initial introduction of surround sound.[1] It is only now that the film image has become 3-D and has finally caught up with sound. Despite Thom's view, and although agreeing with him that surround sound adds another 'dimension' to a film, I argue that 3-D sound is quite different.

With new immersive film sound technologies marketed as providing 3-D sound, some scholarly figures researching outside of the film sound discipline claim that it is almost too difficult to have true 3-D sound recreation using a sound system that replicates sound through loudspeakers. This is echoed in a recent patent for an Object-based audio system using vector base amplitude panning.

> Typical channel-based audio distribution systems are also unsuited for 3-D video applications because they are incapable of rendering sound accurately in three-dimensional space. These systems are limited by the number and position of speakers and by the fact that psychoacoustic principles are generally ignored. As a result, even the most elaborate sound systems create merely a rough simulation of an acoustic space, which does not approximate a true 3D or multi-dimensional presentation.[2]

For the argument for 3-D sound to be true, there must be complete control over the perceived spatial imagery. Acoustics and environment have such an impact on this

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[1] Randy Thom has recieved two Oscar awards and has over 100 screen credits including Post-Production recordist for *Apocalypse Now* (Coppola, 1979). This interview was recorded at Skywalker Ranch CA, Feb 2012.

[2] Pierre-Anthony Stivell Lemieux, Roger Wallace Dressler, and Jean-Marc Jot. *Object-Based Audio System Using Vector Base Amplitude Panning.* Patent WO2013181272 A2, filed May 29, 2013, and issued December 5, 2013.

replication that controlling these variables whilst using speakers within a cinema space is extremely difficult and ultimately impractical. As every seat in a cinema is in a different location 'it is impossible to predict the position of the listener or of the speakers in any given situation and impossible to compensate for multiple listeners.'[3] Sound Designer, David Farmer and executives from Auro- Technologies also express concern over the limitations of speaker formats.[4,5]

This study investigates the relationship between the stereoscopic image and the soundtrack in this new wave of digital 3-D filmmaking. The investigation explores sound as a discrete 3-D entity, and considers how the 3-D representation of sound relates to the 3-D representation of the image. This study questions the contemporary working methodologies of sound design practices for 3-D cinema, and investigates alternative methodologies for both the creation and exhibition of cinema sound. The study achieves this through explorations of the creative, practical and technological limitations of contemporary cinema sound.

The research is conducted through a combination of both qualitative and quantitative research methodologies. It includes: practice-led investigations including my personal experience working on the soundtrack for several of Australia's highest grossing digital 3-D feature films; the creation of soundtracks using non-traditional audio formats for a selection of short films and film scenes; an online survey; critical examination of recent 3-D feature film releases with immersive sound; and interviews with key leading industry persons. These interviewees include professionals working at the pinnacle of international production in Australia, New Zealand and the United States.

Author background

Working in the Australian film industry since 1998 as a sound supervisor, sound designer, sound editor and re-recording mixer, I have had many years of experience in all aspects of audio production and post-production. My credits include feature films, television, games

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[3] Durand Begault, *3-D Sound for Virtual Reality and Multimedia* (NASA, 2000), 176.
[4] David Farmer, Personal Interview: 3-D Sound Discussion at Park Road Post, NZ., August 1, 2013.
[5] Brian Claypool, Wilfried Van Baelen, and Bert Van Daele, *Auro 11.1 Versus Object-Based Sound in 3D* (Technical report), 2, accessed March 1, 2015, http://testsc.barco.com/~/media/Downloads/White%20papers/2012/WhitePaperAuro%20111%20versus%20objectbased%20sound%20in%203Dpdf.pdf.

and music. My engagement on feature films has been highly acclaimed, with the screen credit of Sound Effects Editor on the following 3-D feature films:

- *The LEGO Movie* (2014)[6]
- *The Great Gatsby* (2013)[7]
- *Sanctum* (2012)[8]
- *Happy Feet Two* (2011)[9]
- *Legend of the Guardians: The Owls of Ga'Hoole* (2010)[10]

In 2010, I was elected onto the Board of Directors with the Motion Picture Sound Editors (MPSE) as an Out of Area representative, the first for an Australian.[11]

Having extensive first-hand international industry experience and serving as a Board Member on the MPSE qualifies me as an industry expert in the field of motion picture sound. Throughout this thesis I utilise my personal expertise and the expertise of fellow industry colleagues as well as traditional scholarly research methodologies in the areas of sound for screen and 3-D sound. It was through my engagement in the creation of sound effects for *Legend of the Guardians: The Owls of Ga'Hoole*[12] that I was inspired to conduct formal research in the area of sound for 3-D film. With research regularly conducted into

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[6] Dan Hageman and Kevin Hageman, *The LEGO Movie,* directed by Phil Lord and Chris Miller, (Burbank CA: Warner Bros., 2014).
[Please note that the Chicago Manual of Style 6th Ed. Has been used in this thesis. The style requires films to be listed in the order of Firstname Lastname, *Title of Work*, directed by Firstname Lastname (Original release year; City: Studio/Distributor, release year.). Appendix A contains a filmography sorted by film title and director.
[7] Baz Luhrmann and F. Scott Fitzgerald, *The Great Gatsby,* directed by Baz Luhrmann (Burbank, CA: Warner Bros., 2013).
[8] John Garvin and Andrew Wight, *Sanctum*, directed by Alister Grierson (Universal City, CA: Universal Studios, 2011).
[9] George Miller, and Gary Eck, *Happy Feet Two,* directed by George Miller (Burbank, CA: Warner Bros, 2011).
[10] Orloff and Stern, *Legend of the Guardians*.
[11] Founded in 1953, Motion Picture Sound Editors (M.P.S.E.) is an honorary society of motion picture sound editors. The society's goals are to educate others about and increase the recognition of the sound editors, show the artistic merit of the soundtracks, and improve the professional relationships of its members. Being a full member of the MPSE allows the use of the post nominals *MPSE* for onscreen credits.
[12] The theatrical release of *Legend of the Guardians: The Owls of Ga'Hoole* will now be referred to as *Legend of the Guardians* and the DVD/ Blu-ray release will be referred to as *Legend of the Guardians* (DVD).

film sound and film theory, there is growing research into 3-D imagery, with only very limited research specifically directed towards sound for 3-D films.

Although in many instances exactly the same soundtrack is used for both the 2-D and 3-D releases of a film, it is the way in which the soundtrack relates to both of these visual representations that is of particular interest. These relative differences are considered from both a creative industry practitioner's point of view (the creation of the sounds) and from that of an audience member (critical listener). It has been through identifying differences between the relative relationships of the soundtrack of the 2-D and 3-D releases that inspiration to undertake this PhD came about.

Since I am also employed as an academic, the nexus between my industry practice and research situates this thesis in a unique position between first-hand industry experiences and a traditional research and creative practice-led PhD. For a more comprehensive list of the author's screen credits refer to Appendix C.

Establishing the framework

As cinema continues to evolve, the object of many films is to provide an immersive experience. Although many films are created purely with the intent of telling a story through strong narrative and with little consideration for the technology used, in many instances, particularly for contemporary films, the opposite is true. This especially relates to the Hollywood blockbuster, where many films are created purely to immerse the audience into the onscreen action by bombarding their senses.[13]

Kerins argues that through an increase in cuts per minute in film editing, and the breaking of traditional shot and framing structures —possible because of advancements in technology— a new cinema style is reflected that can also be associated with the emergence of the Digital Sound Cinema (DSC). 'The DSC style centres on a strategy of

[13] The blockbuster is a film produced and marketed as an *event film*. The term was adopted by Hollywood to mean large-scale productions or large-scale box office hits after the term was originally used to describe a large-scale bomb in World War II. Steve Neale, "Hollywood Blockbusters: Historical Dimensions," in *Movie Blockbusters*, ed. Julian Stringer (London, New York: Routledge, 2003), 47.

immersion in the filmic environment - audiences are, visually and aurally, literally placed in the middle of the action.'[14]

Throughout this thesis, when referring to immersion within film, I will be using the term as defined within digital media. This definition will also be inclusive of the visuals, and also the sound in the same context, as defined by Lister et al.

> The image is not before the viewer on a surface from whose distance they can measure their own position in physical space. Rather, it appears to surround them. By extension the term is used to describe the experience of the user of certain new media technologies (particularly virtual reality (VR), but also videogames) in which the subject loses any sense of themselves as separate from the medium of its simulated world.[15]

By substituting 'subject' with 'viewer' and 'simulated world' with 'cinematic environment,' this definition is more concisely representative of a film immersion definition, that is, the term 'immersion' is used to describe the experience of the viewer losing any sense of themselves as separate from the medium of the cinematic environment.

My reappropriation of the definition also complements Price's description of the nature and intent of contemporary cinema narrative. Price explains that 'cinema marries a compelling presentation of sound and moving images to the depiction of what often are worlds of the imagination. The more perceptually convincing these imaginary worlds can be made to seem, the more virtual and immersive the spaces of story and image become.'[16] This also holds true with Kerins' definition:

> The audience is literally placed in the dramatic space of the movie, shifting the conception of cinema from something "to be watched from the outside"—with audience members taking in a scene in front of them—to something "to be personally experienced"— with audience members literally placed in the middle of the diegetic environment and action.[17]

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[14] Mark Kerins, "Narration in the Cinema of Digital Sound," *Velvet Light Trap*, no. 58 (2006): 44.
[15] Martin Lister et al., *New Media: A Critical Introduction*, 2nd ed. (London; New York: Routledge, 2009), 424.
[16] Stephen Prince, *Digital Visual Effects in Cinema : The Seduction of Reality* (Piscataway, NJ: Rutgers University Press, 2011), 183.
[17] Mark Kerins, *Beyond Dolby (Stereo): Cinema in the Digital Sound Age* (Bloomington, IN: Indiana University Press, 2010), 130.

When talking about the 3-D conversion of James Cameron's *Titanic* (2012),[18] Barbara Klinger comments on the advantage of the post-converted 3-D version of the film from the 2-D original: 'The word immersion is kind of a cliché, but I think it does have the effect of immersing you more in the action. And I'm not a huge fan of that film, but I admire what he did in the conversion process.'[19] *Titanic* (1997),[20] the winner of 11 Academy Awards including Best Picture after already making US$600 million from an estimated US$200 million budget from the original release, did not need a 3-D release to sell tickets. However, as director James Cameron is such an advocate of 3-D, he recognised that by creating a more immersive experience, the conversion of the film to 3-D was warranted. In its initial 3-D release the film made approximately US$58 million in the US and another US$156 million in China.[21, 22]

Although 3-D films aim to create a superior immersive experience compared to 2-D films, many in industry are divided on this. Walter Murch comments on 3-D and immersion, stating the importance of suturing an audience through narrative, where the term 'suture' refers to the audience 'stitching' itself into a film. This can be by relating to characters, identifying with a character's point of view or with world views expressed in a film, and then filling in the temporal and spatial gaps between scenes with imagination. Murch states that:

> 3-D films remind the audience that they are in a certain "perspective" relationship to the image. It is almost a Brechtian trick. Whereas if the film story has really gripped an audience they are "in" the picture in a kind of dreamlike "spaceless"

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[18] James Cameron, *Titanic* (3-D Version), directed by James Cameron, (Hollywood, CA: Paramount Pictures, 2012).
[19] Ted Phillips, "Recess Interviews: Barbara Klinger," *The Duke Chronicle*, March 21, 2013, accessed April 16, 2013. http://www.dukechronicle.com/articles/2013/03/21/recess-interviews-barbara-klinger.
[20] James Cameron, *Titanic,* directed by James Cameron, (Hollywood, CA: Paramount Pictures, 1997).
[21] Pamela McClintock, "Box Office Shocker: 'Titanic 3D' Scores Top Opening of All Time in China," *The Hollywood Reporter*, April 15, 2012, accessed April 7, 2014. http://www.hollywoodreporter.com/news/box-office-shocker-titanic-3d-china-leonardo-dicaprio-kate-winslet-312267.
[22] Clifford Coonan, "Legend 3D Seeks to Establish China Unit," *The Hollywood Reporter*, October 16, 2013, accessed April 7, 2014. http://www.hollywoodreporter.com/news/legend-3d-seeks-establish-china-648906?utm_source=pulsenews&utm_medium=referral&utm_campaign=Feed:+thr/news+(The+Hollywood+Reporter+-+Top+Stories).

> space. So a good story will give you more dimensionality than you can ever cope with.[23]

Although the term 'suture' can be used to describe this seamless integration between film narrative and spectator as described by Murch for 2-D film, this relationship is dependent on the strengths of the narrative. The term 'immersion' is extremely important, and I build on the use of it throughout this thesis, referring to an increased participation and absorption with the narrative through our senses. This is also an extension of 'suture' as it represents far more than an emotional connection, but also a sensory connection or absorption. This thesis investigates the individual visual and aural connections with the audience, and connections made when the audio and vision are cohesive.

Cinematographer Oliver Stapleton shares Murch's view, suggesting that 3-D reminds an audience that they are watching a screen, thus preventing emotional involvement. Stapleton also suggests that '3-D is antithetical to storytelling, where immersion in character is the goal.'[24] Stapleton believes that 3-D cinema is not a true representation of real life.[25] Although film does not necessarily always aim to reflect reality, it often aims to draw the audience into the narrative and characters.

Film technology companies are continually developing products that reinforce realism. This includes higher resolution capture and projection. Contrary to Murch and Stapleton's views, Mendiburu argues that digital 3-D is recognised as advancing this progression towards stronger realism, at least through sensory means if not additionally through narrative.

> Because 3-D is our natural way of seeing, it brings a feeling of realism to the audience. With 3-D, we no longer have to rebuild the volume of objects in the scene we are looking at, because we get them directly from our visual system. By reducing the effort involved in the suspension of disbelief, we significantly increase the immersion experience.[26]

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[23] Roger Ebert, "Why 3D Doesn't Work and Never Will. Case Closed.," January 23, 2011, accessed April 16, 2013. http://www.rogerebert.com/rogers-journal/why-3d-doesnt-work-and-never-will-case-closed.
[24] Vincent Dowd, "Has 3D Film-Making Had Its Day?," *BBC News*, December 25, 2012, accessed April 15, 2013 http://www.bbc.co.uk/news/entertainment-arts-20808920.
[25] Ibid.
[26] Bernard Mendiburu, *3D Movie Making Stereoscopic Digital Cinema From Script to Screen* (Amsterdam; Boston: Focal Press/Elsevier, 2009), 3.

Throughout this thesis, I argue that one of the contributing factors that adds to the shortcomings of the current 3-D film experience is the dislocation between the imagery and the soundtrack. As we see and hear in 3-D in our everyday lives we already have an extraordinary understanding of volume and space. However if we see something and the associated sound appears to be in another location, our concept of reality is broken. This is similar to hearing a supersonic jet pass and when we look up the plane is not where we expect it to be as the sound and the object are dislocated. This also applies when viewing a film. When we listen to a film, the soundtrack needs to complement the visual in terms of its connection to what is unfolding onscreen. Whether 2-D or 3-D, it is important that the soundtrack keeps the audience 'in the picture.'

Project overview

The central argument of this thesis is that current working methodologies and exhibition of sound for digital 3-D films has created a division between the image and the soundtrack. This practice-led research investigates the history of film sound and analyses contemporary film sound for both 2-D and 3-D films. Throughout this thesis I argue that the soundtrack for 3-D films has not adapted to accommodate the added depth and use of the cinematic z-space. This argument considers film theory, film practice and also the traditions that are adhered to in contemporary feature film releases, especially in relation to Hollywood. This argument is put forward through the research questions below.

The research aims

Language

- Does a language exist to describe spatial sound design in 3-D cinema?
- Is surround sound 3-D sound?

Work practices

- Does the relationship between the vision and sound on contemporary 3-D films differ from that of 2-D films?
- Have contemporary work practices in sound design and sound mixing changed since the introduction of 3-D cinema, and if so how?
- Should contemporary work practices change to accommodate the added dimension, volume and depth of 3-D visuals?
- Does the average audience member notice a difference between the audio-visual relationships of 3-D films compared to 2-D?

Technology

- Has sound technology used in 2-D film changed with the introduction of 3-D film? If it has, is this technology an ideal solution, or are further technical developments needed to allow greater creativity and cohesiveness of 3-D film sound design?
- Is the average audience member aware of the various technologies used in film exhibition? Do they make decisions based on this? If so, what decisions?

The research objectives

Language

- Establish a language that describes spatial sound design in relation to cinema sound for 3-D.

Work practices

- Identify differences between the soundtracks of 2-D and 3-D films.
- Through fieldwork, practice-led research and industry interviews, examine contemporary work practices in sound design and sound mixing. Establish the effectiveness with regard to the increased dimension of 3-D.
- Quantify to some extent audience awareness of the audio-visual relationship of 3-D films.

Technology

- Research the changes in technologies from 2-D to digital 3-D films. Through creative practice and interviews, investigate the effectiveness of available technologies, and determine if further technical developments are needed to allow greater creativity and homogeneity of 3-D film sound design.
- Quantify an audience's awareness of contemporary cinema technologies.

Locating the research

This research is located within the area of film production and practice. Throughout this research, theory, technology and working methodologies have drawn upon the following interdisciplinary linkages:

- Film theory
- Film/Sound history
- Sound production
- Acoustics
- Game design
- Sound art

Chapter outline

The chapter outline below summarises the overview of this thesis.

Chapter 1 - Provides an overview of the research topic and establishes the analytic framework of the thesis.

Chapter 2 – Outlines an overview of the developments of 3-D cinema and cinema sound technologies. This contextualises the evolution of cinema from the beginnings of synchronised sound to the introduction of analogue 3-D, through to contemporary digital 3-D cinema.

Chapter 3 - Investigates some of the existing language and literacies for describing the relationships between vision and sound, and how these may be expanded upon to accommodate 3-D film. Additionally, the chapter highlights existing language for describing sound localisation and investigates new descriptions for sound within a 3-D space.

Chapter 4 – Broken into two parts, Part A outlines the working methodologies for creating a contemporary soundtrack and provides a personal insight into the design for several contemporary 3-D film soundtracks. Part B contains two case studies on films with immersive sound releases in addition to the contemporary 5.1 and 7.1 surround formats.

Chapter 5 –This chapter investigates the role of the cinema and the audience. Broken into four parts the areas cover: the role of the cinema upgrading to immersive technologies; the audience and their understanding of cinema technologies; immersive media alternatives to cinema exhibition; and alternative spatial and immersive sound formats. The chapter touches on changes in society, and the relationship of cinema audiences with alternative media, identifying how this relationship may impact future film exhibition.

Chapter 6 – Demonstrates various practice-led research approaches to creating a contemporary soundtrack for a 3-D film. This provides a first-hand insight into contemporary cinema practices and experimentation using non-cinema and alternative 3-D sound practices.

Chapter 7 – Concludes the discussion by reflecting on the key findings from this research.

Methodology

How I went about my research

The research was undertaken using several methodologies including: creative practice and practice-led research, face to face interviews with key international industry experts, film analysis through fieldwork, an online survey and traditional research methods.

Creative practice and practice-led research

Through my engagement in contemporary Australian 3-D feature film productions I was situated in a privileged position where my practice continually informed my research. Films included: *Legend of the Guardians, Happy Feet Two*, *The Great Gatsby*, *and The LEGO Movie*. These films provided an opportunity to create a soundtrack for both animation and live-action 3-D films.

The research process was a hybridisation as I often went between practice-led research and traditional research and back again at various levels of engagement and intensity, depending on the demands and deadlines of the films. Primarily the practice–led components dictated this level of engagement, as my time devoted to the films was non-negotiable due to schedule and delivery requirements.

In addition to the above mentioned feature film releases, I also employed a practice-led approach on two short films and three specific film scenes from *Legend of the Guardians*. This provided a level of autonomy and creative opportunities not possible with a commercially released film.

Face-to-face interviews

I used my personal contacts and the availability of participants to conduct face-to-face interviews with industry leaders. This mode of research was ad-hoc depending on participants' availabilities. The film industry often entails engagement on material or films that are under strict confidentiality requirements. I needed to be flexible and considerate in my approach to obtaining interviews. A trip to the United States in 2012 coincided with me presenting at the Motion Picture Sound Awards in Los Angeles. My trip to New Zealand

in 2013 occurred through a connection that resulted from an invitation to work on *The Hobbit: The Desolation of Smaug* (2013).[27] Although I had to decline working on the film, I capitalised on this connection to provide me with unique research and interview opportunities. With limited traditional research options available for data collecting, the cutting-edge industry insights and data provided through the interviews was invaluable.

My interviews aimed to question the following:

- Have contemporary work practices in sound design and sound mixing changed since the introduction of 3-D cinema and the increased dimension and image depth of 3-D visuals?
- What does the release of Dolby Atmos and Auro 3-D mean to 3-D film sound? Who has worked with these new emerging cinema sound technologies and what do they think?

Film analysis through fieldwork

Although films including *Hugo* (2011),[28] *Life of Pi* (2012)[29] and *Gravity* (2013)[30] have all contributed to the development of the 3-D format, it would be an understatement to say that James Cameron's *Avatar* kick started the digital 3-D revolution. Having grossed over US$760 million at the box office, it is apparent that many people worldwide took the opportunity to see the film in a cinema. With cinema providing a superior experience for a film release, my research also incorporated fieldwork that included film analysis conducted in several cinemas with immersive sound technologies.

During the writing of this thesis, Australia had two cinemas equipped with competing immersive cinema sound technologies. Analysing films under these conditions provided an informative research opportunity. Although a large proportion of this thesis has developed through practice-led research, being able to compare other contemporary

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[27] Fran Walsh and Philippa Boyens, *The Hobbit: The Desolation of Smaug* directed by Peter Jackson (Burbank, CA: Warner Bros., 2013).
[28] John Logan and Brian Selznick, *Hugo*, directed by Martin Scorsese (Hollywood, CA: Paramount Pictures, 2011).
[29] David Magee and Yann Martel, *Life of Pi*, directed by Ang Lee (Century City, CA: Fox 2000 Pictures, 2012).
[30] Alfonso Cuarón and Jonás Cuarón, *Gravity*, directed by Alfonso Cuarón (Burbank, CA: Warner Bros. Pictures, 2013).

digital 3-D film releases has enabled a comparison between the two leading immersive sound technologies.

Online survey

To research quantitative data beyond practice-led and industry-focused film sound production, I investigated what the general public knew and/or thought about 3-D films and emerging cinema technologies. This is important, as the cinema patrons are the primary stakeholders. An understanding of this was achieved by creating an online survey that was accessible to anyone in the world with an Internet connection. The survey had over 200 international participants, with over 60% of these working outside the film industry.

Literature review

Digital 3-D film is a relatively new medium. Traditional academic reference literature specifically in this field of research is limited and has primarily been used for historical, technical and film theory references. Authors including Altman, Chion, Gomery, Gorbman, Kerins, Sergi, Schafer, Smalley, Sonnenschein and Zone have published in the areas of audio-visual relationships, changes in cinema sound technologies and the evolution of 3-D.[31] They have provided many underpinning theories within this thesis. Although traditional texts have been referenced, no single book is explicitly written about 'Sound for 3-D film.' As such I have referenced the above-mentioned authors in the context of 2-D film (with the exception of Zone) and compared their theories to the contemporary 3-D format. In many instances, the theories and working methodologies are unchanged from 2-D filmmaking, allowing these texts to remain applicable.

As 3-D film production and immersive sound technologies continued to evolve throughout the duration of this thesis, my research necessitated being informed on a daily basis. This immediacy required the majority of my research to be conducted digitally online through web articles, blog posts, press releases and other forms of digital publication including e-publications and e-journals. Online sources, including updates on LinkedIn,[32] Designing

[31] Full text details are available in the bibliography.
[32] https://www.linkedin.com

Sound,[33] and the Soundworks Collection,[34] as well as subscriptions to various industry news and information feeds, provided the most immediate forms of information in emerging cinema technologies and statistics.

Research parameters

This research encountered several constraints throughout the various processes. The primary underlying limitation in this research was due to several key authorities in industry, and in particular in Hollywood, unwilling to speak on record. Off the record, in general conversation, most interview participants agreed that changes needed to be made to improve working methodologies and the final exhibition of 3-D film. However on record, some participants declined to be quoted for saying what he or she really thought. As a result I have had to provide some general observations based on these conversations. When asked why they didn't feel comfortable with providing candid feedback, especially if it was negative, the interview participants stated that they feared it would impact both on their chances of future work and also on their reputation amongst their peers in industry, including the studios and production companies where they worked.

The current industry status quo: Film and film sound

Bridging sound and vision

Although this is covered in greater detail in Chapter 2, it is useful to introduce now a discussion of the relationship between the image and soundtrack of film. From the introduction of post-synchronised sound effects and music on film in 1926 with *Don Juan* (1926),[35] and the first use of synchronised dialogue in *The Jazz Singer* (1927),[36] it was not

[33] http://designingsound.org/
[34] http://soundworkscollection.com/

[35] Alan Crosland, *Don Juan*, directed by Alan Crosland (Burbank, CA: Warner Bros. Pictures, 1926).
[36] Alan Crosland, *The Jazz Singer* directed by Alan Crosland (Burbank, CA: Warner Bros., 1927).

long before all Hollywood film companies converted to sound. 'By the autumn of 1930, Hollywood produced only talkies.'[37]

This pairing of synchronised sound and vision has created many technical and creative opportunities throughout the evolution of film from analogue to the contemporary 3-D digital, but throughout developments there has remained a constant desire to provide audiences with the highest quality of production and exhibition. Sound as a contribution to the narrative has developed over time. Although the soundtrack of analogue film was often stored on the same medium as the image on the film print, these restrictions posed many challenges. Throughout the evolution of sound on film, an increase in fidelity allowed an increase in dynamic range and detail within the soundtrack.

Not only has the ability to synchronise audio and vision allowed for the process of Automated Dialogue Replacement (ADR) and foley, it has also led to further creative practices being introduced.[38] These include the addition of spot sound effects, background ambience sounds and rich high fidelity musical scores. As a consequence these allow exploitation and expansion of the film narrative. The soundtrack not only tells a narrative; it has the power to enhance a narrative. Chion uses the term 'added value' when discussing the importance the soundtrack has had on filmmaking: 'sound temporalised the image: not only by the effect of added value but also quite simply by normalising and stabilising film projection speed.'[39] The introduction of the synchronous soundtrack not only provided benefit through the creative content; its introduction also brought consistency to the playback speed of the image. Contemporary supervising sound editor, Lon Bender, echoes the 'added value' of the soundtrack. When interviewed for *Home Theatre Geeks*, Bender explained 'sound really is 50 per cent of the movie going experience as it takes pictures and brings them to life. It turns them into three-dimensional experiences for the audience.'[40] Sound adds another dimension to the visuals.

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[37] Douglas Gomery, "The Coming of Sound: Technological Change in the American Film Industry," in *Film Sound: Theory and Practice*, ed. Elisabeth Weis and John Belton. (New York: Columbia University Press, 1985), 5.
[38] For definition of these terms please refer to Terminology (page xiii).
[39] Michel Chion, *Audio-Vision: Sound on Screen*, trans. Claudia Gorbman (New York: Columbia University Press, 1994), 17.
[40] Scott Wilkinson, *The Sound of Movies*, MP3, Home Theater Geeks, accessed May 9, 2014, http://twit.cachefly.net/audio/htg/htg0205/htg0205.mp3.

Identifying differences between sound for 2-D and 3-D visuals

My line of enquiry into 3-D sound actually resulted from a single problem that I identified whilst working on the first Australian 3-D animated feature film, *Legend of The Guardians: The Owls of Ga'Hoole.* The problem presented itself through the inability to position sound accurately within z-space. An object could be panned around the room, from left to right of screen or from the front to the rear of the cinema; however the sound object could not be located within the centre of the room. No matter how the various sound effects were designed and no matter how the objects were panned throughout the 5.1 surround sound space, limitations of the 5.1 format did not allow for the accurate positioning of the sounds along the z-axis (refer to Figure 1, page xiii). In particular, I wanted the sound of a sword tip passing slowly in front of the audience members' noses as the 3-D imagery showed a blade converged off the screen in strong negative parallax (Figure 3). The objective was to create the illusion that the sound had volumetric depth that complemented the imagery.

The tip of the blade originated from the neutral parallax before extending into negative parallax as it travelled from the screen into the audience. Problems arose when trying to replicate this with various layers of sounds using the parameters of 5.1 panning. Although able to pan the base of the blade as it was anchored on the screen plane, the tip of the blade in strong negative parallax proved extremely difficult. When the sound was panned from the screen into the surround speakers, it became diffused throughout the theatre. To achieve an acceptable outcome, several sound elements were panned independently to create the aural illusion that the overall sound was attached to the blade. This however was a huge compromise.

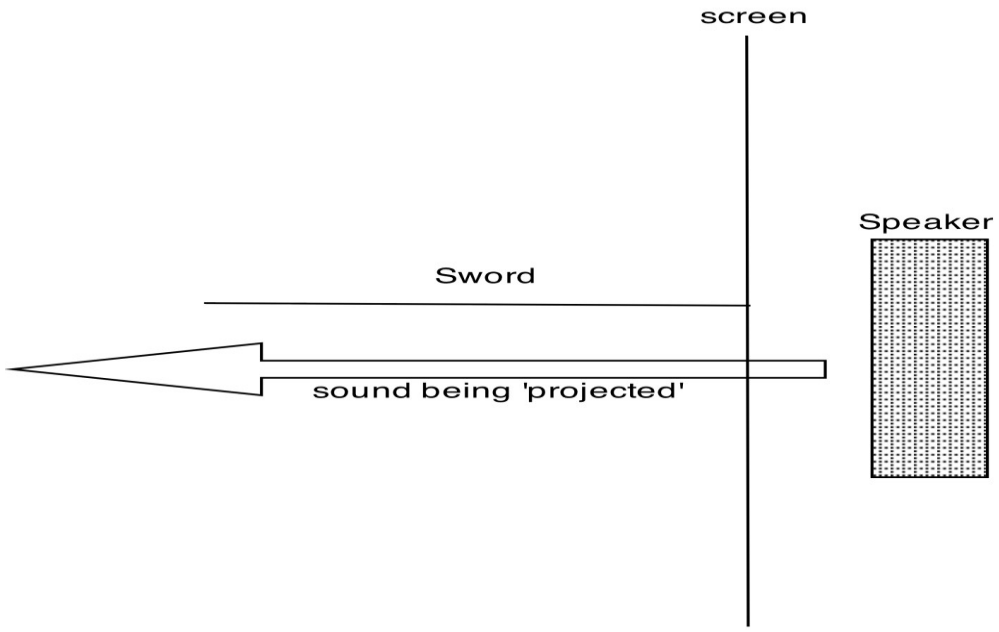

Figure 3: Sound effects and imagery in z-space in *Legend of the Guardians*.

Industry methodologies

The introduction of digital television, both in Australia and overseas, allowed the 5.1 surround sound format to be extended from cinema to a format that was accessible to DVD and to many homes for free through television. Provided that television stations broadcast surround content and the home viewer had a 5.1 amplifier and speakers, television content could be broadcast to 'sound like the movies.' My initial experience with working in 5.1 for television came in 2002 whilst working on the Jim Henson Productions, Sci-Fi series *Farscape* (2002).[41] This production was created for the Sci-Fi network and broadcast through the cable network with a 5.1 soundtrack - a first for an Australian television production. This also signified the change that industry was taking with television by progressing from a two-channel stereo mix to a cinema sound equivalent format. Although the dynamic range of the program was different to cinema, the workflow in terms of sound editing and mixing was the same.

Although Australia had a cable and satellite subscription television network, no Australian television drama was created with 5.1 until *Farscape*, possibly due to budget restrictions. DVD was seen as an additional revenue stream, so it soon became apparent that 5.1 soundtracks would be required for television programs released on DVD. This changed the sound editing and mixing to a 5.1 format by default for almost all television productions. As soon as production houses realised that they had to retrospectively remix hours and hours of content for 5.1, creating a 5.1 version of the program from the outset was deemed more financially viable in the long term. Editors globally began working in 5.1 as their default format as subsequent stereo or Dolby Stereo versions can be created or 'folded down' with minimal additional hours.

The 5.1 format provides great flexibility when needing to convert to other conventional formats. Contemporary software is advanced in comparison to 15 years ago, making working in 5.1 extremely easy. Editors and mixers are able to pan within a 360° horizontal sound field using something as rudimentary as their computer mouse. Although formats such as 7.1 surround and formats with additional channels exist, many editors continue to work in the 5.1 format. During the premixing or final mixing stage, any up-mixing to

[41] The Jim Henson Company, *Farscape*, Television Series (The Sci-Fi Channel, 2002).

increased channel formats can be performed. This also applies to the new immersive sound formats. There is very limited documentation on sound design within the 3-D feature film context, with no rules or standards associated with these new practices. Sound designers and film sound mixers are continuing to use previous 2-D work practices in cinema sound, with limited and cautious experimentation and manipulation of spatial sound design within this new 3-D environment.

Motivation for seeking change

Throughout my career, my work has included all aspects of feature film sound, but predominantly in the creation and sound design of sound effects. Working on the new resurgence of digital 3-D films, the medium has provided many challenges, notably, how the soundtrack is replayed alongside the 3-D imagery. There is a distinct and inherent difference in the cohesive relationship of the image and the soundtrack of 3-D films compared to 2-D films. An audience without knowledge of film sound is unable to notice or articulate many of the details provided by complex contemporary soundtracks. It is not through ignorance that they are unaware of such subtleties of the soundtrack; instead it is from inexperience in the intricate details of soundtrack presentation and not having the privilege to distinguish subtle sonic nuances on a regular basis. However just because an audience is unaware of the limitations doesn't make it acceptable to settle on a format or product that could be better, given that going to the cinema is intended to be a premium entertainment and immersive experience.

As a practising sound artist within the film industry, I see my work on a film as any artist working within the visual medium would. That is, when you have created your work, you want it exhibited in the best possible way. For a visual artist this includes choosing an appropriate gallery with suitable room characteristics, lighting and hanging location. All of these options provide the optimal situation to display and present the image. My motivation for seeking change in the way that sound is created and exhibited for 3-D is similar in many regards. That is, I am seeking to find the optimal means for the creation and exhibition of sound for 3-D cinema, pushing the boundaries for superior cinematic practices.

On one hand we can say that cinemas are already optimal in that they have large screens, surround sound and to some extent acoustic treatment. To the average cinemagoer, compared to their home television or home theatre setup, the cinema is far superior and on the whole, the 2-D film experience is fulfilling. With the introduction of digital 3-D films, the only significant change to the contemporary cinema was an upgraded projector

allowing for the 3-D imagery to be projected. Some cinemas may have also upgraded their screens. However, in regards to the sonic component of the cinema, in many instances nothing changed. Several new cinema sound technologies have emerged since the introduction of 3-D including Dolby Surround 7.1 and immersive audio formats including Dolby Atmos and Auro 3-D. These technologies are slowly being introduced to selected cinemas only, with Australia having one Auro equipped cinema and three Dolby Atmos equipped cinemas as of March of 2015. Immersive sound technologies are still by far in a minority, with the predominant cinema sound technology continuing to be the 5.1 format.

For over 10 years the 5.1 format has also been the choice for most people working in screen sound as it allows for theatrical release, digital television release and also DVD release. When digital 3-D was introduced, the original and dominant sound format used was 5.1 as it was already the default 'sound format.' Sound editors, mixers and designers have continued to use existing sound tools and exhibition formats to create a soundtrack appropriate for this new visual medium. With every 3-D film that I have worked on released in the 5.1 format, the limitations of the format are becoming increasingly apparent.

Through my research I investigate the available options for creating a soundtrack for 3-D film that better represents and is homogenous with the 3-D visuals. The significance of this research lies in identifying working methodologies for the creation of a sonic immersive experience that complements motion picture stereoscopic 3-D imagery. With 3-D in its infancy, this research questions and explores current and future 3-D cinematic sound.

Who dictates how the industry works?

International film industry

Undoubtedly the biggest influences on western cinema are the films produced in the United States, and in particular Hollywood. With the North American Box Office intake being US$10.8 billion in 2012, the North American film industry is the largest in the world. This compares to the Indian film industry with a 2013 Box Office intake of US$1.54 billon

(93.4 billion rupees), up 10% from 2012.[42] The European and Asian Industries combined are expected to expand from US$2.8 billion in 2012 to almost double by 2017.[43]

The North American ticket sales revenue between the first weekend in May and Labour Day 2013 increased by 10% from the previous year, totaling US$4.71 billion. Although attendance rose by 6.6 per cent, it was higher ticket prices that contributed to the remainder of the growth.[44] The introduction of digital 3-D films is well known to have resulted from the desire to increase box office revenue but with debate over the validity of 3-D as a serious format for film narrative, many in the film industry continue to regard the medium as nothing more than a gimmick that demands a premium ticket price.

> The 3-D option has been a huge financial boon to the film industry, allowing movie theatres to justify higher ticket prices. In New York, a normal ticket costs $14, while a 3-D film costs $18, or 28 per cent more. An IMAX 3-D screening costs $20, a 43 per cent premium. As a result of 3-D, films such as *The Avengers* (2012)[45] have sped past the records. But was *Avengers* in 3-D really worth it? [46]

Contrary to the financial motives of the (re)introduction of 3-D film to bring the cinema audience back, several films have proved that strong narrative and filmmaking can be executed through the medium. These include: the 2009 release of James Cameron's *Avatar*, the 2011 release of Martin Scorsese's *Hugo*, and the 2013 release of Alfonso Cuarón's *Gravity*.[47] All three films were nominated for Academy Awards® for Best Motion Picture of the Year, highlighting the fact that 3-D films do take narrative seriously.

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[42] Nyay Bhushan, "India Box Office Grows 10 Percent in 2013," *The Hollywood Reporter*, March 12, 2014, accessed May 13, 2014. http://www.hollywoodreporter.com/news/india-box-office-grows-10-687933.
[43] John Ruwitch, "Hollywood Must Think Bigger about China, Says Producer Janet Yang," *Reuters*, October 21, 2013, accessed October 22, 2013. http://www.reuters.com/article/2013/10/21/entertainment-us-china-janetyang-idUSBRE99K03420131021.
[44] Brooks Barnes, "Huge Summer for Hollywood, but With Few Blockbusters," *The New York Times*, September 1, 2013, accessed October 8, 2013. http://www.nytimes.com/2013/09/02/business/media/huge-summer-for-hollywood-but-with-few-true-blockbusters.html.
[45] Joss Whedon and Zak Penn *The Avengers*, directed by Joss Whedon (Burbank, CA: Walt Disney Studios Motion Pictures, 2012).
[46] Roger Cheng, "Why 3D Movies Are a Waste of Money" *CNET News*, June 27, 2012, accessed April 15, 2013. http://news.cnet.com/8301-1023_3-57455593-93/why-3d-movies-are-a-waste-of-money/.
[47] Jennifer Wood, "What Gravity's Box Office Triumph Means for the Future of 3-D Film" *Wired*, February 22, 2013, accessed October 24, 2013. http://www.wired.com/underwire/2013/10/gravity-future-3d-movies/.

Australian film industry

By comparison to the North American film industry, the Australian film industry is extremely small. The influence the local industry has on the international filmmaking community is insignificant; with the exception that Australia has produced the occasional highly successful film and provided technical and creative services to several blockbuster film releases. In many instances Australian films are made for Australian audiences and these films rarely have a budget that enables international success. Although there are exceptions, predominantly the successful films made in Australian have international film studio backing. Recent examples of this include the films *Happy Feet* (2006),[48] *The Great Gatsby* and *The LEGO Movie*; all backed by Warner Brothers. Several short films and lower budget feature films have received international acclaim, but this has largely been through festival successes as opposed to international box office success.

As an Australian practitioner, I include within my case studies specific Australian produced films that have had Hollywood studio funding. These films are differentiated from typical Australian productions as the production quality and budget of these films is more aligned with Hollywood productions. This is demonstrated by the successes of *Happy Feet* and *The Great Gatsby,* both of which won Academy Awards® for various production categories.[49]

When observing current work practices, many of the methodologies used today stem from the analogue film medium era. The difference now is that technologies including hardware and software have evolved into digital solutions replicating the former analogue film methodologies. Essentially the rudimentary editing and mixing techniques remain unchanged. However, there are some slight differences in the job titles and nomenclature between countries. One particular example is that the sound teams at Skywalker Sound have a sound designer and a supervising sound editor on each feature film. The supervising sound editor will take the lead of the dialogues and the sound designer will

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[48] George Miller, John Collie, Judy Morris and Warren Coleman, *Happy Feet,* directed by George Miller (Burbank, CA: Warner Bros., 2006).
[49] *Happy Feet* won *Best Animated Feature Film of the Year* in 2007.
Catherine Martin won *Best Achievement in Costume Design* and Catherine Martin and Beverly Dunn won *Best Achievement in Production Design*, for *The Great Gatsby* in 2014.

take the lead of the sound effects. In Australia however, the sound supervisor tends to be credited with both supervising sound editor and sound designer titles.

In Australia many mixers are open to editors preparing the panning and level balancing of individual sound clips and tracks, providing that the mixer can access these parameters if needed. The time schedule of films does not allow for a mixer to balance and pan every individual sound effect. If the sound editor is able to provide these tasks already completed, mostly the re-recoding mixer will welcome these. This is in contrast to the predominant United States method of working, where the mixer will carry out all level balancing and panning.

The internet: Education and collaboration

The internet provides virtual geographical connections across the globe, allowing information and education to be instantaneous from anywhere in the world. This includes 'behind the scenes' clips, DVD extras, instructional videos and product releases, to name a few. The internet also allows knowledge to be shared globally by providing the opportunity for international working collaborations. My first international collaboration was on the Russian film *1612: Khroniki Smutnogo vremeni* (2007).[50] For this particular project the supervising sound designer influenced the working methodologies on the film. In general the overall creative practice working methodologies remain the same globally on any particular film with only the organisational management changing from project to project.

Although no single influence can be credited with dictating how current working methodologies are carried out, primary influences stem from the United States and in particular, Hollywood. Although editors in each country have their own working techniques, they are built upon the many years of traditional working methodologies that have infiltrated the rest of the world.

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[50] Arif Aliev, *1612: Khroniki Smutnogo Vremeni*, directed by Vladimir Khotinenko (Czech Republic, 2007).

Industry leadership

Leadership within the film sound industry is dislocated. On one side there are the technology vendors offering new hardware and software solutions that promise 'improved' quality and 'improved' performances, and on the other hand there are the sound craftspeople working with the tools that are presented to them at any given time. Industry is often resistant to certain technological changes as these frequently stem from the vendors' explicit commercial motive; that is, to make money and not necessarily offer what industry demands. There are exceptions to these cases. Dolby for example has a strong relationship with one of the world's best-known sound post-production facilities Skywalker Ranch, and Auro is based in Galaxy Studios, Belgium.

The film sound industry is unlike many other industries in that there is no single regulating governing body. Instead it is comprised of many unions, guilds and technical organisations that include:

- Motion Picture Sound Editors (MPSE)
- Cinema Audio Society (CAS)
- The Society of Motion Picture and Television Engineers (SMPTE)
- Audio Engineering Society (AES)
- European Broadcast Union (EBU)
- Moving Picture Expert Group (MPEG)
- The Association of Motion Picture Sound (AMPS)

Significantly, many of these groups work in isolation from each other. In Australia, there is only one guild that encompasses all of the disciplines of sound for film and television as well as an Australian branch of both SMPTE and the AES. There is vast fragmentation across the technical and creative leadership of the industry, with government, technology vendors and television and cinemas all having their own standards and requirements. Only since the beginning of 2013 has there been a unified loudness level standard for television in Australia.

Cinema is yet to abide by a formal standard, from film mix through to final exhibition. Although the mixing stages are calibrated to 85 decibels (db), having this translated into every cinema is virtually impossible. Dolby has been at the forefront of introducing a digital solution to self-calibrated cinemas, but this technology only applies to cinemas equipped with the very latest of their digital hardware.[51]

Studio backing

With major studios funding many film productions, it is often these studios that decide what format the film will be released in. This includes both the imagery and the sound format. Throughout the history of film sound, many of the studios have developed their own proprietary sound technologies. Cinemas could only exhibit films produced by particular studios as they all used specific formats, necessitating various playback options. Digital film exhibition has become more universal, allowing any cinema to replay any film. The introduction of Digital Cinema allows the Digital Cinema Package (DCP) to contain all of the relevant formats of the film as digital data. A cinema not equipped to replay a Dolby Surround 7.1 format soundtrack, will replay the Dolby Digital 5.1 soundtrack. As multiple sound formats require additional time in the mixing stage of the filmmaking process, it is up to the studio to determine if funding a particular format is worthwhile.

Developments and experimentation

Cinema is a technology-dependent entertainment medium, with continually evolving developments. Only a few years ago digital cinema was a rarity, with physical analogue film prints being the primary exhibition format. The conversion to digital has seen changes advancing at a rapid pace. These technological advancements are similar to those that took place with personal computing during its infancy in the 1980s and 90s. Initially the technology superseded itself at an exponential rate before plateau-ing. Current cinema technologies are looking likely to follow a similar trend as digital technologies relate to data storage and data speeds. Therefore the current advancements in film technology are in fact 'increases' on current technologies. This includes the capture and projection of increased image resolutions and increased frame rates. 3-D is also dependent on these same developments. 3-D film needs discrete data for both the left and right eyes, using double the data of a standard 2-D film.

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[51] Dolby Digital Cinema Processor CP850

Since converting to digital, cinema sound has seen far less development than the image. Except in the new immersive sound system installations, the majority of cinema sound systems are a combination of analogue and digital technologies. For example, decoders interpret a digital sound file that is converted to an analogue signal for the analogue amplifiers and speakers. Complete digital cinema sound systems exist, including Dolby Atmos; however these are expensive and hard to justify for a cinema already equipped with a working conventional 5.1/7.1 surround sound system.

Opportunities beyond the current state of play in cinema

Although cinema sound is the primary focus of this thesis, I also investigate non-cinematic examples of sound and 3-D vision. In many regards the film industry is built upon earlier working methodologies, making the importance of exploring beyond the film industry extremely important. These technology-associated opportunities include:

- Gaming and virtual reality.
- Ambisonic sound.
- Binaural and headphone sound.

Gaming and virtual reality

The gaming industry is forecasting that total global games software revenue could grow to ~US$100B by 2017. With gaming and cinema often compared, it is important to acknowledge the research and developments that are being carried out in these emerging formats.[52] The entire game industry is built upon the creation and utilisation of technology and in many instances this approach to story telling is often overlooked by the traditionalists within the film industry.

Having had first-hand experience in the game industry in 2004, I could see the potential in what was emerging at that time. The game industry was still relatively young and consumers were beginning to experience cinematic qualities within games for the first time with the 'next generation' consoles of the Microsoft Xbox and Sony's PlayStation.

[52] Digi-Capital, *Global Games Investment Review 2014 Q1 Transaction Update – Executive Summary*, 2014, accessed May 24, 2014. http://digitalcapitalist.blogspot.com.au/2013/04/digi-capital-global-games-investment.html.

Intellectual property was the holy grail of the game business. This resulted in a very closed approach. Game companies worked almost entirely in-house and developments within the games industry were fragmented, with companies not sharing their methodologies or intellectual property. Game companies only employed fellow gamers and there was limited interaction between the game community and the film community. Perhaps this has been one of the biggest lessons for both industries. The film industry needs to look at what alternative mediums are emerging and embrace these, and the gaming industry can utilise the production principles of the film industry. What was apparent with my game experience was that the game companies had grown so quickly from backyard hobbyists to multimillion-dollar enterprises within such a short period of time, that funding was often mismanaged and many companies closed.

Despite the fluctuations of the games industry, many of the large companies are continuing to produce highly profitable games. Utilising the latest in technology, the games are created to provide a highly immersive 3-D narrative experience. In many instances the cut scenes are the most realistic looking sections of games as they are actually short animated movies not relying on real-time game engine renderings. The cut scenes provide linear narrative cues by taking the gamer out of the game during levels loading. Technology is allowing faster and higher resolution renders in real-time and it won't be long before we see original feature films created with game engines, similar to machinima.[53] Gaming and virtual reality are investigated in greater detail in Chapter 5 (page 169).

Ambisonic sound

The Ambisonic format allows the recording of a 360º sound field. The recordings can be decoded to generate conventional film formats and many alternative sound formats. The format is investigated in greater detail in Chapter 5 (page 175).

Binaural technology

Although conventional cinemas utilise loudspeaker installations for sound replay, I will also investigate the validity of headphone sound as an appropriate accompaniment for 3-D

[53] Machinima is the use of a games engine to create cinematic productions. An early example is *Red vs Blue* created by Rooster Teeth, based on the *Halo* game from the original XBOX platform. http://roosterteeth.com.

imagery. The binaural technique has been acknowledged as providing a 3-D sound experience for music recordings, and some 3-D sound recordings. With around nineteen million hits on YouTube, one of the most popular recordings is the *Virtual Barber Shop* by QSound Labs.[54] In March 2015, the Audio Engineering Society (AES) published the AES69-2015 Standard, which provides a framework for the growing binaural and 3-D personal audio industries.[55] 'The AES69-2015 standard is seen as a boon to the evolving 3-D audio field. Binaural listening is growing due to increased usage of smartphones, tablets and other individual entertainment systems that primarily present audio using headphones.'[56] Of significance is that there is limited documentation and productions utilising binaural sound combined with vision. Emerging technologies including the Oculus Rift virtual reality headset and 3-D games will provide additional opportunities for sound for 3-D beyond cinema. Binaural sound and headphone technologies are investigated in greater detail in Chapter 5 (page 176).

Challenges and opportunities

One of the prevalent challenges shown throughout this research is that technology development plays such an important role within the working methodologies of film sound professionals. Professionals are reliant on the technology vendors to provide the tools that are necessary to carry out tasks. These tools include recording formats and mediums, editing hardware and software, mixing hardware and software and the cinema exhibition technology. Having said that, technology vendors also pose the greatest opportunities for advancements within the film sound industry since they employ their own Research and Development teams, seeking to provide the best possible opportunities for 3-D digital film sound.

Considering that work practices and technologies are yet to be standardised, my research investigates the practices and relationship between the 3-D image and spatial sound

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[54] Qsound Labs, *Virtual Barber Shop*, Binaural Audio (Calgary, Canada: QSound Labs, 2007), accessed March 1, 2015, https://www.youtube.com/watch?v=IUDTlvagjJA&feature=youtube_gdata_player.
[55] AAES Standards Committee, "AES69-2015 AES Standard for File Exchange - Spatial Acoustic Data File Format," *Audio Engineering Society, Inc*, March 5, 2015.
[56] Mixonline, "AES Publishes New Standard for 3-D Audio," accessed March 21, 2015, http://www.mixonline.com/news/news-articles/aes-publishes-new-standard-3-d-audio/424045.

design of 3-D feature films. In the following chapter I contextualise sound creation and exhibition of film within a historical framework. This provides a better understanding of technological trends and how contemporary 3-D film and surround sound are situated.

Chapter 2: Evolution of Sound and Vision: Film Technologies

Introduction

This chapter highlights some of the key technological developments that have shaped both the visual and sound aspects of film production and exhibition for 2-D and 3-D films. Whilst technological advancements have given audiences 'more' including increased sound fidelity, increased speaker channels and higher resolution image quality, there continues to be a gap in the homogeneity of the soundtrack and vision. This chapter also investigates how technological advancements for the capture and exhibition of sound and vision have influenced working methodologies and practices. The recent transition to digital cinema and the introduction of immersive sound technologies conclude the chapter.

Since the early public exhibition of feature films, the film industry has sought to provide an audience with a unique entertainment experience. Bordwell and Thompson note that film moved quickly into providing popular entertainment.[1] Through advancements in technology, cinema has developed from a predominantly visual format of entertainment to contemporary cinema providing a full-body immersive experience that embraces sight, sound and to some extent, also offering a haptic experience. Altman suggests that 'it is thus no longer the eyes, the ears, and the brain that alone initiate identification and maintain contact with a sonic source; instead, it is the whole body that establishes a relationship, marching to the beat of a different woofer.'[2] Sound has been an integral component of the film-going experience from the early projection of images accompanied by a pianist, pipe organ or orchestra from 1908 to almost 1920, with the human voice, including Japanese benshi narration,[3] commonly accompanying film projections and the first use of

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[1] David Bordwell and Kristin Thompson, *Film History: An Introduction* (New York, NY: McGraw-Hill Higher Education, 2010), 21.
[2] Rick Altman, "The Sound of Sound.," *Cineaste* 21, no. 1/2 (January 1995), 68.
[3] The benshi's narration was extremely important for screenings in Japanese movie theaters. In this sense silent films were already regarded as talking pictures by the audience. For many people, going to the movies meant not only watching films but also listening to the voices of the benshis who narrated them. Hiroshi Komatsu, "The Foundation of Modernism: Japanese Cinema in the Year 1927," *Film History: An International Journal* 17, no. 2 (2005): 368.

synchronised 'Talkie' sound in Crossland's *The Jazz Singer*.[4]

The evolution of soundtrack production and exhibition has expanded from a monophonic reproduction using a speaker placed within the orchestra pit, to a single speaker placed behind the centre of the screen at the front of the cinema, through to contemporary cinema sound utilising many speakers that 'surround' the audience. The contemporary soundtrack allows an audience to not only hear sounds; through the inclusion and replay of sub-harmonic frequencies, the audience can now feel sounds. As Sergi notes, contemporary sound systems are not just louder; they are capable of providing intense sound pressures. The same systems also provide a 3-D auditory experience that no longer envelops just the image on screen, but additionally the entire auditorium.[5]

Transitioning from monaural sound through to contemporary surround sound, the medium in which the soundtrack resides has also changed. These changes have improved sound quality through an increased dynamic range and frequency response and they have allowed for increases in the number of discrete speaker channels. Developments to the sound capture, storage and exhibition mediums have not only provided technical advancements and increases to the capacity of the soundtrack; they have technically and creatively changed film sound working methodologies including sound recording, sound editing and sound mixing. The advancements have allowed for greater increases in signal to noise ratios, recording and editing efficiencies and an expansion of sound mixing possibilities. These are elaborated on further in this chapter.

If we observe the evolution of cinema sound, there have been several significant advancements that can be used to categorise specific time periods. These include the analogue era of pre-synchronous sound, synchronised sound and picture, sound on film, stereophonic sound, magnetic sound and the first use of surround sound. Digital sound began with a crossover accompanying analogue film, before the introduction of digital film. This chapter aims to identify some of the trends that have shaped contemporary 3-D cinema.

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[4] William Kallay, "Interpreting the Sound and Theory," *From Script to DVD*, September 27, 2004. Accessesd 12 November 2013. http://www.fromscripttodvd.com/sound_theory.htm.
[5] Gianluca Sergi, "The Sonic Playground: Hollywood Cinema and Its Listeners," in *Hollywood Spectatorship: Changing Perceptions of Cinema Audiences*, ed. Melvyn Stokes and Richard Maltby (London: BFI Pub, 2001), 128.

Analogue film: Physical limitations

Invention of the 3-D image

For many centuries artists have been drawing and painting to capture moments in time. 3-D reproduction has existed since 1838, when Sir Charles Wheatstone discovered binocular stereopsis.[6] Wheatstone noted that if we can channel the individual visual information of two viewpoints of an object separately to each eye, the brain is able to recreate the illusion of the solid object. In the physical world, our brain interprets 3-D objects by combining the two slightly different viewpoints from our left and right eyes. The closer an object is, the greater the difference is between what the left and right eyes see and the more volume the object appears to have. The further an object is, the less difference there is between what the individual left and right eyes see and the object appears to be flatter and increasingly 2-D. Wheatstone's discovery has provided the foundation for all 3-D filmmaking technology to date.

Early 3-D was handcrafted. Created from illustrations or paintings, these images displayed in 3-D preceded the invention of both photography and of motion pictures including stereo peep show cabinets that existed prior to Edison's moving picture kinetoscope.[7] With the advent of photography came the natural progression from showcasing hand crafted illustrated and painted imagery to showcasing realistic photographic stereography. The race to create a realistic three-dimensional image proved to be one of the highest sought after goals of the nineteenth century. The introduction of early 3-D peep show cabinets catalysed such fundamental pioneering developments for not only photography, but also for motion pictures.

Cinema evolved through the culmination of technologies primarily from the United States, Germany, England, and France.[8] Prior to 1906-07, factual information and actuality was the dominant content that formed early filmmaking, with cinema more about 'showing' rather than providing an engaging narrative to engross the audience. Predating the use of narrative in film, Gunning refers to the early conception of the cinema used for showcasing

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[6] Ray Zone, *Stereoscopic Cinema and the Origins of 3-D Film, 1838-1952* (Lexington, KY: The University Press of Kentucky, 2007), 7.
[7] Ibid., 15.
[8] Bordwell and Thompson, *Film History*, 16.

these films as the 'cinema of attractions.'[9] Georges Méliès *A trip to the Moon*[10] showcased onscreen magical elements to an audience. Murch questions the pace at which the narrative forms of filmmaking were embraced, stating that 'it seems natural to us today, but there were many people a century ago, including even the inventors of film - Edison and the Lumière brothers - who did not foresee this development.'[11] Narrative is explored later in this thesis in relation to contemporary film, and how technological advancements may become increasingly important in compensating for narrative weaknesses.

In France in 1896, the first official motion picture *L'Arrivée du train* (1896)[12] was created for public exhibition. It was a short film single camera shot showing a train pulling into a station and stopping. Originally in 2-D, the Lumière brothers remade a 3-D version of the film nearly forty years later. This early consideration of 3-D indicates a long-standing desire by filmmakers to explore the potential of the medium.

> At the very birth of cinema its founding fathers Georges Méliès and the Lumière brothers dabbled in stereoscopic short films with the Lumière brothers reshooting their original *L'Arrivée d'un Train* in 1935 stating that stereo was how they had conceived cinema would evolve. In *Hugo*, his astute evocation of the period, rendered in 3-D and featuring reconstructions of *L'Arrivée d'un Train* and the fantasy films of Méliès, Scorsese underscores their vision.[13]

In the United States, the first 3-D films were not created until the early twentieth century. Using a twin-film camera system, Edwin S. Porter, working with William E. Waddell, had photographed stereoscopic motion pictures. The anaglyphic (red/blue) 3-D films, *Niagara Falls* (1914),[14] *Rural America* (1915)[15] and a segment from *Jim the Penman* (1915),[16] were projected on June 10, 1915, at the Astor Theatre in New York City.[17]

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[9] Tom Gunning, "The Cinema of Attraction," *Wide Angle* 3, no. 4 (1986): 64.
[10] Georges Méliès, *A Trip to the Moon,* directed by Georges Méliès (France: Star Film, 1902).
[11] Walter Murch, "The Three Fathers of Cinema with Walter Murch," interview by William Kallay, September 27, 2004, accessed Sptember 27, 2013, http://www.fromscripttodvd.com/three_fathers.htm.
[12] Auguste Lumière and Louis Lumière, *L'arrivée d'un Train*, directed by Auguste Lumière and Louis Lumière (France: Lumière, 1896).
[13] Adrian Pennington and Carolyn Giardina, *Exploring 3D: The New Grammar of Stereoscopic Filmmaking* (Burlington, MA: Focal Press, 2013), 19.
[14] Vitagraph Company of America, *Niagara Falls*, Documentary, Short, (USA: General Film Company, 1914).
[15] *Rural America* was never officially released.

In 2011, Australian film director Philippe Mora made a discovery that showed that the Germans had also been filming with 3-D in the first half of the twentieth century. While preparing for a feature length documentary on how the Nazis used images to manipulate reality, Mora came across two films from 1936, both in 3-D. Mora's discovery provides evidence that the Nazi directors were also early developers of a 3-D medium.[18]

3-D predates motion picture and Wheatstone's concept of channeling the individual visual information of two viewpoints to each eye remains the underpinning of contemporary 3-D cinema.

Pre-synchronous sound

Although not the first device to record sound, the phonograph invented by Thomas Edison in 1877 was the first device capable of both recording and playing back the recorded sound. Primitive by today's standard, the phonograph used a stylus to replay waveform grooves imprinted on the surface of a cylinder. Hand operated, the cylinder rotated and the sound resonating from the waveforms was amplified through an attached horn; a system that required no electricity. Although the phonograph went on to be further developed in the following years, the refinement of the cylinder system moved to a disc based system, the gramophone record. The basis of the gramophone record system continued to be widely used into the 1980s and 1990s, only to be superseded by the digital Compact Disc and MP3.

A decade after the invention of his phonograph, Edison idealised the future of sound and vision. In 1887 Edison wrote: 'the idea occurred to me that it would be possible to devise an instrument which should do for the eye what the phonograph does for the ear, and that by a combination of the two, all sound and motion could be recorded and reproduced

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[16] Hugh Ford and Charles J. Young, *Jim the Penman,* directed by Edwin S. Porter (Hollywood, CA: Paramount Pictures, 1915).
[17] Ray Zone, *3-D Filmmakers: Conversations with Creators of Stereoscopic Motion Pictures*, (Lanham, MD: Scarecrow Press, 2005), ix.
[18] Nick Holdsworth, "Third Reich 3D Movies Unearthed," *Variety*, February 15, 2011, accessed December 7, 2013. http://variety.com/2011/more/news/third-reich-3d-movies-unearthed-1118032274/.

simultaneously.'[19] Speaking of the Three Fathers of Cinema (Edison, Flaubert and Beethoven), Walter Murch mentions his involvement in the restoration and synchronisation of an Edison and William Dickson recording dating back to 1894. Possibly the first ever film with sound, Dickson, an Edison employee, is shown playing violin.[20] This predates the 1907 invention of the Audion valve by DeForest that had the ability to play synchronous film sound for a large audience.

Synchronised sound: Changing the audience experience

As studios began earning sufficient funds from silent films, the risk in backing unknown technologies was not a priority. Although Western Electrical developed a successful synchronised turntable and film projector in 1925, it would be another two years before the success of this development was to be truly recognised. Rebranded as Vitasound, the system from Western Electrical was signed exclusively to Warner Bros. and in 1926 the first Vitasound film, *Don Juan*, was released. The soundtrack consisted of both music and limited synchronised sound effects. This release signified the beginning of the synchronous sound revolution, as not only did the technology work; it also gave audiences an additional new interest. Synchronous sound also provided stabilisation to the projector speed, and allowed cinema to be an art of time. As Chion states, 'filmic time was no longer a flexible value, more or less transposable depending on the rhythm of projection.'[21]

Although other studios began to change to synchronous film sound technologies, including Fox with Tri-Ergon and Movietone, they all had one commonality; they all only had music as the sound component. Again a Warners Vitasound release, the next significant breakthrough in the sound technology evolution took place the following year. Crosland's *The Jazz Singer*, is regarded as the first film to be produced with a synchronous film soundtrack that contained elements of music and more significantly, synchronised dialogue. This signaled the beginning of the sound movies as it presented an audience with a narrative sound that differed from the original theatre sound. Audiences experienced the first completed soundtracks the following year with another Warner Bros. Vitasound film

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[19] Dion Hanson, "The History of Sound in the Cinema," *Cinema Technology Magazine*, August 1998, 8.
[20] Murch, "The Three Fathers of Cinema with Walter Murch," interview by William Kallay, Web Interview.
[21] Chion, *Audio-Vision*, 1994, 16.

The Lights of New York (1928)[22] and the Disney created animated short, *Steamboat Willie* (1928).[23] Significantly these films combined dialogue, music and sound effects to create a story through the soundtrack. The introduction of synchronised cinema sound technology was changing the way an audience experienced a film.

Sound on film: Synchronisation between image and sound

Sound on film was born in 1929 with Movietone. The movietone format enabled an optical soundtrack to be contained within the same film print alongside the frames of images. This provided an enormous advantage over previous systems, as there was no longer a need to synchronise two separate replay hardware devices, one being the image on film and the other, sound on disc. Having both the optical soundtrack and images within the same piece of film could eliminate many mechanical errors.

Although this leap in technology is significant, in 1929 the convention of having a speaker located within the orchestral pit ended. Instead, the sound was now delivered entirely from behind the screen. This change in sound replay represents many of the underlying issues for this thesis. Primarily it demonstrates the desire by filmmakers to maintain the connection between the image and sound, relative to the narrative and what is unfolding onscreen. Altman notes:

> Whereas 1926 sound practice recognised the pit orchestra as the source of all music (typically thought of as accompaniment), the many musical films of the 1927-29 period increasingly locate the source of music on the screen. As revealed in a 1929 Western Electric ad this new standard is recognised in theatres by henceforth placing both speakers behind the screen, so that all sound can once again be identified with the activity presented on that screen.[24]

The relocation in speaker placement signifies an acknowledgement that the cinema was becoming its own entertainment medium, and not merely a replication of the theatre. Sound was embraced, and its contribution to the film medium was realised. In 1930 the Academy of Motion Picture Arts and Sciences began recognising sound professionals for

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[22] Murray Roth and Hugh Herbert, *Lights of New York*, directed by Bryan Foy, (Burbank, CA: Warner Bros., 1928).
[23] Disney, Walt and Ub Iwerks, *Steamboat Willie*, directed by Walt Disney and Ub Iwerks (USA: Celebrity Productions, 1928).
[24] Altman, "The Sound of Sound," 68.

their work, with Douglas Shearer the first person to win an Oscar for sound for *The Big House* (1930).[25]

The developments for sound on film identify the importance of establishing an effective sound and image relationship. Embedding the soundtrack onto the filmstrip allowed for precise synchronisation, filling the gap of previous synchronised sound formats, and improving the audience experience.

The birth of early surround sound: Increasing audio channels

Bell Labs were recording two separate tracks onto disk in 1928 with separate high and low frequencies on each track, not full band individual audio recordings. From as early as 1931, the desire to increase the single monaural audio format to a sound format of multiple channels was becoming apparent. Experiments in the production of a stereo soundtrack by Alan Blumlein used a twin microphone technique that was capable of recording a stereo signal within the same space occupied by the existing monaural optical track. It took until 1932 before Bell Labs produced an example of true stereo as we know it today, with two discrete full band audio channels.[26]

Building on from the limitation of the two-channel stereo system, further experimentation into increased speaker channels was conducted by Disney and RCA. Their own proprietary multichannel audio format, Fantasound, exceeded all previous sound systems. This early development of multichannel sound was one of the first experiments into surround sound. Introduced with Disney's 1940 release of *Fantasia* (1940),[27] multichannel sound was showcased to the public for the first time. Fantasound was a manual system that required an operator to perform in real-time the pan and fade cues. The format utilised the optical audio strip on the film as a gain control track for an additional three optical audio tracks running in synchronisation on a second filmstrip. Although accomplishing the task of providing a multichannel surround solution, it was impractical and never appeared beyond a few select venues screening *Fantasia*.

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[25] Frances Marion, *The Big House*, directed by George W. Hill (USA: Metro-Goldwyn-Mayer, 1930).
[26] Kerins, *Beyond Dolby (Stereo)*, 34.
[27] James Algar et al., *Fantasia* Directed by James Algar et al., (Burbank, CA: Walt Disney Productions, 1940).

Klapholz acknowledges the advancement of Fantasound, describing it 'technically as advanced today as the current Dolby cinema format. The innovations by RCA and Disney with Stokowski as a catalyst attest to the fusion of art, technology, and imagination.'[28] The technology used in the creation of *Fantasia* and the Fantasound system provided many innovations and developments for recording, production and playback of cinema sound. It became a precursor to some of the modern day cinema sound systems including stereo and surround sound, and also introduced various techniques including multitrack recording, overdubbing of orchestral parts, close miking for orchestras, the use of the Click-Track and the introduction of the pan-pot.

Magnetic sound and Cinerama

Magnetic audio recording and playback was non-existent within the United States until the magnetic format being used by Germany was introduced into the United States after World War II and adapted to filmmaking. The magnetic soundtrack offered a far better frequency response and dynamic range to that of the optical soundtrack, and by 1952 had been adopted by film. Similar to the discovery of the Nazi 3-D films mentioned earlier, the Germans were again at the forefront of technology, albeit unknown to the rest of the world at the time.

Introduced in 1952 with *This is Cinerama* (1952),[29] Cinerama carried seven channels of sound on a magnetic filmstrip synchronised to three 35mm film projectors for the vision. The image of Cinerama was projected across three screens, wide enough to cover the audience's peripheral vision (Figure 4, page 38). The format contained the added quality of a superior sounding soundtrack that 'surrounded' the audience; a huge development in early surround sound. It had a frequency response of 50Hz to 15Khz. With *This is Cinerama* receiving positive feedback on the stereophonic sound, other films were also dubbed into stereo. 'First introduced in Cinerama's early Fifties travelogue extravaganzas, cinema stereo was given the double task of meeting the needs both of fidelity (accurate spatialisation) and of spectacle (rapid, energetic movement).'[30]

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[28] Jesse Klapholz, "Fantasia: Innovations in Sound," *Journal of the Audio Engineering Society* 39, no. 1/2 (February 1, 1991): 70.
[29] Merian C. Cooper and Gunther von Fritsch, *This Is Cinerama*, directed by Merian C. Cooper and Gunther von Fritsch (USA: Cinerama Releasing Corporation, 1952).
[30] Altman, "The Sound of Sound." 68.

A premium experience for audiences, this format carried with it an increase in ticket prices. For this exclusivity, it provided a taste of what high quality film was capable of. The practice of charging for a premium experience continues to this day with 3-D films.

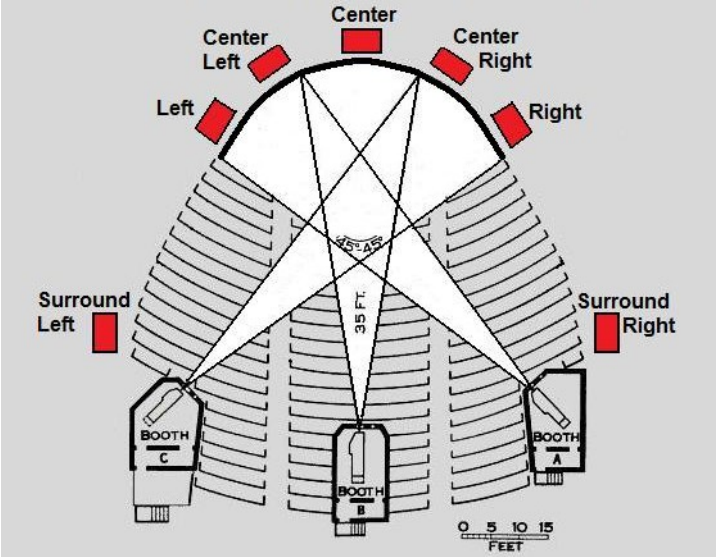

Figure 4: Cinerama Seven-Channel Speaker Layout.[31]

The birth of colour and surround sound 3-D feature films

In 1952, the first full colour feature length 3-D film was released. Independently produced, *Bwana Devil* (1952)[32] had its 3-D world premiere in Hollywood. The film used NaturalVision, a polarised 3-D system that had two projectors mechanically locked with each producing a left and right image that complemented the polarised glasses of the audience; however it only had a mono soundtrack. Proving to be a box office sensation, the film inspired the major studios to consider and experiment with 3-D widescreen films. 'The race was on and RCA demonstrated a new widescreen to exhibitors on March 24, 1953. The new era of screen dimensions had begun.'[33]

In 1953 Warners introduced WarnerPhonic four-channel surround sound to 3-D with the premiere of De Toth's *House of Wax* (1953).[34] It had a separate 35mm magnetic film

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[31] Image from k3dav.com, accessed June 27, 2014. http://www.k3dav.com/cinerama.htm.
[32] Arch Oboler, *Bwana Devil*, directed by Arch Oboler (Beverly Hills, CA: United Artists, 1952).
[33] Bob Furmanek, "The New Era of Screen Dimensions," *3D Film Archive*, 2013, accessed November 17, 2013. http://www.3dfilmarchive.com/home/widescreen-documentation.
[34] Charles Belden and Crane Wilbur, *House of Wax* directed by André De Toth (Burbank, CA: Warner Bros., 1953).

containing the left, centre and right channels and was synchronised to the optical track on the release print that contained a channel for the surround sound in the auditorium. With limited audience exposure to stereophonic cinema sound with *Fantasia* and *This is Cinerama*, *House of Wax* was the first film that most people experienced and heard true stereophonic reproduction. As Furmanek describes, *House of Wax* provided a realistic and immersive experience for the audience:

> With fully directional sound, and sound effects that emanated from the sides and rear of the auditorium (during the fire in the wax museum, for instance) it helped to immerse the viewer in the action, adding an important element to the superb realism of the three-dimensional photography. *The Hollywood Reporter* noted: "The result has a kind of spellbinding effect on the audience, giving a feeling of realism to a completely unreal story as well as a sense of participation." As an example of the important role of sound in this presentation, the New York Paramount installed 25 speakers throughout the huge auditorium.[35]

Released over a decade after Fantasound, the Warnerphonic format provided a simpler method of providing a higher quality surround soundtrack to larger audience numbers.

Widescreen 2-D challenges 3-D

In 1953, Henry Koster's *The Robe* (1953)[36] was released by Twentieth Century Fox in the CinemaScope format. CinemaScope was promoted aggressively by Fox right at the outset of the Hollywood 3-D movie boom as a viable option to 3-D.[37] This was an anamorphic system with the image squeezed to allow room for a four-track magnetic sound strip on the same filmstrip as the vision. The application of magnetic oxide strips to motion picture film won the company Reeves Soundcraft a technical Oscar for their process. When projected, the image would be expanded back up to size using a specialised anamorphic lens. The first CinemaScope release was similar to NaturalVision as it also had left, centre and right screen channels and a surround channel. Because of the magnetic strip, there was no additional room for an optical soundtrack, limiting the compatibility of the format. Due to growing competition and the need for greater compatibility with older optical

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[35] Furmanek, "The New Era of Screen Dimensions."
[36] Philip Dunne and Gina Kaus, *The Robe,* directed by Henry Koster, (Century City, CA: Twentieth Century Fox Film Corporation, 1953).
[37] Ray Zone, *3-D Revolution: The History of Modern Stereoscopic Cinema* (Lexington, KY: University Press of Kentucky, 2012), 72.

playback, the size of the CinemaScope image was reduced further to provide enough room for the omitted mono optical soundtrack.

In 1954 and lasting for around four years, MGM had adopted the three screen channel optical Perspecta system. The Perspecta system offered an enhanced system that could be played in theatres without magnetic playback. Although a mono system, Perspecta was unique by including an inaudible low frequency tone that was used as an automated switch. This enabled the system to switch the sound to the three screen speakers individually or simultaneously. Being inaudible also meant that the mono optical track remained compatible with older and non-Perspecta sound systems.

As an original Cinerama investor, Mike Todd closely mimicked this system as a six-channel format. Its first incarnation for the first Todd-AO production *Oklahoma!* (1955),[38] used a 35mm magnetic film running in synchronisation with the 70mm release print. The format was later modified to allow the six-track sound to be incorporated onto the 70mm release print. This system utilised five speakers across the width of the screen (CinemaScope had three) with the sixth channel used for surround sound. Although used intermittently to highlight visual effects, as Altman points out, the 'surround sound worked directly against the ideal of spatial fidelity applied to the three directional front speakers.'[39]

Dialogue was seldom panned across the front speakers, with MGM, Warners, Columbia and Universal only having the dialogue in mono in the centre channel, reserving the other front channels for music and sound effects. The surround channels were also seldom used. Many of these traditions continue to this day in contemporary film sound mixing. This is further elaborated on throughout this thesis. Altman proposes that screen technicians were not content with the relationship between the screen image and the behind-the-screen sound, suggesting they wanted to enhance the spatial correspondence between cinema sound and image.[40] My line of enquiry follows this same notion, but to a larger extent with 3-D due to the imagery no longer merely sitting on a single plane.

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[38] Sonya Levien and William Ludwig, *Oklahoma!,* directed by Fred Zinnemann (USA: Magna Theatre Corporation, 1955).
[39] Altman, "The Sound of Sound." 68.
[40] Ibid.

With what played out as a format war, many multichannel systems were invented and only saw market shares for small bursts. Economics, inconsistent formats and the introduction of television saw ticket sales at the cinema decrease. Cinemas were unable to justify updating to new technologies, and in many instances not even maintaining their current sound systems. It was not until the 1970s that a new standardised film sound format was utilised across all of the various film studios.

Dolby expands into film sound

Originally working with noise reduction technology in the music industry, Dolby began to explore the possibility of high-quality optical stereo sound on film. Introduced in 1971, the Dolby noise reduction system was the catalyst for continued technological developments. 'This element of continuous change has been characterised by a remarkable ability to identify new markets and possibilities.'[41]

Released in 1975, Ken Russell's *Tommy* (1975)[42] employed a Dolby soundtrack that achieved five-channel stereo sound within a conventional 35mm film. It was the first film released using matrix encoding technology, making this development significant. The five channels were encoded within three channels on the print. When decoded, track one provided the left front and left rear channels, channel two provided the centre channel, and channel 3 provided the right front and right rear channels. Chion acknowledges the contribution made by Dolby, giving films 'a wide sound strip and a substantial number of tracks, permitting one to hear well-defined noises simultaneous with dialogue.'[43] Chion states by doing this, 'noises have a living corporeal identity rather than merely exist as stereotypes.'[44]

The use of matrix encoding was the beginning of Dolby's establishment within the film sound world. Although *Lisztomania* (1975)[45] was the first Dolby Stereo release, it was the

[41] Gianluca Sergi, *The Dolby Era: Film Sound in Contemporary Hollywood*, illustrated edition (Manchester: Manchester University Press, 2005), 181.
[42] Pete Townshend, *Tommy*, directed by Ken Russell (Culver City, CA: Columbia Pictures, 1975).
[43] Michel Chion, *Audio-Vision*, trans. Claudia Gorbman (Columbia University Press, 1994), 147.
[44] Ibid.
[45] Ken Russell, *Lisztomania,* directed by Ken Russell (Burbank, CA: Warner Bros., 1975).

following year with *A Star is Born* (1976)[46] that Dolby debuted their four-channel matrix system. Stereo matrix encoded a separate left, centre, right and surround channel on only two tracks. The major advantage of the technology was that the optical track was in the same position on the 35mm print as previous mono optical tracks, making it also compatible with older mono theatres. Released as the surround sound format for *Star Wars* (1977)[47] and *Close Encounters of the Third Kind* (1977),[48] it was this method of four-track stereo matrix encoding, the creation of Dolby Stereo, that made Dolby famous for film sound.

Dolby demonstrated 70mm magnetic film sound technologies worldwide with the release of *Apocalypse Now* (1979).[49] The technology included noise reduction and also incorporating a sub bass frequency track. The domination of the Dolby surround technologies gave sound professionals faith in using all speakers. As Altman explains:

> The sound designers of the post-*Star Wars* era regularly placed spatially faithful narrative information in the surround channel. Recalling the 3-D craze in the mid-Fifties, for a few years every menace, every attack, every emotional scene seemed to begin or end behind the spectators. Finally, it seemed, the surround channel had become an integral part of the film's fundamental narrative fibre.'[50]

After several years of experimentation with the surround channels, film sound practitioners recognised that cinemas did not have consistent quality control over the cinema surround speakers. In response, the industry changed its way of working during the early 1980s and began to mix sound, sacrificing spatiality for narrative clarity. This would mean that all sound related to the narrative would be played through the front speakers, with only spectacle sound coming from the surround speakers. This trend is a similar repeat of the 1950s with several formats placing sounds around the audience and with the Todd-AO format bringing the narrative focus back to the front of screen, ensuring that the sound does not become a feature in itself.

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[46] Frank Pierson, William A. Wellman, Robert Carson, John Gregory Dunne and Joan Didion, *A Star Is Born,* directed by Frank Pierson (Burbank, CA: Warner Bros., 1976).
[47] George Lucas, *Star Wars,* directed by George Lucas (Century City, CA: Twentieth Century Fox Film Corporation, 1977).
[48] Steven Spielberg, *Close Encounters of the Third Kind,* directed by Steven Spielberg (Culver City, CA: Columbia Pictures, 1977).
[49] John Milius and Francis Ford Coppola, *Apocalypse Now*, directed by Francis Ford Coppola (Hollywood, CA: Paramount Pictures, 1979).
[50] Altman, "The Sound of Sound." 68.

It was almost another 10 years before Dolby released Dolby SR, their next incarnation of 35 mm film sound technology. Dolby SR offered greater dynamic range to the soundtrack by reducing noise. Dolby SR is sometimes referred to as a signal processing system rather than just a noise reduction system. In 1987 both *RoboCop* (1987)[51] and *Innerspace* (1987)[52] were the first Dolby SR releases. The Dolby SR System remained in existence until it was replaced by digital technologies.

Although not technically a Cinema sound format, it would be remiss not to include THX in the history of cinematic sound. It was for the release of *Star Wars: Episode V - The Empire Strikes Back* (1980)[53] that George Lucas commissioned Tomlinson Holman to design the mixing facilities at Skywalker Ranch. Lucas wanted to ensure the highest level of sound quality from set to screen. Debuting with *Star Wars: Episode VI Return of the Jedi* (1983),[54] THX established standards and certification for high-quality cinema sound. Theatres with inconsistent film playback quality prompted this. THX also provided additional advantages in the creation and exhibition of the soundtrack including extending the frequency and dynamic range, allowing the soundtrack to provide a more immersive experience. The advantage of THX meant that the standards and quality control could be set and applied to both analogue and digital formats.

The analogue sound era established many film production methodologies that continue in digital sound production, including the placement of the dialogue in the centre channel. Developments of surround sound including Fantasound and WarnerPhonic in the 1940s-50s and Dolby SR in the mid to late 1980s have provided significant advancements towards creating a high quality soundtrack.

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[51] Edward Neumeier and Michael Miner*, RoboCop*, directed by Paul Verhoeven (Los Angeles, CA: Orion Pictures, 1987).
[52] Jeffrey Boam and Chip Proser, *Innerspace,* directed by Joe Dante (Burbank, CA: Warner Bros., 1987).
[53] Leigh Brackett and Lawrence Kasdan, *Star Wars: Episode V - The Empire Strikes Back*, directed by Irvin Kershner (Century City, CA 20th Century Fox, 1980).
[54] Lawrence Kasdan and George Lucas *Star Wars: Episode VI - Return of the Jedi*, direcetd by Richard Marquand (Century City,CA: Twentieth Century Fox Film Corporation, 1983).

Digital sound: Establishing format standards

During 1987, the Society of Motion Picture and Television Engineers (SMPTE) created technical specifications in an attempt to standardise theatrical digital surround sound. The SMPTE specified discrete channel sound without the use of matrixing. The specification included at least three front channels across the width of the screen and at least two surround channels with a discrete channel for low-frequency effects (LFE). The configuration of three screen channels, two surround channels plus the LFE channel is known as 5.1.

Digital sound in the cinema first appeared in the 1990 release of *Dick Tracy* (1990).[55] Released in the CDS (Cinema Digital Sound) format developed by Kodak and ORC (Optical Radiation Corporation), it had inherent problems. The optical track was replaced by a magnetic track, making the digital sound format incompatible with unequipped cinemas. Two years later Dolby debuted their digital technology with the Warner Brothers *Batman Returns* (1992).[56] Dolby Digital utilised the space between the sprocket holes, allowing their digital optical soundtrack to be carried in addition to the existing optical track on the 70mm print.

The following year, Universal Pictures released the Steven Spielberg directed *Jurassic Park* (1993)[57] in the Digital Theatre Systems (DTS) format. The DTS Soundtrack differed from other digital soundtracks inasmuch as it was carried on a separate CD-ROM, similar to the early Vitasound system. This disk was synchronised to the film print and required specific DTS decoders. The DTS Soundtrack didn't interfere with the existing film print, allowing alternative sound formats to be used if the cinema wasn't equipped with DTS.

Also in 1993 Sony debuted its Sony Dynamic Digital Sound (SDDS) with the release of *Last Action Hero* (1993).[58] Dolby Digital and DTS were 5.1 formats, with Sony's SDDS offering

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[55] Jim Cash, Jack Epps, Jr. and Chester Gould, *Dick Tracy*, directed by Warren Beatty (Burbank, CA: Buena Vista Pictures Distribution, 1990).
[56] Bob Kane and Daniel Waters, *Batman Returns*, directed by Tim Burton (Burbank, CA: Warner Bros., 1992).
[57] Michael Crichton, *Jurassic Park*, directed by Steven Spielberg (Universal City, CA: Universal Picture, 1993).
[58] Zak Penn and Adam Leff, *Last Action Hero*, directed by John McTiernan (Culver City, CA: Columbia Pictures, 1993).

an additional two channels designated as inner left and inner right screen channels. Like Dolby Digital, SDDS was also stored on the 70 mm filmstrip, printed down both sides.

Dolby, the masters of matrixed sound, exploited the Dolby Digital 5.1 format to accommodate an additional centre surround channel. *Star Wars Episode 1: The Phantom Menace* (1999)[59] was the first film released in the Dolby Surround EX format. Also in 1999 DTS debuted its 6.1 channel format, DTS-ES, with the release of *The Haunting* (1999).[60] Although not a matrix format, the original DTS codec allowed expansion to 6.1 channels with this extra channel used as a centre surround. In 2008 DTS abandoned pursuing cinema sound as the company was divested to form DTS Digital Cinema.[61]

With continued improvements on 1980s cinema sound, digital sound is providing renewed confidence to sound practitioners. Multichannel sound has opened up many possibilities for creative sound design and it provides an audience with greater aural satisfaction. Having the flexibility to pan a sound around the auditorium, or having an orchestral score fill an auditorium so the audience feels surrounded by musicians has seen surround sound embraced by all. Sound has become an integral component of filmmaking. Sergi echoes this:

> The audience's powerful sensual involvement with this three-dimensional sonic space is clearly designed to fulfil their high aural expectations, to heighten the cinematic experience and to provide audiences with a constant source of pleasure. The contemporary Hollywood aural experience elevates the spectator to a state, which we may define as that of a super-listener, a being (not to be found in nature) able to hear sounds that in reality would not be audible or would sound substantially duller.[62]

Digital sound technologies preceded digital film. The digital sound formats were embedded into the analogue filmstrip or in the case of DTS, a physical disc that was

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[59] George Lucas, *Star Wars: Episode I - The Phantom Menace*, directed by George Lucas (Century City, CA: Twentieth Century Fox Film Corporation, 1999).
[60] David Self and Shirley Jackson, *The Haunting*, directed by Jan de Bont, (Universal City, CA: Dreamworks Distribution, 1999).
[61] Michael Karagosian, "The Challenge of Immersive Sound," *Digital Cinema Report*, September 17, 2013, accessed November 13, 2013, http://www.digitalcinemareport.com/article/challenge-immersive-sound#.UoNRyY3lw8G.
[62] Sergi, "The Sonic Playground: Hollywood Cinema and Its Listeners," 125.

synchronised to the analogue film. The analogue release print posed several limitation for sound technologies as there was no room for any further formats to exist.

Digital film: Digital 3-D and the Digital Cinema Package

Within the first two years of writing this thesis (2011-2013), the industry has transformed film release formats, going from analogue film projection to digital data projection. Analogue film releases have now become obsolete in contemporary film production. In 2011, Panavision and Aaton announced they would cease production of 35mm motion picture cameras as digital cinematography, a complete digital workflow and 3-D pushed analogue obsolescence.[63] On April 19, 2013, Australia closed its last film-processing facility, Deluxe Film Laboratories, with New Zealand closing its last film-processing facility, Park Road Film Laboratory in June 2013.[64, 65]

The transition to digital film no longer restricts formats to 'what can fit' on the physical film medium. Digital film exists as a file format known as the digital cinema package (DCP). Although having strict guidelines, the original DCP specification allowed for up to 16 independent channels of uncompressed PCM audio.[66] In March 2014, the Society of Motion Picture and Television Engineers (SMPTE) expanded the standard to allow additional immersive audio formats.[67]

James Cameron's 3-D blockbuster *Avatar* was theatrically released with a conventional Dolby Digital 5.1 soundtrack, and in the following year a change in sound for 3-D began to take place with the release of *Toy Story 3* (2010)[68] in Dolby Surround 7.1. Increasing the speaker channels from six (5.1) to eight (7.1), Dolby Surround 7.1 offers both the creators and the audience an increase of an additional two surround channels. The additional

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[63] David Bordwell, *Pandora's Digital Box: Films, Files, and the Future of Movies*, 2012, 33.
[64] Ron Johanson, "A Letter to the Minister for the Arts - Australian Cinematographers Society," May 4, 2013, accessed August 9, 2013. http://www.cinematographer.org.au/cms/page.asp?ID=20924.
[65] Kevin Riley, "The Last Lab in NZ to Close. | NZCS," March 27, 2013, accessed August 9, 2013. http://www.nzcine.com/index.php/archives/3422.
[66] Pulse code modulation (PCM) is an uncompressed audio format.
[67] Society of Motion Picture and Television Engineers®, *Report of the Study Group on Immersive Audio Systems: Cinema B-Chain and Distribution*, March 31, 2014, 6, http://survey.constantcontact.com/survey/a07e95c4mughtlrzbx7/a022dai6xc2djg/questions.
[68] John Lasseter and Andrew Stanton, *Toy Story 3*, directed by Lee Unkrich (Burbank, CA: Walt Disney Picture, 2010).

channels divides the side walls from the rear walls; increasing the surround channels allows for greater directionality and movement of sound from the front of screen to the side walls and to the rear of the cinema. The 7.1 surround format: Left, Centre, Right, Left Surround, Right Surround, Left Back, and Right Back channels, plus an LFE channel. The difference between 5.1 and 7.1 is illustrated in Figure 5.

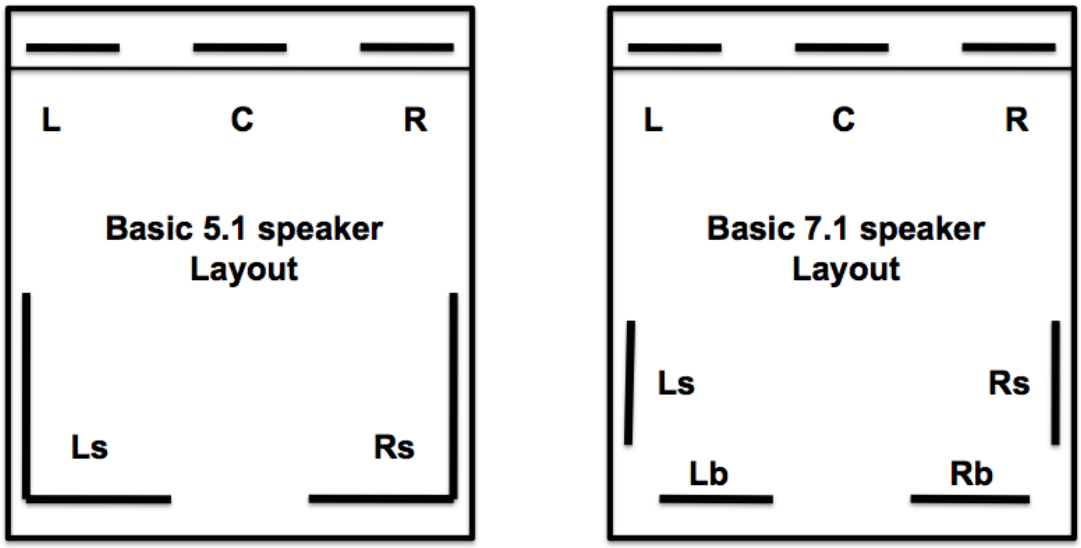

Figure 5: Speaker layouts for 5.1 and 7.1 formats

The founder of THX, Thomlinson Holman has been an advocate for a 10.2 surround system. Holman argues that 10.2 is the next logical step in the progression towards better spatial reproduction. Although adding an additional 2 surround channels to the 5.1 format, Holman also recommends the addition of 2 ceiling channels, a rear centre surround channel, and a second LFE channel. The additional LFE channel allows the two LFE channels to be separated between the left and right hand sides of the screen, resulting in enhanced spaciousness of the lower frequencies.[69] To date, Holman's 10.2 format is yet to be adopted by industry with alternative immersive formats gaining momentum in the last couple of years.

Moving to digital film has come an opportunity to find the most efficient way to store as much data as possible within the confines of the medium. Since digital cinema was introduced, the resolution of the cinema projection has doubled, increasing from 2K (2048 x 1080) pixels of resolution to 4K (4096×2160) and we have also seen the frame rate of

[69] Scott Wilkinson, *Surround Sound with Tomlinson Holman*, MP3, Home Theater Geeks, accessed June 12, 2013. http://twit.tv/show/home-theater-geeks/1.

the images for certain films double. *The Hobbit: An Unexpected Journey* (2012)[70] was the first 3-D release to be filmed and projected at 48 frames per second (HFR).[71]

Immersive sound: Expanding opportunities

Two years since the introduction of the 7.1 speaker format, Dolby in early 2012 again offered an update to its technology with the release of Dolby Atmos. Jackson's *The Hobbit: The Desolation of Smaug,*[72] in addition to HFR visuals, had a Dolby Atmos release.[73] *The Hobbit* is examined as a case study in the second part of Chapter 4 (page 131). In a statement to the Hollywood Reporter, Peter Jackson commented about the Dolby Atmos release of *The Desolation of Smaug:*

> I strive to make movies that allow the audience to participate in the events onscreen, rather than just watch them unfold. Wonderful technology is now available to support this goal: high frame rates, 3-D, and now the stunning Dolby Atmos system.[74]

Dolby Atmos provides a new sound exhibition format for 3-D as it allows a 9.1 bed plus up to 118 audio objects outputting to 64 speaker channels. Dolby Atmos uses a model known as 'object-based' panning, as individual objects within the soundtrack can be isolated and independently positioned around the cinema, including overhead in the ceiling with far greater directional accuracy than previous surround systems. *Making a Reality a Reality*, quotes Dolby Senior Vice President Ioan Allen stating that 'each of our improvements over the years has been another link in that chain to make movies sound right. I would say with Atmos, we're close to perfection.'[75]

Dolby Atmos draws upon working methodologies used in both 5.1 and 7.1 surround sound. The format is a hybrid between 'object based' sound and the traditional sound beds. The

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[70] Peter Jackson, *The Hobbit: An Unexpected Journey*, directed by Peter Jackson (Burbank, CA: Warner Bros., 2012).
[71] High frame rate (HFR) is defined in Terminology (page xv)
[72] *The Hobbit: The Desolation of Smaug* will now be referred to as *The Desolation of Smaug.*
[73] HFR- High Frame Rate (48 frames per second)
[74] Carolyn Giardina, "'The Hobbit' to Receive Dolby Atmos Sound Mix," *The Hollywood Reporter*, October 24, 2012, accessed April 16, 2013. http://www.hollywoodreporter.com/news/hobbit-receive-dolby-atmos-sound-382197.
[75] Amy Nicholson, "Making a Reality a Reality," *Boxoffice* 148, no. 7 (July 2012): 29–30, 32.

traditional sound systems use mixed sound beds where all panning has been committed during the mixing phase of production, with no panning calculated during exhibition. The 'object based sounds' in Dolby Atmos, however, contain meta-data that is used to calculate the panning during exhibition based on each individual cinema configuration. Dolby Atmos provides the traditional cinema sound model with the ability to pan additional individual elements. Two case studies are included in this thesis in Chapter 4, describing the format in great detail.

In August 2013, Australia's first Dolby Atmos equipped film sound mixing stage was installed at the largest independent post-production company, Soundfirm, at their Melbourne facility. *Film Journal International* states 'that the facility has been designed from the ground up with the latest tools, technology and equipment to support the needs of the content creation industry as they aim to create immersive audio experiences for moviegoers with the help of Dolby Atmos technology.'[76] This coincides with Reading Entertainment installing the first ever Australian Dolby Atmos cinema at Waurn Ponds. Marvel's *Thor: The Dark World* (2013)[77] was the first film exhibited in Dolby Atmos in Australia.

Although Dolby Atmos has a strong foothold in immersive cinema sound, Auro Technologies have partnered with Barco, a name synonymous with cinema projection, to provide an alternative immersive sound format. In either an 11.1 or 13.1 configuration, the Auro 3-D concept is not object-based, instead building upon the traditional 5.1 format with an additional height and an additional ceiling layer, providing a three-tiered format.

Failing to gain any traction in Hollywood, one of the first cinema sound systems declaring technology to produce a true 3-D sound solution was IOSONO. Acquired by Barco Auro in 2014, the IOSONO system is entirely object-based and differs considerably from Dolby Atmos, Auro and other conventional surround formats. Significantly, IOSONO 3D uses wave field synthesis (WFS) technology to create virtual wave fronts that enable the

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[76] Film Journal International, "Reading Entertainment Adds Dolby Atmos at Geelong Cinema," *Film Journal International*, accessed November 17, 2013, http://www.filmjournal.com/filmjournal/content_display/news-and-features/news/technology-and-new-products/e3id38e6d8809d7a6dcf4de41207b5d4c41.
[77] Christopher Yost and Christopher Markus, *Thor: The Dark World*, directed by Alan Taylor (Burbank, CA: Walt Disney Studios Motion Pictures, 2013).

localisation of virtual sound sources regardless of the listener's position. IOSONO uses many speakers spread equidistant across a horizontal plane around the perimeter of the cinema, creating a 360˚ array (Figure 6). Having experienced the format, John Neill, Head of Sound at Park Road Post Production, praised it, although he was concerned about the practicality of the system.

> IOSONO sounded amazing, however it is completely impractical due to both the cost and aesthetically, as it needs SO many speakers around the perimeter of the walls. This is a great system because it uses wave field synthesis allowing a sound to appear around each audience member. In order to keep the cost down the speaker numbers can be reduced, however it then tends to make the wave field synthesis not work anywhere near as well. This then compromises the sound. Aesthetics are important also - especially at Park Road.[78]

Figure 6: IOSONO Sound installation Todd-AO, Burbank, USA[79]

It is apparent when comparing emerging immersive cinema sound technologies that all formats require an increased number of speakers and audio channels (Figure 7).

Company	System	Channels
Dolby	5.1	5 + 1 LFE
	7.1	7 + 1 LFE
	ATMOS	64 (including LFE)
Barco	Auro 3-D 11.1 / 13.1	11 or 13 + 1 LFE
IOSONO	IOSONO 3D sound	308 + 5 LFE

Figure 7: Current surround sound formats

[78] John Neill, Personal Interview: 3-D Sound Discussion. Head of Sound, Park Road Postproduction, NZ, August 1, 2013.
[79] Image courtesy of IOSONO.

What is industry doing to address sound for 3-D?

At the time of writing there is debate from within industry as to how best to approach sound for 3-D. This is further complicated with sound for 3-D films and 3-D sound not being the same, as discussed in throughout this thesis. Industry is not so much concentrating on 'sound for 3-D film,' but rather creating 'immersive 3-D sound.' A format war between the Auro format and the Dolby Atmos format has developed and cinema managers have expressed concerns of backing the wrong sound format, as this has financial implications.[80] This is discussed in great detail in Chapter 5.

In 2013 Barco, Auro Technologies and audio technology developer DTS made the announcement that they would join forces to support an open standard for immersive object-based cinema sound, recommending DTS' object-based MDA (Multi Dimensional Audio) as their preferred format (Figure 8, page 52). The MDA Group's immersive-surround proposal is an uncompressed PCM sound format based on Multi-Dimensional Audio that derives from research initiated at SRS Labs and refined by DTS. The Digital Cinema Initiative understands the pressure on cinema managers, whilst also wanting to standardise 'object-based immersive sound.' A joint venture of Disney, Fox, Paramount, Sony Pictures, Universal and Warner Bros. motion-picture studios, Digital Cinema Initiative is seeking support from the Society of Motion Picture and Television Engineers to create an open-standard immersive surround sound format. The proposal puts forward a standard that uses object based panning within a space and not sounds derived from speaker channels. The reason for this is that it doesn't matter what format the film is mixed in or what format the cinema has installed; the open format algorithms will allow the sound data to be decoded and adopted by whatever system is installed within the cinema, thus translating the position of a sound and not tying the sound to a specific channel.[81]

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[80] Due to interviewees wishing to remain anonymous, these discussions have taken place through personal communication with cinema managers.
[81] Mel Lambert, "Toward An Open-Standard Surround-Sound Format," *MPEG*, March 11, 2014, accessed March 24, 2013. https://www.editorsguild.com/FromtheGuild.cfm?FromTheGuildid=454.

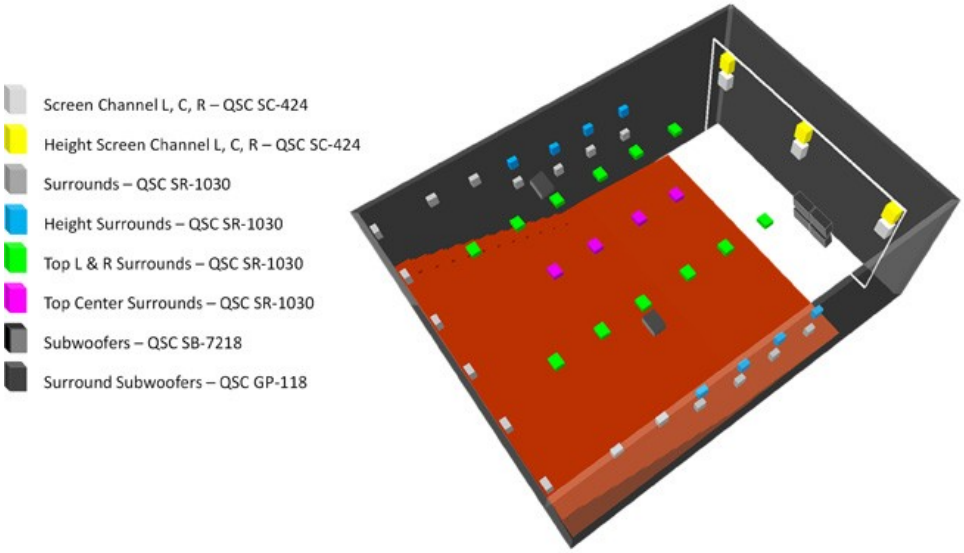

Figure 8: Immersive sound configuration in Theatre 8 at AMC 16, Burbank[82]

Conclusion

This chapter has provided an overview of the initial introduction of sound on film, the introduction of 3-D film, the evolution from analogue to digital technologies and digital 3-D. A consistent trend along the timeline confirms that audiences have been given more with each development. Evolving from early analogue film-based cinema to the contemporary digital cinemas, many of the concepts and ideals continue today. Several developments have provided the foundational platforms for cinema from past, present, and into the future including: the introduction of Synchronised Sound (1927); Fantasound (1940); and Cinerama (1952).[83] In recent years film has evolved from a physical medium (that is, an actual roll of film), to a virtual digital product.

Transitioning to digital cinema, technologies and working methodologies of both the visual and sound disciplines are continually evolving in terms of the creation and exhibition of content. This includes greater increases in frequency range, dynamic range, definition within the soundtrack due to more included sounds, frame rates and image

[82] Image from Motion Picture Editors Guild, accessed March 24, 2014. https://www.editorsguild.com/FromtheGuild.cfm?FromTheGuildid=454
[83] In the early 1930s, Technicolor introduced a new system involving prisms to split the light coming through the camera lens onto three strips of black-and white film, one for each primary colour Bordwell and Thompson, *Film History*, 221.

resolution. The contemporary 3-D film with immersive sound is the pinnacle of this pursuit.

Throughout the evolution, there has never been a perfect film format. Although new emerging technologies are claiming to be the best, my question remains, 'Are they perfect, or is there room for improvement?' Chion suggests that in ten or twenty years, what seems like perfected digital recordings now will obviously be coloured by the technical process.[84] Chion made this claim twenty years ago, and he predicted accurately. In another twenty years this statement is likely to continue to hold true. Throughout this thesis I investigate this notion in more detail, arguing that although technology is making imagery and sound better, it continues to fail at delivering a homogenous 3-D audio-visual experience. To better understand this, language is needed to articulate the intricacies of the relationship between image and sound, and their use of the cinematic space. This is covered in the following chapter.

[84] Chion, *Audio-Vision*, 1994, 103.

Chapter 3: Soundtrack Language and Space

Introduction

In the previous chapter I discussed the developments of film image and sound technologies. Typically the sound and image are treated as individual elements throughout the film production pipeline. My research questions the effectiveness of their homogeneity when combined in the final exhibition. This chapter investigates current language in describing this relationship and identifies terminology that may be used to describe the use of space and localisation. The chapter also considers the contribution made by an effective soundtrack as described by Chion. That is, when used effectively, a well-created soundtrack has the potential to provide 'added value' and influence perception.

> Sound has an influence on perception: through the phenomenon of added value, it interprets the meaning of the image, and makes us see in the image what we would not otherwise see, or would see differently. And so we see that sound is not at all invested and localised in the same way as the image.[1]

With limited existing language for both the sound design and the visual elements of 3-D films, articulating the relationships, processes and use of space (particularly z-space) is challenging. I argue there are shortcomings in articulating the language and space for 3-D film soundtracks and the relationship with the 3-D image. Broken into two parts, the first section will investigate some of the language shared between the image and the soundtrack. The second section identifies the use of space within the soundtrack by the various sound elements, and also the relationship between the soundtrack and the 3-D cinematic space.

[1] Ibid., 34.

Part 1: Literacies in audio and vision

Introduction

In this section I define the term 'soundtrack' and then identifying some of the limited language commonly shared across the sound and image formats. I identify that the language gap has increased since the introduction of 3-D film, including the definition of '3-D sound.'

Defining the soundtrack

An audience discussing or describing the soundtrack of a film predominantly associates the music of the film as being the soundtrack. In many respects this is true as we can go to our local music store or online and buy the soundtrack. In this instance we purchase a product that contains the musical score and songs from the film. However, the true soundtrack of a film is made of many elements that, when combined, work together to form the soundtrack. This contains the dialogue, foley, music, atmospheric and ambience sounds, spot sound effects and designed sounds, both diegetic and non-diegetic. Although Chion argues that the use of the term 'soundtrack' is 'deceptive and sloppy' as not all audio elements are recorded together on the optical track, I justify using the term as it provides inclusivity for all audio elements.[2]

Music can be perceived to have its own language. Music can be notated, and the notation can be reinterpreted and reproduced. A composer uses this language to write music for screen. An orchestra recreates the musical score with pitch, placement, timing and timbre reproduced with utmost perfection. Designing and composing sound effects has a limited associated language, making the description of the sound design very difficult. Jonathan Rosenbaum claims there is an inadequate vocabulary for describing sound due to the domination of the visual metaphor in our culture.[3] This lack of vocabulary makes it difficult to describe individual sound elements, and also the placement of sounds within a space. When interviewed to comment on the outlook of 3-D for the magazine

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[2] Michel Chion, *The Voice In Cinema*, trans. Claudia Gorbman (New York: Columbia University Press, 1999), 3.
[3] Jonathan Rosenbaum, "Sound Thinking," *Film Comment* 14, no. 5 (October 1978): 38.

Postmagazine, Steve Sklair, CEO of 3ality Technica, acknowledges a lack of vocabulary used in 3-D filmmaking. He states:

> On the creative side, the opportunity is to invent the language. Filmmaking has so many things that are part of its language, but 3-D is new enough and hasn't been experimented with enough. If I was a director, I'd want to shoot 3-D so I could participate in or help to and invent language of how this medium works.[4]

The introduction of digital 3-D films did not demand new sound formats, with 5.1 continuing to remain the default format for many releases. I argue there are shortcomings in accepting contemporary sound formats for 3-D, and this is primarily due to a misunderstanding of the mediums and the inability to articulate through language some of the hidden challenges. Understanding technology is relative to previous technologies. When DVD was first released, members of the general public were overwhelmed with the visual representation compared to VHS. However when Blu-ray was introduced, DVD was then seen as an inferior product. I question if the 3-D visual 'wow factor' has taken any focus away from the soundtrack, making it now invisible? Gorbman states that 'ultimately it is the narrative context, the interrelations between music and the rest of the film's system, that determines the effectiveness of film music.'[5] I argue that the same is true for the entire soundtrack. By thinking of the music, soundtrack and the imagery as separate entities, we are ignoring the collaboration that is film. The soundtrack is overshadowed by the vision, and there is less of a priority to develop a soundtrack language.

What language already exists?

As mentioned above, any language that exists in describing sound design and the 3-D visual aspects of filmmaking is limited. It is therefore important to acknowledge whatever terminology exists to determine where there is a need for further development. This research questions the spatial cohesion between sound and 3-D vision and how these elements support the narrative, and strengthens the argument for the need to develop an associated language. Listed below are some key words that are commonly used within both the sound and visual disciplines of film production. They highlight an inconsistency between shared terms.

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[4] Randi Altman, "Outlook Stereo Another Dimension," *Post Magazine*, no. 111210 (December 11, 2011): 25.
[5] Claudia Gorbman, *Unheard Melodies: Narrative Film Music* (London: BFI Publishing, 1987), 12.

- Pan
- Depth
- Track
- Headroom

Pan. Commonly used in both aural and visual contexts, 'pan' refers to movement, generally from side to side. However, when referring to *pan* in the visual context we are referring to the movement of the hardware device that is capturing the content; that is the camera. The camera pans from left to right or right to left across the horizontal axis. When we refer to 'pan' in the context of sound, we do not refer to the capturing of the sound; instead we are referring to how the sound is replayed through the speaker system or headphones — for example, sound pans from the left speaker to the right speaker or vice-versa, or it may pan between any of the multiple speakers in a surround sound installation.

If we use the visual definition of pan and apply it to sound, the audio capture device (microphone) would then be required to move from side to side panning with the source sound. As a microphone in most instances is monophonic, this would be contrary to the current definition, as the sound itself would not actually pan. Likewise, the aural definition of pan does not translate to the image. Since we normally only view a film at the cinema on a single screen, it is not possible to pan an image from one screen to another.

Depth. Similar to the word pan, 'depth' also has various meanings in the context of image and sound. The visual interpretation refers to the apparent distance between foreground and background. In relation to 3-D imagery this may also include, and work in conjunction with, parallax or the use of z-space; the way an image appears to come into the theatre or go beyond the screen.[6]

Depth in regards to the soundtrack can refer to several features. It may refer to the amount of layering within the soundtrack, and the complexity of the tracklay in relation to the various sound elements.[7] For example, a soundtrack with only a single track of dialogue and a couple of spot sound effects would not have the same sonic depth as an

[6] Parallax is defined in Terminology (page xv).
[7] The term tracklay is used in industry to describe the sound effects editing process as sounds are laid down onto the audio tracks.

action scene where there may be main character dialogue, background character dialogue, tracks of shouting, multiple sonically rich ambience tracks, main character action sound effects and weaponry, mass background weaponry, impacts and explosions, foley and an orchestral score etc.

Depending on how the soundtrack is mixed, these individual elements can also have added perceived spatial depth applied. This does not relate to the complexity of the sounds, instead it relates to the use of artificial reverberation and acoustic manipulation to allow the sounds to be given depth or perspective within an acoustic environment. These depth techniques are referred to in Chapters 4 and 6. Sonnenschein identifies that 'if different sounds have the same reverb or filtering, then their associated sources are all perceived to be the same distance or in the same space. If they have different reverb settings, then they will appear to be in different visual planes, helping to design the audio space.'[8]

Track. The term 'track' is best defined as 'follow.' Shared between audio and visual, it refers to the way in which the capture device follows the subject. This may be a camera following a car driving past, or it may be the boom microphone recording the sound of the car as it drives past. To avoid confusion, the term track differs from pan. Track refers to the microphone following the sound source, whereas pan refers to the sound being placed in the speaker(s) that best represent the spatial location of the sound in relation to its narrative or onscreen placement. In this instance the sound pans as the onscreen image tracks past. In the visual context track refers to a camera attached to a vehicle, dolly,[9] or steadycam[10] that moves with the filmed subject. The visual use of pan refers to the camera rotating along the horizontal plane.

Track is also a term relating to where a sound is located in the recording, editing, mixing and exhibition processes. For example, a sound recordist may have the capacity to record eight-tracks of sound; that is, the capacity to record or play eight simultaneous sources of audio. In the audio editing and mixing stages, there are hundreds of audio tracks that get mixed together to create the final soundtrack.

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[8] Sonnenschein, *Sound Design*, 2002, 160.
[9] A camera mount that is able to move smoothly along a set of tracks.
[10] A stabilised camera mount that is worn by a camera operator.

Headroom. 'Headroom' is a term commonly used in both visual and audio contexts. The visual definition relates to the amount of space or room in a shot above the subject. For example, if the frame contains a close up of a person, headroom refers to the amount of space between the top of the person's head and the top of the frame (screen).

The sound definition of headroom refers to how much sound level there is before distortion occurs. This can be an issue in the recording and mixing phases of production.

Defining 3-D sound and sound for 3-D

One of the most crucial yet confusing contributors to contemporary surround sound and 3-D is the use of the phrase '3-D sound.' Many in industry, including Andy Nelson and Randy Thom, believe that 3-D sound has existed since the introduction of surround sound, fifty years ago.[11,12] Altman views all recorded sounds as being 3-D, as all sounds have a 'spatial signature.'[13] Now immersive technologies are marketing themselves as the first to offer 'true 3-D sound.' This is in contrast to others proclaiming that sound played through speakers is unable to be 3-D due to acoustic deficiencies.[14] Although I will not debate the definition of the term here, the significance of the term is covered in great detail throughout the entire thesis. It must also be noted that 3-D sound and sound for 3-D films are not one and the same. Although a film may be 3-D, this does not qualify the soundtrack as being 3-D as it is common for a 2-D and 3-D version of the same film to share the exact same soundtrack. The ambiguity of the definition of '3-D sound' and '3-D film sound,' highlights the extent of a misunderstanding across the film industry and beyond.

Lack of sound design language

Any commonality of language shared between sound and vision is primarily in the description of the technicalities. As Altman notes, 'even the terminology with which we describe film sound is often built around image vocabulary.'[15] The language associated with the creativity of the soundtrack is further limited. For instance, in describing

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[11] Andy Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA, February 2012, 2.
[12] Randy Thom, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., February 2012, 2.
[13] Rick Altman, ed., *Sound Theory, Sound Practice*, New York (Routledge, 1992), 5, 24.
[14] Claypool, Van Baelen, and Van Daele, *Auro 11.1 Versus Object-Based Sound in 3D*, 4.
[15] Altman, *Sound Theory, Sound Practice*, 171.

individual sound effects, unless we know or associate the individual sounds with their original sources, we struggle to identify the sound being made by a particular sound effect. Rosenbaum generalises, stating that if it is a non-musical or nonverbal sound then it is simply an effect.[16] Rosenbaum also draws a comparison to the description of visual artworks. We seem to be able to articulate the composition of visual artefacts, but in regards to the sound effects in film we fall short. This extends beyond simply being unable to describe sound effects. Rather, there is a language deficiency in describing the space, localisation and positioning of *all* sounds within the soundtrack. This includes soundtracks in stereo, 5.1 surround or any of the immersive sound fields. As immersive sound formats develop, and 3-D visualisation becomes more complex, articulating the relationship between sound and image localisation within a 3-D space will become increasingly important. This is investigated in the following section.

Conclusion

This section has revealed that there is a lack of language in the description of a soundtrack, and the term '3-D sound' continues to be debated. It also highlights that some common sound and vision terminology has different definitions depending on the context. 3-D film provides increased opportunities for the soundtrack to occupy a 3-D space. The lack of language however creates challenges in articulating the cohesive union between image and sound. The following section investigates articulating the relationship between the soundtrack and the 3-D vision, and their relationship with the cinematic space.

Part 2: Sound and the 3-D Film Space

Introduction

This section investigates the relationship between the soundtrack, the image and the cinematic space. The various spaces within the 3-D cinema soundtrack creation and exhibition are identified, leading on to an investigation of the most appropriate way to articulate these. The use of existing language for music and space definitions has been adapted to the overall soundtrack where possible and new terminology has been introduced. This includes identifying language to describe the placement of sounds within

[16] Rosenbaum, "Sound Thinking," 38.

a 3-D space. The section explores the soundtrack as a single entity and its relationship with vision.

Sound space: dialogue, atmospheres, foley and sound effects

In academia the term 'film sound' often refers to the research of film music. Existing research into film music far exceeds research into sound design and in particular, sound effects. It is therefore appropriate that I use language relating to film music, as this can be adapted to most elements of the soundtrack, including the sound design. I argue that the dialogue, atmospheres and ambiences, foley and sound effects can work in much the same manner as individual musical instruments, complementing each other to create an overall sonic score. Each individual sound element has its own place within the audio spectrum, including frequency, spatial design, tonality, filtering and reverb and echo. This follows Smalley's analysis of music:

> Sounds occupy areas of spectral space. Each piece of music will have its upper and lower boundaries within which spectromorphologies act – in narrow bands, concentrated knots, masses, layers, extended spreads, dispersed clouds; they may remain stable or evolve over time, moving through ranges and registers with greater or less energy and alacrity, smoothly or by step or in leaps, in an orderly or erratic manner.[17]

Smalley's description actually applies to all soundtrack elements. Chion also shares the view that sound editors and mixers act as conductors, choosing certain sound effects and then blending these to create an overall sound.[18] In contrast to the musical track, the dialogue, foley and sound effects often have greater restrictions on their creative use. The music for a film in many instances is non-diegetic, instead complementing what is happening onscreen by providing an additional layer to enhance the portrayed emotion or the action. As Gorbman states:

> Music has persisted as an integral part of the sound film because it accomplishes so many things at once. Its freedom from the explicitness of language or photographic images, its usefulness denotative and expressive values easily comprehended by listeners raised in the nineteenth-century orchestral tradition,

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[17] Denis Smalley, "Space-Form and the Acousmatic Image," *Organised Sound* 12, no. 01 (2007): 44, doi:10.1017/S1355771807001665.
[18] Chion, *Audio-Vision*, 1994, 21.

> its malleability, its spatial, rhythmic, and temporal values, give it a special and complex status in the narrative film experience.[19]

However, the dialogue (except some forms of voice over), foley and the majority of the sound effects are diegetic and represent sound from within the story, often binding them to the image. As Smalley mentions in reference to the spectromorphologies of the music, this also occurs when the remaining soundtrack elements and layers are well designed. Having the sound effects weave in and out of each other and around the foundational dialogues is an example. Bordwell and Thompson explain: 'the filmmaker may create a mix in which each sound modulates and overlaps smoothly with others, or one that is composed of much more abrupt and startling contrasts.' Although the sound team will consider volume and frequency whilst editing and creating their individual sound elements (as mentioned later in this section in reference to *The Great Gatsby* sound design, page 63), it is the responsibility of the re-recording mixer to bring all of the sound elements together.[20] The re-recording mixer identifies 'a hole for every sound,' including frequency, volume, pan placement and reverberation. This is both a technical and creative role as not every sound can play with the same amplitude; hence allocating space within the soundtrack challenges the re-recording mixer. Generally the dialogue is prioritised first as it leads the narrative and storytelling of the film. Every other sound element is placed around the dialogue. Again, relating to Smalley's definition of spectromorphologies with every sound having its place.[21]

If an audience can't hear the dialogue and can't follow the narrative of the film, dense sound effects and wall-to-wall music are meaningless. The re-recording mixer will painstakingly adjust the most miniscule of volume changes if it means that the story can be told clearer by highlighting one particular sound over another. Decisions will also be made to remove sound effects and music if they mask the dialogues, making them unintelligible. Randy Thom has had to train himself to not be bothered if his sounds are cut during the mix, stating that you have to do what is important for the film and to not take these

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[19] Gorbman, *Unheard Melodies*, 55.
[20] David Bordwell and Kristin Thompson, "Fundamental Aesthetics of Sound in the Cinema," in *Film Sound: Theory and Practice*, ed. Elisabeth Weis and John Belton (New York: Columbia University Press, 1985), 187.
[21] Smalley, "Space-Form and the Acousmatic Image," 44.

decisions personally.[22] A combination of utilising the sound spectrum space and the panning of sounds within the volumetric cinema space allows the audience to constantly be directed and engaged with the various elements of the story.

There are some strict limitations when we consider all aspects of the soundtrack excluding the music. Primarily, the greatest limitation imposed on the soundtrack is the imagery, which often dictates the placement of sounds. For example, if we have a scene with two characters talking, the onscreen action may show a monologue from the film's protagonist looking straight down the camera in a mid-shot. The orchestral score for this scene may contain a lead flute that makes full use of the speaker and surround spectrum of the cinema by panning from left to right and then back into the surrounds whilst drawing slight attention from the remainder of the orchestral instrumentation. In this example the flute is able to move freely. However if we pan the dialogue in the same way for this same scene, the audience will be taken out of the story due to a dislocation with the image. The dialogue, foley, atmospheres and ambience, and sound effects (although not always) help create a representation of reality. They provide a bond between what we see and what we hear, and create the illusion of reality. It is with this same audio-visual connection that the design of sound effects for a 3-D film needs to be considered.

What creative liberties can be taken?

If we listen to the sound effects of a film in isolation, the creation of the track is made up of many individual elements that intertwine similarly to a musical score. The accompanying Blu-ray/DVD has some examples of scenes minus the music. The sound designer spends many hours creating, recording and editing sounds that are appropriate for the scene, and considering how these relate to each other and to the narrative. For example, in Luhrmann's *The Great Gatsby*, the sound design for the death of Myrtle was created by two separate sound editors. Supervising Sound Effects Editor Fabian Sanjurjo created the sounds that represented the actuality of the scene, whilst I designed the surreal sounds. For this to be an effective sound piece, an awareness of each other's work was necessary. We provided each other with works in progress and played these alongside our own tracks; this allowed us to edit and manipulate our own sounds with consideration of each

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[22] Randy Thom, "Designing a Movie for Sound," in *Soundscape: The School of Sound Lectures, 1998-2001*, ed. Larry Sider, Jerry Sider, and Diane Freeman (London: Wallflower Press, 2003), 129.

other. Sanjurjo's primary sound came from the engine of the car. This was an authentic recording of a Duesenberg car that had been designed to give a more menacing and aggressive sound.[23] Sanjurjo's car took up quite a lot of the bottom to mid range sound spectrum, and I designed my components outside of this frequency range. This included the very low frequency and high frequency ghostly car pass-bys.[24]

In the same way that sound effects can be choreographed around each other through layering and texturing, the final combined sound effects track can also be choreographed with the music as Walter notes:

> Just as the sound editor assembles his sound effects to create an almost musical effect in some sequences, so the music composer creates the instrumental background, to become at times an additional sound effect in itself. Often, it is an augmented effect blending with a dialogue scene so that one is almost unaware of its musical presence, yet adding so much to the value of the scene.[25]

Donnelly notes that 'both technology and aesthetics have dictated a headlong rush into establishing a unified aural field of music and other sounds in many films.'[26] Perhaps one of the most important principles of creating the overall soundtrack is that every sound needs its own place and space. Primarily this relates to the use of the frequencies, with each sound, musical instrument or dialogue having its own frequency space and allocation. Without following this rule, the soundtrack becomes indistinguishable and representative of white noise that no longer serves the narrative of the film. The sound levels will need to be mixed down to allow the important elements (usually dialogue) to cut through. Chion states 'it is the voice that is isolated in the sound mix like a solo instrument—for which the other sounds (music and noise) are merely the accompaniment.'[27] Doane also

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[23] The Duesenberg is a make of car that is often referred to as a 'Duesy.'
[24] Pass-bys is an industry term associated with vehicles passing across the screen frame. For example the cars in a cityscape driving across the screen are known as pass-bys. In *The Great Gatsby* the pass-bys mentioned above refer to the Duesenberg panning across the screen.
[25] Ernest Walter, *The Technique Of the Film Cutting Room*, 2nd ed. revised. (London: Focal Press, 1973), 212.
[26] K.J. Donnelly, "Extending Film Aesthetics: Audio Beyond Visuals," in *The Oxford Handbook of New Audiovisual Aesthetics*, ed. John Richardson, Claudia Gorbman, and Carol Vernallis, New Audiovisual Aesthetics (Oxford: Oxford University Press, 2013), 358.
[27] Chion, *Audio-Vision*, 1994, 7.

acknowledges that 'dialogue is given primary consideration and its level generally determines the levels of sound effects and music.'[28]

Although the frequencies of each particular element of the soundtrack are important considerations, the use and manipulation of these allows for expansive creativity, not necessarily bound to the screen. It is these flexibilities that allow the soundtrack to enhance the story including the ability to make the film appear larger than life. The use of the LFE channel can enable many onscreen events to appear bigger than they actually are.[29] For example in *The LEGO Movie*, the LFE track has been used to help sell the idea that the antagonist, Lord Business, is an intimidating character with huge mechanical legs. One of the initial sounds heard in the film is his feet. Although we don't see the character in the opening shots, we are made aware of the physical size of the character through the sound of thumping feet. To complement the subwoofer thumps, high frequency metal sounds were added to the feet to provide detail and promote the illusion of reality. Low frequencies lack directionality in the cinema as there is only a single LFE channel, so the high frequencies provide realism through expanding the frequency range allowing the sound to be panned across screen improving the connection with the visual.

Off-screen sound

As screen literacies continue to evolve, the relationship between sound and vision also continues to advance. The creative use of sound to enhance the narrative continues to expand with an increase in speaker channels from monaural to stereo, surround sound and now with immersive sound. Surround sound and immersive sound allow the sound designer to position sound not only with far greater accuracy in relation to the onscreen action, but also to position sound independently from the image. This can be highlighted through the effective use of off-screen sound, or acousmatic sound as originally described by Schaeffer and later theorised by Chion.[30]

Although off-screen sound was used effectively throughout the monaural era, a limitation of the technology meant that an audience was left questioning the localisation of the sound

[28] Mary Ann Doane, "Ideology and the Practice of Sound Editing and Mixing," in *Film Sound: Theory and Practice*, ed. Elisabeth Weis and John Belton (New York: Columbia University Press, 1985), 58.
[29] LFE (Low Frequency Effects) see Terminology
[30] Schaeffer refers to sounds that you can't see their originating cause as being *Acousmatic.* Chion, *Audio-Vision*, 1994, 71.

originating from screen. The use of stereo eliminates this problem by allowing the sound to be positioned anywhere between the left or right hand side of screen. The introduction of surround sound and immersive sound expands upon this as sound can be placed beyond the single x-axis plane of the screen to include the y-axis and z-axis.[31] This flexibility provides 'added value' to the soundtrack. For example, if we only see one character on screen, we use off screen cues to indicate a second character even though we may never see them. Another example may be a scene where we can use sound cues to introduce an advancing army from the left hand side of screen, despite never seeing them. Off-screen sound may be obvious or subtle, with an audience not always aware of the use of specific off-screen sounds and how they are providing vital story telling clues. By providing off-screen additional dimensionality, stereo and surround sound enhance localisation. Sonnenschein describes off-screen sound having one of two states, active or passive.

Active off-screen sound

Active sounds raise questions and curiosity to see what is making noise: What is it? What's happening? I have used off-screen sound to reinforce times of the day and location of the scene when it is important to the story, an obvious example is the creation of atmosphere and ambience sounds. The film *Candy* (2006)[32] has a scene where the protagonist Dan, played by Heath Ledger, lives in a small apartment at the back of a mechanic's workshop. We never see the workshop as there are no establishing shots, but through the use of sound we know that the scene is set in the morning within a mechanic's workshop. This was achieved through layering the sound of a roller door with increasing sounds of power tools and workshop activity, emphasising that the day was getting under way. In the same film when Dan moves into a flat with Candy, played by Abbie Cornish, we hear through Dan's point of view (POV), sounds of the neighbourhood. As Dan comes down from a heroin fix, we understand the pain and irritability of the character through the exaggeration and harshness of sound effects that are generated by items that we never see until the end of the scene when he looks out of his window.

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[31] Refer to Figure 1 (page xiii.).
[32] Luke Davies and Neil Armfield, *Candy*, directed by Neil Armfield (Australia: Dendy Films, 2006).

Passive off-screen sound

Passive sounds create atmosphere and environment, enveloping and stabilising the image across edit cuts to make them seamless. If I continue to use the example of the scene in the flat from *Candy* above, the external atmospheres and ambience sounds remained consistent throughout the entire scene. The scene uses some degree of audio perspective changes that mirror the onscreen action, with the volume of the exterior atmosphere track rising and lowering depending on whether the shot shows the interior of the room or a POV from the window looking outside. Mixed inversely to this exterior atmosphere is the internal atmosphere sound of a fluorescent light buzz. This is represented in Figure 9 by the volume graph of the top track the inverse of the bottom track.

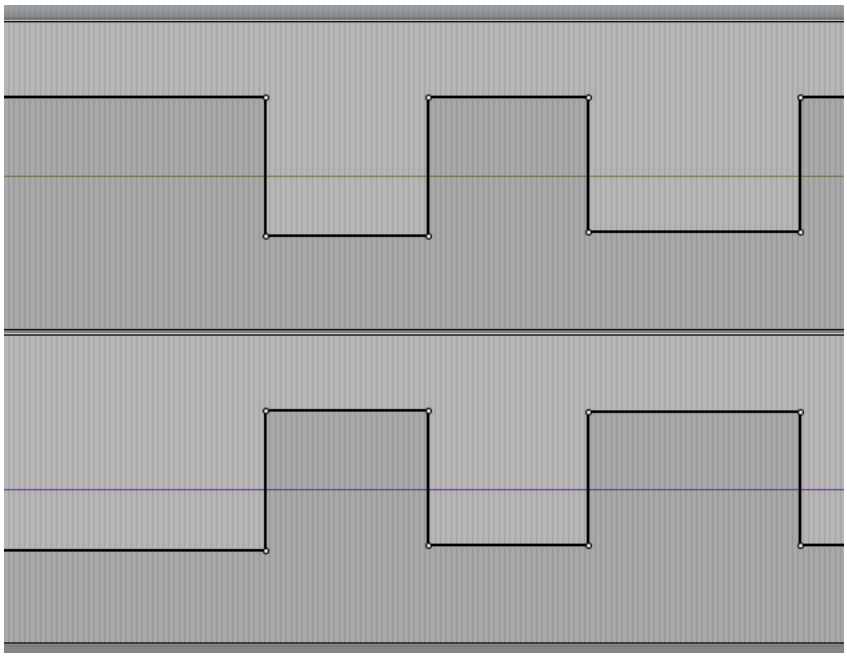

Figure 9: Volume graph for perspective cuts

Source bonding

What goes unrecognised by the average cinemagoer is that the majority of a soundtrack is constructed in post-production (that is, the sound is fabricated). The birds, the wind and the background sounds are all edited in post-production. On many film productions, often the dialogue will be the original dialogue from set, but almost every other sound is a fabrication and is added after filming is completed. Although authentic sounds are captured on set and supplied to the sound editors, often the editors recreate many of the

sounds themselves. These sounds may be original recordings, manipulated recordings of sounds completely unrelated to the actual onscreen item, or completely synthesised sounds. An example of where a sound doesn't actually exist can be heard in *Transformers* (2007).[33] The sounds of the hydraulic legs are not captured on set; instead they are created by sound designers and sound editors, providing the audience with sounds that they would expect to hear. When these sounds are implemented effectively, the audience automatically assumes that these sounds did in fact originate from the original onscreen sources. Chion's term 'synchresis' describes this 'spontaneous and irresistible weld produced between a particular auditory phenomenon and visual phenomenon when they occur at the same time.'[34]

Smalley suggests that the term 'source-bonding' can relate to actual or imagined sound as it is based purely on the listener's perception. Although Smalley coined the term in reference to music, the term is also relevant to screen sound in general. Smalley defines the term as: 'The natural tendency to relate sounds to supposed sources and causes, and to relate sounds to each other because they appear to have shared or associated origins.'[35]

Of importance is the section of the definition which refers to relating sounds to their sources and causes. Placing this term in the context of film where we have vision and sound working together, there is an advantage in having the screen 'tell' the audience what they are listening to, and not have the ears provide this information exclusively. This relates to the individual sound elements within the soundtrack and also relates to the sound localisation. This is similar to the McGurk phenomenon.[36, 37]

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[33] Roberto Orci, Alex Kurtzman, John Rogers, Roberto Orci and Alex Kurtzman, *Transformers,* directed by Michael Bay (Hollywood, CA: Paramount Pictures, 2007).
[34] Chion, *Audio-Vision*, 1994, 63.
[35] Denis Smalley, "Spectromorphology: Explaining Sound-Shapes," *Organised Sound* 2, no. 02 (1997): 110, doi:10.1017/S1355771897009059.
[36] The McGurk effect demonstrates the intrinsic link between aural and visual cues when perceiving speech. It was discovered during a study to understand how speech is perceived by infants in various stages of cognitive development. McGurk and McDonald found that if you combine a sound recording of one phoneme (for example, "ba") with a video recording of someone mouthing another phoneme ("ga"), the brain combines the two into a completely different phoneme, "da."
[37] Dominic W. Massaro and David G. Stork, "Speech Recognition and Sensory Integration: A 240-Year-Old Theorem Helps Explain How People and Machines Can Integrate Auditory and Visual Information to Understand Speech," *American Scientist* 86, no. 3 (May 1, 1998): 236.

Smalley's definition of source-bonding also applies to the spatial placement of sound. Observing the foley track for a film, we notice that there is minimal panning between speakers. This is due to the dialogue track in most instances only coming from the centre channel. The foley is tied to the dialogue as the illusion of reality would be lost if the character's voice was coming from the centre speaker and their feet were coming from either the left or right hand side of screen. To the astute listener, this juxtaposition is further challenged with 3-D films as the sound loses its source bonding with the image along the z-axis in z-space.

The storytelling relationship between the sound and the image

The term 'sound design' was invented by Ben Burtt and Walter Murch in the late 1970s. Both recognised that their contribution to *Star Wars* and *Apocalypse Now* was more than merely creating powerful sound effects. One of the earliest and most documented examples of collaboration between director and sound team throughout the entire production process was for the film *Apocalypse Now*. With the term 'sound design' coined on this film, it is one of the most documented film sound relationships, as described by Thom.

> By experimenting with sound, playing with sound (and not just sound effects, but music and dialog as well) all through production and post-production, what Francis Coppola, Walter Murch, George Lucas, and Ben Burtt found is that sound began to shape the picture sometimes as much as the picture shaped the sound.[38]

By Coppola allowing his sound team to 'experiment' with sound, he very quickly realised what a powerful story telling accompaniment sound was. This luxury is rarely afforded today, but *Apocalypse Now* remains one of the most productive and innovative film sound collaborations, and as directors begin to further understand the power that sound design can contribute to their films, sound will continue to grow as an equal partner to the accompanying images. In discussing his approach to recording location sound for *The Great Gatsby*, Guntis Sics mentions that the reintroduction of 3-D films is questioning the focus within the frame, and as a consequence this impacts on the sound.[39]

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[38] Randy Thom, "Designing A Movie For Sound by Randy Thom," 1999, accessed December 11, 2013. http://www.filmsound.org/articles/designing_for_sound.htm.
[39] Guntis Sics, Personal Interview: 3-D Sound The Great Gatsby Location Sound Recording, Australia., Telephone, January 14, 2014.

Director Alfonso Cuarón, when discussing the sound design for *Gravity*, spoke about the desire to have a soundtrack that was true to the science of space.[40] As a vacuum, space is essentially silent, since the lack of atmosphere does not allow sound waves to propagate; Cuarón wanted the sound team to consider this. The soundtrack is minimal, with many of the sounds presented being recordings of vibrations. Cuarón states 'that through touch, the vibrations move through the body and are then interpreted as sounds.'[41] Using this approach, Re-recording Mixer Skip Lievsay in the same interview mentions that all of the manual sounds including foley and the loosening of bolts were recorded using transducers as opposed to more conventional microphones.

Sonnenschein describes that when a sound is synchronised with image, the illusion of diegesis occurs. 'The dictum "see a dog, hear a dog" refers to hearing exactly what we are seeing, forming a redundancy that is normally part of our daily lives.[42] Lievsay echoes this by stating that *Gravity* still has the Hollywood film sound approach of 'see an event, hear a sound.'[43] However through careful mixing and combining the transducer recordings with the other sound effects that contain a greater frequency range, the sound represents a halfway mix between science and what the audience expects to hear.

Having a collaborative approach to the sound design early in the film production allows for a powerful relationship between sound and image. Thom suggests that 'only when each craft influences every other craft does the movie begin to take on a life of its own.'[44] 3-D film also needs to consider sound early in the production process, in addition to the individual sound elements, the position and placement of each sound is important.

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[40] Michael Coleman, *The Sound of Gravity*, Web Video, *Soundworks Collection*, 2013, accessed October 24, 2013. http://www.soundworkscollection.com/videos/gravity.
[41] Ibid.
[42] Sonnenschein, *Sound Design*, 2002, 166.
[43] Coleman, *The Sound of Gravity*.
[44] Thom, "Designing A Movie For Sound by Randy Thom," 1.

Vision first—Sound later

In the tradition of live-action filmmaking, it has usually been that the image is captured before the sound (with Eisenstein's *Alexander Nevsky* (1939)[45] being a notable exception). This sequence of filmmaking stems from the beginnings of cinema when it was only the visual that could be captured due to technological limitations. Although the coming of sound brought with it a new dimension to filmmaking, the emphasis of filmmaking has always favoured the visual. Doane notes that by one going to *see* a film, this affirms the denial of heterogeneity between image and sound. 'Sound is something that is added to the image, but nevertheless subordinate to it - it acts, paradoxically, as a "silent" support.'[46]

Although the contemporary filmmaker has access to digital cameras and multichannel sound recording on set, their primary goal is to capture the actor's performance. Recording the dialogue is also a priority, although this is out-weighed by the visual domain. With onset crews generally larger and costing more per day than post-production costs, budgets influence these priorities. It would be very rare for a director to film another take because there was a foreign sound that presented itself in the sound recording. However if something like a boom microphone appeared within frame, then the director is far more likely to film another take.

Creating a soundtrack in post-production is a relatively cheap process in comparison to the various other film production processes. Prioritising the importance of capturing the sound on set is purely the director's decision, restricted only by the overall film budget and their own personal ideologies. For example, during the filming of *Batman The Dark Knight* (2008)[47] director Christopher Nolan considered sound to be as important as the visuals whilst shooting. Sound was such a consideration that Nolan invited the sound department to scout the location and identify potential sound problems including

[45] Sergei M. Eisenstein and Pyotr Pavlenko, *Alexander Nevsky*, directed by Sergei M. Eisenstein and Dmitriy Vasilev (USA: Amkino Corporation, 1939).
[46] Doane, "Ideology and the Practice of Sound Editing and Mixing," 54.
[47] Jonathan Nolan, Christopher Nolan, David S. Goyer and Bob Kane, *The Dark Knight*, directed by Christopher Nolan (Burbank CA: Warner Bros., 2008).

escalators, air-conditioning, elevator dings, etc.[48] Nolan wanted to be aware of such intrusions so that when shooting began, these extraneous sounds could be eliminated and he could capture the dialogue performances from his actors. By capturing the dialogue performance cleanly on set, the recording of ADR could be reduced.[49]

Although Nolan is a director who is conscious of his soundtrack, Thom explains that this is not typical of most directors. Thom claims that it isn't until a director needs to fix flaws in the story, or deal with weak scenes or bad edits, that sound is treated with short-lived faith in its importance of enabling their film to be watchable. Often this happens too late in the production process, with the director again losing faith until late in their next film.[50] Australian director Baz Luhrmann has a great appreciation for the soundtrack, with this providing a collaborative approach in the creation of *The Great Gatsby.* 3-D is now changing the way that the shot is composed especially in regards to focus and depth of field, and this poses many challenges for the sound recordist. When questioned about whether or not *The Great Gatsby* was recorded differently because it was shot in 3-D, sound recordist Guntis Sics mentioned that it depended on the shot. 3-D has more going on in the shot as the backgrounds are still in focus, meaning that you see more in the shot looking from near to far.[51] Greg Toland popularised the 2-D deep focus cinematography technique on Orson Welles' *Citizen Kane* (1941),[52] however 3-D extends the deep focus along the z-axis. Sics stated that having sharp 3-D backgrounds means that people in the background also need to be miked. This results in more swinging of the boom microphone and more cross fading between the radio microphone to the boom, and then back to the radio microphone.[53] Viewing the final 3-D rendered scene makes the omission of certain background sounds far more noticeable. Luhrmann's consideration of sound early in the post-production process allowed the image and sound relationship to be heightened when projected in 3-D. *The Great Gatsby* is discussed in greater detail in Chapter 4 (page 118).

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[48] Jake Riehle, "'The Dark Knight' (Pt.2) - Exclusive Interview with Sound Mixer Ed Novick," *Designing Sound*, July 23, 2008, accessed January 5, 2014. http://designingsound.org/2008/07/the-dark-knight-pt-2-exclusive-interview-with-sound-mixer-ed-novick/.
[49] ADR is defined in Terminology (page xiii).
[50] Thom, "Designing A Movie For Sound by Randy Thom," 2.
[51] Guntis Sics, Personal Interview: 3D Sound The Great Gatsby Location Sound Recording with Guntis Sics, Telephone, January 14, 2014.
[52] Herman J. Mankiewicz and Orson Welles, *Citizen Kane* directed by Orson Welles (New York: RKO Radio Pictures, Inc., 1941).
[53] Sics, Personal Interview: 3-D Sound The Great Gatsby Location Sound Recording, Australia.

Bringing life to animation

Film technologies are improving and elements of contemporary filmmaking are challenging the methodology of the image preceding the sound. This is most notable with animated films. Animated films generally begin their production process with the dialogue script recorded first, and the animation following. As suggested by Thom earlier, with a movie only taking on life through collaboration, this approach to sound and vision is becoming more important as films become increasingly fabricated and/or digitally enhanced. Sound for animation has the power of transforming stilted imagery, thus creating the illusion of fluidity and reality. Although it is undoubtedly true that sound contributes to live-action film, it is the contribution that sound makes to animation and computer generated special effects that yields even greater results. Sonnenschein recognises that sound can provide the impression that it is contained within the image when it is derived from the interaction between the natural world and our psychological responses.[54]

3-D animated feature film production is an organic process as the film evolves graphically over time. This provides an opportunity for the accompanying soundtrack to also evolve alongside the imagery. Although the evolution of the soundtrack has many advantages, it also creates disadvantages, especially compared to a live-action film. Live-action film allows the sound practitioner to capture sound and dialogue on set and also see what elements are composed within the frame, but with animation, there is no on-set sound and the frame is constantly evolving. As the graphic elements gain more detail, they transform from blocks, to shapes, to rendered animations, to the final shots with lighting effects.

As the compositors also work on these shots it is not uncommon to find additional elements appearing within the frame — elements that require supplementary sounds. Animated films make up a high proportion of contemporary 3-D film releases, and these additional elements require not only sound creation considerations, but also 3-D spatial considerations. An example of this took place on *The LEGO Movie* with additional elements including cars on a highway, and background spaceships required for two of the scenes. It was not known that these background items would exist when work initially began on these scenes. This creates ongoing problems for the sound team as time is of the essence.

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[54] Sonnenschein, *Sound Design*, 2002, 168.

As the deadlines for mixing the sound approaches, so too is the deadline for the final animated images, with any changes in the visual making it difficult for the sound team to keep up. This is not exclusive to animated films. The high levels of visual effects now utilised in live-action films also creates problems as will be discussed in Chapter 4.

In both live-action and animated 3-D films the consideration of sound spatial localisation is not at the forefront of 3-D film developments. This is evident with a film released with exactly the same soundtrack for both the 2-D and 3-D release of the film. In an online survey offered to film industry and non-industry cinemagoers, when asked if the soundtrack for a 3-D film could be labelled as 3-D sound, almost 36% of participants had never thought about it; around 36% answered no and 28% of participants answered yes (Figure 10).[55] However when asked if they thought that surround sound is the same as 3-D sound, only 9% agreed (Figure 11, page 75) with over 48% answering no and 42% of participants having not thought about it. This reinforces that an audience is unaware of what they are hearing as in both cases, the soundtrack is usually the same.

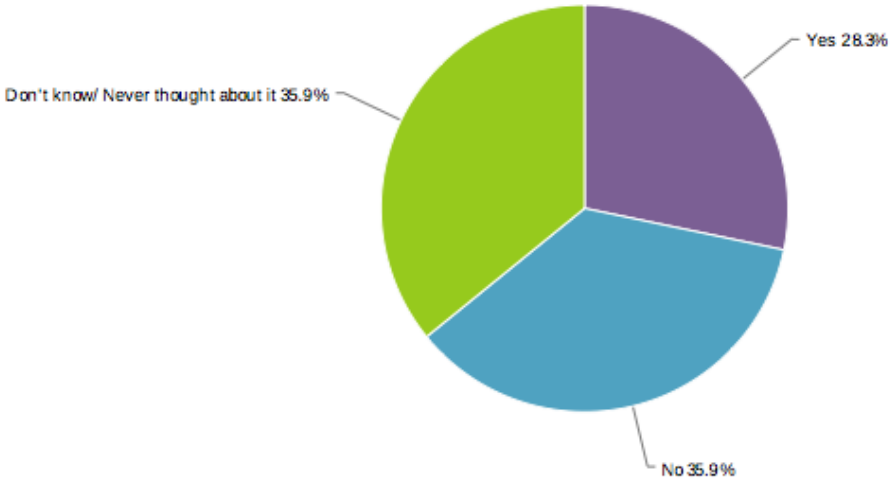

Figure 10: Do you think sound for 3-D films can be called 3-D sound?

[55] For complete survey details, please refer to Appendix E.

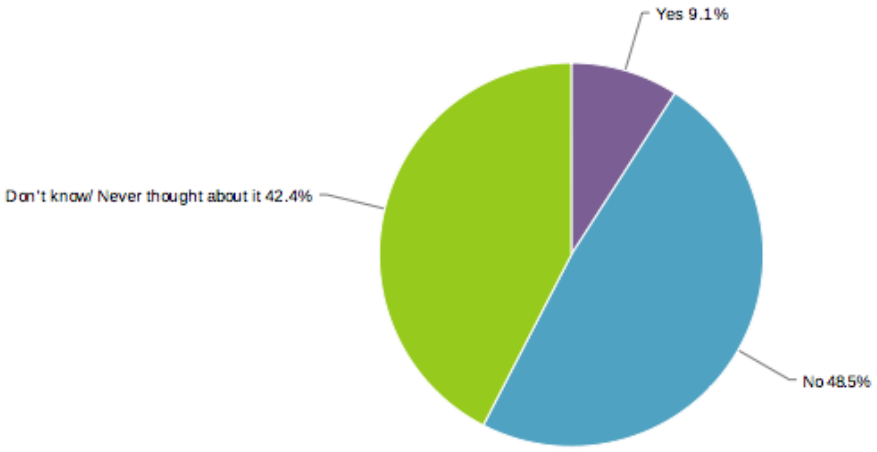

Figure 11: Do you think surround sound is the same as 3-D sound?

A lack of understanding about what defines 3-D sound reinforces why sound for 3-D films is seldom questioned. It is this same passion that is shared with Thom on sound design that has driven my research into the relationship between sound and the 3-D image. Whilst working on 3-D feature films as a creative practitioner, the inability to accurately localise sounds with 3-D imagery was obvious. I argue that the effective homogenous relationship that sound shares with 2-D films diminishes with 3-D. Instead of having one solid unified narrative shared across a single plane, the 3-D imagery and sound are independent of each other, leaving the audience to patch them back together or worse still, ignore their differences. Although this is going unnoticed by the audience, it is creating a problem whereby we are experiencing a breakdown in source bonding (as defined by Smalley).

Film depth and space

The spatial relationship between sound and vision

Surround sound provides an additional dimension to 2-D films by allowing sound to be propagated not only from the image plane, but also from the side and rear of the audience. Although I argue that this is not true of 3-D sound, I agree that it adds an additional dimension to traditional stereo or monophonic sound. Altman describes sound recordings as having their own unique '"spatial signatures," carried in the audible signs of each hearing's particularities.'[56] Altman explains that even though these signatures may not

[56] Altman, *Sound Theory, Sound Practice*, 24.

necessarily match the visual data, they still have spatial information. This spatial information is encoded, and the sound designer may choose to exploit this information or they may chose to ignore it through digital audio manipulation. By placing sound through the various cinema speakers, the sound designer can introduce many new aural situations that complement 2-D imagery and provide sonic immersion. Lon Bender believes 'there is still a great experience and wonderful sense of putting sounds together with picture. It's just an amazing experience putting sound to picture and have them leap off the screen at you and create a whole three-dimensional world, even when the movie is not 3-D.'[57] Sergi takes this notion further stating that 'once inside the auditorium, we are confronted with a situation where we're placed 'inside' the filmic space, not simply in front of one. The invitation to explore these new surroundings is emphasised by the way sound designers have approached the concept of audience space and the reproductive environment.' [58]

Creating a spatial environment for the screen

The concept behind the atmosphere and ambience soundscape is to situate the audience within the onscreen environment. If we think about our real world, we know that our eyes see in front of us, yet we hear sound from all around us; in front, the sides, behind and above. Although traditional cinema hasn't provided ceiling or 'voice of god' speakers, the traditional surround formats have done an acceptable job of providing sounds from in front, from each side and from behind the audience – and through a combination of these, sometimes even from above us. The advantage of ambience and atmosphere tracks is that they are not picture dependent, that is, their sole purpose is to situate the audience within the onscreen environment and not to draw attention to any particular element of sound or image. By not relating directly to the image, these ambience and atmosphere tracks contribute to the image by situating the audience within the frame. Through surround sound, new immersive sound formats and 3-D imagery, the frame has become unbound, allowing it to extend into the audience. This differs from previous 2-D technologies including Cinerama, which had the vision contained to a single plane, regardless of the screen size. Altman recognises that 'sound was once hidden behind the image in order to allow more complete identification with that image, now the sound source is flaunted,

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[57] Wilkinson, *The Sound of Movies*.
[58] Sergi, "The Sonic Playground: Hollywood Cinema and Its Listeners," 124.

fostering a separate sonic identification contesting the limited, rational draw of the image and its visible characters.'[59]

Although the atmospheres and ambiences are less dependent on visual cues, the same cannot be said for the other sound elements including dialogue, sound effects and foley. These elements are often dependent on the image, and are now posing spatial relationship complications with the 3-D imagery within z-space. The added image depth of 3-D is posing new challenges for the accompanying supporting sound. Visual cues are coming 'out of the screen' in 3-D and require sound effects and dialogue to match the spatial positioning without losing cohesion. Although the soundtrack for 3-D remains largely unchanged from 2-D, the traditional 2-D film sound working methodologies have become incompatible in many instances, as it is difficult to pan sounds 'off the screen' into z-space to match the imagery. This will be further discussed with reference to case studies and the practice-led research in Chapters 4 and 6.

Bringing sound off the screen

During an interview at Skywalker Sound, David Acord spoke about the differences between 2-D and 3-D that he has experienced. Acord noted that there had been quite a lot of discussion at Skywalker about the resurgence of 3-D and 'how to handle that whole centre channel issue.'[60] The issue of dialogue placed only in the centre channel is highlighted in *Hugo* when the Station Inspector, played by Sacha Baron Cohen, speaks to camera. In the 3-D version the Station Inspector is framed in negative parallax, but the dialogue does not follow the imagery into the space along the z-axis, instead only coming from the centre speaker, thus breaking the bond between image and sound. The 2-D version has the image and the sound coming from the same plane. As Sonnenschein points out, sound induces the sensation of space, volume, and texturing of a film. He further states that distance and dimensionality is coded by our body, and when it is combined with vision, the viewer is 'immersed in a more complete virtual reality.'[61] Although emerging technologies, including Dolby Atmos and Auro 3-D, are slowly being deployed into cinemas for exhibition, I question if these technologies are in fact providing true 3-D

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[59] Altman, "The Sound of Sound." 68.
[60] David Acord, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., February 15, 2012.
[61] Sonnenschein, *Sound Design*, 2002, 159.

sound or merely providing an improved sonic experience compared to traditional 5.1 surround sound. Through surround sound absorbing an audience and extending the image, traditional surround formats have continued to remain a standardised format.

Despite the widespread use of surround sound, there is a lack of language able to describe the localisation of sounds within the cinema z-space. Industry has ways to describe the use of the individual speaker channels, volume and frequencies, but there remains a limitation in the language used to articulate the placement of surround sound within the cinematic space. Terms such as 'pull off the screen,' 'bring into the room,' 'push the surrounds,' 'reduce the mids,' 'hit the sub a bit harder,' and 'pull out of the centre,' describe the process of how to achieve the outcome. These terms are all relative and lack quantification and specificity.

The utilisation of the cinematic volumetric space is complicated as both the 3-D vision and the surround sound are independently bound to their own conventions and technical limitations. This is a core underpinning of this thesis and highlights not only a void in the articulation of spatial sound language, but also a void in describing sound that is dependent on being attached to 3-D imagery. Using the visual xyz coordinate model and applying it to sound will enable a more effective and accurate solution. 2-D films do not require accurate sound placement in z-space as the image is on a single plane, unlike 3-D films. Bonding sound with 2-D imagery along the x-axis is possible, as the placement of onscreen sound is positioned utilising a combination of the three screen speaker channels. The surround channels primarily support off screen cues and are not image dependent. The introduction of 3-D vision has meant that the surround channels are not only used for off screen sound, but more importantly they are now required to support the visuals in z-space along the z-axis.

The depth script

3-D allows directors and other filmic disciplines opportunities in rethinking the use of the frame of the image. The image for 3-D now has added depth value and this is adding to the complexities of framing the sound. As 3-D film develops, there are additional considerations and creative opportunities when telling a story compared to 2-D. One of the recent developments has been through the introduction of the depth script, as noted

on *Wreck it Ralph* (2012).[62] Hazelton notes that the stereoscopic depth of the film changed throughout the film. The use of the 'film's *depth script* resulted in deploying less stereoscopic depth in the emotional scenes and gradually increasing the depth as Ralph, an old-school video-game villain, ventures into more and more advanced games.'[63] This is akin to the use of soft focus for romance films.

With varying levels of visual depth deployed throughout a film, does the soundtrack need to accommodate these variations in visual depth? Australian based Supervising Sound Editor Wayne Pashley describes his use of sound depth as something that relates to the sonic layering of sounds and not necessarily to the depth of the 3-D visuals. Pashley explains:

> I always try to ensure that my atmospheres and crowds are recorded, edited and mixed with near, middle and far perspectives in mind. This allows for greater depth within the soundtrack. In particular it also allows us to replace the close perspective crowds with local language for the foreign versions. In the transition to 3-D films, nothing has really changed for us. Most of the time we are still working to 2-D images, so the depth in the soundtrack relates to the sonic depth more than being dictated by the visual depth.[64]

The depth script allows the director to plan for increased immersion, and therefore the way that scenes are filmed and exhibited. Although a sonic equivalent does not formally exist, the visual depth script can provide valuable additional information and cues in creating a more coherent and immersive soundtrack. This would strengthen the bonding of image and sound. Thom suggests that 'whenever we as an audience are put into a visual "space" in which we are encouraged to "feel" rather than "think", what comes into our ears can inform those feelings and magnify them.'[65]

Sound depth

The use of image depth is not unique to 3-D film production as it is also used with 2-D films. However, no matter what extent the depth of a shot is, in 2-D the image always sits

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[62] Rich Moore and Phil Johnston, *Wreck-It Ralph*, directed by Rich Moore (Burbank, CA: Walt Disney Studios, 2012).
[63] John Hazelton, "Immersed in the Story," December 18, 2012, accessed April 16, 2013. http://www.screendaily.com/reports/in-focus/immersed-in-the-story/5050117.article.
[64] Wayne Pashley, "Sound Depth," November 7, 2013.
[65] Thom, "Designing A Movie For Sound by Randy Thom," 6.

on a single plane — that is, all depth cues, including foreground, background and perspective, remain visually located on a single image plane. It is the soundtrack that provides the additional depth cues to the 2-D imagery. Mixing sound for cinema to evoke apparent depth necessitates following conventions and working methodologies that allow the sound to provide the illusion of depth. Primarily this includes the use of reverbs, frequency filters and volume mapping. Following on from Pashley's notion of sound layering, Sonnenschein indicates that:

> Layers of space can be distinguished by their respective sound qualities and the proportion of direct to indirect signals. If characters are close, their voice will have more high frequencies and less reverb from the ground and walls; as they retreat these qualities invert. In this manner, the space and distance can actually be implied by the sound, even if we don't see the character or source of the sound event.[66]

Although providing additional depth to 2-D films, this approach is less effective when applied to 3-D films. A thorough understanding of image depth is paramount to effective 3-D film production including an understanding of depth relative to shot composition, depth of field and parallax. Sound is no different and can be compared to its visual counterpart. As stated by Sonnenschein: 'With the use of surround channels a tremendous variety of aural movement can accompany images that come and go on the screen. Any such occupation of the real 3-D space of the theatre helps break through the 2-D film image to create a 3-D visual space as well.'[67] Surround sound adds another dimension, however, I believe Sonnenschein's statement only applies to 2-D films. For 3-D film, the use of the z-axis and z-space commonly creates dislocation between the sound and image. 2-D films have the sound and image on a single plane, with the additional surround speakers adding value and dimensionality. With 3-D, as the parallax becomes either negative or positive, the sound becomes detached from the image despite the use of additional surround speakers. Maintaining this bond is seldom achieved due to limitations with current cinema sound technologies as discussed in Chapters 4 and 6.

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[66] David Sonnenschein, *Sound Design: The Expressive Power of Music, Voice and Sound Effects in Cinema* (Michael Wiese Productions, 2001), 160.
[67] Ibid.

Several complexities obstruct the bond between sound and image. A 3-D scene may contain elements that are in negative or positive parallax; or possibly both concurrently. All contemporary surround sound formats are capable of producing a homogenous relationship between image and sound across either a 2-D image or a 3-D image situated with neutral parallax. Through the use of the three screen channels (Left, Centre and Right), this is effective. As an image comes into z-space, for the sound to maintain its bond, it relies on the use of the surround speaker channels. Capable of producing sounds in z-space, current sound formats are unable to position a particular sound accurately; instead the surrounds flood the space with sound. Further limitations become noticeable when an image is in positive parallax. As the image goes beyond the screen plane, the sound emanates from the 2-D plane in front of the image, and not within the same space. The only method of addressing this is to use the 2-D sound mixing methodologies mentioned above, but these are not ideal.

Dialogue space

A common example of the way that sound can create the illusion of depth can be seen through the analysis of the dialogue track. When we see someone speaking at a podium or lectern, the post-production treatment given to the track is altered depending on the shot. If the shot is a close-up, there would be minimal reverberation; however when the shot is a long shot there would be an increased amount of reverb, despite the actual dialogue recording being the same take, with the same microphone. Altering the amount of reverb provides the dialogue with different acoustic spatial properties. The image utilises perceived depth within the constraints of a 2-D plane, however it is the sound that provides the additional cues to the audience to promote the depth of the shot.

However this approach is ineffective with 3-D film. If the above reverb and filter approach is used on a scene of dialogue with a character in strong negative parallax, the image protrudes from the screen and into the cinema z-space. As such, the sound continues to emanate from the 2-D plane in line with the screen. The obvious solution for this is to pan the dialogue from the centre screen speaker and into the surround speakers. In theory this seems a plausible solution as conventions from 2-D filmmaking have had an audience believe that sound coming from the surround speakers is creating 3-D sound, or sound with an additional dimension. The execution of this is far from accurate. Due to the acoustic properties of the speakers and the cinematic space, there is crosstalk from the speakers, making sound localisation ineffective. This crosstalk makes the voice appear to be coming concurrently from in front of the audience, and from either side and behind the audience, as shown in Figure 12 (page 82).

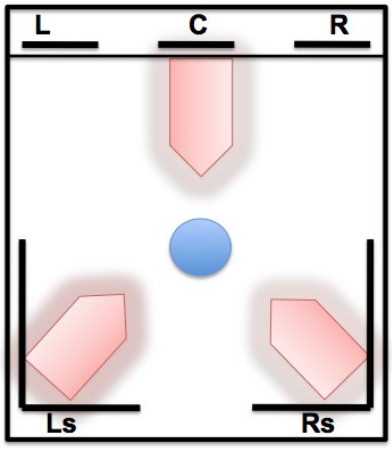

Figure 12: Dialogue from centre and surround speakers

With sound emanating from the front, sides and rear of the cinema, the localisation of the dialogue is lost, hence the re-recording mixers' hesitation to change the film sound convention of having the dialogue in the centre speaker. This convention dates back to early cinema sound. Altman suggests that 'given Hollywood's establishment during the Thirties of a clear preference for clarity of dialogue over careful matching of sound and image scales, it is hardly surprising that stereo imaging would eventually be reserved primarily for music, with dialogue routed uniquely through the centre speaker.'[68]

Academy Award winning Re-recording Mixer Andy Nelson also abides by this Hollywood notion of keeping dialogue in the centre channel, even with 3-D films. When asked if he mixes dialogue differently for 3-D he stated that he doesn't, 'because if you even tried to start putting dialogue into the surrounds to pull it off the screen, it would become very much like a voice of god - it wouldn't really anchor itself on the character, and I don't personally think that would work.'[69] Nelson's notion of not wishing to pull the dialogues off the screen is also shared by Australian Sound Designer/Supervising Sound Editor and Re-Recording Mixer Wayne Pashley. When discussing panning dialogues into z-space, Pashley states that 'in a feature film where the story and the dialogue is so important to drive the narrative forward, I think (it) is very dangerous to over push it.'[70] Gwen Whittle, Supervising Sound editor on *Avatar* also describes the placement of dialogues in the

[68] Altman, "The Sound of Sound."
[69] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA.
[70] Wayne Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia., December 2011.

surrounds as too distracting, taking you away from the screen in front of you. Additionally Whittle suggests that just because the speakers are there, some people abuse this simply because they can, however they need to be very careful.[71]

A contemporary example of keeping the dialogues on the screen despite the image in negative parallax is in *Hugo*. In almost every frame of the film the main character dialogue is exclusively reserved for the centre speaker channel. The only dialogue that tends to utilise any other channels is general hubbub and crowd vocalisations. These are generally unintelligible lines of dialogue that help situate the environment. They are placed in the left, right, left surround and/or right surround channels to create the illusion of space. This is also aided by the re-recording mixer applying reverb and filtering to help situate the crowds into a particular space. In the example of *Hugo* this is the railway station.

Non-dialogue space

As discussed above, the centre channel is reserved for the main dialogue and foley, allowing all other sound elements to be placed in any of the remaining channels. This flexibility allows the sound effects and sound design to take advantage of technological advancements, utilising the creative potential of placing sounds around a room. The simplest of examples is a bird flying from left of screen to right of screen. In this instance the wing flaps and bird tweets pan with the image from the left screen speaker to centre and then through to the right hand speaker, creating the illusion of movement, convincing an audience that the bird is in fact real.

Consider this same scenario in 3-D with the exception that instead of flying from left to right, the bird now flies from strong positive parallax, through zero and into strong negative parallax. The bond between the visual and the sound panning will not be as accurate as in the first example. This is a result of the sound originating from the centre speaker, additionally coming through the left and right speakers depending on the framing, before finishing in the surround speakers. Although we will get some sense of sound in front and then behind us, we are unable to have the bird sound as though it is flying through the middle of the cinema. Sonnenschein suggests 'when sound works well with

[71] Gwen Whittle, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., February 2012.

the image, the impression is that the sound is already contained in the image itself.'[72] However this is not the case when inaccurate **positional rendering**[73] along the z-axis occurs. Questioning our understanding of sonic space, Smalley states:

> Focusing on space as the key, integrating element requires a reorientation of listening priorities and attentions: in my experience we are not that used to listening out for spatial attributes, for spatial forms, and space-form, partly because there is so much else to listen out for. But perhaps this is also because we are not sure what space really is, in sonic terms, or that we lack a sufficiently comprehensive bundle of concepts to talk about it, or that we think it tangential rather than central.[74]

Listening to the sound depth of a film, the listener must distinguish between the ambience and atmospheric sounds that are creating the locale, and the sounds that are tied to the visual cues. The atmospheric sounds allow the sound designer to portray an infinite amount of depth depending on the story. Although the atmospheric sound is very sparse throughout *Gravity*, it is the use of sonic space through a well-crafted ambience soundtrack that allows the viewer to be further immersed into the visuals. The onscreen action directs the audience member's eyes to the movement, and the accompanying sound draws the audience's active listening attention. Only once a scene has had the action removed is the depth of the entirety of the scene fully established through the use of atmospheric sound.

Creating sound elements that are connected to 3-D images in negative parallax is challenging. The solution requires the re-recording mixer to utilise the surround channels to bring the sound 'off the screen.' Although the surrounds work well with off screen cues, using these to bring onscreen imagery off screen is problematic. As with the issues of bringing the dialogue off the screen, sound effects prove to be similarly challenging. As Mendiburu asks 'now that the images have caught up, how do both 3-D volumes interact with each other?'[75]

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[72] Sonnenschein, *Sound Design*, 2002, 168.
[73] An original term coined by the author. Further information can be found in the Terminology section on page 84.
[74] Smalley, "Space-Form and the Acousmatic Image," 35.
[75] Mendiburu, *3D Movie Making Stereoscopic Digital Cinema From Script to Screen*, 155.

One method of keeping sound effects bonded to the image is through movement. Most sound effects tend to be connected to an action, allowing the sound to pan from speaker to speaker. Additionally with sound effects, the multiple elements that make up the sound can be panned individually. This is in contrast to dialogue that always originates from the character's lips. An example can be highlighted in *The LEGO Movie*. At the end of the film the giant yellow robot controlled by the protagonist Emmet, is running towards camera with chains spinning from both arms. The feet sounds are utilising the left and right speakers and the sub woofer, whilst the chain sounds are coming from both the front left and right speakers and the surround left and right speakers.

Defining sound space

Gravity, a film set in space, provides an example of defining sound space. It is the detail in establishing the environmental vastness that enables the soundtrack to punctuate and accentuate this infinite perception of space portrayed by the visuals. Shot in 3-D, *Gravity* has explored not only the visual medium, but also the sonic medium so that both elements work in unison. Smalley suggests that: 'A listener needs time to progress from an initial listening encounter with the soundscape to a state of engaging actively and fully in scanning and exploring the spectromorphological and spatial properties on offer.'[76] *Gravity* provides an example of this.

The film begins with a musical crescendo before abruptly stopping to complete silence, reflecting the science of space. In many ways *Gravity* is mixed quite unconventionally, in that the dialogues do in fact pan across screen and beyond, with the characters even panning into the surround speakers. Notably the music is also composed for surround sound with different elements panning throughout the various speakers, at times spinning around the room alongside the camera and dialogues. In an interview for the Soundworks Collection, director Alfonso Cuarón makes particular mention of how the panning of the dialogues and the music helps provide a superior immersive experience.[77] In combination with the atmospheric soundscape, *Gravity* is successful in providing an aural illusion of infinite space by allowing the music and dialogue to also pan and make use of all speakers. This was a brave move by Cuarón as it goes against convention. Cuarón made a conscious

[76] Smalley, "Space-Form and the Acousmatic Image," 37.
[77] Coleman, *The Sound of Gravity*.

decision to allow the sound and the speakers to work for the narrative of the film, rather than following traditional mixing practices. *Gravity* was released in Dolby Atmos in addition to 5.1.

The art of mixing a film is knowing where to direct the audience's attention in relation to the story. In many instances and as history has shown, the direction is always forward towards the screen. *Gravity* is an example of these rules having been broken deliberately. By complementing the unique story and setting of the film, this is done deliberately to orientate the audience with the characters as they are often off screen, floating in space. Seldom seen in 2-D films, this luxury and freedom of expressive panning and movement into all speakers is not relevant to many narratives.

Smalley uses the terms 'prospective space,' 'panoramic space' and 'circumspace' to describe three identifiable boundaries of the cinematic space as shown in Figure 13. 'Prospective space is the frontal image, which extends laterally to create a panoramic space within the range of vision; circumspace – space around the listener – extends panoramic space to encompass the listener.'[78]

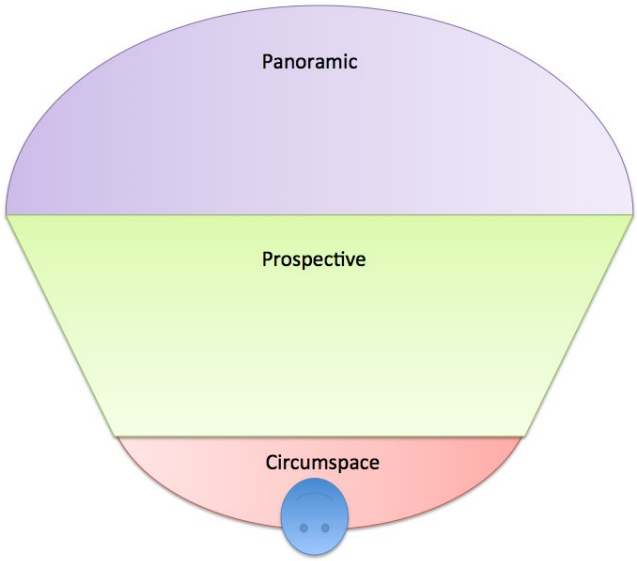

Figure 13: An illustrated interpretation of Smalley's space definitions as they apply to the visual.

[78] Smalley, "Space-Form and the Acousmatic Image," 48.

The diagram above illustrates how Smalley's definition is representative to stereo sound, as all sound is generated in front of the viewer. With increases in surround sound channels and immersive sound systems these spaces are no longer applicable. I propose that the increased spatial definition within contemporary cinema sound systems (that is, 5.1, 7.1 surround, immersive sound) and surround speaker placement instead provide three spaces 'around' the viewer/listener as illustrated in Figure 14.

In my professional opinion, the cinematic experience and conventional cinematic sound systems portray the panoramic space exceptionally well. However, as the number of speaker channels increases, these three discrete spaces become overlapped as the distance between the listener and the speakers varies depending on the seating position and speaker configuration. 'It is impossible to predict the position of the listener or of the speakers in any given situation and impossible to compensate for multiple listeners.'[79] This ambiguity of space definition and accuracy contributes to the dislocation between sound and image, especially with 3-D films.

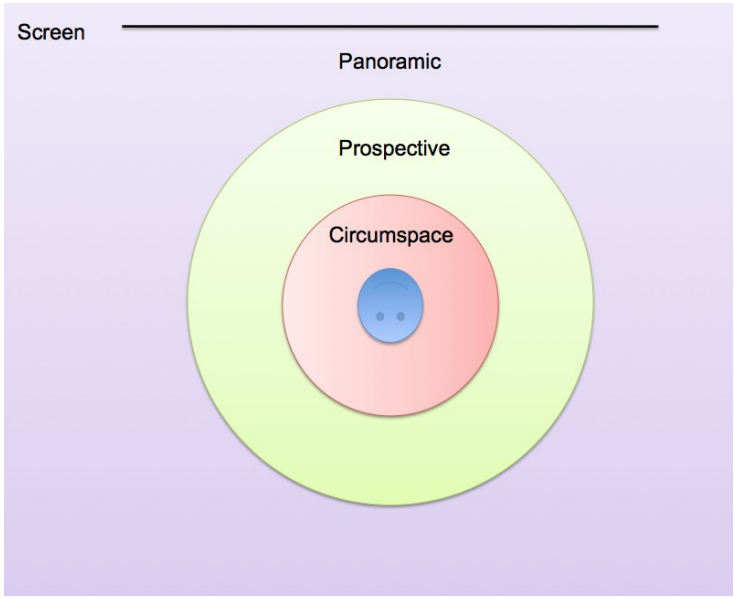

Figure 14: An illustrated interpretation of Smalley's space definitions as applicable to surround sound

Current surround sound formats provide adequate directionality and definition in both the prospective and panoramic space, but contemporary cinema sound is unable to

[79] Begault, *3-D Sound for Virtual Reality and Multimedia*, 176.

produce sounds exclusively or accurately within the circumspace. A limitation of current technologies and acoustic inconsistencies between cinemas contributes to this.

The inability to position sound within the circumspace is increasingly apparent with contemporary 3-D films. Taking 2-D film as an example, the front speakers suffice in providing an effective panoramic space. There are 3 discrete front speaker channels in a 5.1 system and these allow for sounds to be screen left, centre, and screen right, with any proportional panning of these speakers allowing a pan across the x-axis. As 2-D images are also limited to a single 2-D plane, the relationship between the image and sound in 2-D films allows for homogeneity across the screen. The surround speakers are not generally used in conjunction with onscreen action and do not relate directly to an image as they are merely providing added value. An exception to this may be in very rare cases of using the first person point of view (POV) shot. This will be expanded upon in the upcoming section 'Sound POV' (page 89).

3-D film expands upon the visual depth of a single 2-D plane, and depending on the way the visuals are projected, the circumspace becomes an important sound consideration; one that has been previously overlooked. If the imagery is in positive parallax only, then the sound considerations can remain similar to 2-D cinema sound practices. A positive parallax 3-D image will not have any action within the circumspace. However any use of negative parallax will necessitate a considered approach when positioning sounds within the prospective space, and in the circumspace. The use of circumspace is inversely proportional to the amount of negative parallax, that is, as parallax becomes more negative (decreases), the importance of circumspace increases.

Defining the position of sound

Throughout the case studies and practice-led research as discussed in Chapter 4 and Chapter 6, it was necessary to clearly define and articulate the positioning of sounds within a 3-D space. It became evident that although a sound was positioned in a specific location within the 3-D space during the editing and mixing process, it was seldom reproduced accurately. To identify these differences the author has introduced the term **positional data** to identify the location given to a sound, and the term **positional rendering** to identify the location of a sound when played back during exhibition.

Positional Data

Positional data is the pan location assigned to a sound during the production process.

Limitations to positional data can be a result of the sound team having to work with 2-D imagery, or by not having enough time to pan individual sounds. By not having access to 3-D imagery (even if only used for referencing), the sound crew is unable to identify the position of objects along the z-axis within z-space. As time spent in the final mix is expensive, there is seldom time to adjust panning in the final stages of production. Further compounding the issue, many sound crews are creating soundtracks for either 5.1 or 7.1 releases and it is not until after mixing has begun that immersive releases are considered.

Positional Rendering

The positional rendering on playback refers to the ability of a cinema sound system to accurately reproduce a sound to be in exactly the same apparent location as where the sound is located with the positional data. Contemporary 3-D films are in either 5.1, 7.1 or immersive sound formats, with the spatial positional rendering accuracy of the soundtrack confined to the configuration of each format. For example the sound in the left surround channel will be positioned differently between 5.1, 7.1 and the immersive sound formats. Due to varying speaker placements, there are discrepancies in the spatial positioning of sounds. This highlights some obvious shortcomings in the ability of contemporary speaker systems to provide a homogenous audio-visual 3-D experience.

2-D does not have this problem, as sounds that are placed in the surround speakers are not bonded to the image. For example a helicopter flying in from behind the audience will use the surround speakers on the helicopter's approach, but it will then play through the front screen speakers once the helicopter is visually on screen. 3-D differs as the surround speakers can additionally be used to complement onscreen visuals that are in z-space. Although various techniques and methods are often able to create the illusion of sounds bonded to the imagery within z-space, at present there is no single definitive solution. As sound goes between the panoramic space and the prospective space, the spatial definition dissipates due to speaker crosstalk, making it impossible to have defined sound in the circumspace. Although immersive sound formats provide a detailed canopy envelopment of the audience, they are not 3-D exclusive formats.

Sound point of view (POV)

Earlier in this chapter I stated that circumspace was seldom a consideration with 2-D films as the medium rarely necessitated its usage. The sound for 2-D visual POV shots is a passive accompaniment that situates the audience. Many times the POV shot is used to provide a first person perspective, but it is not always used to replicate the actuality of

that person. Sonnenschein makes the analogy that sound can have a point of audition in the same way a camera can have a point of view.[80] Thom also recognises:

> That one element of writing for movies stands above all others in terms of making the eventual movie as "cinematic" as possible: establishing point of view. The audience experiences the action through its identification with characters. The writing needs to lay the ground work for setting up POV before the actors, cameras, microphones, and editors come into play. Each of these can obviously enhance the element of POV, but the script should contain the blueprint.[81]

Depending on the narrative, the POV can provide important narrative cues, without intending to provide a realistic perspective. For example, sound is often used to focus the viewer on a single aspect of the POV. In this instance it may be used to provide a mask to allow the audience to hear only a single conversation despite the shot showing a room full of people having conversations. Terrence Malick's *The Thin Red Line* (1999)[82] relies on this technique consistently throughout the film. Another common example is the use of both a visual and audio mask to provide a POV shot looking through binoculars or a telescope. Depending on the narrative of the scene, the sound from the first person's perspective may be replaced by the sound of the point source through which the binoculars are observing.

Current sound practices allow for sound to be effective with the 2-D POV as the sound source is in the distance, even in close up. The videogame-inspired *Doom* (2005)[83] portrayed the POV in a 2-D environment with great effect as the audience became the protagonist for almost four minutes of non-stop action. Here, sound is used effectively to heighten the immersive experience (Figure 15, page 91).

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[80] Sonnenschein, *Sound Design*, 2001, 163.
[81] Thom, "Designing A Movie For Sound by Randy Thom," 3.
[82] Terrence Malick and James Jones, *The Thin Red Line*, directed by Terrence Malick (Century City, CA: 20th Century Fox, 1999).
[83] Dave Callaham and Wesley Strick, *Doom*, directed by Andrzej Bartkowiak, (Universal City, CA: Universal Pictures, 2005).

Figure 15: Screenshot from the *Doom* POV scene

The first sense that the audience becomes John Grimm, played by Karl Urban, is hinted at by hearing the character's breaths. The breaths are placed throughout all five main speakers and are effected in such a way (using phase, flange, filters and reverb) that it sounds as though you are the character producing these breaths. Once the action begins, the music increases in volume and the breaths are no longer heard. This allows any additional sounds to come from the weapon in Grimm's hand or from the attacking beasts. A limiting factor for this sequence that wasn't exploited enough was the use of the surround speakers to introduce the enemy monsters. Almost every sound generated by the monsters, including growls, impacts, weapons and blood splatter, is in the front speakers only. Apart from the first few breaths and a few lines of "Sam" from Grimm, the only other sounds heard in the surround speakers apart from the music are some sound-designed whooshes used to exaggerate the camera moves that accentuate the head turns.

Local Australian director Rolf de Heer also utilised the POV shot in many scenes throughout his film *Bad Boy Bubby* (1993).[84] Although paying attention to the visuals, de Heer was conscious of the associated soundtrack and considered the sound design from early on in the production process. During filming, de Heer, working with Sound Mixer/Sound Recordist/Supervising Sound Editor James Currie, recorded the character Bubby, played by Nicholas Hope, using the binaural recording technique. Binaural recording is a technique that uses two microphones to replicate the human ears. Placing microphones in Bubby's ears was deemed problematic as they would be seen in shot so

[84] Rolf de Heer, *Bad Boy Bubby,* directed by Rolf de Heer (Sydney: Roadshow Entertainment, 1993).

instead they were hidden within the wig. Binaural is inherently problematic, as the only way to hear the decoded binaural recordings is to use headphones, meaning that it does not work within a contemporary cinema environment.

Listening to the binaural DVD version of *Bad Boy Bubby* (2005),[85] the film is distinctly different to all other audio formats.[86] The binaural recording technique is capable of recreating a 360˚ perspective of the recording space, working exceptionally well when Bubby wraps plastic cling wrap across his face (10 min. 55 sec.). Hickey-Moody and Iocco describe the effect this has on an audience:

> The effects of binaural sonic containment and excessive over-amplification are, at times, veritably nauseating for the viewer. When Bubby fastens glad wrap around his skull, the viewer's aural hemisphere is drawn into the muffled, uncomfortable soundtrack of refracted breathing. The corporeal effect this sound creates is palpable. Indeed, if fear is a sound, it is the billowing, crackling, subterranean noises associated with being enfolded in glad wrap.[87]

As humans we are capable of hearing in 360˚ with our two ears, and the binaural technique is somewhat capable of reproducing this. A stereo binaural recording (two-channel) is capable of capturing spatial information and replicating this when played back through headphones.

During *Bad Boy Bubby* the POV shots work exceptionally well, with the image and the sound completely bonded in spatial integration, the binaural soundtrack replicating reality. Not only is the sound authentic as it was all recorded on the set and not recreated in post-production, but the perspectives and orientation of the sounds are exceptionally accurate. However when we are out of the POV shots, the binaural soundtrack no longer serves as the optimal companion to the imagery. There is a complete juxtaposition between image and sound due to the camera now not in the first person. Instead we are seeing in the third person perspective, yet still hearing in the first person perspective.

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[85] Rolf de Heer, *Bad Boy Bubby*, directed by Rolf de Heer (Kew, Victoria: Umbrella Entertainment, 2005).
[86] The DVD version of *Bad Boy Bubby* will be further referred to as *Bad Boy Bubby* (DVD).
[87] Anna Hickey-Moody and Melissa Iocco, "Sonic Affect(s): Binaural Technologies and the Construction of Auratorship in Rolf de Heer's *Bad Boy Bubby*. [Film.]," *Metro (Melbourne, Vic: 1974)*, no. 140 (2004): 80.

Derobe's 3-D live-action short film *Souviens-Moi* (2013)[88] was also released on DVD with both a 5.1 and binaural soundtrack. The 3-D camera imagery representing human 3-D vision and the binaural recordings capturing the 3-D aural elements, when combined, both mediums provide a 3-D homogenous audio-visual experience. One of the shortcomings however, is that there is little room for error when using this recording technique. Noticeably, the binaural recordings captured the footsteps louder than the other sounds, including the dialogue, causing a distraction from the narrative. The viewer is taken out of the film, albeit momentarily.

A battle of volumes: volumetric space occupied by the visuals versus the volumetric space occupied by the sound

One of the greatest distinctions with 3-D is the way in which directors and creatives are rethinking the use of the frame of the image. The 3-D image has added depth value and this is adding to the complexities of framing the sound. 3-D visuals are capable of being perceived to protrude into the cinema z-space in addition to the surround sound that also emanates into this cinema space. Maintaining a cohesive bond between each respective element within this z-space is one of the greatest challenges facing 3-D film as these 3-D volumes do not perfectly overlap. Mendiburu states: 'The multichannel sound occupies the theatre room, with left, centre, right, and LFE sources right behind the screen, and one or two layers of stereophonic sources along the room length. The stereoscopic image occupies a volume designed by the comfort zone, a truncated triangle that extends a long way beyond the screen.'[89]

Further complicating the issue, each respective volumetric space is relative to each possible seating position within the cinema. For example, the perceived spatial volume occupied by the sound and vision from seat A1 is completely different to the perceived spatial volume from seat Z40. The problem is compounded when a cinema is incorrectly calibrated or all you hear is the speaker closest to you, especially the surround speakers. These issues are common occurrences, supporting the argument of why mixers tend not to 'push' too much sound into the surround speakers. Supervising Sound Editor Wayne

[88] Josephine Derobe, *Souviens-Moi*, short film, directed by Josephine Derobe. (France: 2013).
[89] Mendiburu, *3D Movie Making Stereoscopic Digital Cinema From Script to Screen*, 155.

Pashley was questioned on the calibration of cinemas and how *Legend of the Guardians* has translated to multiple cinemas. He explains:

> The exhibition is always in question because at the high-end cinemas who care, they get it right. Cinema to cinema it's so, so different. I've seen *Legend of the Guardians* many times now in various cinemas - panning translates well, generally speaking, but actual levels of where they should be is always in question. That includes the sub (LFE), that includes the centre speaker, the surrounds - the levels as designed from the mixing stage to exhibition are always in question.[90]

Lacking confidence in cinema playback quality, the re-recording mixer does not always mix the film for the best possible outcome, instead opting for a safe mix. This is not so much an issue for 2-D, but for 3-D, this lack of confidence in cinema playback quality stifles creativity and more importantly limits the narrative. Compounding the lack in confidence in sound replay quality is the immense variation between the acoustic properties of each cinema. Every cinema is designed differently, with different dimensions, different noise floors and different acoustic treatment and design. As materials change, and dimensions change, so too do the acoustic properties of the cinema. Different acoustic spaces represent the final sound mix differently, making it difficult for re-recording mixers to create a single mix that is acoustically transparent across all cinemas. Digital technologies are endeavouring to promote self-calibrating cinemas though this requires costly upgrades.

The acoustic properties of the cinema play an increasing factor in providing calculated boundaries and parameters for the cinema sound volumetric space, especially in regards to 3-D films. What this means for cinema sound is yet one more factor to consider when creating a soundtrack for 3-D. As immersive sound technologies, including Dolby Atmos and Auro 3-D, show increased installations into premium cinemas, the concept of creating a 'spatially confident' soundtrack is gaining traction. In Chapter 4 Part 2, I discuss immersive sound film releases in greater detail.

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[90] Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia.

Sound and 3-D film space conclusion

This section has identified existing language that has been adopted to define the relationship between the soundtrack and the use of the 3-D cinematic space. Although some language has been identified, it clearly highlights that there is a deficiency in the language of sound for 3-D films. The terms 'positional data' and 'positional rendering' were introduced by the author through identifying a gap in the articulation of the placement of sounds in the creation and exhibition of the soundtrack.

Conclusion

There is a lack of language to describe the spatial relationship of the soundtrack and the cinematic space. Sound mixing practices have remained relatively unchanged between 2-D and 3-D. The effective storytelling capabilities of the soundtrack do not always translate as well when combined with 3-D visuals. Despite 3-D visuals occupying the cinema z-space, re-recording mixers are hesitant panning dialogue to match the imagery due to cinema inconsistencies, recognising that this may break the suture with the film narrative. Further complicating the creative decisions made by re-recording mixers is the limitation of the cinema multichannel sound systems and acoustics. Gierlich states the authentic reproduction of sound events is either not possible or only possible up to a point.[91] Re-recording mixers are panning safely, and this limitation of not using the entire cinematic space is creating a dislocation between image and sound within z-space. With limited language, articulating the use of space by the soundtrack is challenging. This is compounding many of the limitations facing the description and recognition of sound space for film production professionals.

The following chapter investigates in greater detail the creation of the contemporary 3-D soundtrack. The chapter explores several 3-D film releases, and investigates the creation and exhibition of their respective soundtracks.

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[91] H. W. Gierlich, "The Application of Binaural Technology," *Applied Acoustics* 36, no. 3–4 (1992): 220, doi:10.1016/0003-682X(92)90047-V.

Chapter 4: Contemporary 3-D Filmmaking - Creating and Exhibiting the Contemporary Soundtrack

Introduction

Sound is a very powerful tool in contributing to film narrative, beyond merely supporting the visuals. Sound and vision in the context of film provide an audience with varying levels of meaning. Bresson states 'that a sound always evokes an image (but never the reverse).'[1] In contemporary cinema, there has been a shift in thinking and sound is beginning to be noticed by an audience. This is covered in great detail in Chapter 5. The cinema audience is becoming increasingly aware of Digital Surround Sound (DSS) and contemporary production practices. Although the audience is gaining an understanding of the modern soundtrack and the possibilities offered through surround sound and high quality sound reproduction, Kerins points out that sound could be further taken advantage of in helping narrative. Thom concurs stating that 'starving the eye will inevitably bring the ear, and therefore the imagination, more into play.'[2]Although advancements in technology have led to the narrative burden of film being shared by the soundtrack through voices, sound effects, and music, the technology of digital surround sound has not been exploited to its full potential.[3] In many instances immersive technologies are also not exploited to their full potential. As discussed further in this chapter, a recurring contributor to this is a lack of soundtrack planning from the film producers factoring in the 3-D medium. This is critical, as time is often not considered in the schedule for the immersive mixes.

The introduction of surround sound, and in particular Digital Surround Sound, allows sound editors, sound designers and sound mixers greater flexibility for soundtrack creation. Although the general public may not have a thorough understanding of sound literacies, cinema goers not only expect to hear clear dialogues, sound effects and music, but they often also expect to *feel* these sounds through their whole body. The introduction of the Low Frequency Effects (LFE) channel component of the surround mix provides

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[1] Rosenbaum, "Sound Thinking," 40.
[2] Thom, "Designing A Movie For Sound by Randy Thom," 2.
[3] Kerins, "Narration in the Cinema of Digital Sound," 41.

'sounds that the audience feels rather than hears; this physical power creates the very physical sensation of being at an earth-shaking event, not just watching one.'[4] An example is the way in which a close up explosion may be heard. Not only do we hear the crack and bang, but we also feel the boom component of the explosion.

In the first section of this chapter I will provide a personal insight into the soundtrack design for several contemporary 3-D film soundtracks from the perspective of a Sound Effects Editor.[5] I will compare and contrast the working methodologies of both animation and live-action film productions, and discuss some of the approaches that are unique to sound creation for 3-D. The films include:

- *Legend of the Guardians: The Owls of Ga'Hoole*
- *Happy Feet Two*
- *The Great Gatsby*
- *The LEGO Movie*

The approaches to creating a soundtrack for animated and live-action film vary considerably. Live-action affords the capture of both image and sound from an actual location, whereas with animation, all imagery and sound need to be created from the ground up. In many instances a hybridisation also occurs as many live-action films contain heavily animated components and sequences. Using *The Great Gatsby* as an example, almost every exterior set was created in post-production. The characters were filmed in front of a green screen with the backgrounds composited in towards the end of the filmmaking process.

The second section of this chapter contains case studies on two 3-D films that I had no production involvement with: *The Hobbit: The Desolation of Smaug* and *I, Frankenstein* (2014).[6] Both films were selected as each was released in 5.1 and Dolby Atmos formats, with *I, Frankenstein* additionally having an Auro 11.1 release.

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[4] Kerins, *Beyond Dolby (Stereo)*, 134.
[5] I am credited on these films as Sound Effects Editor.
[6] Stuart Beattie and Kevin Grevioux *I, Frankenstein*, directd by Stuart Beattie (Sydney: Hopscotch Films, 2014).

An overview of the process

In order to provide an overview of the sound production process I have listed the various roles within film sound. This is important as not every role involves the exploitation of the spatialisation of the surround sound field. Only a few of the roles are concerned with the placement of sound within the cinema space. It should be noted that in many instances the music department is separate to the sound team. For a breakdown on these positions please refer to the Terminology section (page xvii) at the beginning of this thesis.

The roles within the sound team include:

Location

- Boom Swinger(s)
- Location Sound Recordist/Mixer

Post-Production

- ADR Recordist/Mixer
- ADR Editor
- Foley Recordist/Mixer
- Foley Editor
- Foley Artist/Walker
- Dialogue Editor
- Atmosphere Editor
- Sound Effects Editor
- Sound Designer
- Supervising Sound Editor

Music

- Music Recordist/ Engineer
- Music Editor
- Music Mixer

Mixing

- Re-recording Mixer

The groupings shown above illustrate the production roles in terms of location sound, post-production sound, music, and mixing respectively. Although the roles may differ in terminology and job description depending on the country of the sound crew, essentially these roles are universal. The one major difference is that the terms 'sound designer' and 'supervising sound editor' in Australia are quite different to what they are in the United States. The actual term 'sound design' was introduced on Francis Ford Coppola's 1979 film about the Vietnam War, *Apocalypse Now,* by Walter Murch to describe his innovative

sound work.[7] As stated by Kerins, 'the ubiquitous phrase "sound design" is convenient, yet ambiguous—it has no agreed-upon definition even within the industry.'[8]

In recent years there has been an increase in the crossover between sound roles. For example, it is not uncommon for sound effects editors to design many of their own sounds. They may also provide a mixdown of certain sounds with spatial information and panning assignments. If the film has a small budget, the sound effects editor may also create and edit the atmospheres. This is important to this discussion of 3-D, as the spatial decisions made by the editorial crew may remain unchanged during the final mix.

Contemporary sound editing

As discussed in Chapter 2, the technology of cinema sound has changed considerably since the introduction of synchronised sound in the mid to late 1920s. One of the greatest advancements has been in the medium used for the soundtrack production. We have gone from a variety of physical mediums to a virtual medium. Although not necessarily changing the fundamental working methodologies of creating a soundtrack, these changes have allowed for greater flexibility and improved workflow efficiencies.

The introduction of digital audio workstations (DAW) has provided the greatest change in industry practices in the crafts of sound creation, editing and mixing. The DAW has allowed for greater crossover between the various roles of the sound professional by increasingly blurring the division between sound editor and sound mixer. Without doubt, this is a direct result of the technology not only providing creative flexibility, but also due to the affordability of the hardware. However as more people have access to the technology, this does not qualify them to be experts. Just as an apprentice builder may have every tool – this does not qualify them to be a master builder!

The affordability and flexibility of sound editing tools allow anyone to position sounds in a 3-D space using a DAW. The editor is now able to spend time during the highly detailed editing process giving each sound individual panning cues using software. These panning

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[7] William Whittington, *Sound Design and Science Fiction* (Austin, TX: University of Texas Press, 2007), 21.
[8] Kerins, *Beyond Dolby (Stereo)*, 11.

cues provide positional data for the sounds. If this were to take place in the mixing stage, time may not be as flexible in providing individual sounds such detailed positioning by the mixer. The ability to create an acoustic space can now begin in the editing suite.

Filling the acoustic space

Traditionally the sound effects and ambiences are the greatest contributors in occupying the complete speaker array of contemporary surround sound. Later in this chapter and again in Chapter 6, this is demonstrated through the practice-led research. Sound effects are individual sounds that accompany specific actions or are used non-diegetically for narrative purposes, with the atmospheres situating the audience within the onscreen environment. By providing the sense of location as imagined by the onscreen characters, the atmospheres are the primary sound component that contributes to immersing the audience. Kerins describes how, through creating the right multi-channel ambient space, the foundation allows audiences to feel they are immersed in the diegetic world.[9]

Often recorded on location, the ambiences and atmospheres are generally recorded in at least a two-channel stereo format. Depending on the recordist, atmosphere recordings may be recorded with as many as six tracks (5.1) and above or in an ambisonic format.[10] Sound effects on the other hand are often recorded in mono, then edited and embellished through sound design, and panned to follow the onscreen or narrative cues.

Ambiences

Ambiences and atmospheres are conventionally edited in discrete tracks, either stereo or surround, and then mixed to the relevant surround format used for the film. These sounds play throughout the full range of cinema speakers, providing a constant foundation on which all other sounds are then layered.

Depending on the scene, *Happy Feet Two* included a combination of the following:

- Background penguin feet

[9] Kerins, *Beyond Dolby (Stereo)*, 167.
[10] The ambisonic format is discusseed in Chapter 5 (page 164).

- Non-descript penguin vocalisations
- Winds
- Snow flurries
- Iceberg shifts

Additionally, Supervising Sound Editor, Wayne Pashley, approached these sonic atmospheric elements in terms of dimensional layers. As stated earlier in Chapter 3 (page 79), Pashley provides depth for close, near and far perspectives.

Through the combination of editing, panning and creative volume mapping of each element, the scene begins to resemble actuality. There is depth and space and the audience begins to be situated within the scene as these sounds evolve and envelop the cinema. To increase the detail further, these tracks will often have additional sounds multilayered to provide each individual speaker channel greater separation, increasing dimensionality within the soundtrack.

Another example may be an exterior city scene where, in addition to the general city ambiences, there are specific background sounds that highlight the space. This may include a specific siren playing only through the left rear surround, and a traffic light ticking in the right screen speaker. These sounds are not played to dominate or draw attention within the scene, merely playing loud enough to distinguish where they are. This separation creates the illusion that the space is wider than if both of these sounds were to be played in monaural together. This methodology translates to immersive technologies. David Acord from Skywalker Sound was very positive about the effectiveness of creating space through additional speaker channels in the Auro format. He suggests creating a slightly different ambience for the height layer that differs from the lower layer allowing the 11.1 format to work very effectively.[11]

The use of reverberation is also used widely to provide a sense of space. By adding reverberation to the atmospheres, the space can be opened up or even closed in, creating

[11] Acord, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA.

the illusion of a vast expanse of land, or conversely, the sense of claustrophobia.[12] Sonnenschein advises that when considering reverberation to make a space feel larger, caution should be taken if it is applied to all elements, which may just make it muddy.[13] He also suggests that applying reverberation to a single sound may provide a 'vastly more effective expanse.'[14]

Sound effects

Sound effects differ from ambiences as they do not necessarily situate the audience within a location. Instead, the sound effects, diegetic and non-diegetic, relate to the story, characters and the action. These may take place on or off screen, and may be positioned within the surround field to match or highlight either the framed image or the narrative. An example is a car passing from the left of screen to the right of screen. In this instance the sound of the car will pan from the left speaker through to the centre speaker and to the right speaker along with the image. The speakers in a cinema are behind the screen for the left, centre and right and therefore can accurately create the illusion that the sound is connected to the source image as the car travels across screen. This of course is dependent on screen size, as the larger the screen, the greater the distance between the speakers.

The introduction of surround sound has allowed the sound practitioner to move sounds from apparently within the visual frame and place them from apparently beyond the auditorium. This technique is also used to bring content from beyond the screen into the frame. An example is to utilise the surround speakers to introduce sounds from behind the audience as in the film *Australia* (2008)[15] where we first hear the sound of wind in the surround speakers before a stealth-like Japanese Zero bomber appears onscreen.

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[12] Reverberation is the lengthening of a sound due to the source sound being reflected and echoed off surfaces. In sound production this a process applied by hardware or software.
[13] Sonnenschein, *Sound Design*, 2001, 84.
[14] Ibid.
[15] Baz Luhrmann, Stuart Beattie, Ronald Harwood and Richard Flanagan, *Australia*, directed by Baz Luhrmann (Century City, CA: 20th century Fox, 2008).

Mixing

One of the most contested areas of concern with sound for 3-D is in the sound mixing. Since the introduction of surround sound and digital surround sound, new creative opportunities became available, as noted by Chion:

> As new technologies of sound mixing were developed, it became easier to produce sounds that were well-defined and individuated in the mix. The means became available to produce sounds other than conventionally coded ones, sounds that could have their own materiality and density, presence and sensuality.[16]

Many in industry share Thom's notion that surround sound is 3-D. When asked if the soundtrack for *Avatar* was treated any differently being a 3-D film, Gwen Whittle from Skywalker Sound responded saying 'that sound has been 3-D long before picture has. That's what 5.1 gives you - it gives you true 3-D sound.'[17] Andy Nelson, Head of Sound at Fox Studios Los Angeles also agrees: 'We've been mixing in 3-D for years. The picture hasn't been in 3-D for years, so they've caught up with us.'[18] From personal experience, I believe that sound has become dislocated from the image since moving from conventional 2-D film to digital 3-D. The image is no longer sitting on a 2-D plane, and it is now artificially detaching from the screen. If the image is detached from the screen, then the traditional soundtrack emanating from behind the screen has now lost its spatial connection with the image. Wayne Pashley states that 'what I realise now is that we need to move into pre-mixing in 3-D, because what's happening is we're staying in a 5.1 traditional sense.'[19] David Farmer shares this concern. Farmer argues that an audience is taken away from a film when the sound and image are competing on two separate planes. This is compounded when the dialogue is split across multiple channels. An example is when a character stands over the audience and the dialogue is split between the ceiling and the centre speakers. Farmer recognises that unless the audience is seated within the 'sweet spot,' the sound will appear to be biased to whatever speaker is closest to the

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[16] Chion, *Audio-Vision*, 1994, 148.
[17] Whittle, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 2.
[18] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA, 2.
[19] Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia., 1.

listener.[20,21] As 3-D film production increases, perhaps industry professionals will reconsider what defines 3-D sound.

In all interviews that I conducted, the participants unanimously agreed that Dolby Surround 7.1 improves the sound design of 3-D films over Dolby 5.1. This is attributed to the side surrounds being separate to the rear wall surrounds. The additional two speaker channels provides additional perceived space and resolution for the sound designer and re-recording mixer to place sounds. Greater fluidity of movement between the screen and the rear of the room is a result. Andy Nelson discusses mixing the music of *War Horse* (2011)[22] in Dolby Surround 7.1. The 7.1 format allows the mixer to have greater control of discrete sounds. Nelson states that 'as a music mixer, I've approached each of the music films I do now, each of the scores by not really utilising the music into the back of the room, just into the sides, which allows a kind of a whole different dynamic to take place with the sound effects.'[23] Will Files, Sound Designer at Skywalker Ranch also recognises the increased dimensionality of 7.1 compared to 5.1. In discussing the 7.1 creation of *Mission Impossible Ghost Recon* (2011),[24] Files talks about dimensionality 'in terms of articulating the panorama and moving things around in the theatre in a way that was very 3-dimensional, even though the picture was actually flat (2-D).'[25]

The introduction of mixing and exhibiting in immersive sound formats challenges the notion that any form of surround sound is 3-D sound. Immersive formats are being marketed as true 3-D sound since they have additional height and/or ceiling speakers when compared to 5.1 or 7.1 surround sound formats. This implies that the traditional surround formats are 2-D as there is no height dimensionality as all speakers are located on a single horizontal plane. Thom claims that the focus of creating a soundtrack for 3-D should not evolve around the technology, but instead should maintain focus on the story.

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[20] Farmer, Personal Interview: 3-D Sound Discussion at Park Road Post, NZ.
[21] The 'sweet spot' refers to the position which a listener sits where the sound quality and sound field (stereo or surround sound imagery) is at its optimum.
[22] Lee Hall and Richard Curtis, *War Horse*, directed by Steven Spielberg, (Universal City, CA: Dreamworks SKG, 2011).
[23] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA, 4.
[24] Josh Appelbaum and André Nemec, *Mission: Impossible - Ghost Protocol*, directed by Brad Bird (Hollywood, CA: Paramount Pictures, 2011).
[25] Will Files, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., February 2012, 3.

He has reservations about 3-D sound focusing on technology rather than the art. 'There's a long tradition in film sound I think of paying too much attention to technology, and not enough to the art of story telling.'[26] Thom consistently reiterates the importance of story through his writing and I agree that narrative should be the priority of every film. Technology however does provide practitioners with important tools that enable them to create a better soundtrack.

Although Hollywood produced films such as *Red Tails* (2012)[27] which had an Auro sound release and *Brave* (2012)[28] which was the first Dolby Atmos release, it is not always known what the final sound format release will be during the film production process. For example, *Red Tails* was not originally intended to be an Auro mix. David Acord mentions that the original 5.1 mix was created at Skywalker Sound, before the 11.1 Auro up-mix took place in Belgium. The up-mix required separated sound effects that could be added to the height channel enabling the spread of ambiences. Acord also mixed the music differently depending on whether it was source or score, and also experimented with dialogue reflections in the height speakers.[29]

Technology vendors are continually updating software and hardware with products that increase the immersive film viewing experience. Although limited, developments have primarily come from Dolby and Auro. Whilst other smaller companies are also working on products, Dolby and Auro have had successful theatrical released films using their proprietary surround formats. In a bid to avoid a format war for the next generation of content creation, as discussed in Chapter 2 (page 51), an open object-based audio authoring format known as Multi-Dimensional Audio (MDA) has been proposed.[30] As immersive sound technologies expand in production and exhibition, the articulation of sound dimensionality will continue to embrace higher levels of resolution.

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[26] Thom, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 2.
[27] John Ridley, *Red Tails*, directed by Anthony Hemingway (Century City, CA: Twentieth Century Fox Film Corporation, 2012).
[28] Mark Andrews and Brenda Chapman, *Brave*, directed by Mark Andrews and Brenda Chapman (Burbank, CA: Walt Disney Pictures, 2012).
[29] Acord, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 3.
[30] Business Wire, "DTS and Fairlight Collaborate to Deliver the Industry's First Next-Generation 3D Audio Creation Platform to Support MDA | Business Wire," *Business Wire*, April 8, 2013, accessed April 16, 2013. http://www.businesswire.com/news/home/20130408005416/en/DTS-Fairlight-Collaborate-Deliver-Industry%E2%80%99s-Next-Generation-3D.

Part 1: Approaching the soundtrack creation for 3-D

As stated in Chapter 1, this research was initiated as a result of a challenge I faced whilst working on the film *Legend of the Guardians*. The first digital stereoscopic 3-D film release for Australia meant that as a sound team, we were trialling and pioneering our own work practices and methodologies. Although our tools remained unchanged from traditional 2-D films, it was evident that we continued to follow 2-D working practices despite the film being a 3-D release.

All aspects of the film sound production remained unchanged from that of a 2-D film production; the software remained the same and we worked with 2-D images throughout the entire editing process. It was not until the final mixing stage that 3-D images were screened against the soundtrack. We had to speculate what the final 3-D rendered images would look like, and create of sounds accordingly. This unknown is not uncommon. With an increase in visual effects, having final renders throughout the sound production process is a rarity. As noted by Gwen Whittle whilst working on *Avatar,* they worked with 'blocky blue people until the very end. The visual effects came in late, even during the pre-mixing, with some final shots not making it for the final mix.'[31]

The following practice-led research includes: *Legend of the Guardians: The Owls of Ga'Hoole*, *Happy Feet Two*, *The Great Gatsby* and *The LEGO Movie.* Credited as a sound effects editor, my role consisted of creating many of the stylised sound effects for the films. This provided many creative opportunities to craft unique sounds that were often highlighted through the use of 3-D. Working within the 5.1 sound format limited the positional rendering of sounds in z-space. At the time, 3-D filmmaking was new and there were no new tools available specifically for 3-D sound design. Supervising Sound Editor Wayne Pashley explains that this allowed a degree of freedom in the soundtrack creation.

> Like anything with sound design for these feature films, particularly in animation, there's a lot of latitude with the sound scope because it's built from nothing. I think that the palate is so open, that 3-D imagery and the complementary sound is wide open at this point for interpretation.[32]

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[31] Cameron, *Avatar*.
[32] Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia.

Prior to commencement on these films, several successful 3-D films had already been produced in the United States. These included *Chicken Little* (2005),[33] *Bolt* (2008),[34] *Monsters vs Aliens* (2009)[35] and James Cameron's *Avatar* to name a few. The only preparation or research available for our Australian sound crew was to critically analyse and listen to these previous US releases. As 3-D technology was still evolving, it became apparent that these films did not demonstrate anything drastically different to previous 2-D releases. In the following practice-led research I highlight some of the limitations faced whilst creating sound effects for several 3-D film releases.

***Legend of the Guardians: The Owls of Ga'Hoole* (2010)**

Legend of the Guardians provided my first opportunity to work on a stereoscopic 3-D film. Although 3-D films had been made prior to this film, this was a first for the Australian film industry. Working with animation is unique in that it is not uncommon to be creating sounds for unfinished imagery. This may include simple static hand drawings, as it is often not until the end of the production process that images begin to resemble the final shots. An ability to mentally visualise the final imagery and how the accompanying sound should play in order to create a sonic solution for such primitive visuals is necessary.

One of the primary creative considerations is what sound will need to be implemented; the other is where does the sound belong in terms of both the frame and the spatial sound field. This unknown belonging results in the sounds having inaccurate positional data. Editing sound against still images or animatics makes it next to impossible to predict exact timings.[36] The process of sound creation and design for *Legend of the Guardians*, consisted of an organic approach that took into consideration the constant evolution of the visuals, with the sound having to be constantly renewed with every picture update. These updates were regular, and helped provide an insight as to what the final rendered images would be.

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[33] Mark Dindal and Mark Kennedy *Chicken Little*, directed by Mark Dindal (Burbank, CA: Buena Vista Pictures Distribution, 2005).
[34] Dan Fogelman and Chris Williams, *Bolt*, directed by Byron Howard and Chris Williams (Burbank, CA: Walt Disney Studios Motion Pictures, 2008).
[35] Maya Forbes and Conrad Vernon, *Monsters vs Aliens*, directed by Rob Letterman and Conrad Vernon (Universal City, CA: Dreamworks Animation, 2009).
[36] An animatic is an animated version of the storyboard that is often used to provide timing of sequences, scenes or the entire film.

As a sound effects editor, my role was to create many of the designed sounds for the Fleck Field, the slow motion scenes and for what was termed as the owl 'silent flight' scenes.[37] These visually rich scenes allowed the progression of the sound elements to be created over a 30-week period. The sounds were built from the ground up, much like the visuals were created. This meant that I would create many of the sound beds, and then increase the detail as the images and timings progressed. In designing many of these previously unheard of sounds I used original recordings, synthesised sounds and plug-in processing.

This case study identifies some of the shortcomings associated with 3-D films and contemporary surround sound formats. In particular, the limitation of the 5.1 format highlights a lack of homogeneity between the positioning of the sound and image within the 3-D z-space. This includes creating positional data (inputting the pan positions into the DAW software) and also the positional rendering (how accurately the sound positional data is reproduced through speakers).[38]

Silent flight

Creating the sound for the silent flight provided many challenges. The design needed to consider the sound of an approaching owl that produced a sound that was 'silent' yet menacing, without giving away the impending visual shot. The sound was stealth like on the approaching owl and when in close proximity to the prey, the sound had a steep attack with little lead in transitioning to the huge 'thwump' for the actual attack. This process of creating the silent flight was used sparingly for several scenes when an owl would attack specific prey.

[37] The fleck field is a magnetic force that has the ability to weaken the owls energy.
[38] Positonal data and positonal rendering are original terms coined by the author. Please refer to the Terminology section for further details.

Figure 16: Legend of the Guardians mouse attack

The first time we hear the silent flight is within the opening sequence where a field mouse is scampering along a branch (Figure 16), seemingly safe and happy. From out of nowhere the first owl in the film appears, arriving into shot from the top left of screen without any aural warning. The owl swoops and snatches the mouse with both claws, flying into strong negative parallax, before disappearing behind us. We hear only the slightest wind for the owl's approach as it glides in for the attack. Only when the owl's claws strike and grab the mouse do we hear the full sonic impact. The impact is stylised as it's not using the entire frequency spectrum, instead, using low frequencies. These frequencies play through the sub woofer (LFE) track and represent the concussive force experienced by the mouse. We also hear a close up sound of the final downward wing flap, which utilises the surround speakers, further hinting at the proximity, aggression and surprise of the attack.

During this 3-D scene, the mouse is in the foreground and the owl is in the background. The sounds of these characters replicate this initially, as the main soundtrack is playing from the front speakers, with only the atmospheres and music playing in the surrounds. However, once the owl approaches for the attack, the wings and the sonic boom dissipate through all of the speakers, utilising the entire 5.1 surround sound field.

Fleck Field

The Fleck Field is made up of magnetic iron fragments that interfere with the owls' brains by taking away their ability to navigate, rendering them immobile. Visually they look like magnetic, electric charges that zap the owls similar to electrical arcs. Towards the end of the film when we are in close up on the character Ezylryb (voiced by Geoffrey Rush), we

can see that the Fleck Field envelops us with specific spot zaps striking and attaching to the owls (Figure 17). Approaching the task of designing the sound for these shots required orchestrating the overall Fleck Field sound, whilst keeping the specific and isolated Fleck zaps defined.

The first task was to design the overall Fleck Field, using the entire 5.1 surround space. Comprised of multi-layered plasma, magnetic/electric sounds with a slightly pulsating humming tone, the Fleck Field resonates around all speakers in 5.1 surround. This provides an aural environment that situates the audience well within the Fleck Field with the onscreen characters. As this general sound was not specific to spot effects, it created the ambience and was not synchronised to any onscreen action or characters. Providing added value to the 3-D imagery, the immersive 5.1 sound design extends beyond the screen and into the audience, bringing the audience into the frame.

Figure 17: Legend of the Guardians Fleck Field

The specific Fleck zaps for the scene were delicate to create as the sounds needed to be defined from the general Fleck Field sound bed. Considering the 3-D visuals, the sounds needed to pan in z-space bonded to the negative parallax 3-D Fleck zap vision. Although many of the cues for positioning along the x and y axes were onscreen, no cues were provided for positioning along the z-axis in z-space. Creating these sounds, I had no 3-D rendered reference imagery; instead the depth cues and the fleck positioning were anticipated.

The sounds created for this scene were the most dynamic in terms of utilising the surround sound channels, and the 3-D z-space of the cinema. Great consideration was placed on having the zaps pan radically with the 3-D images. This was to bring the audience into the frame. As mentioned earlier, the general Fleck Field sounds enveloped the audience so it was important that these visually dependent sounds also enveloped the audience, rather than just playing through the front speakers. Without this, the scene would be less harmonious as we would have two aural spatial elements competing and contradicting each other. In this instance the audience would be torn as to which sound to listen to, and thus the continuity of the scene would be lost. This scene is analysed in greater detail in Chapter 6 (page 199).

Battle scenes

Designing the sounds for the slow-motion battle scenes allowed for great creative freedom again in terms of the design and placement of sounds. Playing in slow-motion, these sounds had a relatively longer amount of screen time. This proved challenging, as a typical attack sound on a film is relatively short and sharp. However, these were elongated, crafted so that the sound would remain realistic, yet be detailed and heightened with character. An example is the blade swing that provoked and inspired this thesis as seen below in Figure 18.

Figure 18: Legend of the Guardians bat blade

The first sound that comes to mind to use for this shot could be a well-recorded blade sheath. However, the sound of a sheath doesn't suit the image as the sheath sound represents a sword sliding over, or being pulled across an object. The problem we have is that the blade takes up so much screen real estate with strong negative parallax. A single sound would not suffice for the detail of the imagery (Figure 19, page 112).

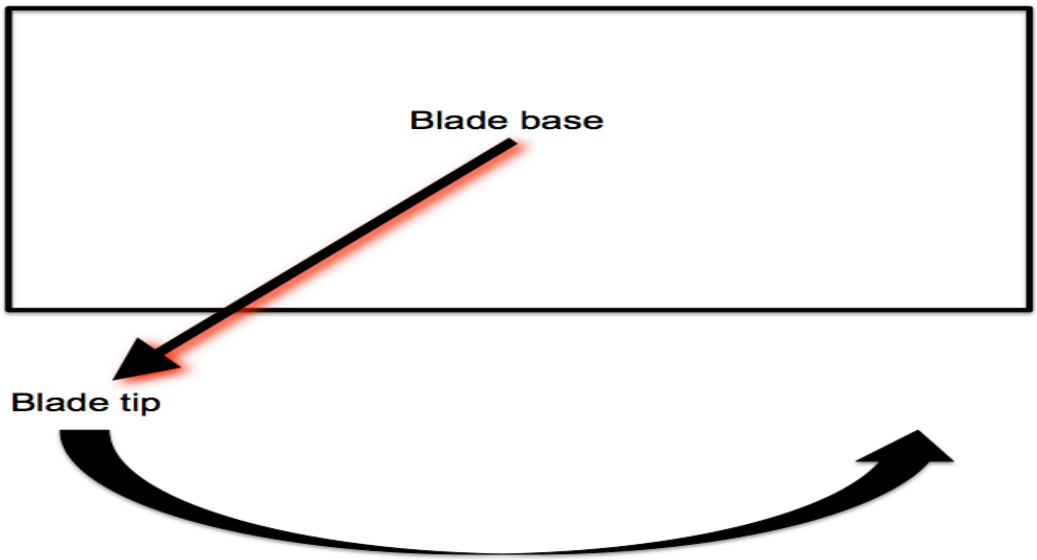

Figure 19: Slow-motion blade swing

Considering the two images above (Figure 18 and Figure 19), a single sound did not provide the accuracy needed to represent a blade swinging in 3-D z-space. In response, I created a set of sounds that appropriately represented and provided greater homogeneity between the image and sound. The blade was broken into two distinct components; the first was the blade swinging action including the whoosh and metal swing, whist the other component was the actual tip of the blade slicing through the air. Combined, these created an overall sound that had a three-dimensional feel. By having two different pivot points, I was able to create a sound attached to a 3-D object with depth. For example, as the image appears in strong negative parallax, I can pan my blade tip sound into z-space through the use of the surround speakers. With the opposite end of the blade in positive parallax, I can pan the second sound across the front screen speakers only. Played against the imagery, the two sounds on two different z-axis points allow a sound to have perceived depth. This aligns with Chion's description of added value. Sound is influencing perception; it is making us see in the image what we would not otherwise perceive through interpreting the meaning of the image.[39] Although the sound of the blade contributed to a successful 3-D audio-visual experience, in Chapter 6 I argue that this methodology relies on perception and is far from ideal.

[39] Chion, *Audio-Vision*, 1994, 34.

Water vortex

Another slow-motion stylised sound designed sequence included an owl (Soren) flying in negative parallax through a water vortex (Figure 20). This is a spectacular 3-D moment, as the vortex is comprised of many water drops that flow from behind the camera and disappear into the distance in positive parallax in front of the camera, as the owl flies towards camera with its wings stretched across the screen.

Figure 20: Legend of the Guardians water vortex

During this sequence, the water droplets are also spiralling around the owl. The challenge was to convey not only the sound of droplets moving from the rear of the cinema and into the distance in front of the audience, but additionally to have the sound appear to be swirling around the audience, above and below (see Figure 21 below).

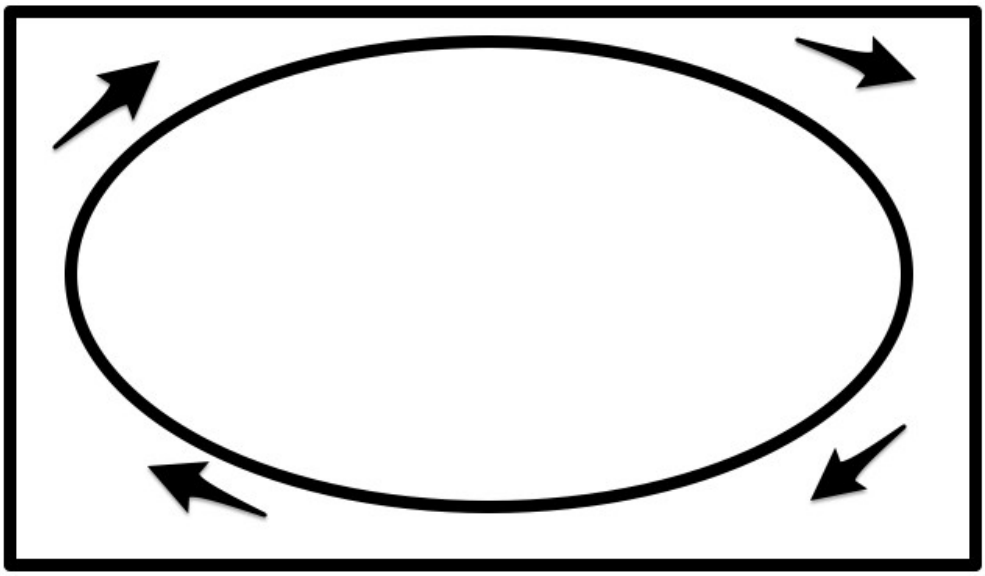

Figure 21: Legend of the Guardians water and sound movement

Limited to using the 5.1 format, it was impossible to pan the sounds into the ceiling or under the audience to create a sound that spun above and below them. To achieve this illusion of movement, I manipulated frequency shifts and applied filtering techniques through my design. As the sound panned from right to left, the technique consisted of increasing the low frequencies and using the LFE track whilst removing the high frequencies so the sound appeared to be under the audience and for the water onscreen to swirl under the owl, then as the water came up on the left hand side, decreasing the lower frequencies and increasing the high frequencies as they also panned from left to right so the water appeared to go above the audience. This created the illusion of the sound swirling. In addition, the sounds concurrently panned from the surround speakers to the front speakers, highlighting the illusion of the owl flying through the 3-D rain. For this particular sequence I was able to request some of the unfinished 3-D imagery so that I could calculate how much parallax would be used. Although I didn't edit my sounds to these 3-D shots, they did provide an invaluable 3-D depth reference. I was able to play these side-by-side (SBS) 3-D images from a 3-D television and anticipate the composition of the final renders of the film.[40]

After the completion of *Legend of the Guardians*, I was familiar with the limitations of creating a soundtrack for a 3-D film. The film utilises the entire 3-D visual space with both strong negative and positive parallax used in many shots, providing valuable experience with visual positioning along the z-axis. The placement of visuals in negative parallax in particular, highlights the shortcomings of accurately attaching sound to the image when using the 5.1 surround sound format.

***Happy Feet Two* (2011)**

With less action than *Legend of The Guardians*, the approach to the sound design for *Happy Feet Two* was very different in regards to the relationship with the 3-D imagery. The film has an underlying theme of global warming, and part of my primary responsibilities included the creation of the sound for the characterisation of the Doomberg iceberg. The Doomberg plays the role of the antagonist and is slowly on a collision course towards Emperor Land, the home of the Adele penguins.

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[40] Side-by-side is a 3-D format that uses alternating frames to provide the left and right images within a single image stream. This is a common television broadcast format.

Despite not always having 3-D visualisation within negative parallax, *Happy Feet Two* demonstrated consistent limitations of the bond between the 5.1 format and the 3-D visual positioning.

The Doomberg

In the opening scene the audience is introduced to the Doomberg as it cracks and breaks free from the main land mass. The ripping crack starts as a single short sharp monophonic ice chink. It gradually grows and approaches the camera as it develops into a huge earth shaking ripping tear of seismic proportions. As it approaches, the sound transforms in intensity and frequency range, including increasing in the amount of low frequencies. As these intensify, the physicality of the sound begins to allow the audience not only to see and hear the scene, but also to feel it through the soundtrack. This ability to feel sound echoes Altman's comments.[41] Beginning as a single monophonic sound, the sound space increases with the inclusion of the left and right front speakers until also panning into the rear surround speakers, enveloping the audience.

Combined with the Doomberg breaking free and sounds of ice cracking, the addition of ice particles and snow falling from the cracks add to the detail of the overall sound. Working only to 2-D images meant having to speculate what the crack would look like in the final rendered 3-D, and anticipate the 3-D imagery in negative parallax, with the crack moving from the screen speakers and into z-space by playing out of the surround speakers. When the crack has completed and the Doomberg has broken away, the audience gets the first hint that the Doomberg is not just part of the landscape, but is an integral character. This is achieved through designed sound effects combined with a vocal exhale. The framing at this stage is a long shot, with the sounds of the Doomberg character through the front speakers only.

Throughout the film, the Doomberg's impending danger is experienced. As it moves through the water on a collision course (8 min. 30 sec.), the ripple effect it causes generates a giant wave of water. Seeing this wave come towards camera provides one of the most visually stunning 3-D sequences of the entire film. Not only do we see the wave

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[41] Altman, "The Sound of Sound.," 68.

with its bubbles, but we also see thousands of krill, providing a visually enriched scene with multiple layers, as shown in Figure 22.

Figure 22: *Happy Feet Two* krill

Before learning of the impending wave, we first see the water and krill get sucked forward, before being thrown into turmoil as the wave passes through camera in negative parallax. As the krill and wave pass, the use of the surround field could be pushed quite hard into the rear surrounds. The vision sweeps along the z-axis, in z-space oscillating from the negative parallax, through screen into positive parallax, before returning into negative parallax. The sound follows by being present in the rear surrounds, sweeping to the front speakers before again panning back into the rear surround speakers. As the wave, water and krill fill the entire screen, the panning of these sounds works very effectively with the 3-D visuals, as both image and sound immerse the audience. This effective immersion with 5.1 and 3-D is similar to the practice-led research on *Carwash* (2013)[42] discussed in Chapter 6 (page 182).

Chainsaw

Despite working predominantly on the Doomberg, one of the incidental spot effects I created was the chainsaw that was used by the human rescue team to create an escape for the penguins. Of particular interest is the way in which the chainsaw is filmed. The

[42] Damian Candusso, *Carwash*, 2013.

chainsaw is first introduced as Will (voiced by Brad Pitt) climbs onto the chain and then ends up inside the motor after one of the rescuers tries to start it. As the chain spins, Will zips past camera in strong negative parallax before we cut to a close up interior shot inside the motor (Figure 23). The sound design for this scene replicates the use of z-space by the image.

Figure 23: Happy Feet Two Will on chainsaw

Firstly we hear the pull chord through the right hand front speakers followed closely by a petrol squirt and ignition spark. As these take place, the chain spins in the surround speakers creating the illusion that the audience is also inside the engine. As we cut from the interior to the exterior we go from being inside a chainsaw surround soundscape to seeing Will coming towards us in negative parallax as he clings on to the chain as it rotates. A long shot of the chainsaw follows, the sound playing only in the front speakers. Using a convolution reverb I slightly delayed and echoed the chainsaw sound to also play in the surround speakers. The purpose of this was not to draw attention to the rear, but to situate the chainsaw in front and in the distance through replicating real life acoustics. Sound was positioned behind the audience to emphasise the perspective of the shot. The surround sound reverberation has acoustically positioned the chainsaw relative to both the audience and the frame. It wasn't until the premiere that I saw the 3-D images of *Happy Feet Two* for the first time.

Happy Feet Two highlights many of the consistent shortcomings of designing a soundtrack for 3-D. Limitations with the 5.1 format and the positioning of sound within z-space are

problematic. This was a combination of the limitations of the technology and not having 3-D imagery to work with during the sound editing process.

The Great Gatsby (2013)

The Great Gatsby is a significant 3-D film to analyse in terms of both imagery and sound. As a live-action film, it provides a comparison to the previously mentioned animated films. However, despite being live-action, the film does contain many visual effects, with many created to enhance the 3-D visual style and take advantage of the depth of the 3-D medium. Typical of Luhrmann film's, *The Great Gatsby* is a stylistic visual feast. From early in the pre-production process, Luhrmann's vision for the film in 3-D was highly anticipated as Dowd suggests. 'The next big test may be Baz Luhrmann's version of *The Great Gatsby*, due for release in May and starring Leonardo DiCaprio. It doesn't seem like a natural fit for 3-D, but Luhrmann's a very stylistic director and he may make it work.'[43]

The sound design that I contributed to the film included creating the sonic accompaniment for many of Lurhmann's most stylised visual shots. This included 'the green light,' the death of Myrtle in slow-motion and several other stylised effects, including the flash backs. These stylised visual shots provided many creative opportunities to position sounds within z-space, however the limitations of the 5.1 format were apparent.

The green light

From the opening moments of *The Great Gatsby*, when the film transitions from the 2-D logos into the 3-D world of the film, the first image we see and the first sound we hear is that of the green light.[44] This is a signature motif that appears several times throughout the film. The character Jay Gatsby, played by Leonardo DiCaprio, is in love with his former sweetheart Daisy Buchanan, played by Carey Mulligan. Daisy lives across the bay from Gatsby and it is this green light that continually draws at Gatsby's heart as it symbolises the woman he loves.

Generally speaking, lights are quiet with the exception of some high-powered lights or the electrical capacitors of fluorescent lights. The green light in this film has both a physical

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[43] Dowd, "Has 3D Film-Making Had Its Day?"
[44] Luhrmann, *The Great Gatsby*.

presence and a narrative responsibility as it sits just beyond the jetty. Approaching this, my design factored in what may be an actual light sound combined with the aural symbolism of what the light means to Gatsby. It is in this respect that we have two separate elements for the light; one that is diegetic, and the other in Gatsby's head, or meta-diegetic as defined by Gorbman.[45]

The light is unobtainable by Gatsby. It is an ephemeral calling that constantly reminds Gatsby of Daisy, pulling him towards her. In one scene we actually see Gatsby reaching, trying to grab the light with one hand. Through sound this is achieved by creating two separate sound sets that play in unison with each other. Depending on the shot and how the light is framed, they are mixed accordingly. On a long shot, and only seeing the illumination of the light, we hear the light calling; however if we are in close up on the actual light, we hear the more realistic, organic sounds.

For the opening shot of the light we see a strobing green hue illuminated from a long distance across water on a moonlit night, before transitioning into snow. The light in this shot appears very faint and delicate as the audience is introduced to the light without anything being given away. As a long shot, the light is primarily in the mono centre speaker with some very slight reverb playing in the other speakers to provide perspective, acoustic space and distance. In this instance the sound is primarily a buoy bell with some high pitched resonating tones that fluctuate in volume with the sound of waves.

At around the twelve and a half minute point in the film, we are taken back to the green light for the second time. It is only now that the source of the green light is revealed as the camera provides an opportunity to explore it in detail. The camera first zooms in to the light from a distance, before slowing down in close-up to allow the audience a moment, before tracking past the light on the right hand side. The camera then continues to travel beyond the light and across the bay into the headlights of Nick Carraway's (played by Tobey Maguire) approaching car on the other side of the bay. The camera zooms into the headlights, providing the opportunity for a creative sonic transition.

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[45] Claudia Gorbman, "Teaching the Soundtrack," *Quarterly Review of Film Studies* 1, no. 4 (November 1, 1976): 450, doi:10.1080/10509207609360969.

This entire sequence provides several opportunities that exploit 3-D and the use of the surround space. It is created similarly to the opening sequence, with the exception that the bell on the buoy is less distinguished and we have more of the meta-diegetic designed resonant tones. As the camera zooms in however, the diegetic sounds are introduced, both for the light and for the structure that is holding the light. In the creation of the realistic light sounds, much time was spent auditioning many alternative sounds. Framed as a close-up meant that we could exploit the conventions of reality and therefore hear what I term the 'micro-diegetic' light filament flutter within the light bulb.[46] The light passing on the right hand side is allowed to pan across the right of screen and into the rear right surround speakers. As the camera zooms in, these sounds fade up louder, before disappearing and fading out under the ephemeral calling sounds of the light as they too wash away with the camera move across the water.

As the camera zooms into the oncoming headlights, the glow fills the entire frame. Again, sound was created for these headlights. In this instance, the light sonically explodes from the front screen speakers into the surrounds and also through the LFE. The purpose of this was to heighten the reality of the onscreen action, whilst providing an opportunity to sonically flash the transition into the following scene. Utilising every single speaker including low frequencies creates sonic depth. Sound has been used to emphasise the 3-D visuals whilst providing 'added value' to the narrative.

The death of Myrtle

Throughout *The Great Gatsby* the vehicles are a feature that not only serve as props, but also are integral to the story. In a tragic turn of events, when driving home from town, Gatsby's Duesenberg is responsible for killing Tom Buchanan's mistress, Myrtle (Isla Fisher). What makes the story of further interest is that it is Gatsby's true love Daisy (Tom Buchanan's wife) who is actually driving and runs into her husband's lover.

[46] Micro-diegetic is an original term that the author defines as the sound that the character would hear if the sound was amplified to a volume or scale matching the imagery. For example in real life it would be difficult to hear a light filament vibrating. However if the screen shows the filament in close up, then if the filament sound was also amplified, this would allow the sound to be heard.

Figure 24: Death of Myrtle

When we first see the Duesenberg approach in the scene, we are greeted with not only the sounds of an authentic Duesenberg engine, but also aggressive animalistic roars. These animal sounds increase as the vehicle approaches Myrtle as if a predator is going in for the kill of its prey. Visually, this shot makes full use of the 3-D medium (Figure 24). Using a combination of real-time and slow motion shots intercut, the use of the negative parallax is restrained until we see Myrtle floating through the air after being hit by the Duesenberg. On this shot, Myrtle is entirely in strong negative parallax, surrounded by stylistically created shards of glass. The sounds created for the glass are a blend of actual glass and original high frequency sound design, symbolising a tragic yet beautiful moment. These sounds utilise the entire 5.1 speaker array, surrounding the audience. The 5.1 format allows the sound to envelop the audience, but the inability to position the sound within the centre of z-space is consistent with the shortcomings of the format.

Cigar close up (CU)

One of the most pronounced 3-D sequences in the film involves Tom Buchanan's cigar being lit by a lighter in close up (Figure 25, page 122). Converged out of the screen in strong negative parallax, the hand holding the lighter is in the extreme foreground. Framed on screen-right the hand is holding the lighter low in shot allowing the audience to focus on the flame that is half of the screen height, igniting the end of the cigar. As the lighter exits frame to the right, Tom draws air through the cigar. As this happens we see both the end of the cigar ignite and also we hear in extreme detail the crackle of the tobacco combusting.

The mixer at this moment has the room ambiences quite low in level and background dialogue has been suppressed, demanding our attention. The only other sounds we hear are some of the underscore that has come across the transition from the previous scene. Although the shot isn't held for long, it is significant that there is such detail and clarity with both the visual and audio. This isolation of the cigar draws the audience in on the tension that has just unfolded. Although the cigar sound is detailed, there is dislocation as the sounds are positioned in the front speakers despite the cigar in extreme negative parallax.

Figure 25: Cigar close up

Luhrmann has deliberately utilised the 3-D in such a way as to not over use the negative parallax or z-space. Instead the film is framed like a staged theatre, with most of the action happening beyond the screen plane. This technique of framing the 3-D in positive parallax is representative of the stage as one of the origins of films. The soundtrack complements the imagery with seldom use made of the surround speakers. The use of negative parallax has been reserved for specific narrative moments, including the death of Myrtle and the cigar. These negative parallax scenes highlight the inability of the 5.1 format to allow the accurate positional rendering of sound within the cinema z-space.

Andy Nelson notes that 3-D is not necessarily about the image coming out of the screen. Having mixed films extensively in 3-D, Nelson has witnessed a change in the use of the 3-D space with his biggest revelation being that 3-D can be like a theme park ride, an abusive

assault that makes you duck for cover, making the film less of a movie.[47] Nelson estimates that 80% of 3-D films are now using the positive parallax and going from the screen back, whereas the sound starts at the screen and comes towards the audience.[48] Not all contemporary 3-D films have chosen to discount the use of negative parallax. As noted by Puchko, '3D can go great with action, and truly sings in computer-generated productions. Stuffed with car chases, explosions and flashy battle scenes all constructed with CGI, *The LEGO Movie* is a perfect venue for the use of 3D.'[49]

The LEGO Movie (2014)

Having completed several 3-D films prior to *The LEGO Movie,* the question was raised - 'Would we treat the film as a 2-D film or 3-D film during the editing process?' [50] The answer was to treat *The LEGO Movie* as every other film, either 2-D or 3-D; that is keep everything in the front speakers unless the action is obviously off screen to the side or behind us. Although knowing that *The LEGO Movie* was going to be a 3-D release, at no point during the sound editing process were 3-D images provided.

Consistent with previous films, the first 3-D screening of *The LEGO Movie* I saw was the theatrical release. Prior to release, I had only seen the film in 2-D. Throughout the production process, the visuals in the scenes were constantly updated. Figure 26 and 27 (page 124), show the evolution of visual developments between May and November 2013. This posed many challenges, as not only were we working to the 2-D version of the film, but in many instances scenes were still in sketch form. As scenes were updated, the soundtrack also required updating to reflect these changes, usually requiring additional sounds. The updates also provided a degree of anticipation of depth cues for the positioning of sound along the z-axis. Although sounds were panned along the z-axis, the 5.1 format demonstrates several instances of dislocation between the positional rendering of sounds and the 3-D imagery.

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[47] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA, 3.
[48] Ibid.
[49] Kristy Puchko, "To 3D Or Not To 3D: Buy The Right LEGO Movie Ticket," February 6, 2014, accessed September 5, 2014. http://www.cinemablend.com/new/3D-Or-3D-Buy-Right-LEGO-Movie-Ticket-41514.html.
[50] Lord and Miller, *The LEGO Movie*.

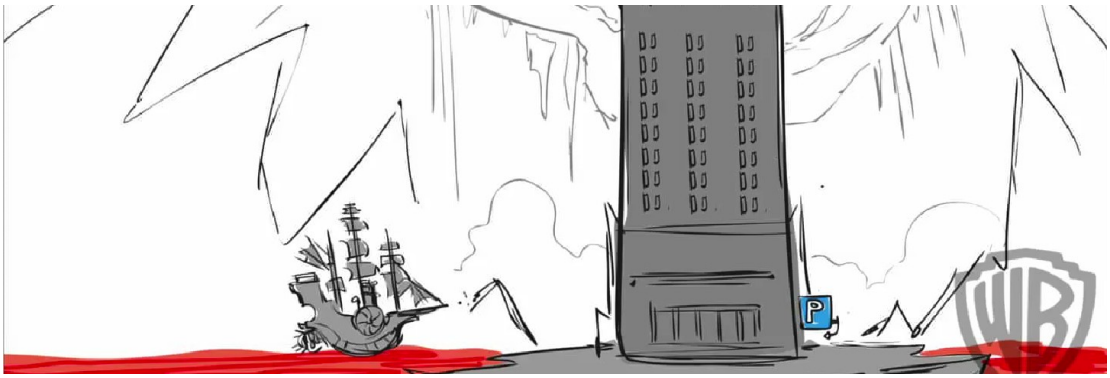

Figure 26: LEGO Screenshot taken on May 31st 2013.

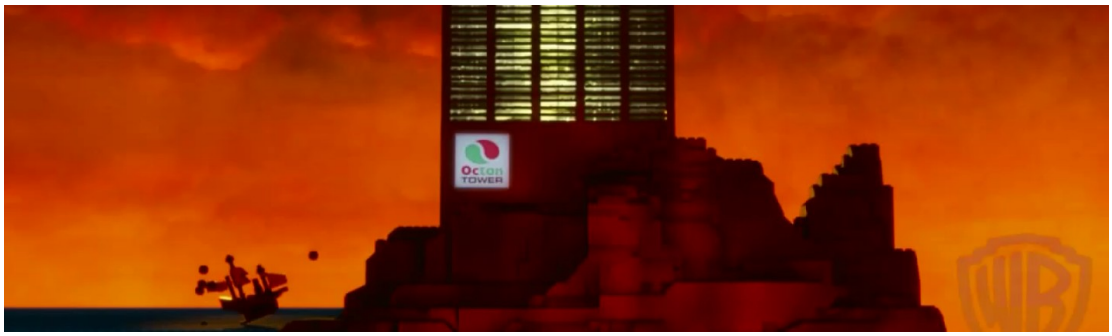

Figure 27: LEGO Screenshot taken on November 19 2013

One of the first uses of negative parallax takes place in the opening scene with Lord Business (voiced by Will Ferrell) walking towards camera and leaning forward saying, "A special one? What a bunch of hippy dippy boloney." This shot provides one of the first dislocations between image and sound. The character's visuals are in extreme negative parallax, with the dialogue source remaining on the screen plane (Figure 28).

Figure 28: Lord Business in extreme close up in z-space

Another noticeable dialogue dislocation occurs at 6 min. 45 sec. During the song *Everything is Awesome,* the big brother surveillance camera sweeps into z-space resulting in a close up. Again, the sound remains on the screen plane despite the camera located in z-space. At the conclusion of the film, another example of dislocation between image and sound occurs. In the final scene, Vitruvious' (voiced by Morgan Freeman) ghost floats in z-space talking, despite the dialogue located on the screen plane.

As discussed in Chapter 3 (page 89), the POV is a powerful filmmaking technique. Thom states that the POV allows a movie to be as cinematic as possible.[51] I argue that the POV in 2-D films is more effective than 3-D films due to the inability to accurately position sound within the circumspace using contemporary cinema speaker formats. This is highlighted in *The LEGO Movie* at around eight minutes when we are in the POV of the protagonist Emmet as he is holding up his instructions to camera. Emmet (voiced by Chris Pratt) says to himself, 'If you see anything weird, make sure you report it immediately.' The dialogue is in the centre speaker, but the POV situates Emmet within z-space, with the instructions on the screen plane, thus creating a dislocation. Ideally the scene would have the dialogue originating from inside the audience member's head, but this isn't possible because of limitations of contemporary cinema speaker formats.

A highlight of the film that demonstrates homogeneity between the positioning of sound in unison with the 3-D imagery can be observed at 14 min. (Figure 29, page 126). This scene takes place in the 'Melting Room' during a laser gunfight. The imagery makes effective use of negative parallax with lasers travelling throughout the cinema z-space.

[51] Thom, "Designing A Movie For Sound by Randy Thom," 3.

Figure 29: LEGO Melting Room laser fight

As Puchko states, the effective use of 3-D imagery allows the gunfire blocks to 'pop right out of the screen and it allows the audience to get closer to Emmett and the gang as they are thrown sky high and right at us.'[52] The soundtrack complements the imagery as we also hear laser shots and ricochets in the front and surround speakers. As the laser imagery is travelling fast, firing a laser from a front speaker with a ricochet in a surround speaker provides the illusion that the laser has fired and travelled through the room.

The use of z-space in *The LEGO Movie* is constantly taken advantage of with the visuals often coming off the screen. Although this section has identified only a few of the noticable dislocations, what should be noted is that these primarily are identifiable with the dialogue. The example of the effective use of the laser guns demonstrates that certain elements do in fact work well. It is not however appropriate to break down the entire film for this thesis. These examples of dislocation and effective homogeneity highlight a trend on all of the 3-D productions that I have been involved with.

Conclusion: Working on 3-D feature film productions

All films that I have discussed in Part 1 of this chapter were created, mixed and released in the 5.1 format. Although sound formats above 5.1 were available including 7.1 and

[52] Puchko, "To 3D Or Not To 3D."

immersive sound formats, 5.1 was the format nominated by the film studio. This signifies that just because newer formats exist, studios aren't necessarily adopting these for their releases, but are instead cautiously waiting. Having worked on 3-D films since 2010, I became aware of some consistencies that have emerged between the relationship of the 3-D image and the soundtrack. However, for this immediate comparison I would like to ignore the music and the atmosphere components of the soundtrack, focusing only on the dialogue and sound effects. It is the dialogue and sound effects that commonly relate to the 3-D imagery specifically, especially in the films that I have referenced.

One of the most common and consistent dislocations that occurred was the dialogue playing from the centre speaker with the character positioned along the z-axis in negative parallax. Knowing that dialogue has traditionally only been mixed to the centre channel, it is apparent that despite a film being in 3-D, this convention continues. This is further recognised when a character is within a POV shot. Wayne Pashley explains why dialogues are seldom panned from the centre channel:

> The dialogue has still got to stay on the screen. I find with tests that we've done where a character's beak, let's say - in an animation if it was a bird, that came out into the audience and if you try to follow or pan that dialogue out into the audience, I think it's a bit of a mistake because all of a sudden the surround component gets too overloaded and all that it does is throw the interpretation of the narrative off the screen, and I think it's very distracting.[53]

Will Files from Skywalker Sound suggests that perhaps this is a limitation of the 5.1 format. Files suggests that 'you're much more likely to bring the dialogue off the screen and into the surrounds if you're in 7.1 than if you're in 5.1, because if you bring something off the screen in 7.1, it's only going halfway into the auditorium instead (of) all the way wrapped around the audience.'[54] There are exceptions to mixing dialogues exclusively in the centre channel for 5.1 releases including *Gravity* as discussed in Chapter 3 (page 85). *Gravity,* however, also had a Dolby Atmos release.

Dislocation also occurs with the sound effects of 3-D films, but these are less noticeable. This may be a result of the mixer having the freedom and flexibility to bring the sound

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[53] Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia., 1.
[54] Files, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 2.

effects from the front speakers and into the surround speakers. Limitations are presented though in the accurate positional rendering of some sounds, with the blade from *The Legend of The Guardians* providing an example. However panning the movement of sounds from speaker to speaker aids in creating the illusion that the sound has travelled through the z-space of the auditorium. As an audience, we are used to sound effects in the surround speakers, and either don't notice or don't question the accuracy.

Part 2 below, will critically analyse two films that I had no involvement with. These films have been selected as they provided an opportunity to hear them in Dolby 5.1, and also the immersive sound formats.

Part 2: Case studies on immersive sound releases

Cinema sound vendors are marketing immersive sound technologies as providing 3-D sound due to the addition of height channels. In this section, I argue that these formats fall short in providing a true 3-D sound experience. Despite having many more speakers and sounding superior to previous surround formats, the technology continues to demonstrate many of the shortcomings of conventional surround sound. Although this is primarily a limitation of most speaker formats, the immersive formats are also not being fully exploited due to a lack of decision making, resulting in vast time restrictions when creating an immersive sound mix.

Dolby Atmos demonstrations

During a field trip to the United States in early 2012, I visited Dolby laboratories in San Francisco. At this time, Dolby Atmos was in the final development stages, just prior to its commercial debut. During this visit, I experienced several demonstration pieces that highlighted the capabilities of the Dolby Atmos format. The technology sounded superior to contemporary surround sound formats due to the addition of LFE channels, many more surround channels and ceiling channels. The demonstration provided an opportunity for sound to envelop or cocoon an audience, but it fell short in rendering sounds placed accurately within the cinema space. What it did provide was an excellent portrayal of a highly detailed canopy of sound.

In February 2014, Dolby provided a local showcase of the Dolby Atmos format at the first Australian facility equipped to mix sound in Dolby Atmos, Soundfirm Melbourne. The first piece demonstrated did not have picture and it depicted a jungle scene. I had heard this on my San Francisco trip so I was familiar with this piece. The jungle scene utilises the

overhead speakers and has many panned elements (objects) travelling across the ceiling. This includes animals scampering across foliage and animal calls. Without any imagery, this is difficult to judge in terms of how sound and image would bond, or how this sonic experience would translate with an actual film. Throughout this entire piece I felt as though I was sitting 'under' these trees and not actually 'amongst' the trees.

The next piece to play was a Dolby Atmos demonstration animated film written by Gary Rydstrom about a leaf. Rydstrom had experience with the Dolby Atmos technology and wrote the film from the 'sound up.' That is, he designed the film using sound, and then the animation was created. Again, this was another jungle piece with a leaf as the protagonist. The leaf falls and the camera follows the leaf, with Dolby Atmos conveying the foliage through the panning of objects utilising the ceiling speakers. Although this was played with pictures, the soundtrack was larger and exaggerated compared to the imagery. There was a large disconnection between sound and image.

The third and final piece was another animation. This was inspired by the transformer franchise and displayed glass tiles flicking and folding around the screen in 3-D. Sound Designer Eric Aadahl created a very well suited soundtrack that was reminiscent of the sound of the *Transformers* franchise, which he is also credited with working on. This provided the best use of the Dolby Atmos format, although both the imagery and soundtrack were crafted specifically for the medium. Here, the sound and image 'wrap around' the audience, with less movement across the ceiling. In particular, the sound travels around every speaker in the room, almost as a disguised form of speaker calibration. The sound pans in a smooth circular motion, going from left front, across the left wall, behind the audience and then down the right hand side. Fuchs notes this smoothness of panning:

> With Dolby Atmos, because of sound objects addressing individual speakers, you can make the transition go around terribly smoothly. Suddenly I can put a sound anywhere I like. In fact, not just on the horizontal plane but in the vertical plane as well. Dolby Atmos creates a totally symmetrical hemisphere in terms of the playback.[55]

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[55] Andreas Fuchs, "Soundsational!," *Film Journal International* 115, no. 5 (May 2012): 7.

The demonstrations highlighted the superiority of the full range surround speakers, ceiling speakers and the bass management of the Dolby Atmos format, however the technology did not allow the soundtrack to spatially support the 3-D.

Despite being a superior sounding system in comparison to conventional 5.1 and 7.1 systems, what remained a limitation was that there continued to be a sonic void in the centre of the theatre. The format allows for a cocoon, or as Fuchs states, a hemisphere. The detail in panning is extremely accurate around the perimeter and the ceiling, but sounds are unable to be positioned accurately along the z-axis. Following on from these examples of Dolby Atmos in controlled calibrated environments, the following section analyses two immersive sound films in a commercial cinema environment.

Dolby Atmos in the cinema

As of February 2014, Reading Cinemas in Waurn Ponds, Victoria, was Australia's only Dolby Atmos cinema. Situated five hundred kilometres from my home, this limited opportunities to see and hear films in the format. The Dolby Atmos installation is in the premiere Titan XC auditorium, however the cinema management prioritises the screening of films based on anticipated revenue generation, irrespective of the film being in Dolby Atmos or not.

My first comparison between a Dolby Atmos screening and a Dolby Digital 5.1 screening of the same film was *The Hobbit: The Desolation of Smaug* in early 2014. Seeing the film in both formats allowed the opportunity to compare and contrast the immersive technologies against conventional surround sound formats. The screening commenced with previews of upcoming film releases. This provided an opportunity to not only see a film in Dolby Atmos, but also to hear conventional 5.1 through the Dolby Atmos speaker system. When Dolby created Dolby Atmos, the company was conscious of backward compatibility and as such, the Dolby CP850 Cinema Sound Processor can upscale or downscale content to suit each particular cinema.[56]

[56] The CP850 Dolby Atmos Cinema Processor supports legacy formats and amplifiers and can also route non Dolby Atmos mixes to speaker arrays within a Dolby Atmos installation. The processor is also capable of automated calibration depending on the cinema installation configuration.

The first trailers to play were the Dolby demonstrations that I have discussed previously - the jungle, and the *Transformers* sounding clip, both in Dolby Atmos. The two film trailers following these reverted to the Dolby Digital 5.1 format. This included the 2-D trailer for the remake of *Robocop* (2014).[57] Although a 5.1 mix, the film sounded far superior when played back through the Dolby Atmos system compared to being played in a 5.1 equipped cinema. During the Dolby Roadshow I questioned Stuart Bowling, Director of Market Development, about the difference in sound quality between exactly the same two trailers played back on the different technologies. He stated that this was due to the quality of the speakers used and the fact that all speakers in a Dolby Atmos installation are full range, except for the sub woofers. I was very surprised at how much better the 5.1 trailer sounded through the Dolby Atmos speaker array, despite still being in 5.1.

The Hobbit: The Desolation of Smaug.

Having seen several trailers and demonstrations in the Dolby Atmos format, hearing *The Desolation of Smaug* allowed me to make a direct comparison between the traditional Dolby Digital 5.1 and the immersive Dolby Atmos formats. The initial screening of the film took place at Waurn Ponds in the Titan XC auditorium in HFR (High Frame Rate) and in Dolby Atmos format. I sat within the 'sweet spot' of the cinema. The second screening took place at a regional cinema (Forum6 cinemas, Wagga Wagga) in digital 3-D (24 fps) and with a Dolby Digital 5.1 soundtrack. Again, I sat within the sweet spot of the cinema.

Comparing the Atmos mix to the 5.1 mix, there were minimal noticeable differences. The opening rain scene sounded almost identical in both the Atmos and 5.1 versions, with the rain mixed very much on the screen, despite the camera moving through the 3-D rain. There were many scenes with rain, and not once did the positioning of the rain sound effects convincingly match the rain imagery in z-space. Although a general rain atmosphere was created, I was not immersed in the rain through sound, contrary to the images. The 5.1 mix sounded identical.

However the music did provide an obvious difference between both mixes, with the Atmos mix utilising the surround and ceiling speakers. The music noticeably demonstrated

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[57] Joshua Zetumer, Edward Neumeier and Michael Miner *RoboCop*, directed by José Padilha (Culver City, CA:Columbia Pictures, 2014).

movement and placement throughout all the various speakers. Brent Burge, Sound Designer on the film explained that although ceiling tracks were supplied for the music, re-recording mixer Michael Semanick remixed some of the music specifically for the Atmos format.[58]

The inability to position a sound accurately within the z-space of the cinema was consistent in *The Desolation of Smaug.* For example when the camera is on a close-up of the bear's nose (Figure 30) in 3-D, the nose protrudes noticeably into strong negative parallax, but the bear's breaths and growls are attached to the screen speaker channels with nothing in the surround speakers (at 11 min. and 8 sec.). This creates a dislocation with the image. An example of another detachment comes later in the same scene (12 min.), with a close up of an orc snarling. It is difficult to know if this was omitted deliberately because of the historical and conventional methodologies of mixing and panning dialogues, or if it was a direction from the director, or if there wasn't time to pan these elements.

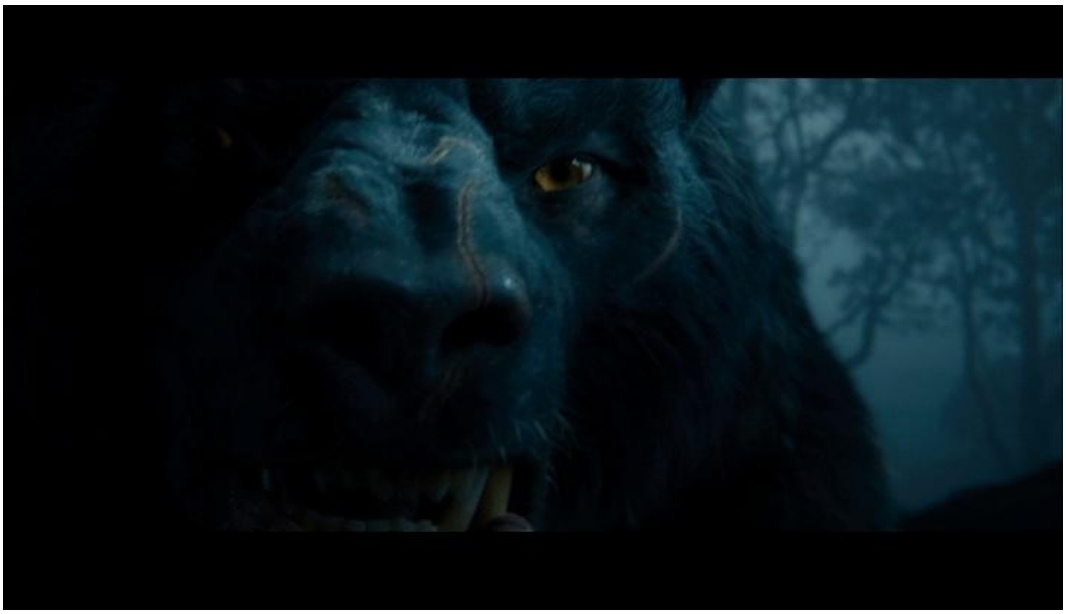

Figure 30: *The Desolation of Smaug* – close up of bear

Burge noted that the Atmos mix had only a few additional days beyond the main mix. The main mix was done to a 9.1 format that would allow the Atmos upmixing to be an easier

[58] Brent Burge, "Personal Interview: 3-D Sound Email Questions With Brent Burge," February 23, 2014.

process. He stated that 'selected FX were assigned as objects - but not many in the overall scheme of things - only really specific choices that we felt would benefit beyond the 9.1.'[59,60]

This explains why more opportunities were not taken including a scene inside the hut, where a bee is flying around (15 min. 30 sec.). The bee flying in negative parallax would have been an ideal candidate as an Atmos sound object (Figure 31). This provided another situation where the image and sound have become detached. Hearing the same scene in 5.1 was not noticeably different compared to the Dolby Atmos mix. Burge also emphasised that they were not working to 3-D images during the sound production.

> If we were able to see the images early enough, or better still, work to 3-D images, it would inform us and open up the possibility of concepts that embrace it, but to be honest, it would be unusual we would want to change anything dramatically if we were to see the images in 3-D later. The focus always is story and how best to embellish this without resulting in distractions.[61]

Figure 31: *The Desolation of Smaug* – close up of bee

[59] Ibid.
[60] An object is a particular sound element that can be panned independantly with the pan data rendered in the cinema through a decoder. It is only relevent to the immersive sound formats.
[61] Burge, "Personal Interview: 3-D Sound Email Questions With Brent Burge."

Similarly, the scene where we see the butterflies in the trees being disturbed also sounded similar in both the 5.1 and the Dolby Atmos versions, with the sound panning from the screen to the surround speakers. The Dolby Atmos version additionally had a more fluid linear action as the sounds also panned from the screen to the ceiling before finishing at the rear. Consistently, both formats displayed a hole in the centre of the cinema, which allowed the sound to become detached from the image. Burge noted that he 'doesn't apply sound to image to enhance the 3-D exclusively.'[62]

A general observation with the Dolby Atmos version of the film was the noticeable difference in the increased dynamic range of the low frequencies. The Atmos system allows for increased subwoofer channels and in the Waurn Ponds cinema, subwoofers were additionally installed at the rear of the theatre. Traditionally sub woofers in a 5.1 system are installed behind the screen, in front of the audience and only from a single channel.

Traditionally the foley on a film is mixed to the centre speaker behind the screen and only seldom does the sound move. Towards the end of the film, as Bilbo is walking off towards Smaug, there is a noticeable 'exit door effect' with the Dolby Atmos version of the soundtrack (104 min.). As described by Kerins, the exit door effect occurs when a sound draws attention to itself, resulting in the audience turning around towards the rear exit door. 'Concerns over this effect can be traced back to the very first cinematic use of surround sound: supposedly some audience members ran screaming from *Fantasia* when, late in the movie, sounds suddenly appeared in the rear of the theatre.'[63] This phenomenon, however, was far less noticeable in the 5.1 mix because of the speaker configuration and the panning of the particular sound. In the Dolby Atmos version, the sound panned to a single speaker isolated to a single location in the rear right of the cinema. Within the 5.1 format, the side and rear speakers are banked together (Figure 5, page 47) as either surround left or surround right, resulting in the 5.1 version having the foley footsteps transition with a smoother flow from the screen to behind the audience as the camera reverses.

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[62] Ibid.
[63] Kerins, *Beyond Dolby (Stereo)*, 158.

The Dolby Atmos version provided a superior immersive experience where Bard is kept in captivity (Figure 32). This scene allows the audience to experience the claustrophobia and textures of the location through the atmospheric sounds in the full Dolby Atmos configuration (125 min.). We hear many individual elements of wood creaking all around us. The Dolby Atmos version defines the details in the acoustic space and in the creaks with far more detail than the 5.1 format provides.

Figure 32: *The Desolation of Smaug* - Bard in captivity

A comparison of the Dolby 5.1 and Dolby Atmos formats highlights several factors facing contemporary cinema sound. Although Dolby Atmos has the ability to provide far more accurate panning of objects, creating the sensation of sound within the z-space of the cinema continues to be a challenge. Dolby Atmos works exceptionally well with atmospheres, music and sounds that surround or 'cocoon' the audience member.

Throughout the Dolby Atmos version of *The Desolation of Smaug* I found two conflicting problems.

- Problem #1 –Knowing the capabilities of the Dolby Atmos system, I was expecting more elements (objects) within the film to capitalise on the ability to be panned throughout the entire speaker configuration.

- Problem #2 – When an object was panned, it was often quite noticeable and at times jarring.

These issues are not a result of the sound team. As continually echoed by Burge, 'with the time constraints in the mix, we first remaster from the 9.1/7.1 stem beds, then objects that will be effective.'[64] Time restraints dictate that the traditional mix formats have priority, with any additional time left for the immersive mix. These issues noted with *The Desolation of Smaug* are not isolated, as discussed in the following section.

I, Frankenstein

The second case study with immersive sound was for the Stuart Beattie film *I, Frankenstein* (2014).[65] In addition to the standard 5.1 format and a Dolby Atmos release, *I, Frankenstein* also had a Barco Auro 11.1 release. It is extremely rare that a film is released in both competing immersive sound formats as studios tend to elect only one, if any. Set in a dystopic present where vigilant gargoyles and ferocious demons rage in a battle for ultimate power, Victor Frankenstein's creation Adam (Aaron Eckhart) finds himself caught in the middle as both sides race to discover the secret to his immortality.[66] Over a single weekend I travelled approximately 5000 kms along the East Coast of Australia between Waurn Ponds and Townsville to experience the film in 3-D and in both Dolby Atmos and Auro 11.1 formats. The following provides a comparison of each format and is broken down into the basic sonic components: Dialogue, Atmospheres, Foley, Sound Effects and Music.

The original mix of *I, Frankenstein* was created as a 7.1 Dolby Surround format, in Sydney, Australia. A combination of the original 7.1 stems and 32 raw object tracks were sent to Los Angeles for the Dolby Atmos version. This necessitated that objects be stripped out of the original pre-mix stems so that they could be panned as objects. These stems and raw object tracks were also provided to the Auro sound mixers in Belgium.

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[64] Burge, "Personal Interview: 3-D Sound Email Questions With Brent Burge."
[65] Beattie, *I, Frankenstein*.
[66] Rotten Tomatoes, "I, Frankenstein" 2014, accessed April 5, 2014. http://www.rottentomatoes.com/m/i_frankenstein/.

Dolby Atmos	**Barco Auro**
Waurn Ponds, 22 March 2014	Townsville, 23 March 2014

Atmospheres

The atmospheres represent the foundations of a film soundtrack, situating the audience within the location and the setting of each scene. In the film, the atmospheres were noticeably sparse considering the replay capabilities of the Dolby Atmos format. They were restrained in spatial depth, lacking sonic texture and detail. The Dolby Atmos format atmospheres were the original 7.1 mix and as such, continued to play as a 7.1 bed without having any additional panning or separation of objects applied.	The atmospheres were mixed quite narrowly. This is a result of the atmospheres being the original 7.1 mix. This is the same as used within the 7.1 bed of the Dolby Atmos format. As with the Dolby Atmos mix, the sound design of the atmospheres was lacking in detail. The wind and snow swirls in the opening scene lacked movement and did not complement the imagery. This was a limitation of source material and not the Auro format.
The laboratory scenes were mixed well and made full use of both the Dolby Atmos and Auro formats. The sparks and electrical sounds created an excellent atmosphere that immersed the audience. These sounds did not relate directly to any onscreen imagery; however they reinforced the electrical energy within the location. This use of the immersive sound field to surround the audience with the sound of electronics, machines humming and electricity generation worked very effectively.	

Music

The music was mixed unconventionally compared to a conventional 5.1 or 7.1 mix. Noticeably the music took advantage of the Dolby Atmos format with the entire speaker array being used. This included the music panned into the ceiling speakers and also having a wide spread into the surround speakers.	The music was mixed very wide with the instrumentation encapsulating the audience. Auro mixer Gareth Llewellyn stated, 'There was just the 7.1 music stem to work with. It was upmixed with the Auromatic Pro (plug-in) - and I adapted the settings and the levels and the weighting throughout the film.'[67]

[67] Gareth Llewellyn, Personal email discussion on "I Frankenstein Auro Upmix," April 23, 2014.

Dialogue

In the opening scenes of the film (8 min. 30 sec.) there was no panning of the dialogue between Leonore (Miranda Otto) and Gideon (Jai Coutney). Here we have much dialogue on screen intercut with reverse shots. Although switching to reverse shots, with Leonore and/or Gideon behind us, the dialogue remained in the centre speaker, creating a dislocation with the characters' location. This could have been avoided if the dialogue had been panned into the surrounds as the characters were obviously behind the audience. This was consistent across the Dolby Atmos and Barco Auro versions and is consistent with Hollywood mixing practices.	
The dialogue was mixed conventionally with the centre channel used almost exclusively for all main character dialogue. An exception to this was the use of the ceiling speakers to bring the voiceover (Adam Frankenstein) into the top front of the cinema to help create a 'Voice of God' effect.[68] This partially worked, however it was slightly distracting as the action was onscreen and the voiceover was projected from the top of the cinema space.	
Conversely, later in the film, there was a situation where Adam Frankenstein said, 'Come with me' (47 min. 20 sec.) as he walked away from camera (downstage). Although he is walking into the distance, his dialogue is panned to the surrounds behind the audience, again creating a dislocation.	

Foley

Similar to the dialogue, the foley was mixed traditionally, with almost all panning in the centre channel only. For a film that had many objects across the entire screen and off-screen, having the foley in the centre limited the spatial opportunities, and contributed to a narrow mix.

[68] The term 'Voice of God' is used in the film sound industry to refer to sounds that come from above an audience.

Sound effects

SFX that worked well

After Adam Frankenstein first picked up his two metal rods, he swung them around (Figure 33, page 141). The panning complemented the imagery by utilising the screen and surround speakers (10 min. 44 sec.).

At 24 minutes 46 seconds, there was a mass group of gargoyles flying. The Atmos format provided effective movement and sound placement, achieved not only through precise panning into the surround speakers, but also through the use of the ceiling speakers.

One of the larger flame whooshes at (28 min. 56 sec.) was a standout compared to other whooshes. With the visuals demonstrating movement into strong negative parallax through an extreme close up, the sound also panned off the screen and into the surround speakers. This movement of panning created the illusion that the sound had travelled through the cinema.

The first shot of wings as the gargoyle crashes through the ceiling at 34 minutes was very effective in the Auro height speakers (Figure 34, page 141). The sound matched the imagery as the camera was located below the ceiling, providing an opportunity for the height speakers.

When Frankenstein jumped through the glass into the lab (41 min.), the panning of glass into the surround channels provided additional detail that helped immerse the audience.

When the gargoyle Gabriel (at 64 min. 22 sec.) crashed through the ceiling into Frankenstein's apartment, both the Dolby Atmos and Barco Auro mixes conveyed the action accurately. There was a great homogeneity between the 3-D imagery and sound through the use of the height speakers.

The scene in the corpse chamber demonstrated the panning resolution and capacity of both immersive formats. The electricity panned around the room, adding to the immersive experience by providing additional off-screen cues. This worked effectively as the sound effects were not synchronised to the imagery.

SFX that didn't work well

One of the first moments in the film that strongly utilised the expanse of both immersive technologies was the panning of the finger scrape in the first few minutes of the film (Figure 35, page 141). The sound of the scrape was panned in a full 360° circumference around the auditorium, and although it took advantage of the panning capabilities of the immersive technologies, it dislocated from the imagery that remained on screen (3 min. 30 sec.).

There were often shots with sparks (for example with the fire balls) that were close to camera, but there was no sound attached to the sparks. This created some obvious holes, especially as they were in z-space.

The lightning strikes didn't utilise the ceiling speakers because the lightning sounds were embedded into the original 7.1 atmosphere beds and not split out as 'objects.'

The gargoyle, Ophire, flew into shot to pick up Frankenstein before flying out of shot from the top of screen (4 min. 40 sec.). This seemed an obvious omission of using the ceiling speakers in the Atmos format. Throughout the film there were several battles that took place between the gargoyles and the demons. When the demons were killed, they disintegrated into a fireball with their spirits descending into the ground (to hell). The fireballs flew around the screen, taking full advantage of the entire frame. Although the fireballs had vast onscreen movement, they were comparatively stark in auditory movement. At times, there were so many fireballs on screen at once that the sound of them combined, created white noise with all definition lost. This was a noticeable problem, although it may also have been a time issue with the original sound edit. There was one obvious exception to this. The demon holding the journal who was killed by Frankenstein (52 min. 35 sec.), disintegrated into a fireball that panned with the image and worked very well in creating a homogenous audio visual component.	The sound of the water running down the wall of the building at 'Central Station' (66 min. 31 sec.) panned from the ceiling, so the water appeared to be off screen despite the water visually being in positive parallax (away from the audience). The fireballs had greater pan positioning and spatial definition in the Auro version of the film compared to the Atmos version.

Figure 33: *I, Frankenstein* - weapons

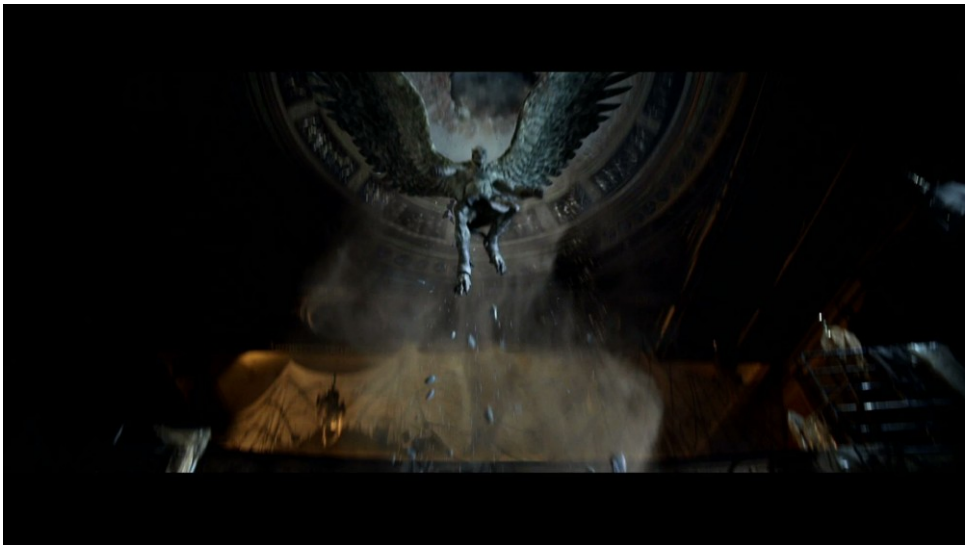

Figure 34: *I, Frankenstein* – gargoyle jump through ceiling

Figure 35: *I, Frankenstein* – finger scrape

I, Frankenstein- Dolby Atmos conclusion

Generally *I, Frankenstein* did not take advantage of the full capacity of the Dolby Atmos premiere exhibition experience. The Dolby Atmos format was seldom exploited, with only a few exceptions including some very occasional spot effects within the laboratory. The music also took advantage of the format, while at times conflicting with the narrative and screen action due to being panned into the ceiling. The sound effects that were treated as objects and had additional panning applied were inconsistent, with only specific sound effects panned beyond the general 7.1 soundfield.

Overall the Dolby Atmos presentation of the film demonstrated many shortcomings. The following factors contributed to this:

- Sound editors were unaware that the movie would be a Dolby Atmos release, therefore there was no preparation of objects.
- Visual effects were completed late in the sound production process making it difficult for the sound team to know exactly what was happening onscreen.
- Mixing of the 7.1 version took place without the mixers knowing that a Dolby Atmos upmix would be required.
- Mixing of the Dolby Atmos version did not have sufficient objects to allow consistent panning throughout the entire film.
- There was a lack of time throughout the sound-editing phase and for the Dolby Atmos upmix.

It should be noted that although the Dolby Atmos format was not fully exploited, this does not reflect on the capacity or talents of those working on the film's soundtrack. According to several key people who worked on the soundtrack, challenges for the sound team included visual effects delivered very late in the production, which resulted in inadequate time to create the soundtrack to finalised images.

With time an underlying issue, I do not see any advantage in this film being upmixed into the Dolby Atmos format. The format failed to provide a noticeably superior experience to the 5.1 mix. With many of the sounds not set as objects, the ability for the mixer to pan and utilise the potential of the Dolby Atmos format was limited, resulting in a film that displays many elements of dislocation between sound and image. If time and preparation for the upmix could not be prioritised, I question the validity and cost of the Dolby Atmos release. This is a serious consideration, as the mix is rarely dissimilar to the original 5.1 mix.

I, Frankenstein- Barco Auro conclusion

Overall, there was a great deal of detailed panning applied to the sound effects in the Auro version of the film when compared to the Dolby Atmos version. However, the Auro 11.1 version of *I, Frankenstein* lacked opportunities to exploit the spatiality of the format. Noticeably, there was a lack of content that matched the 3-D visuals within the cinema z-space. Created as an upmix from the original 7.1 stems, this limited the mixer's ability to add dimensional information. Auro re-recording mixer Gareth Llewellyn describes what his creative options were:

> - upmixing - the Auromatic upmixer is an upmixing algorithm designed by Auro Technologies that does the 11.1 upmixing. It's what I used particularly for the music upmix, in combination with volume/panning adaptations (and occasional height reverb additions). This can also be used with great effect on appropriate ambience tracks.'
>
> - repanning - a lot can be achieved - even with stems - by judicious chopping up and repanning of the individual legs of stems.'
>
> - reverb - you have to be very cautious with adding reverb to a completed mix, but it is possible to apply a complementary reverb to the height channels to mimic the reverb in the lower channels, giving a sense of height depth. It is key to try and get the pre-delay time and so on sounding appropriate.'
>
> In all of the above my aim is always to stay as faithful as possible to the original sound team's creative work so I would try not to reinvent or change the original work, other than in ways which complement those original creative decisions.[69]

Comparison of Atmos and Auro versions of I, Frankenstein

Comparing the Dolby Atmos and Barco Auro 11.1 versions of *I, Frankenstein* highlighted many similarities between both formats. As both versions of the film were produced by upmixing many of the original 7.1 components of the film, the mixing process for each format had limitations imposed. Similar to *The Desolation of Smaug*, the flexibility and creative opportunities were limited due to the film not created specifically for the medium. Visual effects appearing late in the mixing process and sound objects not easily accessible from the original mix inhibited creativity. Although the dialogue and sound effects were similar sounding between each mix, the music demonstrated one of the greatest differences between both immersive sound mixes. Due to the speaker configurations, the

[69] Gareth Llewellyn, Personal email discussion on "I, Frankenstein Auro Upmix," April 24, 2014.

Dolby Atmos version had the music spread wide laterally, whereas the Auro 11.1 mix was higher in the ceiling.

Another noticeable difference between the Dolby Atmos and Barco Auro 11.1 versions of the film was the detail in the panning. The Atmos version was quite limited, with minimal panning except for some occasional panning across the screen. The Auro mix however, demonstrated more noticeable detail in the panning, with the fireballs having movement throughout the entire z-space. This provided greater definition between multiple fireballs onscreen as the sounds panned, bonding to each fireball. Both versions of the film however demonstrated a lack of homogeneity between the soundtrack and close up visuals in negative parallax. The sound team were handed imagery late in the production process and they were unaware of preparation for the impending immersive mixes.

Comparing the immersive versions of I, Frankenstein with the 5.1 version

Although the above sections have provided an overview of the immersive mixes created for *I, Frankenstein* I would like to briefly outline how these compare to the 5.1 mix. Despite the immersive mix providing some superior moments to the 5.1 mix, overall the 5.1 version of the film provided a more consistent cohesive soundtrack. This highlights the importance of time. Since the original mix had more time allocated to it than the immersive mixes, the attention to detail in the immersive mixes was lost. The immersive formats are superior, but time is needed to execute the intricacies to make the upmix worthwhile. It should be noted that again this does not reflect on the capabilities of the people engaged to create the soundtrack, but rather highlights the importance of providing adequate resources for a creative team - in this instance, time.

Observations on immersive sound

Undeniably, the Dolby Atmos and Auro 11.1 formats provide superior sound compared to previous surround sound formats. For instance, both formats work exceptionally well at providing convincing canopy effects. This is due to having speakers that not only surround the audience, but also provide height information through ceiling speaker channels. However, a noticeable limitation of both formats is apparent when 3-D imagery is in strong negative parallax. Both formats fail to provide a convincing sound image that is within the cinema z-space and is localised with the image. Borrowing from Schafer's

definition, this dislocation of image and sound creates a 'schizophonia' for the audience.[70] Although Schafer's definition relates to the distance a mechanical recording allows between the origins of sound events and its human listeners, I argue this term can also be applied to spatial differences between sound and image reproduction.

Dolby, Auro and other manufacturers are currently working on new panning tools that allow sound designers and editors to create detailed positional data for objects from within the editorial process. As stated by David Farmer: 'one problem with Atmos is that you can't monitor it in an editing room… yet.'[71] Having this ability to pan in immersive formats will greatly improve the detail and complexity required to provide objects with accurate positional data, saving the mixers time from the onerous task of panning the individual objects themselves.

When Andy Nelson, Head of Sound at Fox Studios, was asked about the introduction of the Dolby Surround 7.1 format, he stated that 7.1 allows the music to be pulled back from the front speakers leaving more room for the sound effects.[72] Having heard several 7.1 mixes, including *War Horse,* I agree with Andy, and have felt that bringing the music back into the surrounds just a little actually opens up the entire mix, making it sound far wider than the previous 5.1 format. Both immersive mixes of *I, Frankenstein* took this notion even further. That is, the front is almost completely free from music, with the dialogues and foley panned in the centre channel, sound effects in the left and right channels, and the music using the sides and ceiling channels. This requires a new way of thinking as we are accustomed to hearing music played from the front (like an orchestra) with some reverberation used in the surround speakers that helps situate audience members within the acoustic space. The movement of music was distracting, especially considering that the sound effects were relatively static within each format despite the imagery showing otherwise. Having the movement in the sound effects and having the music bedded and mixed as if one were listening to an orchestra in a concert hall, would be more engaging and limit the possibilities of, 'schizophonia' as defined by Schafer.[73]

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[70] R. Murray Schafer, *The New Soundscape : A Handbook for the Modern Music Teacher* (Don Mills, Ont.: BMI Canada, 1969), 34.
[71] Farmer, Personal Interview: 3-D Sound Discussion at Park Road Post, NZ.
[72] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA.
[73] Schafer, *The New Soundscape : A Handbook for the Modern Music Teacher*, 34.

The contemporary soundtrack - conclusion

With ongoing developments in 3-D vision and immersive sound technologies there are several consistent challenges that affect the overall final exhibition of a film soundtrack. These include:

- Not receiving the final completed images until the final mixing stage, including visual effects and the 3-D stereoscopic images.
- Inaccurate positional data (input) and inaccurate positional rendering (output) due to limitations of contemporary surround sound speaker formats.
- Not being aware during the editing and mixing stages that a film will be exhibited in an immersive format.
- Not having time to prepare material, including sound objects, for an immersive mix.

This chapter has investigated contemporary 3-D films through practice-led research and case studies. It has included films released in contemporary 5.1 surround sound and immersive sound formats, largely from an industry perspective. The films with the 5.1 releases consistently demonstrated a dislocation between imagery and sound in the z-space. This is a result of the positional data not replicated through accurate positional rendering. Despite advancements beyond the 5.1 format, it is evident that industry recognises filmmakers are not taking advantage of immersive sound formats or opportunities. Fairweather argues that sound is an equal partner and can contribute as much meaning as any other cinematic feature, suggesting that the director must work it to his advantage.[74] This is also a concern for Randy Thom, as discussed during his keynote speech at the 2014 *Immersive Sound Conference* in Los Angeles. Thom 'urged the sound community to encourage directors and screenwriters to 'design scenes and moments around immersive sound to take advantage of the sonic cinematic experience.'[75]

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[74] Elizabeth Fairweather, "Andrey Tarkovsky: The Refrain of the Sonic Fingerprint," in *Music, Sound and Filmmakers: Sonic Style in Cinema*, ed. James Wierzbicki. (New York: Routledge, 2012), 35.
[75] Carolyn Giardina, "Randy Thom Urges Directors, Screenwriters to 'Create Moments' for Immersive Sound," *The Hollywood Reporter*, September 7, 2014, accessed September 8, 2014. http://www.hollywoodreporter.com/behind-screen/randy-thom-urges-directors-screenwriters-730846.

A common underlying issue with immersive soundtrack releases is that the decision to release in an immersive format is often only considered in the final stages of production and not throughout the entire production workflow. With an immersive release often not factored into the production process early, these mixes demonstrate many of the shortcomings associated with the 5.1 releases. This is both a time issue and a problem of the immersive formats being unable to place a sound accurately within z-space, despite offering height channels. I recommend that directors and producers consider immersive sound early in the production process, and factor in additional time and funds for immersive versions of their films. As demonstrated with the two case studies, if an immersive sound mix is an afterthought, there is little advantage, if any, in spending time and money if the mixes are not going to be superior to the original 5.1 or 7.1 mix.

The case studies in this chapter have identified challenges in the production of sound for 3-D films. This includes the creation of the soundtrack and the final exhibition of the 3-D film. Despite the shortcomings, does the general cinema audience notice these? The following chapter will examine the cinema audience and the use of technology in the cinema. It will also investigate beyond contemporary cinema, by investigating alternative immersive entertainment.

Chapter 5: Film Exhibition and Audience Expectations

Introduction

Cinema provides the initial exhibition medium for a completed film production, and it is here where the success of a film is judged. Although film revenue continues to be generated long after a film has left the cinema, through various domestic releases and ongoing broadcast and online distribution, it is ultimately the cinema release that is used as the benchmark for a films' success. Cinema owners are constantly anticipating audience trends in order to increase revenue generation. Ultimately the scope of any technological upgrades depends upon theatre owners taking risks by investing in new technologies and anticipating audience demand for such technologies. Audiences have vast choices when it comes to consuming media, with developments into virtual reality and personal devices providing 3-D and immersive sound alternatives to the cinema.

The previous chapters have investigated the history and the production processes involved in the creation and exhibition of 3-D films and the soundtrack. Broken into four parts, this chapter will investigate: the role of the cinema upgrading to immersive technologies; the cinema audience and their understanding of immersive technologies; immersive media alternatives to cinema exhibition; and alternative immersive sound formats.

Part 1: The role of the cinema

In this section I will discuss the role of the cinema in the uptake of emerging technologies for film exhibition. Investing in technological upgrades provides a challenge for theatre managers as competing formats and revenue forecasts need to be considered. This determines how films are presented to an audience, and also potentially has implications for how films are created technically.

The 3-D push

In 2005, three of the world's best known directors - George Lucas, James Cameron, and Robert Zemeckis - appeared at the ShoWest convention hosted by the National Organization of Theatre Owners (NATO). The mission of these industry icons was to advocate for the transition to digital cinema, with the anticipation that they could grow cinema audiences and increase cinema revenue. It was here that Cameron made the

promise that digital 3-D was the future that would 'get people to come out from behind those HD flat-screen TVs and into the theatres.'[1] The prediction proved to be correct with *Chicken Little*, the first 3-D Disney Animation Studios feature, having an average seat occupancy of 96 percent over the opening weekend.'[2]

It did not take long before the three directors delivered on their vision. Only two years later Zemeckis released *Beowulf* (2007)[3] and *A Christmas Carol* (2009)[4] two years later, both in 3-D and both strong performers at the box office. Cameron in 2009 released the iconic 3-D flagship film *Avatar*, yielding the most revenue (in unadjusted dollars) of any film in history.[5] Although not originally a 3-D release, Lucas saw the rewards being offered and began releasing 3-D post-converted versions of his Star Wars series. Also post-converted for 3-D, a century after the historic ship's sinking and 15 years after the original release, Cameron rereleased *Titanic* (2012).[6] By the end of 2013 it was evident that 3-D filmmaking was making an impact. Many people were saying that the resurgence of 3-D was a fad, but the worldwide box office grosses proved otherwise, with thirteen of the top fifteen films being 3-D releases. Of these thirteen 3-D films, three were animated, two were live-action 3-D native and the remaining eight were 3-D post-converted films.[7]

Uptake on digital cinema technologies

For a cinema to be able to exhibit 3-D content, 3-D digital projection is needed. In 2011, cinema growth increased by 3% worldwide with double-digit growths in the Asia Pacific. Over the past few years, cinemas globally have increased their adaption to digital screen technologies. Throughout the United States and Canada, analogue screens decreased from 14,921in 2011 to 6,426 screens in 2012. Conversely, digital screens increased from 13,774

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[1] Bordwell, *Pandora's Digital Box: Films, Files, and the Future of Movies*, 66.
[2] Mendiburu, *3D Movie Making Stereoscopic Digital Cinema From Script to Screen*, 5.
[3] Neil Gaiman and Roger Avary, *Beowulf*, directed by Robert Zemeckis (Hollywood, CA: Paramount Pictures, 2007).
[4] Robert Zemeckis, and Charles Dickens, *A Christmas Carol*, directed by Robert Zemeckis (Burbank, CA: Walt Disney Studios Motion Pictures, 2009).
[5] Bordwell, *Pandora's Digital Box: Films, Files, and the Future of Movies*, 66.
[6] Cameron, *Titanic (3-D Version)*.
[7] Box Office Mojo, "2013 Yearly Box Office Results," *Box Office Mojo*, accessed January 6, 2014, http://boxofficemojo.com/yearly/chart/?view2=worldwide&yr=2013&p=.htm&utm_content=buffer9e9ac&utm_source=buffer&utm_medium=twitter&utm_campaign=Buffer.

non 3-D in 2011 to 21,643 non 3-D in 2012, and from 13,695 3-D screens in 2011 to 14,734 3-D screens in 2012.[8]

Despite upgrades and an increase in digital screens, had the novelty of 3-D already worn thin? 3-D films demand a premium surcharge and in the United States consumers decided the visual gimmick was not worth paying an extra $2 to $5 per ticket.[9] Barnes suggests that although cinema numbers were growing, this may not have resulted exclusively from 3-D releases. *Turbo* (2013)[10] set a new industry low for the format. According to analysts, 3-D screenings accounted for only 25 per cent of its opening-weekend results.[11] The decline in 3-D ticket sales may be a reflection on the quality of the films available at the time as opposed to the 3-D medium itself. *Gravity*, with seven Academy Award® wins and another three nominations, proved that 3-D was not just a gimmick, generating almost US$100 million from the box office after only two weeks.

Uptake on emerging cinema sound technologies

The success of 3-D and the number of 3-D released films gave cinema managers confidence in digital projection upgrades. Managers are constantly weighing up the risks involved in technological advancement and Bordwell acknowledges that although film technologies are introduced into the production sector, exhibitors often resist them. This is a costly gamble as it involves not only upgrades to equipment, but also to the auditoriums. 'If the technology doesn't catch on, as 3-D didn't in the 1950s, millions of dollars can be wasted.'[12]

Despite upgrading screens, cinema managers have been cautious in upgrading their current sound systems to the next generation of immersive sound formats. At present there are two competing formats with what is emerging as a format war between Dolby Atmos and Barco Auro. Both formats are gaining momentum with cinema installations, albeit slowly. This is described in further detail over the following pages. It is also appropriate to recognise a third format, IOSONO 3-D, as there are two IOSONO

[8] Statistics sources from Motion Picture Association of America.
[9] Barnes, "Huge Summer for Hollywood, but With Few Blockbusters."
[10] Darren Lemke, Robert D. Siegel and David Soren, *Turbo*, directed by David Soren (Century City, CA: 20th Century Fox, 2013).
[11] Barnes, "Huge Summer for Hollywood, but With Few Blockbusters."
[12] Bordwell, *Pandora's Digital Box: Films, Files, and the Future of Movies*, 8.

installations at the Mann's Chinese complex in Hollywood.[13] To date, mainstream cinema has not embraced the IOSONO holographic sound technology. IOSONO struggled to the gain the traction it had originally hoped for with only 7 installations worldwide, and the company was declared insolvent on February 7, 2014 before being acquired by Barco on the 24 September, 2014.[14, 15]

Although not wishing to speak on record, several well respected international award winning re-recording mixers and sound designers stated in interview that the IOSONO technology is amazing. The format provides some of the most realistic immersive and accurate sound possibilities that they had ever heard. Several made particular mention of a demonstration in which they 'could hear a drop of rain land on their shoulders,' a hyper-real effect rather than enhanced reality. The IOSONO system proposes an alternative sound format that is based on Wave Field Synthesis (WFS).[16] When interviewing John Neill from Park Road Post, he spoke highly of the technology, although he also noted the impracticality of such a product due to both the cost and aesthetics. The format necessitates many speakers located around the perimeter of the walls and aesthetics are important at Park Road. Reducing the number of speakers can reduce the cost, but this compromises the quality of the sound reproduction.[17]

With all sound technology vendors hoping to have been the preferred 3-D film sound solution, they began introducing industry to their respective technologies long before the theatre owners and the general public became aware of the formats. The vendors anticipated that if they could gain loyal industry endorsement for their format, this would help them sell to film directors, producers, studios and more importantly, the theatre owners. As Bordwell suggests, the theatre owner has the most to lose if a new technology

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[13] Blair Jackson, "Sound and the Fury," *Variety* 419, no. 6 (June 21, 2010): 18.
[14] IOSONO, "IOSONO Starts Investor Talks,", February 24, 2014, accessed March 4, 2014. http://www.iosono-sound.com/news/detailansicht/iosono-starts-investor-talks/.
[15] Barco, "Barco Gains the Team and Expertise from IOSONO GmbH to Further Enhance the Immersive Sound Experience in Cinemas Worldwide," September 24, 2014, accessed October 10, 2014. http://www.barco.com/en/News/Press-releases/Barco-gains-the-team-and-expertise-from-IOSONO-GmbH-to-further-enhance-the-immersive-sound-experienc.aspx.
[16] Wave Field Synthesis (WFS) in some respects is similar to Ambisonics in so much that it is not a channel based format. Instead, WFS creates artificial wave fronts from a large number of speakers across a horizontal array.
[17] Neill, Personal Interview: 3-D Sound Discussion. Head of Sound, Park Road Postproduction, NZ.

fails to catch on. This was demonstrated between the 1970s and the 1990s with theatre owners resisting the parade of digital sound systems.[18]

The Dolby Atmos and Auro 3-D rollout

Introduced in 2011, Barco, the company best known for its cinema projectors, established Auro 3-D. Claiming to produce 3-D sound using a 3-layered sound field, the Auro 3-D system has seen gradual adoption by industry. Barco Auro cinema installations surpassed 500 in 2014 and this number is continually growing. Many films are opting to have an Auro release in addition to the traditional 5.1 or 7.1 soundtracks with the table below showing this increase.[19]

Year	Releases
2012	4
2013	15
2014	17

Figure 36: Barco Auro Releases (as of February 2014)

Wim Buyens, senior vice president of Barco's Projection Division, points out that Auro is proud of their industry infiltration, with 50 films committed to the Auro 11.1 format, supported by Hollywood and regional content producers worldwide.[20] Barco are known for their projector technologies, so gaining recognition for their Auro audio technologies has proved challenging. This is in contrast to Dolby, a company best known for audio innovation.

Introduced in April 2012, Dolby Atmos signalled the most publicised introduction of a new emerging cinema sound technology to date. As Nicholson states, Dolby provided this through creating partnerships with cinemas to push the message that 3-D sound is the

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[18] Bordwell, *Pandora's Digital Box: Films, Files, and the Future of Movies*, 76.
[19] Barco, "Barco Gains the Team and Expertise from IOSONO GmbH to Further Enhance the Immersive Sound Experience in Cinemas Worldwide."
[20] Film Journal International, "Auro 11.1 Sound Exceeds 50 Film Releases," June 26, 2013, accessed September 9, 2014. http://www.filmjournal.com/filmjournal/content_display/news-and-features/news/technology-and-new-products/e3i280b0b4c0471e0eec77cd1a9f0825b26.

future of movies.[21] Research into media coverage showed that Dolby Atmos gets 83% coverage compared to 17% for Auro. This includes articles in *Time, USA Today, ET Weekly, NY Times* and *Bloomberg.*[22] In February 2014, there were 450 screens worldwide equipped with Dolby Atmos, and the number of films released in Dolby Atmos has passed 100 since the release of *Godzilla* (2014).[23]

There are more than fifty studios equipped to provide the mixing of films in the Dolby Atmos format, compared to twenty-six Auro 11.1 equipped mixing facilities worldwide, with the majority in the United States.[24] As of September 2014, the combined international uptake on Dolby Atmos and Barco Auro 11.1 immersive sound systems is estimated at around 1000 worldwide.[25] Although both immersive sound technologies are being marketed with 3-D films, Dolby Vice President Ioan Allen states that he does not want Dolby Atmos to be associated with 3-D exclusively, believing that it can work for any movie. 'Coming up with a format that can be universally adopted and is not just tied to some 'boutique' experience is something that we've done very consciously in the past.'[26] Allen's comment confirms my observations made during the case studies of *The Desolation of Smaug* and *I, Frankenstein* described in Chapter 4.

As the format war continues and there is lack of agreement on a common format, including the Auro endorsed DTS proposed MDA format, it is little wonder that theatre owners are not rushing to immersive sound. Further complicating the decision to upgrade to immersive sound is the fact that Dolby Atmos and Auro 11.1 systems share little in common, including the final film soundtrack deliverables and the cinema speaker and hardware configurations. John Kellogg warns that the immersive sound business needs to be affordable for theatre owners; if not, they will invest in upgrading their chairs. Kellog notes that '*The Wall Street Journal* recently reported that AMC is spending US$600 million

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[21] Nicholson, "Making a Reality a Reality," 3.
[22] Statistics provided by Dolby during Atmos showcase in Melbourne.
[23] Max Borenstein and Dave Callaham *Godzilla*, directed by Gareth Edwards (Burbank, CA: Warner Bros., 2014).
[24] Statistics based on listed facilities from Dolby And Auro websites, accessed September 6, 2014.
[25] Giardina, "Randy Thom Urges Directors, Screenwriters to 'Create Moments' for Immersive Sound."
[26] Fuchs, "Soundsational!," 7.

on larger, fully reclining seats.'[27] An upgrade to immersive sound is estimated between US$35,000 to well into six figures, making the investment a serious consideration.

Australia's uptake on emerging cinema sound technologies

Until mid 2014, the only installations of immersive cinema sound technologies in Australia were two Titan XC auditoriums owned by Reading Cinemas. Hedging their bets, their first installation was the Auro 11.1 format based in Townsville Queensland, and the Dolby Atmos format was installed at the Waurn Ponds cinema in Victoria. Both Reading Cinemas however state that their respective sound systems offer 'full 360˚ immersive sound.'[28, 29] A third installation arrived in Australia in mid 2014 featuring a Dolby Atmos installation at Village Cinemas within the Crown Casino, Melbourne.[30] Australians are mostly unaware of immersive sound formats as publicity remains limited, and there are limited immersive cinema installations and limited film releases. However publicity is beginning to grow. David Lovell, Manager of Reading Waurn Ponds, is positive that increasing publicity 'may actually make people aware of how good sound can be, and raise awareness of new technologies in sound, such as Dolby Atmos.'[31] The number of immersive sound installations in Australia is set to increase dramatically in the very near future. AHL, Australia's premium entertainment and hospitality leisure company, announced in October 2014 that they were about to invest in 20 Dolby Atmos installations across Australia.[32]

In personal telephone conversations with the managers at Waurn Ponds and Townsville Reading Cinemas, each independently discussed that not all films are shown in 3-D when screened using immersive sound formats. On Wednesday 11 December 2013, each cinema

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[27] Giardina, "Randy Thom Urges Directors, Screenwriters to 'Create Moments' for Immersive Sound."
[28] Reading Cinemas, "Reading Cinemas Townsville," accessed October 16, 2014. http://readingcinemas.com.au/locations/theatre/townsville.
[29] Reading Cinemas, "Reading Cinemas Waurn Ponds," accessed October 16, 2014. http://readingcinemas.com.au/locations/theatre/waurn-ponds.
[30] Campbell Simpson, "Dolby Atmos Is Coming To Australian Cinemas," June 3, 2014, accessed July 21, 2014. http://www.gizmodo.com.au/2014/06/dolby-atmos-is-coming-to-australian-cinemas/.
[31] David Lovell, Reading Cinema Waurn Ponds Dolby Atmos installation, Personal Interview, January 13, 2014.
[32] IF, "AHL to Roll out 20 Dolby Atmos Screens in Australia," October 13, 2014, http://if.com.au/2014/10/12/article/AHL-to-roll-out-20-Dolby-Atmos-screens-in-Australia/FUAVWYYEEA.html.

was screening *Enders Game* (2013)[33] in Dolby Atmos and Barco Auro, although the film was not a 3-D release. This raises the question - why mix and release the film in these immersive audio formats if the film is a 2-D release? As mentioned earlier, Ioan Allen of Dolby states that the immersive sound formats are not exclusive to 3-D film releases.

Cinemas prioritise profit over content, as noted by the managers at Waurn Ponds and Townsville cinemas. Both stated that it is common for immersive sound films to be bumped out of the immersive equipped Titan XC auditoriums for non-immersive sound format films. It is not the film format exclusively that determines if a film will run in their 'immersive sound' equipped auditorium; rather, projected ticket sales are the determining factor. Reading Cinemas pride themselves on their flagship Titan XC auditorium as they have the latest in technologies, including immersive sound and the largest screens; they can also seat the largest audience. Revenue generation is prioritised, despite a film having a Dolby Atmos or Auro release. If another film released without these technologies will sell to a larger anticipated audience, then the immersive film will be rescheduled to a non Titan XC auditorium. As a result, the premium immersive sound films will have their Auro or Atmos soundtracks downgraded (down mixed) to the conventional 7.1 or 5.1 format in a smaller cinema.

Part 2: The cinema audience

For a cinema to warrant upgrading technology, an increase in revenue needs to be forecast, and this relies solely on audience patronage. This section of the chapter questions the role that the cinema audience plays in determining future technological adaptations. This requires that an audience not only attend a cinema, but also be literate in identifying advantages of the cinematic experience based on particular technological improvements. My hypothesis is that audiences are unaware of, and illiterate in, cinema technologies. Providing the picture plays clearly, is framed on the screen, and the sound is intelligible, the general audience is content.

[33] Gavin Hood and Orson Scott Card, *Ender's Game*, directed by Gavin Hood (Universal City, CA: Summit Entertainment, 2013).

In the final year of this thesis I conducted an online survey to determine audience awareness of current and emerging cinema technologies. This information provides insight into how an audience makes decisions based on particular cinema technologies.

Survey aim

Although industry may be determining the future of film technologies, it is important to compare these changes with customer expectations. The survey aims to identify the cinematic technical literacy of an audience, including their understanding of contemporary film sound formats and 3-D technologies. It also seeks to find out if an audience may select a particular film or cinema based on the exhibition format.

Survey method

An online survey was created using the online survey tool SurveyGizmo.[34] An electronic invitation seeking participants was sent via industry mailing lists, academic mailing lists and via social media platforms. There were a total of 201 participants. The following figures outline the breakdown of participant demographics.

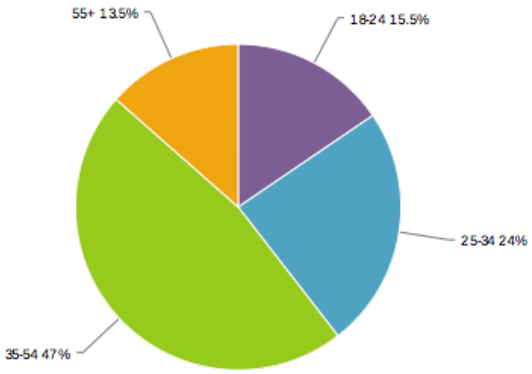
[34] "SurveyGizmo," *SurveyGizmo*, accessed January 3, 2014, http://www.surveygizmo.com/home.html?utm_expid=50278599-38.IvyK6zaHQhyHmIbsXTKy8g.1.

Source country of participants

Australia	80.6%		162
Belgium	0.5%		1
Canada	1.0%		2
France	0.5%		1
Germany	1.0%		2
India	1.5%		3
Italy	0.5%		1
Mexico	0.5%		1
New Zealand	0.5%		1
Singapore	0.5%		1
Spain	0.5%		1
Sweden	0.5%		1
Switzerland	0.5%		1
United Kingdom	2.5%		5
United States	9.0%		18
		Total	201

Figure 37: Survey participant source country

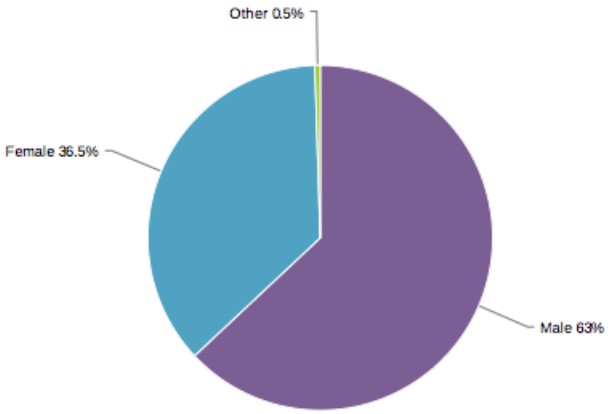
Age group of participants



under 18	0.0%		0
18-24	15.5%		31
25-34	24.0%		48
35-54	47.0%		94
55+	13.5%		27
		Total	200

Figure 38: Survey participant age

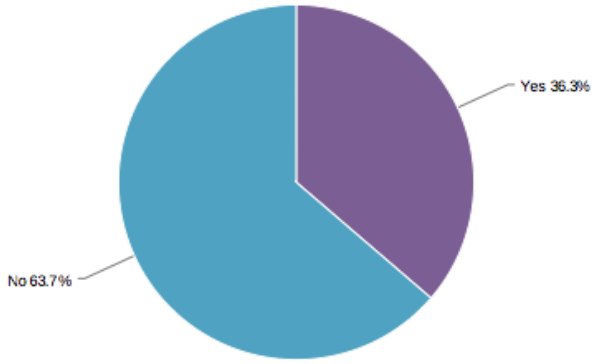
Gender of participants.



Male	63.0%		126
Female	36.5%		73
Other	0.5%		1
		Total	200

Figure 39: Survey participant gender

Participants that work in the film industry.



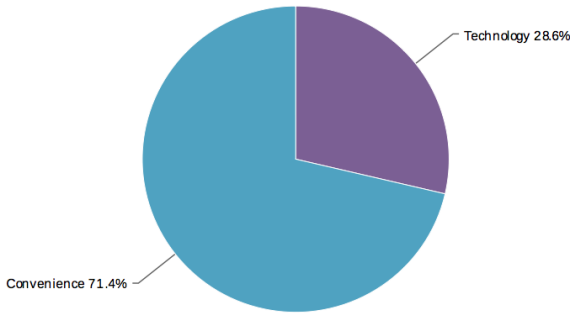
Yes	36.3%		73
No	63.7%		128
		Total	201

Figure 40: Survey participants that work in the film industry

The breakdown in demographics shown in the figures above indicates that of the 201 participants, many are Australian based, and almost two thirds do not work in the film industry.

Responses to the survey

When asked how audience members select a particular cinema, 71.4% of participants prioritise convenience over technical capabilities (Figure 41).



Technology	28.6%		57
Convenience	71.4%		142
		Total	199

Figure 41: Participants selecting a cinema based on convenience or technological capabilities

The introduction of digital 3-D films has resulted in audiences paying a premium surcharge for the 3-D cinematic experience, but is it worth it? When asked if participants were willing to pay this surcharge, participants' responses were fairly evenly split (Figure 42).

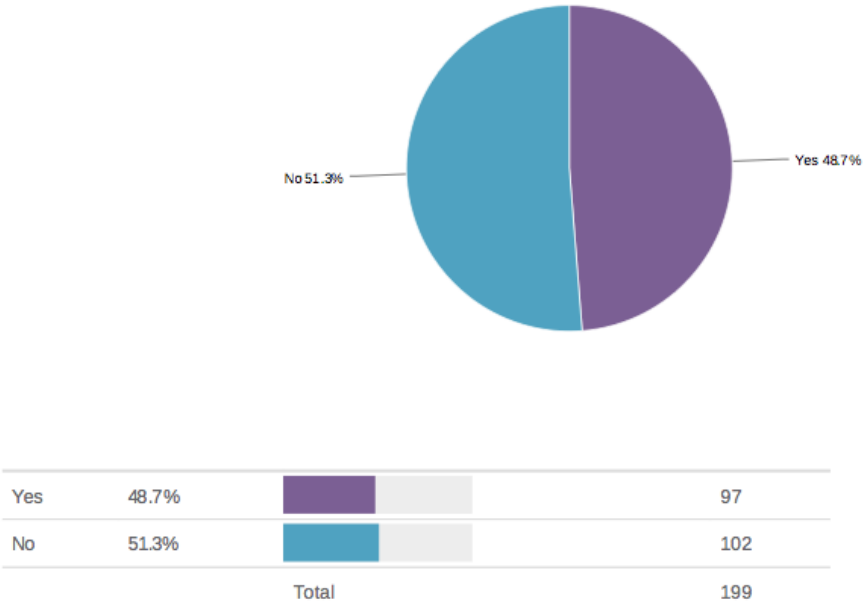


Figure 42: Do you accept paying a premium surcharge for 3-D films?

However, when asked if they would pay a surcharge for a superior sound experience to contemporary 5.1 or 7.1, 43% of participants agreed (Figure 43).

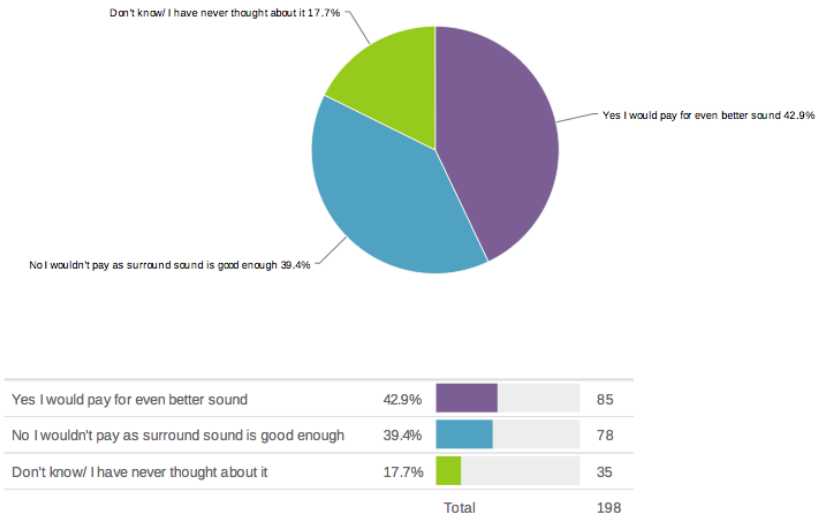


Figure 43: Would audience members pay a surcharge for a superior sound experience?

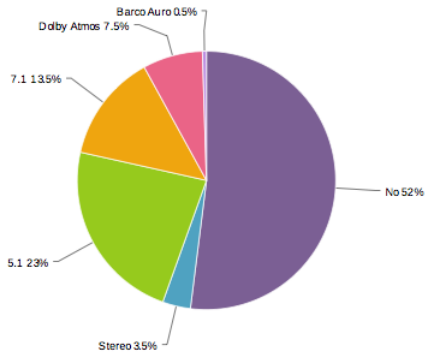
Paying a premium ticket price and having to wear special glasses suggests that audience members are obviously aware of seeing a film in the 3-D format. However, are they equally aware of listening to an immersive soundtrack? Sergi suggests that the Hollywood sound

'is experienced by audiences in the technologically advanced space of the film theatre itself, which has become a sonic playground in which the spectator actively participates, making sense of what is around him or her, and discovering new pleasures.'[35] Although actively participating, is the audience aware of differences in cinematic listening environments?

On a field trip to the Waurn Ponds cinema in January 2014, I questioned cinema manager, David Lovell, about the audience awareness of the Dolby Atmos system, and how his patrons perceived this. Lovell's reply reiterated the perception of vision being the dominant medium. 'People really relate to the image as it is visual and they get it, but with sound they really aren't too fussed as they tend to forget about it and get engrossed in the story…. As long as the audience can hear it and it sounds good… then they are happy with the sound.'[36]

Lovell's observations align with the following survey results. Asked about their knowledge of the sound format of the most recent film they had seen, over 50% of participants were unaware (Figure 44, page 162).

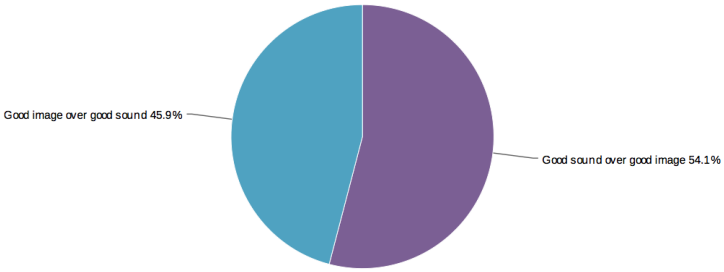
[35] Sergi, "The Sonic Playground: Hollywood Cinema and Its Listeners," 121.
[36] Lovell, Reading Cinema Waurn Ponds Dolby Atmos installation.



No	52.0%		104
Stereo	3.5%		7
5.1	23.0%		46
7.1	13.5%		27
Dolby Atmos	7.5%		15
Barco Auro	0.5%		1
IOSONO	0.0%		0
Other	0.0%		0
		Total	200

Figure 44: The previous sound format that the audience experienced

Many cinemagoers are able to recognise whether or not a particular film 'sounded great,' but how many would prioritise a cinema with good sound over a cinema with good visuals? The survey results indicate that 54% of people would prioritise a cinema with good sound over good image (Figure 45).[37]



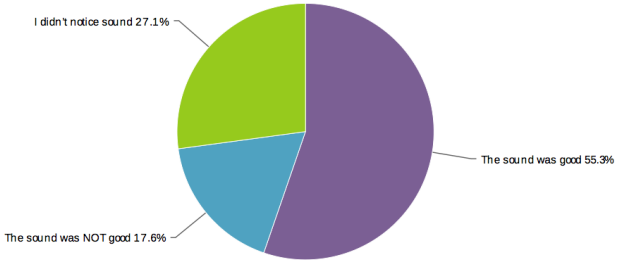
Good sound over good image	54.1%		106
Good image over good sound	45.9%		90
		Total	196

Statistics	
Total Responses	196

Figure 45: Graph showing audience priority in selecting a cinema based on sound or image quality

[37] For complete survey details, please refer to Appendix E.

The results are surprising given that 50% of participants were unaware of the sound format experienced with their most recent film, as suggested earlier. However when also asked about the quality of sound for the most recent film they had seen, nearly 30% of participants didn't even notice the sound quality (Figure 46).

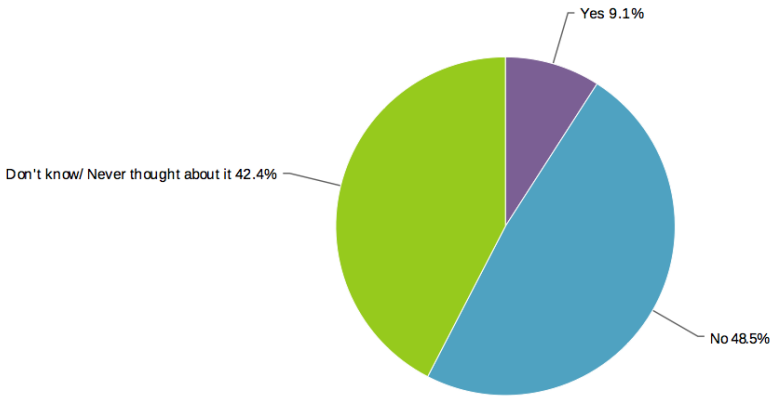


The sound was good	55.3%		110
The sound was NOT good	17.6%		35
I didn't notice sound	27.1%		54
		Total	199

Statistics	
Total Responses	199

Figure 46: Graph showing participants' opinions about the quality of sound on the last film that they experienced

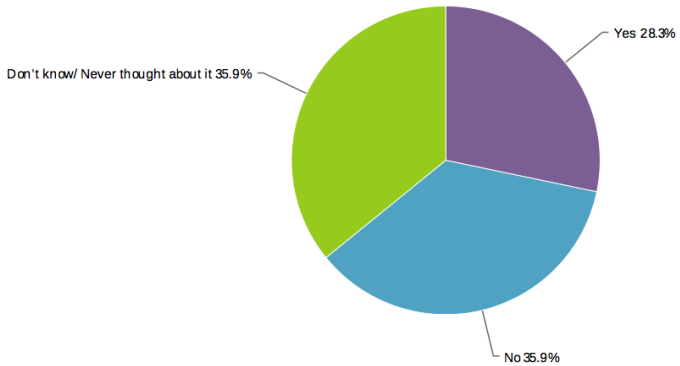
Participants were asked if they thought surround sound is the same is 3-D sound. Only 9.1% thought so, although over 40% of participants didn't know or had never thought about it (Figure 47).



Yes	9.1%		18
No	48.5%		96
Don't know/ Never thought about it	42.4%		84
		Total	198

Figure 47: Is surround sound the same as 3-D sound?

The definition of 3-D sound is clearly misunderstood as participants were also asked if they thought sound for 3-D films can be called 3-D sound. Regardless of the soundtrack being stereo, surround or immersive sound, over 28% of participants thought that a soundtrack associated with a 3-D film was 3-D sound (Figure 48).



Yes	28.3%		56
No	35.9%		71
Don't know/ Never thought about it	35.9%		71
		Total	198

Figure 48: Can the sound for a 3-D film be called 3-D sound?

These results provide a broad overview of the technical understanding participants have for contemporary cinema technologies and formats. This includes surround sound formats and 3-D sound and imagery.

Survey conclusions

The survey results indicate that the majority of participants would select a cinema based on convenience rather than technical capabilities. The results also indicate that audience members are aware of the soundtrack and sound formats since over half the participants prioritised good sound over good imagery. Despite this preference, however, they are largely unaware of the soundtrack or the various sound formats. Sound plays an important role in film, whether it is noticed or not. Randy Thom believes that film is definitely not a visual medium, stating that, 'If you look closely at and listen to a dozen or so of the movies you consider to be great, you will realise how important a role sound plays in many if not

most of them.'[38] This creates a difficult situation for cinema managers - although audiences may not be aware of each particular sound format, they are aware when sound fails. Doane suggests that 'the invisibility of the work on sound is a measure of the strength of the sound track.'[39] This is echoed by Will Files stating 'we are an invisible art.'[40]

The survey results confirm Lovell's suggestion that although an audience is unaware of each sound format, the sound needs to be good.[41] Although 9% of participants believe surround sound is 3-D sound, this jumps to over 28% when asked if the soundtrack for a 3-D film can be called 3-D sound. This indicates that there are limitations to the cinema audience's understanding of contemporary film sound formats. This may also suggest the hesitation by cinema managers to upgrade. If an audience already thinks that the sound is good, then why upgrade? I question the relative notion of sound being good, and suggest that just because it sounds good, it doesn't make it ideal. This is discussed again later in this chapter.

The survey conducted may have some limitations. For instance, although having around 200 participants, many were Australian based and at the time of the survey, Australia only had two immersive sound installations. This obviously limited the number of participants who had experienced these formats.

Part 3: Beyond the cinema: Alternative 3-D and immersion

Prior to the introduction of television, the movie theatre was a place people went to escape into a world removed from their own. By 1930 American families were virtually living at the movies, with many attending at least once a week. Dixon & Foster report that many saw the same film over and over again to avoid the cold and the confines of their own homes.[42] The cinema has evolved to provide a premium service that facilitates escape and immersion through narrative and technology. Since the introduction of affordable

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[38] Thom, "Designing A Movie For Sound by Randy Thom," 3.
[39] Doane, "Ideology and the Practice of Sound Editing and Mixing," 54.
[40] Giardina, "Randy Thom Urges Directors, Screenwriters to 'Create Moments' for Immersive Sound."
[41] Lovell, Reading Cinema Waurn Ponds Dolby Atmos installation.
[42] Wheeler W Dixon and Gwendolyn Audrey Foster, *A Short History of Film* (New Brunswick, N.J.: Rutgers University Press, 2008), 90.

consumer technologies, a new wave of alternative contemporary immersive experiences has been introduced. Immersion is available through 3-D attractions, art installations, home theatre, computer games, virtual reality, and personal smart devices including phones and tablets. Consumers now have the option of choosing a premium cinematic experience or choosing convenience when deciding on engagement with immersive entertainment. We live in an enriched media world with technologies capable of producing and exhibiting film material from a portable device that can fit in the palm of our hands. Although these technologies don't claim to be equivalent to going to the cinema, many of them do provide enriched entertainment experiences. The following highlights some of the available alternatives to cinema.

Themed 3-D attractions

Many film studios own theme parks in which some of the primary attractions are based on their film releases. Often these attractions are promoted as being a 4-D experience. This additional dimension often refers to the physical nature of the attraction. In addition to stereoscopic 3-D imagery and various surround sound formats this may include seats that shake, wind that is blown and mist that is sprayed into an audience. An example is *Shrek 4-D* at Universal Studios (Figure 49, page 167). These attractions are often a themed ride as much as a cinematic experience. Andy Nelson warns that contemporary 3-D cinema needs to be careful of not becoming another theme park ride, especially in regards to visuals that overtly come out of the screen.[43]

[43] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA.

Figure 49: Shrek 4-D at Universal Studios, Florida[44]

Art installations

The art world provides many examples of immersive media experiences. This includes organic exhibitions and exhibitions that utilise digital technologies. Personal computers and digital technologies have become affordable and accessible, providing a high quality means to easily capture, create and manipulate audio and visual content. The art world has embraced these technologies, often blurring the line between filmmaker and artist. Janet Cardiff's *Muriel Lake Incident* (1999)[45] provides an example of the exploration of image and sound depth, perception and immersion through art (Figure 50, page 168).

[44] Universal Studios, "Shrek 4-D at Universal Studios Florida (promotional Image)," *Shrek 4-D at Universal Studios Florida, accessed* December 22, 2014. https://www.universalorlando.com/Images/BB_vert_1_tcm13-5091.jpg.
[45] Janet Cardiff, *Muriel Lake Incident*, Multimedia construction with video projection and binaural audio (Canada,1999).

Figure 50: Muriel Lake Incident, Cardiff, 1999[46]

Home cinema

The affordability of technology has benefited home theatre growth. Ellis-Geiger notes that DVD and home entertainment have rapidly increased due to a decline in the cost of technology since just before the turn of the century.[47] The home entertainment experience is rapidly approaching a level of quality similar to that of a premium cinema. The introduction of 3-D televisions, affordable 3-D projectors and surround sound has narrowed the gap between home theatre and cinema. Sontag acknowledges that 'home screens can be as big as living room or bedroom walls. But you are still in a living room or a bedroom. To be kidnapped, you have to be in a movie theatre, seated in the dark among anonymous strangers.'[48]

Although Sontag suggests that 'to be kidnapped, you have to be in a movie theatre,' current cinematic immersive technologies are allowing the cinematic immersive experience to be affordable and replicated at home almost as soon as these new technologies are released exclusively for cinema. Since the introduction of the DVD player, the home viewer has

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[46] Image accessed March 28, 2013, from http://www.cardiffmiller.com/artworks/smaller_works/muriel_lake.html
[47] Robert Ellis-Geiger, "Designing Surround Sound Facilities for Higher Education" (Audio Engineering Society Conference: 19th International Conference: Surround Sound - Techniques, Technology, and Perception, Audio Engineering Society, 2001), accessed October 31, 2014, http://www.aes.org/e-lib/browse.cfm?elib=10102.
[48] Susan Sontag, "The Decay of Cinema," *New York Times*, February 25, 1996.

experienced digital vision and digital 5.1 sound. Blu-ray has expanded this by offering true high definition images and uncompressed 7.1 sound. The gap between cinema and home theatre narrowed again in 2014 with 4K resolution televisions and projectors released domestically. As of September 2014, it became possible to purchase an amplifier that is capable of supporting both Auro 11.1 and Dolby Atmos on the same device for the domestic market. Although a format war is taking place in the cinemas, the Auro-3D Mensa amplifier, delivered in partnership with Datasat, significantly offers the domestic market compatibility of both immersive sound formats from a single device.[49]

Gaming and virtual reality

Gaming is not only evolving technologically; it is also evolving with respect to storylines, closing the narrative gap with film. Gaming has matured from a simple button click based platform to a narrative driven immersive adventure. The highly acclaimed *Red Dead Redemption* (2010)[50] takes upward of 30 hours to complete.[51] As games become more filmic in narrative, many films are beginning to resemble computer games as they increase the usage of visual effects and digital manipulation. Although films have been made into games for many years, we are now seeing more games made into films. The *Den of Geek* blog reported that in August 2013, thirty-one games were to be made into films.[52] The games industry has become a parallel media platform to film, with the two media often compared. This is particularly true when comparing revenue. In 2013, *Iron Man 3* (2013)[53] was the highest grossing film of the year making US$1.2 billion worldwide. However the

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[49] Wilfried Van Baelen, "Breaking through the Immersive Sound Barrier: Auro-3D® Mensa™ to Feature Both Auro-3D® and Dolby Atmos™," *Auro-3D*, September 2014, accessed September 12, 2014. http://www.auro-3d.com/blog/breaking-through-the-immersive-sound-barrier-auro-3d-mensa-to-feature-both-auro-3d-and-dolby-atmos/.
[50] Rockstar Games, *Red Dead Redemption*, Computer Game (New York: Rockstar Games, 2010).
[51] Blake Snow, "Why Most People Don't Finish Video Games," August 17, 2011, accessed December 22, 2014.
http://www.cnn.com/2011/TECH/gaming.gadgets/08/17/finishing.videogames.snow/index.html.
[52] Megan McGill, "31 Videogames Heading to the Movies," *Den of Geek*, August 12, 2013, accessed December 22, 2014. http://www.denofgeek.com/movies/games-to-films/26784/31-videogames-heading-to-the-movies.
[53] Drew Pearce and Shane Black, *Iron Man 3*, directed by Shane Black (Burbank, CA: Walt Disney Studios Motion Pictures, 2013).

game *Grand Theft Auto V* (2013)[54] made US$800 million in its first day of sales and surpassed *Iron Man* in just over three days.[55,56]

Competition between games and film is projected to decrease, as the two media look set to complement each other. Denis Dyack, co-founder of Quantum Entanglement Entertainment, will produce game and cinematic content concurrently ahead of what he calls "'The Singularity," a future state of entertainment where games, film and TV blend together to be indistinguishable.'[57]

Experiencing the games industry first hand, I have witnessed endeavours to push technological boundaries. This creates many new developments for games that should not be ignored by the film industry. Of interest are the relevant 3-D gaming technologies, as games utilise 3-D positional data with real-time rendering of the soundtrack. 'Most contemporary games rely on the same high-quality sound encoding and playback schemes as the film industry, using digital surround sound systems such as Dolby Digital and DTS.'[58] The PlayStation 3 and Xbox 360 also feature real-time 5.1 channel (or better) mixing capabilities.[59] As of 2013, the restriction of 5.1 or 7.1 sound was lifted with games now offering immersive sound integration with Auro Technologies integrated into the Wwise game middleware.[60] This provides the ability to have an interactive immersive cinematic soundtrack for games.

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[54] Rockstar Games, *Grand Theft Auto V* (New York: Rockstar Games, 2013).
[55] Gary Baum, "How the New 'Grand Theft Auto' Goes Hollywood," *The Hollywood Reporter*, September 18, 2013, accessed May 17, 2014. http://www.hollywoodreporter.com/gallery/how-new-grand-theft-auto-631763.
[56] Stuart McGurk, "Gaming Special: Welcome to the World of Grown up Gaming," *GQ*, February 19, 2014, accessed May 17, 2014. http://www.gq-magazine.co.uk/entertainment/articles/2014-02-/19/video-game-industry-evolution-2014.
[57] Tim Biggs, "Halo Everywhere: Nightfall and the Collision of Games and Film," November 10, 2014, accessed November 11, 2014. http://www.smh.com.au/digital-life/games/halo-everywhere-nightfall-and-the-collision-of-games-and-film-20141110-11id2w.html.
[58] Mark Kerins, "Multichannel Gaming and the Aesthetics of Interactive Surround," in *The Oxford Handbook of New Audiovisual Aesthetics*, ed. John Richardson, Claudia Gorbman, and Carol Vernallis, New Audiovisual Aesthetics (Oxford: Oxford University Press, 2013), 585.
[59] Ibid., 586.
[60] Auro Technologies, "AudioKinetic Brings Auro-3D® to Interactive Media and Gaming," August 19, 2013, accessed September 12, 2014. http://us5.campaign-archive2.com/?u=58557cb7d99ab3fe572b680f9&id=9e3b102cc9&e=2e5baee23d.

The current generation of game platforms offers native 3-D visual technology, allowing the integration of 3-D virtual reality headsets. Offering a cost effective virtual reality headset, The Oculus Rift was successfully crowd funded on the website *Kickstarter* by far surpassing the expected US$250 000 goal, with a final pledge in excess of two million dollars.[61, 62] On 25 March 2014, Facebook acquired Oculus for approximately US$2 billion.[63] I first experienced the virtual reality technology on a developer Oculus Rift in November 2013. The device promised to take '3-D gaming to the next level,' and my interest lay in repurposing the device as an immersive film-viewing platform as opposed to interactive gaming.[64] Having experienced several developer configurations, an obvious omission from the headset is that it is purely a vision-based hardware peripheral with no sound integration. This necessitates that the computer provides the sound output to either speakers or headphones.

My first experience was a demonstration of the sample package. This included being able to walk around a building, inside the building, and see a fireplace burning, all in 3-D. Although quite basic in its content, this provided enough information to foresee the potential of this technology. The headset itself was quite light and sat on the front of the face with head straps that kept the unit from falling forward. Wearing stereo headphones, I also experienced the associated sounds with the visuals. As I walked closer to the fire, the louder the fire became. As I turned left or right, the sound also panned accordingly. The sound was simple in detail, density and spatial positioning. On 17 December 2013, I had my second Oculus Rift experience with the 3-D *Half-Life 2* (2004)[65] game. I suffered nausea after 10 minutes of game play, possibly a result of the low resolution (1280 x 800 total, 640 x 800 per eye) and the screen door effect.[66]

In its current state (DK2) the Oculus Rift is inadequate as a 3-D film-viewing device due to the low resolution of the screen. However, developers are creating applications that allow

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[61] Kickstarter, www.kickstarter.com.
[62] KickStarter "Oculus Rift: Step into the Game." August 2012, accessed December 18, 2012. http://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game?ref=live
[63] Facebook newsroom, "Facebook to Acquire Oculus | Facebook Newsroom," March 25, 2014, accessed May 25, 2014. http://newsroom.fb.com/news/2014/03/facebook-to-acquire-oculus/.
[64] KickStarter "Oculus Rift: Step into the Game."
[65] Valve, *Half-Life 2,* Computer Game (Bellevue, WA: Valve, 2004).
[66] When looking at the screen, the low resolution allows the pixels to be obvious and it appears as tough you are watching the vision through a screen door.

the device to emulate cinema with VR Cinema allowing the user to select a seat within a virtual cinema.[67] The Oculus user forum had the following quote that sums up the experience:

> I loved the feeling of being in the front row and looking up at the movie screen. It really felt like I was there. The expected screen door and low-res graphics were noticeable, but the overall effect was great. I can't wait to see how this looks in the HD version of the Rift.[68]

The Oculus Rift will provide an alternative simple and affordable cinematic immersive experience. Although a home theatre sound system would be an excellent sound companion to this product, my informed response is that immersive headphone technology would provide a superior experience. The use of immersive headphone technologies for 3-D films is investigated in the following chapter. The head unit allows the user to be completely visually immersed within the onscreen environment and headphones would complement this experience. Headphone technology can also provide an 'in your head' sound experience that is extremely difficult to replicate with speakers. This feature alone would allow a new authentic sonic experience for first person game usage, akin to the binaural experience of POV film scenes. The audio/visual experience is enhanced with the Oculus Rift's ability to provide real-time head tracking. As noted by Nair 'with VR and head tracking, the difference between binaural audio and traditional stereo panning is huge, especially when dealing with both the horizontal and vertical plane. It is quite a cool experience to see something fly over you and hear it move over your head too.'[69] There is limited real-time binaural integration in commercial games. The potential of the medium has also been explored with the iPhone/iPad iOS audio-only game, *Papa Sangre* (2011).[70]

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[67] Gabri, "VR Cinema | Apps | Oculus VR Share (Beta)," December 16, 2013, accessed December 18, 2013. https://share.oculusvr.com/app/vr-cinema.
[68] Ibid.
[69] Varun Nair, "Audio And VR | Designing Sound Designing Sound," May 28, 2014, accessed May 31, 2014. http://designingsound.org/2014/05/audio-and-vr/?utm_medium=referral&utm_source=pulsenews.
[70] Somethin' Else, *Papa Sangre,* Computer Game (London: Somethin' Else, 2011), accessed 12 November 2013. http://www.papasangre.com/.

Personal smart devices

Sales of personal smartphones exceeded one billion units in the year for 2013, and with tablet sales expected to outsell PCs by 2015, many people are turning to smart devices for entertainment.[71, 72] These devices have evolved from merely being music players, or phones, to becoming a large component of the entertainment experience, capable of playing images, sound, video and games. As described by Mike Dunn of Fox, 'by 2015 Americans will have 861 million internet-connected devices such as games consoles, tablets, smartphones and laptops, up from 560 million in 2012. That translates into every American owning 2.7 devices.'[73]

The first consumer digital music format, the Compact Disc, provided the user with a high quality product far superior to that of previous analogue formats. However with the introduction of the MP3 player, consumers began to sacrifice audio quality for the ability to store many thousands of songs on a single device. The initial introduction of the iPod and other MP3 players shocked the music and sound industries with consumers sacrificing audio quality over quantity. Although there are numerous new audio compression formats that provide sound reproduction quality superior to that of the MP3 format, ultimately these formats are still compressed. We are witnessing a generation of consumers that has grown up without ever experiencing an uncompressed digital recording, instead having listened only to inferior compressed audio formats.

Combining compressed audio with compressed video on the small screen of a smart device, consumers are compromising their entertainment experience. However research by DTS Inc. (an audio solutions provider for high-definition entertainment experiences) suggests that by improving the audio quality, the entertainment experience is enhanced. The research concluded that mobile users preferred to watch videos with their ears and that 'increasing the audio quality of sound on a mobile device provided far greater

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[71] IDC "Worldwide Smartphone Shipments Top One Billion Units for the First Time, According to IDC," January 27, 2014, accessed March 14, 2014. https://www.idc.com/getdoc.jsp?containerId=prUS24645514
[72] Matt Petronzio, "Tablets Expected to Outsell PCs by 2015," *Mashable*, March 7, 2014, accessed March 14, 2014. http://mashable.com/2014/03/07/tablet-pc-chart/.
[73] The Economist, "Split Screens: A Tale of Two Tinseltowns," *The Economist*, February 23, 2013, accessed June 22, 2014. http://www.economist.com/news/business/21572218-tale-two-tinseltowns-split-screens.

enjoyment than increasing the image quality.'[74] The online survey suggested that over 55% of participants regularly watch films on personal devices (Figure 51).

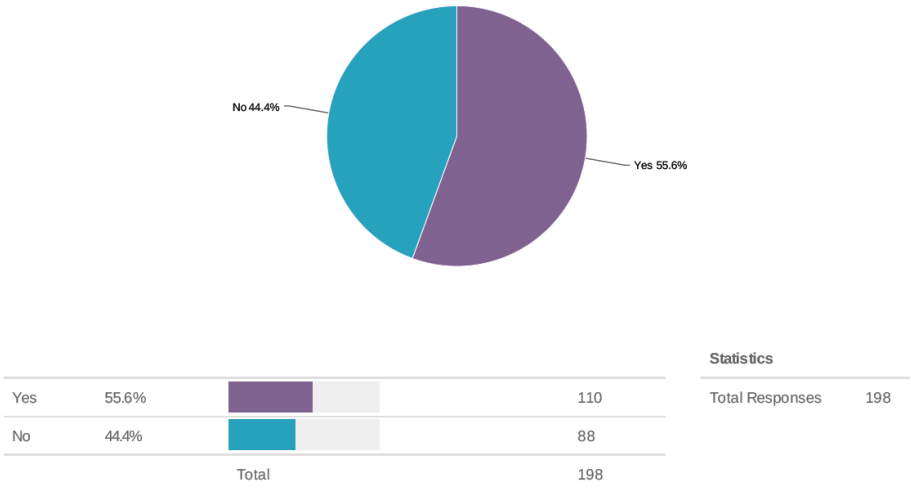

Figure 51: Do you regularly watch films on a personal device?

Acknowledging the uptake of portable technologies, the British Broadcasting Commission has created a specific division to research immersive headphone sound.[75] In parallel with the DTS research, the BBC is dedicated to improving the quality of headphone listening to portable devices suggesting that 'a more immersive surround sound experience could potentially give a big improvement.'[76]

In Chapter 3, I referenced Schafer's 'schizophonia,' describing the separation of replayed sound from its original source and how this can relate to sound and image. With consumers listening to inferior sound quality, combined with viewing inferior images on a small screen, I propose that these quality impairments expand upon Shafer's definition. If consuming low quality media becomes normalised, does this diminish the expectations and relationship between image and sound at the cinema? Perhaps this lack of

[74] DTS, "Mobile Users Prefer to 'Watch' Video with Their Ears," February 26, 2014, accessed March 1, 2014. http://www.dts.com/news/articles/2014/02/mobile-users-prefer-to-watch-video-with-their-ears.aspx.
[75] Frank Melchior, "Audio Research Partnership Starts Working towards Immersive Listener Experience at Home," *BBC R&D Blog*, October 31, 2013, accessed 30th October 2014. http://www.bbc.co.uk/rd/blog/2013/10/bbc-audio-research-partnership-starts-working-towards-immersive-listener-experience-at-home.
[76] Chris Pike, "Workshop on Immersive Audio Over Headphones," *BBC R&D Blog*, June 4, 2013, accessed 30th October 2014. http://www.bbc.co.uk/rd/blog/2013/05/workshop-on-immersive-audio-over-headphones.

technological literacies is already becoming evident with cinema audiences, as shown in the online survey responses. Cinema quality, and especially cinema sound quality, is relative to the audience's experiences and knowledge.

Part 4: Alternative spatial and immersive sound technologies

Binaural and ambisonic formats have the capacity to reproduce the sonic equivalent of a 3-D image. Although not used commercially in cinema, research is continuing in these formats of spatial sound field reproduction. Binaural sound is most commonly a headphone technology, with ambisonics providing a spatial reproduction through the use of speakers. These formats have been included in this chapter as they play an important role in sound spatialisation developments. Increasingly, headphone spatialisation needs to be considered due to increases in personal device usage as mentioned in Part 3 of this chapter. This is also investigated in Chapter 6.

Ambisonics

Ambisonics is not a new technology, having existed since the 1970s. Using multi-channel sound encoding, the format provides the ability to create a planar (2-D) or periphonic (3-D) sound field. As stated by Rumsey & McCormick, the format offers 'a complete hierarchical approach to directional sound pickup, storage or transmission and reproduction, which is equally applicable to mono, stereo, horizontal surround sound, or full periphonic reproduction including height information.'[77] The four-channel B-Format offers a non-channel specific format, with any number of decoded sound format possibilities able to be derived including mono, stereo and 5.1. This is particularly useful for the recording of atmospheres for films where an ambisonic recording can be decoded directly into the 5.1 format.

Personal experience with the format includes *Australia* and *Legend of The Guardians*. It should be noted that although the ambisonic format provides a medium to capture and decode sound into a 3-D periphonic sound field, the reality is that cinemas are unable to reproduce this. Instead, a conventional 5.1 format is derived from the ambisonic B-Format.

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[77] Francis Rumsey and Tim McCormick, *Sound and Recording* (Amsterdam; London: Elsevier/Focal, 2009), 535.

To replay a true ambisonic format in 3-D requires specially calibrated speakers, precise speaker positioning and controlled room acoustics. The practicality of implementing this into the cinema auditorium is almost impossible.

Binaural sound

In recent years, several vendors have investigated headphone technologies for the recreation of the spatialisation of surround sound for films. As discussed in Chapter 3, binaural sound recording and playback was used on *Bad Boy Bubby* (DVD) but the theatrical release of *Bad Boy Bubby* did not utilise the binaural soundtrack in cinemas. For binaural to be effective it must be listened to through headphones, making the technology useful for domestic release only. When critically listening to the soundtrack of *Bad Boy Bubby* (DVD), the binaural recordings represent the POV shots with superb spatial accuracy. By combining a binaural sonic experience with matching POV visuals, *Bad Boy Bubby* creates a perceived 3-D auditory spatialisation, despite the 2-D imagery. This approach is applied to the practice-led components of Chapter 6.

The 3-D French short film *Souviens–Moi* also utilises a binaural soundtrack, providing both visual and aural 3-D spatialisation. Having imagery in both negative and positive parallax, the relationship between image and sound works very well in specific places. Similar to *Bad Boy Bubby,* the most impressive audio-visual homogeneity happens during the POV shots. This occurs at the beginning of the film when we are in the POV of the protagonist, Thomas (Clément Sibony). However, dislocation occurs once we are out of POV as the binaural soundtrack continues from Thomas's perspective and jars against the third person visual, similar to *Bad Boy Bubby*. Here, the binaural perspective of the first person no longer relates to the 3-D third person visuals. This highlights my concerns with current sound practices for 3-D films. By providing an audience with 3-D images within a space and also a 3-D auditory image within a separate space, the keeping both homogenised for every shot is virtually impossible, creating a disconnect as discussed in Chapter 3.

Other headphone technologies

Although the term 'binaural' is used regularly in relation to discussions of headphone 3-D spatialisation, I wish to outline a few additional proprietary headphone technologies. These include:

- Dolby Headphone that originated from Lake Technology in Sydney. Dolby Headphone provides a virtual 5.1 sound spatialisation.

- Developed by DTS, Headphone:X provides a surround sound solution for regular stereo headphones aiming to 'replicate the acoustic environment of the studio that the audio is mixed in, complete with directional characteristics.'[78]
- Auro released the Auro-Headphone immersive 3-D headphone sound encoding technology in December 2014. This is a software plug-in that is incorporated into the Auro 3-D mixing suite and allows an Auro 3-D encoded soundtrack to play back through regular stereo headphones. This software has been used in some of the practice-led components of Chapter 6.

Conclusion

With an emphasis on the end user (the cinema audience), this chapter investigated:

- The influence an audience may have on cinemas investing in new technologies.
- The cinema audience and their understanding of immersive technologies.
- Immersive media alternatives to cinema exhibition.
- Alternative immersive non-cinema sound formats.

Significant investment is required for a cinema to upgrade to emerging technologies, making decisions difficult for cinema managers. This includes determining if new technologies will increase revenue, and also determining audience demand for new technologies. Although the survey results suggest that good quality sound is a high priority, the audience is mostly unaware of specific sound technologies. The cinema audience is also generally unaware of the differences between surround sound, sound for 3-D films and 3-D sound.

The cinema audience has many options for consuming immersive media. Experiencing immersive cinema technology is no longer exclusive to the cinema, with 3-D projection and immersive sound formats available in the domestic market. Gaming is challenging the film medium as a viable immersive media platform offering interactive narrative-driven 3-D virtualisation. The exponential growth of the personal smart device is providing an affordable, portable media platform capable of reproducing films, albeit with inferior

[78] Duncan Geere, "Man of Steel Soundtrack Released with Headphone:X Mix (Wired UK)," *Wired UK*, June 22, 2013, accessed September 18, 2014. http://www.wired.co.uk/news/archive/2013-06/22/man-of-steel.

sound and visual qualities compared to cinema. Consumers however are opting for portability over quality and this is becoming recognised by technology companies. The BBC, DTS, Barco Auro and Dolby have committed to developing headphone technologies, which signifies that headphone technologies are a serious consideration as a potential growth area.

Through practice-led research, the following chapter investigates the creation of a 3-D soundtrack that is homogenous with 3-D imagery, using practices not commonly followed within the commercial film industry.

Chapter 6: Practice-led Research – Using Available Technologies to Create a Homogenous 3-D Soundtrack Experience for 3-D Film

Introduction

In earlier chapters I have drawn upon first-hand experiences of working on commercial 3-D feature films to highlight and provide examples of my line of enquiry. The feature films that I have recently been engaged on, mostly Warner Bros. productions, have followed strict schedules and followed a known formula for producing a high quality soundtrack that satisfies the studio, and equally importantly, the cinema audience. Having worked on such high profile and financially successful films such as *The Great Gatsby* and *The LEGO Movie*, it is difficult to argue that the formula for producing these high quality soundtracks needs to be further investigated. *The LEGO Movie* opened in the US with the box office taking in excess of US$69 million, well above the estimated entire film budget of US$60 million in a single weekend.[1] In Chapter 4, I discussed the challenges faced when designing sounds and producing a soundtrack for 3-D films. This includes limitations of contemporary sound technologies, contemporary mixing practices and a lack of preparation and time for immersive mixes. Many 3-D feature films continue to adhere to traditional 2-D soundtrack methodologies and practices, and I have been bound by these conventions when creating soundtracks for commercial 3-D films.

The film industry has followed a steady path of innovation in relation to developments of the soundtrack and in particular soundtrack exhibition. Generally speaking, advancements within the industry have seen an increase in the number of speaker channels over time, for example, mono to stereo to quad surround to 5.1 surround to 7.1 surround and now the introduction of sixty-four channel immersive sound technologies. Although several formats have explored additional sound channels throughout this linear evolution of sound on film including Fantasound, a general trend can be observed. As discussed in

[1] Box Office Mojo, "The LEGO Movie (2014)," *Box Office Mojo*, February 2014, accessed March, 3 1014, http://boxofficemojo.com/movies/?id=lego.htm.

Chapter 2, previous format limitations were a result of how many sound channels could be accommodated within the available film format of the time; for example, the physical space limitations on 35mm film and 70mm film. However the introduction of digital film has drastically increased the capacity for sound channels through the DCP film format. Although developments in cinema sound have led to increased sound channels, as discussed in the latter section of Chapter 4, I question whether current immersive sound technologies provide a true 3-D soundtrack that is spatially homogenous with the 3-D image.

Previous chapters of this thesis identified the following:

- Contemporary mixing practices often don't have all sound elements panned spatially true to the 3-D imagery, especially dialogue and foley.
- Contemporary cinema speaker formats are limited in rendering sound accurately within z-space.
- Often the pan positional data does not translate accurately to the positional rendering of sounds.
- Binaural headphone technologies allow sound to be positioned accurately with imagery in some instances, depending on the framing of the camera.

This line of enquiry has led me to question the points above through practice-led research. In this chapter I aim to challenge these by investigating:

- The ability to pan all elements within the soundtrack.
- The limitations of contemporary cinema sound formats and the creation of a film specifically to take advantage of these restrictions.
- The limitations of binaural headphone technologies and the creation of a soundtrack that overcomes these restrictions.

I hypothesise that it is possible to create a soundtrack that is more spatially homogenous with the 3-D image than contemporary 3-D cinema releases.

Although research exists within areas of cinema sound and sound spatialisation and acoustics, there is little research that specifically explores sound for 3-D films. Whilst this thesis originally commenced with a 100% theoretical and traditional research approach, it became apparent early in the research investigation that a practice-led approach was more applicable in filling the gap of this line of enquiry.

Practice-led research

In this practice-led research I investigate various alternative approaches for creating an immersive and homogenous 3-D film soundtrack. The aim is to create a more spatially accurate soundtrack compared to contemporary feature film. This will include panning all elements within the soundtrack including dialogue and foley, recording sound with localisation considerations in ambisonic and binaural formats, and where recording is not an option, explore digitally synthesised 3-D spatial sound options.

Three films have been selected for this practice-led enquiry. These are:

- *Carwash*. An original single shot stereoscopic 3-D film clip.
- *Foxed!*.[2] A 3-D stereoscopic short film.
- *Legend of the Guardians: The Owls of Ga'Hoole*. Three selected scenes of approximately one minute duration each.

The accompanying Blu-ray/DVD contains the practice-led investigation mixes for all clips in this chapter. Please see the 'Accompanying Blu-ray and DVD Track Listings' on page xxii for further details.

Through practice-led research I am afforded the luxury of not having to work to any preconceived convention as I investigate the creation of homogenous 3-D spatialisation. This approach of creating and manipulating the soundtrack follows the reflective practitioner approach as described by Schön:

> Skills in the manipulation of media, languages, and repertoires are essential to a practitioner's reflective conversation with his situation, just as skill in the manipulation of spoken language is essential to ordinary conversation.[3]

The research undertaken within this chapter investigates non-conventional mixing, panning and sonic spatialisation practices. Narrative has often been overshadowed to allow the sound to be more accurately positioned with the accompanying 3-D imagery. This research investigates whether it is possible to achieve a more immersive, realistic,

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[2] Stewart, James E. D. and Nev Bezaire, *Foxed!*, Short Film, directed by James E. D. Stewart and Nev Bezaire (Canada: 2013).
[3] Donald A. Schön, *The Reflective Practitioner* (USA: Basic Books, 1984), 271.

and homogenous 3-D audio-visual experience through changing working methodologies and by using existing technologies.

Carwash (3-D)

Carwash is an original film created by the author. It is a single shot scene recorded inside an actual carwash.

Aim

The aim of *Carwash* was to accurately investigate the reproduction of 3-D sound and vision from capture through to exhibition. The limitations of the 5.1 sound format were considered in the conception of the film. Contemporary cinema sound formats provide a canopy effect and *Carwash* exploits this. *Carwash* was purposely created to allow for the simultaneous filming in stereoscopic 3-D whilst capturing the location sound in various formats including binaural stereo and ambisonic B-format, simulating a virtual head. I hypothesise that the virtual head would record vision and sound in 3-D, and when played back, would allow the viewer to see and hear in 3-D.

Method

Filming *Carwash* was a reversal of the industry practice of capturing the best imagery first and considering the sound later. I prioritised recording the best sound, with the image a secondary consideration. For the purpose of this exercise, my priority was to capture sound recordings that could best replicate 3-D sound whilst maintaining homogeneity with the 3-D imagery. Location sound for 3-D films is not typically recorded in a 3-D format. *Carwash* embarked on creating a short film-clip that challenged this notion. The film was captured in stereoscopic 3-D whilst the sound was recorded in the ambisonic B-Format and the binaural format simultaneously. The setup for recording *Carwash* was as follows (Figure 52, page 183):

- 2 x GoPro Hero2 cameras arranged in a side-by-side configured housing.
- Binaural microphones installed inside a binaural dummy head created by the author – recorded onto a Zoom H4N handheld recorder.

- Soundfield ST450 ambisonic (B-Format) microphone – recorded to a Sound Devices 744 recorder in ambisonic B-Format. [4]

Figure 52: Binaural head with 3-D GoPro camera attached and Soundfield microphone in middle.

To create a point of view experience for the viewer, the 3-D camera rig was mounted to the binaural head. This 'virtual head' allowed the capture of simultaneous sound and vision, akin to our own two eyes and two ears. The imagery was captured using two Go-Pro cameras, with the video converted to the 3-D side-by-side format (Figure 53, page 184). The converted video file was imported into the audio editing software Pro Tools 10 along with the 5.1 decoded ambisonic file and the binaural file.[5] No further audio processing was applied to either recording, allowing the original recordings to be unadulterated. (Please note that this is why the *Carwash* files on the Blu-ray/DVD are slightly quiet compared to the other clips. This is to deliberately keep the integrity of the original recordings). An additional binaural version of the film soundtrack was created using the software plug-in Auro-Headphones. The Auro-Headphone plug-in was applied to

[4] Ambisonic sound has various formats including UHJ, G-format and B-format. B-format uses a 4 track encoded matrix that when decoded allows the source of the sound to be derived independent of speaker numbers. It also includes height information and is capable of going beyond the 6 channels of 5.1 sound.
[5] Protools is industry standard professional audio editing and mixing software.

the 5.1 decoded files. This provides a comparison between the synthesised Auro binaural soundtrack and the original binaural recording.

Three versions of *Carwash* were created and are included on the Blu-ray/DVD.

- 5.1 version created from the original ambisonic recording.
- Binaural version recorded through the dummy head.
- Auro-Headphone binaural version created from folding down the 5.1 version.

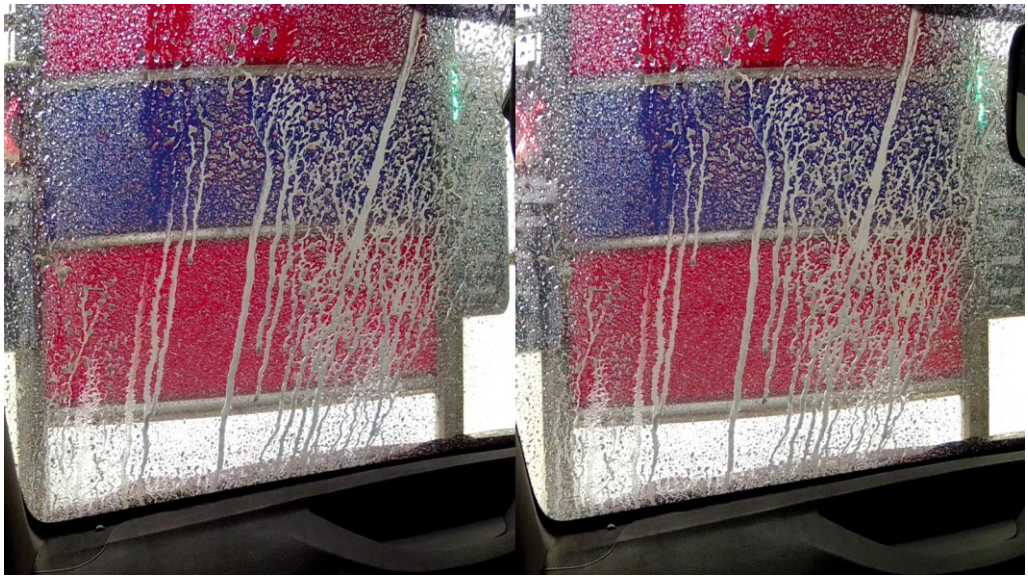


Figure 53: *Carwash* image (side by side 3-D)

Results and discussion

Having experimented with binaural and ambisonic sound formats prior to writing this thesis, I already had experience and an understanding of the capabilities and limitations of each format. However, I had never recorded these audio formats simultaneously with 3-D image capture. Although binaural sound has previously been simultaneously recorded with visuals on films including *Bad Boy Bubby* and *Souviens-Moi,* I am unaware of any films that have been recorded and released with an unchanged or unedited original on-set ambisonic recorded soundtrack. Ambisonic recordings are often used to record atmospheres, but they are mixed down to a conventional surround sound format as outlined in Chapter 5 (page 175) with the film *Australia* (2008).[6]

[6] Baz Luhrmann, *Australia* (20th Century Fox, 2008).

Prior to the filming of *Carwash* in 3-D, I had experimented with several other simultaneous audio-visual 3-D recordings. However the distance between the camera and the subject provided many challenges, including the lack of detail in image and sound in relation to the depth along the z-axis. For the purpose of my line of enquiry, driving through an automated carwash provided the best results for my research, including:

- Depth along the z-axis for both sound and vision.
- Imagery that immersed the viewer.
- A controlled sound environment that immersed the listener.

Recording in the binaural format and the ambisonic B-format synchronised to the 3-D visuals allowed a direct comparison between both sound formats. This also provided the flexibility to create a headphone 3-D soundtrack and a conventional 5.1 soundtrack for speaker playback simultaneously. In the case of this research there is an additional binaural version (Auro-Headphone) of the film synthetically created from the 5.1 version. Based on the Auro 3-D cinema sound engine, Auro-Headphone is a binaural plug-in that allows the 360˚ positioning of sound.

The 5.1 and both of the binaural mixes provide a homogenous relationship with the imagery. Filming in a controlled environment, capturing clean, spatially accurate recordings and suitable imagery allows *Carwash* to have homogenous 3-D audio and vision. The binaural versions provide the addition of y-axis sound, with the sound of the carwash noticeably more detailed passing above the listener. This height information was embedded in the original binaural recording. However for the Auro-Headphone version I had to manually automate the sound into the y-axis to create the sensation that the carwash water passes over the listener.

***Carwash* conclusion:**

Carwash was created to synchronously capture 3-D imagery and various sound formats in a simplistic controlled environment. The aim was to accurately explore the reproduction of 3-D sound and vision from capture through to exhibition and this was successfully achieved. The film represents actuality as it was filmed and recorded from a single point of view in a single take. As discussed in earlier chapters, one of the shortcomings of conventional speaker sound systems is that they are unable to render sound accurately within z-space. As 3-D imagery converges off the screen into negative parallax, this creates dislocation as the sound emanates from around the audience, creating a cocoon effect. *Carwash* deliberately capitalises on this by using an environment that is a cocoon. That is, the car represents a cocoon, with the sound of the carwash emanating outside it.

The film contains no dialogue or any additional sound effects, capturing only the sounds that took place at the location. *Carwash* provides an example of successfully creating a homogenous soundtrack and 3-D imagery in 5.1 and two versions of binaural stereo headphone formats.

Although successful in creating a homogenous audio-visual experience, applying the methodology used on *Carwash* on a feature film would be impractical, but not impossible. It would be successful, as proven here, to work on short films. Having dialogue and/or camera angles with varied use parallax would make the capturing of sound very time consuming. This would be most noticeable in the editing process. The challenges involved in editing binaural sound, or sound with embedded spatial information, is discussed in the following film *Foxed!.*

Foxed!

Foxed! is a 3-D Canadian production that has won many awards at film festivals for *Best Animation* and *Best Direction*. Although I am not credited with the original 5.1 soundtrack, I have recreated various versions of the sound mix to provide different examples of spatialisation.

Aim

Foxed! had a pre-existing soundtrack prior to me being granted permission to use the film for the purpose of this PhD. The original 5.1 mix was created conventionally using common film mixing methodologies, in the same manner as a feature film. The original sound mix demonstrated many of the shortcomings I have already identified in previous chapters when a contemporary sound format is used with a 3-D film.

The practice-led research objectives of considering this film were to create a 5.1 and binaural headphone version of an immersive sound mix. The aim was to:

- Create a more immersive film through manipulating the existing soundtrack.
- Create a soundtrack that is homogenous with the 3-D imagery.
- Support the point-of-view shots aurally to better situate and immerse the audience in the first person.

Method

In my original approach to the remix of *Foxed!*, I intended to create all pan data in a 5.1 version, and then through the use of plug-ins, fold down the mix into a binaural version. It was intended that all 3-D spatial information from the 5.1 version would be compatible, thus saving time and providing an efficient workflow. After several early mixing tests, this methodology proved to be unsuccessful as the z-axis information did not translate into the headphone mix. This necessitated creating two independent versions of the film; one in 5.1 and the other mixed natively in binaural.

This led to approaching the film mix from two completely different perspectives.

1. Create a 5.1 mix that did not follow the Hollywood convention of having sounds primarily in the front speakers, instead utilising the x, y and z axes as appropriate with the 3-D imagery (six channel speaker playback).
2. Create a binaural headphone mix that created or emulated sound within a 3-D space, allowing panning in the x, y and z-axes as appropriate with the 3-D imagery (stereo headphone playback).

Results and discussion

All raw-sounds were supplied from the studio that created the original soundtrack. However, all mix data including volume, reverb, equalisation, compression and all effects were not supplied. This allowed me to remix the film without knowing any original settings, or having any preconceived judgment. The only version of the film I had heard prior to working on the soundtrack was a stereo version on the Internet.[7]

Foxed! (5.1 remix)

Mixing dialogues. Mixing the dialogue in 5.1 required extensive panning on both the x and z-axes. There are many instances where characters move across screen and are off-screen. The dialogue is panned to keep the characters sonically matched to the visuals and the narrative. In addition to panning the dialogue, reverb characteristics were consistently adjusted depending on the position of characters in relation to the camera and the room in

[7] When discussing the possibility of creating an immersive remix of the film, director James Stewart provided a password protected link on the 14th January 2014 for me to view a 2D version of the film with the original soundtrack in stereo.

which they were located. The closer to the camera a character is, the less reverb was used. The reverb adjustments also aided in distinguishing how present the dialogue was within the acoustic space of the scene.

Emily's POV. *Foxed!* centres around the protagonist Emily, with all scenes featuring her on a quest to find her way back home. The film uses many shots that are from Emily's POV perspective, creating a challenge for spatial sound placement. An example is when Emily runs up the stairs (1 min. 34 sec). Conveying this through sound, I created the dialogue and footsteps to seem as if they are in the middle of the cinematic z-space. This was a combination of panning the sounds off the screen, filtering, and using reverberation to give the illusion of the dialogue sitting in the middle of the cinema. Although working well, this technique is more effective during the title credits of the film when Emily runs from out of shot behind us to centre screen. This effectiveness is similar to the movement of panned sounds as previously described in the *Legend of the Guardians* and *The LEGO Movie* in Chapter 4. These instances provide perceived homogeneity as the sounds pan through movement with the action. This movement (panning) helps convey effective perceived spatial accuracy.

As part of the process of creating the binaural mix of the film, it was necessary to re-record the dialogues for the final scene (see Creating 3-D dialogue for headphones, page 191). The re-recordings produced spatially superior results compared to the original raw dialogue tracks. Although the binaural recordings were originally created for the headphone version, they were also repurposed and used for the 5.1 version due to their acoustic superiority. Through the careful consideration of the location used for the re-recording space, the recordings contained appropriately captured reverb and glass filtering characteristics based on the convolutions of an actual acoustic environment.[8] This provided the advantage of allowing the dialogue to pan true to the imagery with minimal additional effects. The dialogue between the mother and Emily fox (the fox that has replaced Emily) at the end of the film highlights this.

[8] Convolutions allow the reproduction of actual acoustic spaces through the decoding of reverberation and spatial information derived from impulse responses.

Panning sound effects. Panning the sound effects for the 5.1 version of the film was conventional with only a few exceptions. Sound effects in the film are relatively minimal, with the most predominant effects being several swings of a pick at the beginning of the film. Emily's second and fourth pick swings are facing camera and feature sparks that fly through the air into negative parallax. To better attach sound to the imagery, new spark sound effects were created in addition to the original sounds. These additional spark sounds were panned in isolation from the other pick sounds to create the illusion of sounds travelling through the screen into z-space. To aid spatial accuracy, the panning of sounds across the z-axis was created at half-speed slow-motion, synchronised with the picture. The divergence of these sounds was manipulated to follow the action; that is the sparks begin in the centre speaker, diverge to the left and right speakers before ultimately finishing in the surround speakers. This technique is similar to the creation of the blade swing in *Legend of The Guardians*, where the sound is separated to allow two individual pivot points. In *Foxed!,* the pick swing and impact are located on the screen plane, however the sparks pan into z-space along the z-axis into the surround speakers. This is explained in more detail in this section under the heading Panning Sound Effects (page 194).

Atmospheres that surround. On many contemporary films the atmosphere track is mixed to immerse an audience by emanating from all speakers in a 5.1 format. *Foxed!* did not have a highly detailed realistic atmosphere track, instead several tones were designed to create tension throughout the scenes. With little detail in the original source sounds, the atmosphere tracks were mixed to envelope the audience with subtle movement aimed at providing acoustic spatial cues that help depict the space represented onscreen. Particular attention was given to some of the water drips and cyclic whooshes that take place just before Emily arrives home.

Enveloping music. The dialogue, sound effects and atmospheres are all mixed to best represent their place within the 3-D acoustic space, as they appear in each scene. The objective was to spread the music, giving the impression that it is wider than all of the other sound elements, and thus not interfering with their spatial cues. Using Smalley's depiction of acoustic spaces, the music is situated in the panoramic space.[9] Through the use of a software up-mix plug-in, I was able to control the placement of the music within a

[9] Smalley, "Space-Form and the Acousmatic Image," 48.

3-D space. In addition to the up-mix plug-in, an independent reverb was applied to provide further spatial refinement of the music. The additional of reverb to aid spatial enhancement echoes Llewellyn's use of reverb on the Auro remix of *I, Frankenstein.*[10]

Foxed! (Binaural - 3-D remix)

Foxed! was never intended to have a binaural soundtrack release and as such, the supplied sound recordings were not in the binaural format. All supplied sounds were a combination of standard monophonic and stereo files. Although conventional for loudspeaker formats, the binaural format requires that sounds be recorded (encoded) using a specific binaural stereo recording configuration. The challenge was to create a binaural soundtrack from non-binaural encoded audio.

Re-recording every sound again in binaural was not an option. Instead, I manipulated the original recordings using computer software processing and a binaural plug-in. In some isolated instances, I re-recorded a few key sounds where absolutely necessary, including some of the original dialogue, using the custom-built binaural head microphone (Figure 54). The recordings were necessary as the binaural plug-in failed to reproduce some of the spatial positioning accurately within z-space.

Figure 54: Custom made binaural head using mannequin head, silicon ears and condenser microphones inside ear canals.

[10] Llewellyn, "I Frankenstein Auro Upmix," Personal email, April 24, 2014.

Creating the binaural mix required a complete remix from the original source files and also necessitated the wearing of headphones for the entire mixing process. A binaural mix must factor in all pan and spatial data necessary to resemble 3-D positioning of sound using only two channels. This posed many challenges including track routing, reverb usage, plug-in efficiencies and other restrictions. The binaural mix process was more labour intensive than the creation of the 5.1 version.

Creating 3-D dialogues for headphones. Having already panned the dialogues for the 5.1 version of *Foxed!*, the process was again repeated for the binaural headphone version. In cinema it is a relatively simple process to down-mix from 5.1 (or any other surround format) to a stereo version, as all of the tracks are 'folded down' – that is, the left, centre, right, surround and LFE tracks are folded down to create a single stereo mix. Although the headphone mix of this film is technically stereo, it is binaurally encoded and thus the fold down from 5.1 does not translate as the y and z-axes 3-D spatial information is lost. A stereo signal contains only the left and right information across the single x-axis; however stereo binaural is encoded with spatial information for all three axes.

The dialogues of *Foxed!* provided the greatest challenge for the binaural soundtrack. In addition to conveying the narrative, the dialogue was mixed to provide a spatially accurate relationship with the 3-D imagery. This is evident when the two foxes are looking for Emily (1 min 5 sec), when Emily hears the discussion between her mother and the fox that has replaced her (2 min 30 sec), and also during the opening of the film. During the opening, the audience is introduced to Emily through hearing her breaths. These were mixed spatially to mirror the localisation of the imagery. One of the greatest challenges is highlighted through the title sequence and again when the audience experiences Emily's point of view through vision and sound as she runs up the stairs (1 min. 34 sec.). Because the dialogue was originally recorded in Canada, there was no option but to use the original breaths, and artificially create the effect of the breaths coming from the viewer's point of view. A combination of mixing techniques, including reverberation manipulation and also a third party binaural plug-in, was used to create this illusion.[11] The use of binaural plug-ins is relatively new, as suggested by Gierlich. The H3-D spatializer plug- in used for *Foxed!* had some limitations, which necessitated that I incorporate additional reverb.

[11] H3-D Binaural Spatializer –v2.1.2 plugin by Longcat.

In studio applications new possibilities for mixing, filtering and post-processing binaurally recorded signals result. Whereas in the past only artificial head systems were available for binaural recording, the use of digital signal processing offers a wide range of recording and post-processing possibilities.[12]

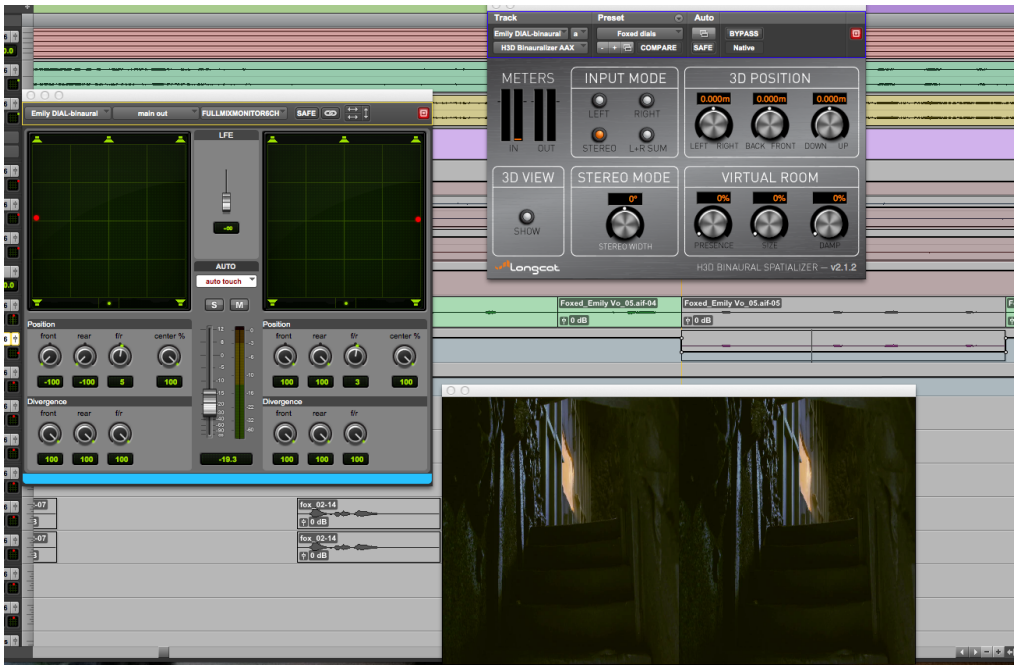


Figure 55: POV from Emily's perspective running up stairs in Foxed!

Figure 55 shows the positional data settings used with the H3-D binaural plug-in for Emily's dialogue as she runs up the stairs. The settings provide an effective method for creating an aural POV perspective, with the dialogue seeming to be coming from within the listener's head. The dialogue for this scene was duplicated onto two separate mono tracks. One track was reserved for the POV shots, and the other track for all other shots of Emily. This enabled the freedom to easily dedicate separate pan, reverb and binaural spatial settings independently of each track.

As Emily arrives at her home (1 min. 38 sec), she is separated from her mother by a glass window. From inside the house, her mother is unable to see or hear Emily as the glass is characteristic of a one-way mirror. The approach to this scene was to not only use sound localisation, but also to portray and replicate the acoustic spaces based on the image and

[12] Gierlich, "The Application of Binaural Technology," 241.

the narrative. The original dialogues from the film were re-recorded using a combination of convolution and binaural recording techniques with the dummy head microphone. Figure 56 below shows the binaural head in a room that is separated by glass doors from the speaker replaying the sound.

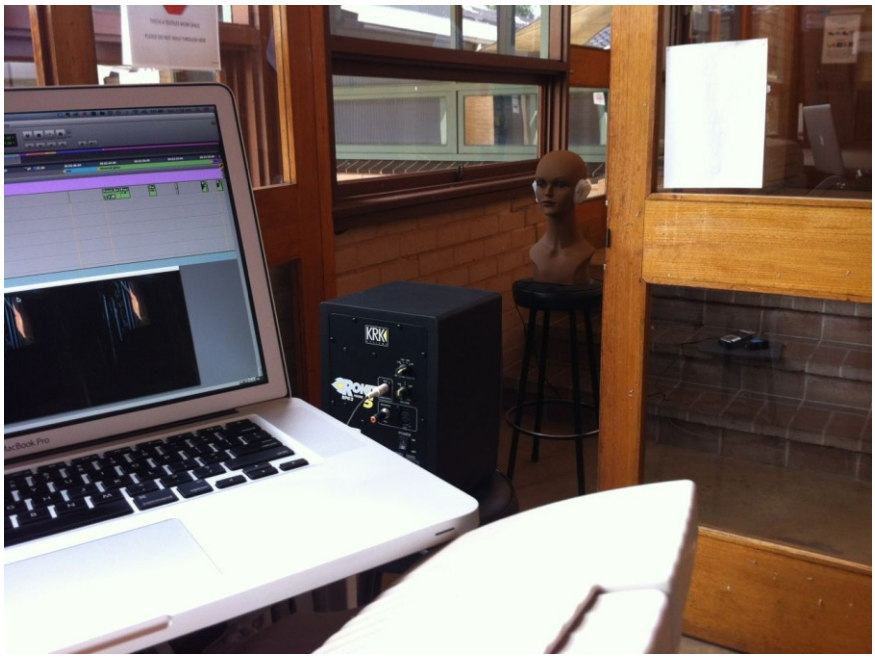


Figure 56: Convolution binaural recording of dialogue through glass – dummy head in distance

The convoluted dialogues for the mix include a combination of synthesised 3-D spatialisation and 3-D binaural recordings captured in a room resembling the acoustic space as prescribed by the visuals. Gierlich mentions that through binaural post-processing, sound engineers can play a creative role by inventing new sound situations above and beyond merely recording the original sound situation as authentically as possible.[13] This practice-led research demonstrated that processing beyond binaural post-processing was necessary. All of the spatialisation of Emily's dialogue during the opening scenes was synthesised using plug-ins; however once Emily arrives back at her home and is peering through the window, the dialogue is a binaurally recreated re-recording from the original film. Not having access to the original cast necessitated that I consider my available options in creating dialogue within the 3-D space. Using a combination of binaural synthesis and capturing the dialogue through the binaural head provided the required spatial results. Some obvious panning reconstructions can be heard when we are

[13] Ibid., 227.

in the POV shot running up the stairs as mentioned earlier (1 min. 35 sec.) and when Emily is peering through the window (2 min. 30 sec.).

Notably, the primary factor that enables the dialogues to be presented in a 3-D space is the labour intensive heavy manipulation of post-production effects. This includes the use of filtering, equalisation and reverb qualities, including spread and tonality. The table below (Figure 57) shows some of the processes used to recreate the dialogue in 3-D. The scene is at the end of the film when Emily arrives home (2 min. 22 sec.).

Character	**Dialogue**	**Sound spatialisation technique**
Mum	"Emily let's go. If you're late one more time Miss Patterson's going to give me detention."	Re-recorded dialogue POV through a glass window with some stereo spread.
Emily	"Mum"	Dialogue panned centre front mono
	"I'm right here mum"	Dialogue is in the centre with some stereo reverb spatialisation
	"Haven't you noticed me missing?"	This reverse shot has the tonal quality slightly adjusted to give distance and depth to the character.
Fox (as Emily)	"I'm ready to go mum."	Dialogue panned into the 'virtual right hand surrounds.'

Figure 57: Character dialogue when Emily arrives at her home, and the process used to achieve spatialisation.

Panning sound effects. The original supplied monophonic sound effects posed challenges when placed within a 3-D space. In traditional 5.1 mixing this is overcome through panning a mono sound to the various individual speakers. In stereo, sounds can be panned to either the left or right side; however binaural requires further attention. This may include panning multiple elements of a particular sound in addition to using multiple binaural plug-ins to create the illusion of a sound moving across the three axes. The table below (Figure 58) is a summary of the workflow, working methods and techniques used to place the sound effects within a 3-D space.

Swinging of the pick and impacts	With the action in the front of screen for three of the four swings and impacts, the sounds

	were panned across the front speakers to match the image, the exception being the sparks that fly towards camera and a reverse shot with Emily behind us. To achieve the sparks flying towards camera, I replicated the 5.1 mix using the binaural plug-in. This meant that a great deal of time was spent automating the spread of the sound, the amount and type of reverb used, and additional equalisation applied to both the original sound and the reverb itself.
Running up stairs	After trialling the binaural plug-in and countless other experimentations for the POV of Emily running up the stairs, I ultimately recorded my own feet running up stairs. For this I used an in-ear binaural microphone setup whilst I performed the running – akin to traditional foley. The original breaths remain and are panned using the binaural plug-in.
Clock	As Emily ascends to the top of the stairs the faint sound of a clock ticking in the distance can be heard. This locates Emily close to home. As we don't see the clock, pitch and delay were used to place the clock in the distance behind us.
Hands on window	Emily slaps the window of her home with a couple of small squeaks when her verbal efforts to communicate with her mother prove fruitless. The hand slaps were recorded using actual glass, with the binaural head placed at an approximate position to where the camera was situated.
Footsteps	At about 45 seconds we first hear one of the Fox's feet pan from slightly left of centre to centre to right to right surround. This was accomplished through plug-in panning,

	filtering and reverb manipulation. Emily's mother's feet were created using the same techniques, as she enters frame from behind us on the right hand side.

Figure 58: Sound effects and the spatialisation techniques used in the binaural mix.

Atmospheres that surround. The original sounds that were supplied contained only a few stereo atmosphere sound files. Creating the sense that the viewer is immersed within a 3-D volumetric space as seen on screen required a fine balance between realism and narrative. The original atmosphere sounds did not resemble the location ambiences; rather they provided a tonal mood for the scenes. The challenge was that these sounds had to represent the space. Prioritising the spatial accuracy of the dialogues and foley of the characters was the primary concern. All other elements were less important spatially. Only after being satisfied with dialogue, foley and sound effects could I situate the atmospheres. This is counter to contemporary film practices.

On a conventional film the atmospheres are often one of the first components to be mixed as they provide spatial cues to help bed the dialogues and foley. With this binaural version, the dialogues were mixed first and then the atmospheres as I was conscious of the atmospheric tones absorbing the spatial placement of the dialogues. Introducing additional sounds into the binaural format causes spatial information of existing sounds to be lost. This diminished the effectiveness of the 3-D spatialisation. There is heavy filtering and reverb on the atmospheres to keep the sounds distinct from the dialogue and to create the illusion that the tonal atmospheric sounds are generated from deep underground. The atmospheres were also split into mono sends that were panned through additional instances of the binaural plug-in. These split tracks were assigned to the four extremities of the x and y-axes (Figure 59, page 197). The exception to this is the water drips during the opening, as they are positioned on a wall behind us. I found that when increasing the volume of the atmospheres, the localisation and placement of the dialogue was absorbed, further reducing the 3-D effect back to monophonic.

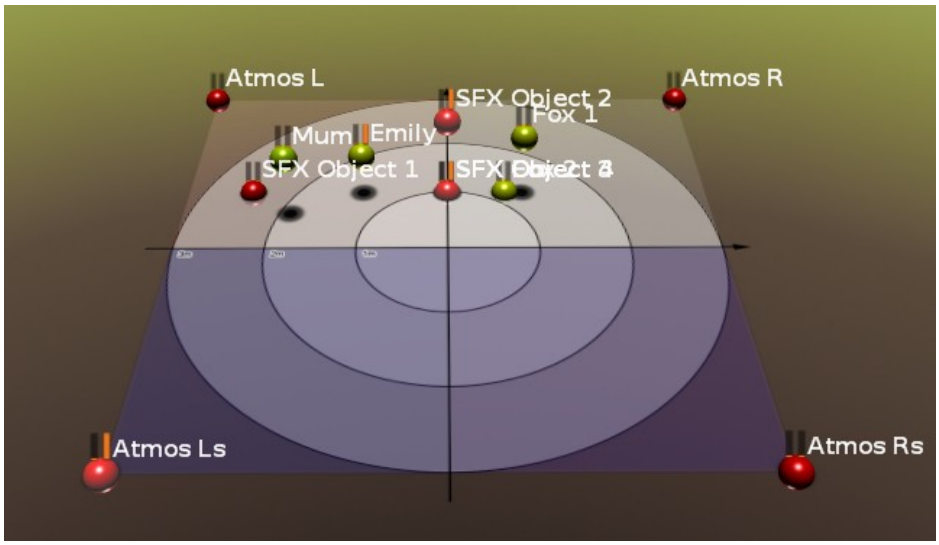


Figure 59: Image of all characters, objects and atmospheres

Enveloping music. Similar to the atmospheres, the non-diegetic music was panned wide to each side to avoid interfering with positional cues of the dialogue, foley and sound effects. The music was filtered, had additional reverberation applied, and was spatially sculpted to enhance the narrative. Although music mostly has reverb added to enhance the acoustic placement of instruments and voice within a song, *Foxed!* had additional reverb applied to support the narrative. By increasing the reverb on the music, spatial depth was increased allowing the dialogue and other sounds to be clearly defined in space. At all times, I was conscious about creating an aural soundscape that supported the narrative.

Comparison of 5.1 and binaural versions of Foxed!

Having set out to create various homogenous 3-D versions of *Foxed!*, it became apparent early in the mixing process that various challenges were arising. Using available technologies and mixing in both 5.1 and binaural formats, creating an audio soundtrack that was aurally and spatially representative of the 3-D imagery highlighted many considerations that are not necessarily applicable to 2-D film. In particular, this included using all three axes of a three-dimensional space. Although current technologies allow this to be achieved to some extent, filmmakers rarely push the use of the surround channels due to contemporary mixing practices. As noted by Kerins, 'most dialogue continues to reside in the front centre channel, and many filmmakers still have some reservations about using the surround channels too aggressively.'[14]

[14] Kerins, *Beyond Dolby (Stereo)*, 71.

The 5.1 and binaural formats each presented their own advantages and disadvantages. Having multiple speakers in a room allows sound to be easily panned between the front and rear of the room. However, to accomplish this in binaural (without having original binaural recordings) necessitates extensive mixing practices and third party software plug-ins. Unfortunately the plug-in that I used had many shortfalls. For example, when a sound was panned to either the front or the rear with distance applied, the volume dropped and the high frequencies were boosted. This is the opposite of reality, so to counteract this effect I compensated with additional equalisation and reverb.

The 5.1 format has limitations, including the inability to position a sound in the middle of the room, not just emanate from the speakers on the periphery. To some extent this is overcome during the POV shot of Emily running up the stairs. However, compared to the binaural version, it is noticeably inferior. A strength of the binaural format is the ability to place sounds as if they are inside the listener's head. The downside is that creating sounds to be in the distance, in front or behind you, is more difficult with binaural. Distance can be achieved, but having to pan and provide many additional processes is much more labour intensive than mixing in 5.1. An example with 5.1 is assigning dialogue to the centre channel; by adding reverb it can appear to be in the distance. However, using the binaural plug-in, the dialogue was panned along the z-axis with several additional parameters adjusted to give it proximity. To compensate for the shortcomings in sound quality, additional reverb and filtering were also needed.

In 5.1, reverb can be applied to provide a believable representation of a space. This represents our real world situation, as reverb is the reflection of sound in the space around us. In binaural, reverb doesn't create the sound of the space as such, instead it applies space to an object or character. Therefore, with every pan movement, the reverb changes relative to the object or the character. If the original source recordings are in binaural then this is less of an issue since the recording contains the location reverb within the recording (this is unless the binaural recording has inappropriate reverb). This only becomes problematic if the recording needs to have the acoustic space amended, or if the sound needs to be repositioned.

Binaural recordings versus binaural plug-ins

The binaural mix of *Foxed!* contained a combination of binaural re-recordings of the original dialogue as well as the use of a binaural plug-in. The plug-in was applied to all sound effects, music and atmospheres. The plug-in was also applied to the dialogue tracks

up until Emily reaches her house (1 min. 38 sec.), with the re-recorded dialogue used beyond this. The re-recorded dialogue provided many benefits compared to using the binaural plug-in to achieve convincing results. Utilising a suitable room space replicated the onscreen space, and the re-recordings provided adequate acoustic characteristics. By positioning the binaural head to match the shot on screen, sound and space characteristics were able to be captured. Although effective, using the plug-in was considerably more labour intensive as it was limited in its replication of situating a sound within a 3-D space. The plug-in coloured the sound quality, and thus every sound that was positioned needed to be corrected to achieve the intended tonal qualities.

Foxed! **Conclusion**

Foxed! was remixed in 5.1 and in binaural formats in order to investigate the effectiveness of creating a more immersive mix; of creating sound that homogenously matches the 3-D imagery within z-space; and of situating the audience within the first person perspective of POV shots. Although providing different results, each remix offered a more immersive mix than the original version.

The binaural remix provides a more homogenous audio-visual experience than the 5.1 version, as sounds could be situated with more accuracy along the z-axis. Although certain elements did work in the 5.1 version, including the sparks and the POV shot, these were not as effective as the binaural version which provided a more immersive and more homogenous experience with the 3-D visuals. There was not a single solution in providing an effective binaural mix. Plug-in processing and additional re-recording were needed on various shots and this added to the complexity of the mix. This complexity also meant that the binaural mix required far more time to create than the 5.1 mix. Having sounds placed behind the listener was more effective with the 5.1 remix.

The limitations of the investigation included working with pre-recorded sounds and not having the original sounds recorded in the binaural format.

Legend of The Guardians: The Owls of Ga'Hoole (remix)

The original theatrical mix of *Legend of the Guardians* took place in Sydney during 2010. Most of the pre-mixing was performed at Big Bang Sound, Rosebery and the final mix was created at Deluxe StageOne Sound, Lane Cove. On 25 April 2014, after a year of seeking permission from Warner Bros., consent was granted to use three x 1 minute scenes for the purpose of this PhD research.

To help identify the panning within the headphone and 5.1 versions of *Legend of the Guardians*, I have included additional versions of each mix minus the music on the accompanying Blu-Ray/DVD. These are located under the 'Additional Clips' menu.

Aim

In creating many of the original sound effects for *Legend of the Guardians* as discussed in Chapter 4 (page 107), I was bound to work within the confines of a typical Hollywood film production including working practices, sound editing practices, sound mixing practices, work flow practices and a tight timeframe. According to Supervising Sound Editor Wayne Pashley, panning helped bring the sound off the screen during the premixing process, but after listening in the cinema the panning was reverted to a traditional mix.[15] Although the final mix of the film is very wide and utilises the entire 5.1 surround spectrum, the film follows contemporary mixing practices, with dialogue and foley dominant in the centre channel.

In this practice-led research I aim to remix three scenes in the 5.1 and binaural formats that are more homogenous with the 3-D imagery, compared to the original theatrical release. I also aim to compare the homogeneity of the 5.1 remix with the binaural remix.

Method

Three scenes were selected that present some of the most challenging sound design through the use of negative and positive parallax. Taken from the Blu-ray edition of the film, they have been labeled as below.

- Fleck Field (20 min. 10 sec.)
- It's a Trap (68 min. 55 sec.)
- Legendary Lyze of Kiel (79 min.)

The remixes utilise the original theatrical release premix stems and have been repanned to match the onscreen action. The 5.1 remix uses contemporary industry standard software, with the panning of the sound elements created using a combination of third party plug-ins and the inbuilt panning tool within Avid Pro Tools. Challenging the notion

[15] Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia., 1.

of replaying film sound through speakers, the three scenes have additionally been remixed using Auro-Headphone, an immersive headphone technology. The plug-in is placed as an insert onto each audio track within the audio software and allows the user to place sounds within a 360˚ sphere. All panning is dictated by the 3-D onscreen visuals as opposed to the narrative, and the convention of having dialogue exclusively in the centre speaker channel has been ignored.

Similar to the headphone remix of *Foxed!*, the headphone mix of *Legend of the Guardians* required a completely separate remix to the 5.1 version.

Results and discussion:

The following section provides a breakdown on the process for creating the 5.1 and binaural remixes for each of the three scenes. In particular it discusses the use of panning across the dialogues, sound effects and other elements. A brief comparison is also made on the use of the Auro-Headphone plug-in for each scene. Due to some of the results for each scene suggesting that some of the low frequencies are lost through the use of headphones, there is additional discussion on the use of a dedicated LFE speaker in combination with the binaural format.

Fleck field

Figure 60: *Legend of the Guardians* Fleck Field

Dialogue. The original theatrical mix has the dialogue placed in the centre channel. The remix has the dialogue panned following the onscreen action. To enable proximity effects, the IOSONO Anymix plug-in was used to control all panning of the dialogues for this scene.

(IOSONO was acquired by Barco Auro in 2014). The panning included repositioning the breaths of Soren and the bat screeches only, as there is limited dialogue in this scene. To attach the breaths to the 3-D visuals of Soren, all pan movements were created at half-speed. This allowed for greater accuracy than in real-time. The bat screech was also pulled out of the front speakers and slightly into the surrounds to help bond with the imagery in z-space. The positioning of the dialogue is consistent between the 5.1 mix and the headphone mix. The IOSONO plug-in panning positional data of the dialogue for this scene was duplicated for the foley.

Sound effects. Mixing the sound effects provided a challenge as they were restricted to the single original 5.1 sfx stem. The original theatrical mix was created quite wide, and all speaker channels were used for the sound of the Fleck Field. The initial Fleck Field zap however originates from behind the audience. For the 5.1 and headphone remix, the centre channel was repanned to enable the zap to originate from the surround right channel before panning to the centre channel. The music element of the scene remains unchanged from the original release.

Headphone remix. Remixing for the headphone format provided additional possibilities to the 5.1 mix. An advantage of the Auro-Headphone format is the ability to pan along the y-axis, enabling the positioning of sounds with height information. Height panning was applied at the beginning of the scene for the bat descending and again for the flight of the second bat that gets called in to take the flecks away.

It's a Trap

Figure 61: ***Legend of the Guardians*** **It's a Trap**

Dialogues. The centre channel was used almost exclusively in the original mix. The remix required considerable repanning to match the action within the images. The IOSONO plug-in was not used for this scene (as with The Fleck Field scene above), as proximity along the z-axis was not needed. All panning was applied directly from the Pro Tools software panner. The panning positional data of the dialogue for this scene was duplicated for the foley.

Sound effects.

Similar to the dialogues, the majority of panning required the repositioning of sounds from the original centre channel. Panning was applied along the z-axis to bring the sounds off the screen to match the use of negative parallax in the images. The music element of the scene remains unchanged from the original release.

Headphone remix. The Auro-Headphone plug-in worked effectively for this scene. In particular the sound effects immerse the listener with sound emanating from all around. The lids of the Fleck pots opening and the Fleck Field in the last twenty seconds of the scene highlight this. The blade swings in this clip are significant to this research. The headphone mix provides a superior homogenous connection between the 3-D image and sound compared to the 5.1 versions. The flexibility of the Auro-Headphone plug-in allows the sound to be situated anywhere within a 360˚ radius, and this eliminates the dislocation that occurs with both the original and remixed 5.1 versions.

Legendary Lyze of Kiel

Figure 62: ***Legend of the Guardians*** **Legendary Lyze of Kiel**

Dialogues. Differing from the first two scenes, this scene has all dialogues situated in all three front screen speakers in the original mix. Although this works well, each track of the dialogue stem was individually re-panned to further enhance homogeneity. The scene is intercut with the characters often walking out of view behind the spectator, and this was replicated through panning the dialogue into the surround speakers for the 5.1 remix, and behind the listener in the Auro-Headphone remix. To aid dialogue placement along the z-axis, the LFE (Low Frequency Effects) was omitted from the antagonist Metal Beak on the long shots. Traditionally the LFE is not commonly used for dialogue, with the exception being monsters, menacing creatures and so on. In the original theatrical mix, Metal Beak has LFE applied, as he is a menacing character who wears a metal faceplate. Although the LFE is effective in portraying his character, on the long shots the LFE dislocates the distance perspectives of the character as he sounds closer than he appears onscreen.

Sound effects. Similar to the dialogues, the majority of panning was involved in repositioning the original centre channel. The panning was adjusted to create further width in the sound effects. The foley was also extensively panned to make greater use of the surround speakers in 5.1 and from behind the listener in the headphone mix.

Headphone remix. Similar to the previous scene (*It's a Trap*), the Auro-Headphone plug-in worked effectively in allowing sounds to be placed anywhere within a 360˚ space. This scene has owls with a lot of height detail in the imagery, so y-axis panning was applied to the headphone mix. This can be heard when the owls are fighting on the flag/banner. Of note is the superior cohesion of the imagery and sound of the claws. This includes the walking, but more impressively, when Metal Beak strikes using his claws during the fight.

Legend of the Guardians: The Owls of Ga'Hoole conclusion

Whilst mixing in 5.1 is effective for 2-D films, it has shortcomings when used for 3-D film, as discussed throughout this thesis. Although the original release of *Legend of the Guardians* was mixed to a very high quality and very wide, making full use of the 5.1 format, it consistently highlights some of the shortcomings of the 5.1 format with 3-D films. Creating the remixes to prioritise homogeneity with the 3-D visuals was difficult. Despite breaking Hollywood conventions by panning the dialogue and foley, the 5.1 format reinforced the fact that panning alone cannot overcome these limitations. The 5.1 remixes provide a more homogenous audio-visual experience than the original theatrical release, albeit minimally, despite panning in minute detail which requires extensive time. The difference is only marginal as positioning sound accurately within z-space is almost impossible.

The Auro-Headphone remixes allowed for the acoustic environment to be controlled with far greater accuracy than the 5.1 speaker mix. This is obvious with the action shots of each scene, and when y-axis panning is implemented. The headphone versions allowed the sounds to be more homogenous with the 3-D image compared to the 5.1 mix when in the z-space. Using my interpretation of Smalley's space zones (Figure 14, page 87), the closer a sound gets to the 'circumspace,' the more homogenous it is with the image in the binaural format. However, the use of binaural and headphones means that the LFE track and the sound pressure of the subwoofer are omitted. During the *Lyze of Kiel* scene, the binaural remixes struggled to represent sound behind the listener whereas the 5.1 remix represented sound behind the listener exceptionally well.

A computer generated animation, *Legend of the Guardians* has a distinct advantage over *Carwash* and *Foxed!*. The animation software relies on xyz coordinates for the positioning of the characters and objects within the scene. There will be many advantages in having this data exported and incorporated into the production workflow. I propose that the animation software renders the xyz positional coordinates as metadata so that they can be imported or linked within the audio software and linked to individual sound files or tracks. This will provide a valuable time saving tool for future 3-D sound mixing for screen. It will also increase the accuracy of positional data, as at present all panning is completed by ear and eye. Currently no workflow exists as contemporary audio technology is incapable of importing positional data, or having sounds attached to data in a non-linear manner. However as stated in Gaming and Virtual Reality (Chapter 5, page 169), this is an area where the film industry can learn from the games industry. Game sound engines use positional data to trigger sounds, and execute pan positional data based on what is happening on screen, in real-time.

Adding LFE to a binaural mix

The three films used for the practice-led research in this chapter highlight the noticeable absence of the LFE channel and subwoofer when creating the binaural remixes. Although headphones are capable of reproducing bass frequencies, there is no haptic sensation as described in Chapter 2. As Altman explains, 'the subwoofer's floor-shaking capacity offers

the possibility of representing cinema as a more participatory event.'[16] This notion of participation provoked further investigation into the combination of a dedicated LFE track with the binaural headphone remixes.

Aim

To investigate the effectiveness of having a dedicated LFE track played through a subwoofer speaker in addition to a binaural mix through headphones.

Methodology

Stereo binaural remixes for the following films were imported into the audio software Pro Tools:

- *Carwash*
- *Foxed!*
- *Legend of The Guardians*

The LFE track from the 5.1 was imported on a separate track remix (Figure 63). The 5.1 remix LFE track was specifically used as it was created for the frequency response range of the subwoofer. Both the binaural and LFE tracks were synchronised.

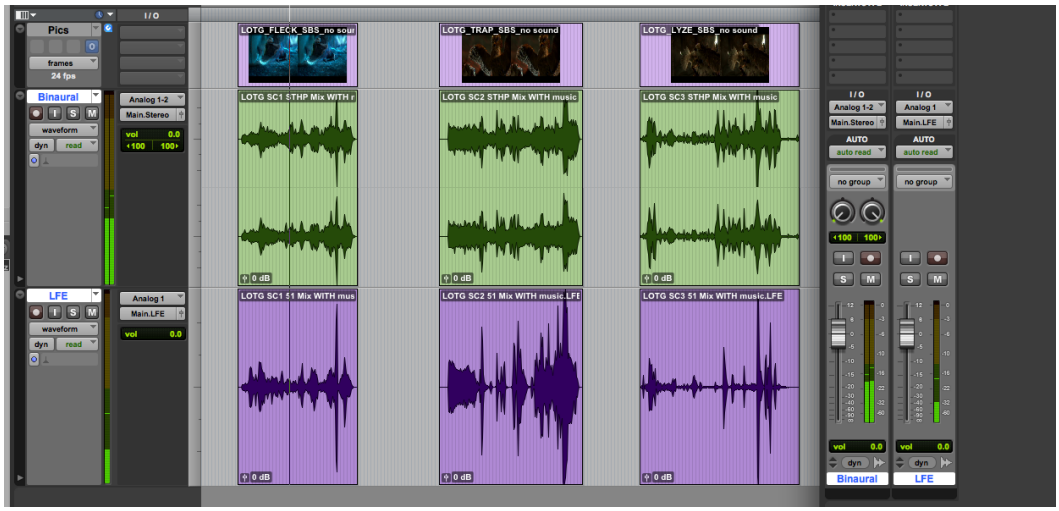


Figure 63: Binaural mix with additional LFE

It should be noted that in order to replay a binaural headphone mix with an additional dedicated LFE track through a speaker requires customising the standard configuration of

[16] Altman, "The Sound of Sound.," 68.

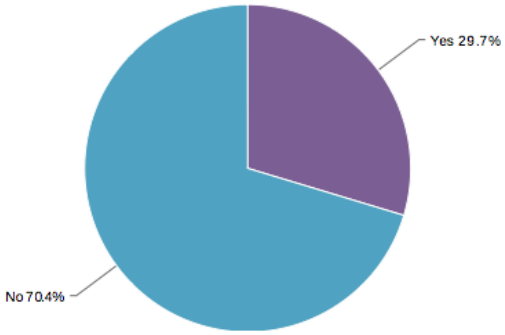
most domestic equipment including home cinemas. The addition of an LFE track to a binaural mix necessitates that three tracks are needed to contain the audio signals. To achieve the desired audio track routing a professional audio interface was used. The two channels containing the binaural mix were routed directly to headphones whilst the third track containing the LFE was routed to a subwoofer.

Results and discussion:

The use of the LFE track through a subwoofer, in addition to the binaural mix through headphones, provided an enriched sonic experience compared to the original headphone-only mixes. The bass frequencies were drastically extended and this enabled an increased immersive experience. The films *Carwash* and *Foxed!* highlight this immersive experience as the low frequencies within the atmospheric sounds, better situate the listener. The atmospheres in the *Fleck Field* also provided an enhanced immersive experience.

Although the LFE track is only used for specific moments in a film, when it is used, the listener hears and feels the action on screen. In the three excerpts of *Legend of The Guardians* the addition of the LFE track highlights much of the action. This includes the specific zaps within the *Fleck Field* and also in the other scenes where there is conflict between the characters. In these instances, the impacts of the characters' physical blows can be felt.

During the online survey used for this thesis, it was asked if it would bother participants to have speakers within the arms of 3-D glasses; 70% of participants said no (Figure 64, page 208). This suggests that headphones may be a consideration for future film exhibition, even if used in a hybridised situation with an LFE track.



Yes	29.7%		59
No	70.4%		140
		Total	199

Figure 64: Would it bother participants to have speakers within the arms of 3-D glasses

Binaural and LFE conclusion

This particular investigation resulted from the notable absence of the LFE track and subwoofer whilst listening to the binaural remixes of the films. By including an additional dedicated LFE subwoofer track to a binaural mix, the listening experience is greatly enhanced. However, the addition of the LFE track increases the binaural format from a two-channel stereo configuration to a three-channel configuration. This is not common in the domestic market or with portable music listening devices.

Creative practice conclusion

Through practice-led research I challenged contemporary feature film mixing practices and methodologies. This approach allowed an investigation into creating a more immersive, realistic and homogenous 3-D audio-visual experience without the restrictions of commercial film practices. The remixes exploited the opportunity to pan all elements within the soundtrack, including dialogue and foley. All three films were remixed in the 5.1 format, in the binaural headphone format and a hybrid format that includes the binaural mix with an additional LFE track.

Remixing each film in the 5.1 format demonstrated that although a more homogenous soundtrack can be obtained compared to the original releases by panning all sound elements including dialogue, the format has positional rendering limitations with sounds situated within z-space. This is a limitation on the use of speakers and is consistent with

observations made in Chapter 4. Using my interpretation of Smalley's space zones from Chapter 3, as sounds move from 'panoramic space' to 'circumspace' the definition in the sounds' positional rendering is lost. Sounds that are located in the 'panoramic space' have convincing acoustic depth in the 5.1 format, with the atmospheres from all clips providing examples of this.[17] If a sound pans quickly through these spaces, the 5.1 format can also be effective in providing homogeneity. The panning of sounds from panoramic in front of the listener to circumspace and then through panoramic behind the listener, is also effective in providing the illusion of sounds passing through these spaces, with *Foxed!* providing several examples. This includes the sparks at the beginning of the film and also Emily running during the opening title card. In very specific cases, the 5.1 format can work effectively in providing homogeneity for the entire soundtrack, not just individual elements, if a film is created without z-space action or dialogue, and therefore no sound in the circumspace as with *Carwash*. This takes advantage of the cocoon effect of speaker formats.

Creating the various headphone remixes required extensive individual attention. *Carwash* was an original film that allowed the sound to be recorded specifically for the 3-D medium, *Foxed!* contained an original soundtrack that needed a considered approach to each particular shot, whereas *Legend of the Guardians* was remixed exclusively using the Auro-Headphone binaural plug-in. Headphone technologies allow for improved homogeneity with sounds located within the 'circumspace' and for POV shots, as demonstrated in all mixes. However creating the headphones mixes was time consuming, with no single technique providing a simple solution. The use of binaural plug-ins was not effective in all instances, with additional binaural re-recordings required for *Foxed!*. Preparing early in the production stages, and accommodating binaural technologies throughout the recording process, is of benefit as demonstrated through *Carwash*.

Overall the headphone mixes, and in particular the Auro-Headphone mixes, provided a homogenous and spatially accurate relationship with z-space 3-D imagery compared to the 5.1 remixes and the original theatrical releases. This became increasingly apparent as sounds moved closer to the 'circumspace' as in Figure 65 (page 210). The 5.1 format was more effective in the positioning of sounds behind the listener compared to all binaural

[17] Smalley, "Space-Form and the Acousmatic Image," 48.

remixes. Contemporary speaker formats provide superior bass reproduction that enables the listener to physically feel a sound as discussed in Chapter 2. As investigated, combining an LFE track with a binaural mix is effective. A binaural format with a dedicated LFE channel however is impractical due to it requiring three channels.

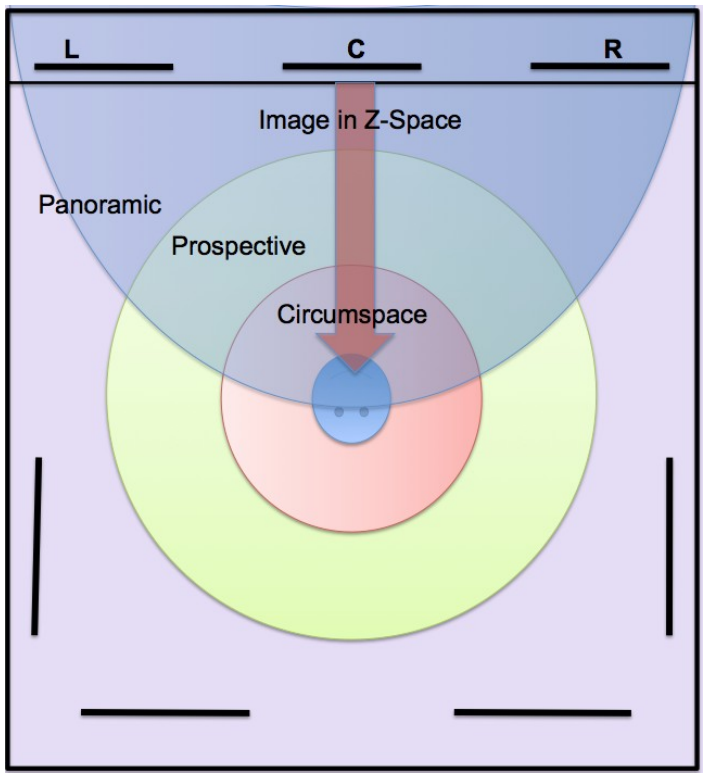


Figure 65: Z-Space imagery with space zones

Through this practice-led research it became apparent that the accurate positioning of sound in any format is time consuming, as every sound needs to be positioned across all three axes and in some instances with automated movement. This highlights that it is often difficult to accurately provide positional data and have accurate positional rendering within z-space in the 5.1 and binaural formats.

Chapter 7: Conclusion

Introduction

This thesis set out to investigate the relationship between the stereoscopic image and the soundtrack for 3-D digital films. Previously there has been minimal research that exists specifically in the area of sound for 3-D films, reflecting the cutting edge nature of the line of enquiry in this thesis. This conclusion outlines and summarises the key findings from the research leading to the argument that there is a dislocation between the soundtrack and imagery of digital 3-D films.

Although the original intention was to take the form of a traditional research and written thesis approach, it became necessary to include a practice-led investigation. The following methodologies were used to provide a substantial foundation to the research:

- Interviews with key international industry leaders.
- An online survey of approximately 200 participants.
- Case studies on digital 3-D film releases in contemporary surround sound and immersive sound formats.
- Practice-led research investigating the creation and recreation of sound for 3-D films using various speaker and headphone formats.
- Traditional research methodologies.

Confronted with several first-hand challenges whilst working on internationally released 3-D films, this research set out to investigate the most effective method of producing and delivering a soundtrack that is homogenous with the 3-D image. Diverse methodological approaches were necessary in investigating the following questions identified in Chapter 1:

- Does a language exist to describe spatial sound design in 3-D cinema?
- Does the contemporary soundtrack suit 3-D films?
- Has sound technology used in 2-D film changed with the introduction of 3-D film? If it has, is this technology an ideal solution, or are further technical developments needed to allow greater creativity and cohesiveness of 3-D film sound design?

- How might industry practices need to develop in order to accommodate the increased dimension and image depth of 3-D visuals?
- What is the audience awareness of emerging film technologies? Does this influence the future of film and/or the cinema?

Key findings

This section identifies the key findings from the research in response to the above questions.

Does a language exist to describe spatial sound design in 3-D cinema?

There is limited language to describe spatial sound design within 3-D cinema. This includes the inability to describe specific sounds as noted by Rosenbaum, and the inability to describe the spatial positioning of sounds.[1] Throughout this thesis I have had to repurpose language from music to help identify the location of sound within space, including Smalleys' space definitions for the positioning of sound relative to the listener.[2] To describe an absolute localisation within the acoustic cinema space I have had to borrow terms from the 3-D visual discipline including: z-space, parallax and the xyz axes format. Establishing a language is difficult with industry divided over what defines '3-D sound.' This is compounded as '3-D sound' and 'sound for 3-D' are not one and the same. There is clearly confusion within industry of definitions.

Industry leaders including Andy Nelson, Randy Thom and Gwen Whittle argue that sound has been 3-D for the past 50 years since the introduction of surround sound, and it is only now that the image has finally caught up.[3] However, the survey conducted for this thesis suggested that only 9% of people think that surround sound is the same as 3-D sound (Figure 11, page 75). Brian Slack, Senior Vice President of studio technologies for IOSONO says that multi speaker 5.1 and 7.1 systems do not, technically speaking, deliver real 3-D

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[1] Rosenbaum, "Sound Thinking," 38.
[2] Smalley, "Space-Form and the Acousmatic Image," 48.
[3] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA, 2.
Thom, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 2.
Whittle, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 2.

audio, instead they provide six points in a room, and the occasional illusion of 3-D.[4] I argue that surround sound provides an additional dimension to the film experience through the use of surround speakers and the LFE track, but I disagree that surround sound (5.1 and 7.1) is 3-D sound. The question also relates to the format of the film. For a 2-D film, surround sound adds another dimension to the film as sounds are projected from the side and behind the audience. This also follows Altman's view that sound can only be 3-D since sound is always recorded in a particular three-dimensional space.[5] However the dislocations that occur with 3-D films suggest that surround sound is not truly 3-D as sound can't always be positioned accurately within z-space.

The question of what defines 3-D sound has been raised again in industry recently with the introduction of immersive sound formats in 2012. The addition of height speakers has technology vendors marketing their respective formats as providing true 3-D sound.[6] New immersive technologies provide the ability to pan sounds across all xyz axes (Figure 1, page xiii). The addition of height channels provides an additional dimension to immersive formats beyond the horizontal plane of traditional surround sound formats. During this research I introduced the term 'positional data' to describe the 3-D spatial positioning a sound is given during the editing and mixing stage of production (input). I also introduced the term 'positional rendering' to describe the position of a sound when it is exhibited (output). The case studies and practice-led research proved that although 3-D pan positional data can be applied to a sound in the editing and mixing phase of production, when played back, positional rendering is not replicated accurately in the z-space.

Does the contemporary soundtrack suit 3-D films?

The contemporary soundtrack has changed over the course of this research. At the time of commencement in August 2011, Dolby Digital 5.1 was the most prominent cinema surround sound format with only select films having Dolby Surround 7.1 releases. Dolby Surround 7.1 was superseded in 2012 with the introduction of the immersive Dolby Atmos sound format, two years after its introduction. In the same year the Auro 3-D immersive sound format was also introduced.

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[4] Jackson, "Sound and the Fury," 18.
[5] Altman, *Sound Theory, Sound Practice*, 5.
[6] Film Journal International, "The Theatre of the Future," *Film Journal International* 115, no. 6 (June 2012): 3.

The case studies demonstrated that although 5.1 allows sound to envelop the viewer, it is difficult to place a sound accurately within z-space, especially within the 'circumspace' around the listener.[7] This dislocation is only a noticeable concern with 3-D films. All films included in the case study and in the practice-led research components of this thesis demonstrated this problem consistently, with the dialogue and foley the most affected soundtrack components. Consistently, interviews with industry experts stated in this thesis that 5.1 has limitations in being able to support 3-D imagery. Following requests by directors to bring sound into the room similarly to the visuals, Wil Files states 'it's very, very difficult to bring anything into the room, and that's the thing that we often get asked.'[8] Thierry Barbier, 3-D producer at AmaK Studio has observed through his experience 'that a 3-D movie sound mix is more of a quadriphonic mix, with emphasis on front-to-back effects, rather than a surround mix with stereophonic voices and ambience effects.'[9]

Observations between the Dolby Atmos and Auro 3-D formats highlighted the shortcomings of positioning sound within z-space and the listener's 'circumspace.' However the detail in the positional rendering was superior compared to the 5.1 and 7.1 formats due to an increase in audio channels and speakers. The full range increased frequency response of the speakers and increased channels improved the pan resolution of the immersive formats. Despite having greater pan resolution (including the height channels), the immersive formats all demonstrated a canopy or cocoon effect as discussed in Chapter 4. Figure 66 (page 215) illustrates this. The increased pan resolution of immersive sound formats can also lead to positional inaccuracies being highlighted. The panning of Bilbo's feet to the rear right surround speakers in *The Desolation of Smaug* and the voice over in *I, Frankenstein* demonstrated this as discussed in Chapter 4.

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[7] Smalley, "Space-Form and the Acousmatic Image," 48.
[8] Files, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 4.
[9] Mendiburu, *3D Movie Making Stereoscopic Digital Cinema From Script to Screen*, 156.

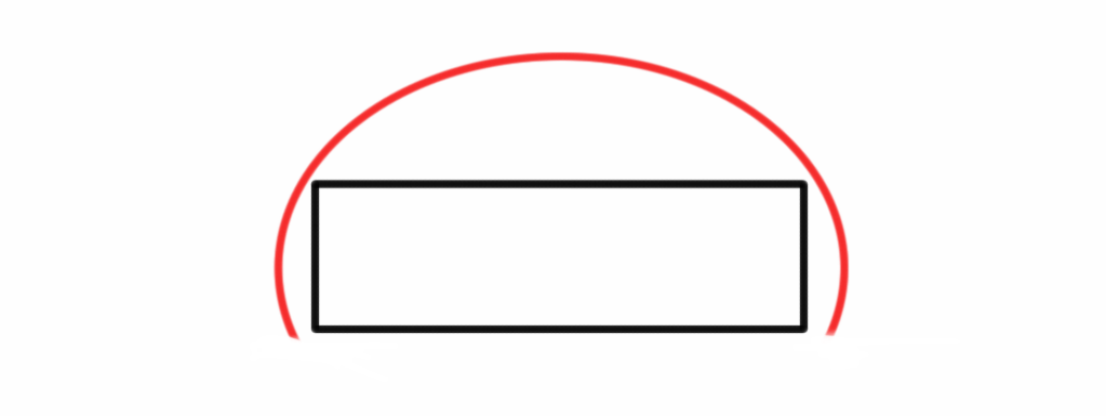

Figure 66: Canopy effect of current cinema immersive sound

As discussed in Chapter 6, the contemporary soundtrack can suit 3-D films, depending on the framing of the 3-D visuals. Although a 5.1 mix, *Carwash* successfully exploited the cocoon effect. The contemporary soundtrack suits 2-D films as surround sound enhances imagery on a 2-D plane. This is complicated with 3-D as the soundtrack not only adds to the experience, but in many instances it also has to support the imagery by bonding to onscreen visuals. David Farmer echoes the concern about contemporary speaker formats, implying that 'sound speakers that aren't customised to each listening position make 3-D sound from projection speakers currently near-impossible.'[10] Technology vendors also acknowledge the limitation of contemporary speaker formats with Auro stating that 'surround sound combined with overhead speakers alone cannot reproduce the full 3-D auditory experience.'[11] In many instances with imagery in z-space, contemporary sound formats fail to accurately match the position of the image.

Has sound technology used in 2-D film changed with the introduction of 3-D film? If it has, is this technology an ideal solution, or are further technical developments needed to allow greater creativity and cohesiveness of 3-D film sound design?

Since the introduction of digital 3-D films, there have been several advancements in sound technologies for cinema including Dolby Surround 7.1, Dolby Atmos and Auro 3-D. Although the first Auro 3-D release was Hemingway's 2-D film *Red Tails,* both Dolby technologies were launched with 3-D releases including *Toy Story 3* in 7.1 and *Brave* in Dolby Atmos. However as Andy Nelson and Ioan Allen state, these formats are not

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[10] Farmer, Personal Interview: 3-D Sound Discussion at Park Road Post, NZ.
[11] Brian Claypool, Wilfried Van Baelen, and Bert Van Daele, *Auro 11.1 Versus Object-Based Sound in 3D* (Technical report), 4.

exclusive to 3-D.[12,13] Unanimously all interviewed participants agreed that increasing speaker channels provided a better soundtrack, with many using the difference between 5.1 and 7.1 as an example. It should also be noted that many of the interviews took place before the commercial release of the Dolby Atmos and Auro 3-D sound formats in 2012. However since the release of *The Hobbit* films in Dolby Atmos, John Neill, Head of Sound at Park Road Post Production (owned by Peter Jackson), praises the advantages of immersive technologies. Neill states that 'Dolby Atmos, even when used as a 9.1 system, is far better than 7.1, the difference being greater than the leap from 5.1 to 7.1.'[14] The release of both Dolby Atmos and Auro 3-D has seen the marketing of these immersive formats pitch their respective products as providing 3-D sound. Although cinema sound technology has changed, it has not been a direct result of 3-D films specifically.

Contemporary surround sound formats including 5.1, 7.1 and immersive sound were not designed to specifically address the 3-D visual medium. Further development is needed to improve the homogeneity between the 3-D visuals and the soundtrack. The challenge lies in speaker format technologies overcoming the cocoon effect by providing accurate positional rendering of sound during exhibition. Since the introduction of immersive sound formats, software vendors have been releasing plug-in panner software that includes the addition of height parameters. Whilst enabling industry practitioners to input pan positional data, speaker formats are unable to replicate the positional rendering in the auditorium. Mixing practices and the placement of dialogue have remained relatively unchanged for many decades. Although technologies are improving the positional rendering of sound, industry practices also need to change to accommodate 3-D.

How might industry practices need to develop in order to accommodate the increased dimension and image depth of 3-D visuals?

The image depth of 3-D films challenges contemporary film sound practices. Working on the 3-D theatrical releases of *Legend of the Guardians: The Owls of Ga'Hoole, Happy Feet Two, The Great Gatsby* and *The LEGO Movie* allowed a first-hand investigation of industry practices. All films demonstrated similarities in regards to the post-production processes

[12] Nelson, Personal Interview: 3-D Sound Discussion. Head of Sound, Fox Studios Los Angeles, USA, 8.
[13] Fuchs, "Soundsational!," 7.
[14] Neill, Personal Interview: 3-D Sound Discussion. Head of Sound, Park Road Postproduction, NZ.

and their final release. A recurring concern was that the completed 3-D visuals were neither seen nor played synchronised to the soundtrack until the final mixing days or the final playouts of the film. With the entire sound production never compared with the 3-D imagery, it is not surprising that dislocation is prevalent. Without working to 3-D imagery, the detail and depth of the shots cannot be matched aurally. Sound design elements and the acoustic placement of sounds, especially along the z-axis, become too much of a risk without seeing the imagery. Mixers are cautious of the implications of misaligned sound in exhibition, continuing to work to traditional 2-D mixing practices. Keeping the dialogue in the centre channel is an example. Restrained panning results in the sounds remaining on the screen plane as opposed to complementing the 3-D imagery in z-space. The resulting dislocation reiterates Schafer's notion of 'schizophonia.'[15] The practice-led research in Chapter 6 demonstrated that by applying more panning to objects including dialogue and foley, the relationship between the soundtrack and the 3-D image can be improved. Rob Engle, with Sony Pictures Imageworks, backs up this notion stating that 'the typical use of the back channel mostly for ambient sound is out-dated. More of the voice tracks should make it to the surround channels to fill up the room space with the actors' lines, along with their images popping out of the screen.'[16] However additional panning comes at a cost, as more time is needed to place each sound and this ultimately will have monetary implications.

Approximately half of the interview participants stated that sound should not come off the screen, especially the dialogue. This contrasts with the remaining participants who believe that 3-D has created a dislocation between image and sound, and therefore sound should come off the screen. Will Files states that 'in general I think the aesthetic is going more and more towards, in Hollywood at least, bringing things into the room, bringing things off the screen - a lot of directors are wanting to put things in the audience's face and put the audience there with the characters.'[17] Erik Aadahl echoes this. As cited in *Exploring 3-D*, Aadahl explains that in 3-D your eye may be drawn to the foreground and you may wish to match it sonically.[18] Industry leading sound designers Files and Aadahl's statements

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[15] Schafer, *The New Soundscape : A Handbook for the Modern Music Teacher*, 34.
[16] Mendiburu, *3D Movie Making Stereoscopic Digital Cinema From Script to Screen*, 156.
[17] Files, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA., 2.
[18] Pennington and Giardina, *Exploring 3D*, 183.

suggest that there is a desire from practitioners to bring sound off the screen and into z-space, however this is risky due to technical limitations.

A recurring concern was raised throughout the interviews. Although a sound team may be aware that a film will be released in 3-D, it is often not until the final mixing stage that the 3-D imagery is seen, if at all. Wayne Pashley noted differences between mixing for *The Great Gatsby* and *The LEGO Movie.* During *The Great Gatsby* the sound team had access to 3-D imagery that they consistently referenced during the mixing process, but during *The LEGO Movie* the film was not seen in 3-D alongside the accompanying soundtrack until the completion of the mixing. This is not uncommon for many 3-D films. Brent Burge states that with 3D films, the problem is that there is no time to experiment with sound. He finds this disappointing as the only real time he sees his work with the 3-D images is after it is finished.[19]

As presented in Chapter 4, further communication with interview participants via personal email indicated that new immersive sound technologies are not considered early in the production process. In many instances, an upmix is created after the original 5.1 or 7.1 mix has been completed and these immersive mixes may be carried out by another studio using premixed stems from the original mix. This is concerning as highlighted with *I, Frankenstein* in Chapter 4. In this example, the sound crew had no knowledge that the film would be released in immersive sound formats. As a result the Dolby Atmos and Auro 3-D mixes provide very different sounding soundtracks, as they were upmixed separately in two different countries. Although the Auro 11.1 version was more immersive, with more object elements panned to the 3-D imagery than the Dolby Atmos version, this may be a result of limited time spent on each version. The introduction of immersive sound for 3-D films has the potential for introducing greater schizophonia if the balance between the spatialisation of the image and sound is not unified.

The panning of more elements including dialogue, made a noticeable improvement to the 3-D films used in the practice-led investigation. This achieved a more homogenous 3-D experience. *Carwash* was an exception. Despite being an original recording with no post-production panning applied, the film purposefully recreated a homogenous 3-D imagery

[19] Burge, "Personal Interview: 3-D Sound Email Questions With Brent Burge."

experience with both a 5.1 and binaural soundtrack as it takes advantage of the cocoon limitation of conventional surround speaker formats.

Foxed! and *Legend of the Guardians* demonstrated that through increased panning of soundtrack elements, the relationship with the z-space imagery is improved. These improvements are primarily effective with sounds that are moving from speaker to speaker as the illusion of movement can be created. The swinging of the pick in *Foxed!*, with sparks located independently, and the blade swing in *Legend of the Guardians* provided an illusion of sound travelling through the cinematic z-space. These required substantial planning and preparation, but they were achieved. The research in Chapter 6 also highlight the limitations of the 5.1 format. Although all clips were remixed in 5.1 with greater panning diversity and improved homogeneity than the original theatrical releases, the ability to place all sounds within the cinematic z-space remained challenging.

Although not always effective with speaker formats, the pan positional data can increase homogeneity when used in the binaural headphone format.[20] This is relevant to dedicated binaural recordings and the binaural plug-ins. The early investigation of the use of binaural for de Heer's 2-D *Bad Boy Bubby* (DVD), Derobe's 3-D *Souviens-moi,* and the practice-led research in Chapter 6 prove this. This use of binaural for 3-D POV shots provides exceptional homogeneity and immersion, closely resembling reality. However, the shortcoming with headphone mixes is the loss of the physical feeling from the LFE channel. Adding an additional LFE track to the binaural mix overcame this as discussed at the end of Chapter 6 (page 208).

To gain full benefit of superior sounding immersive soundtracks, the format must be considered early and incorporated into the entire sound production workflow. As suggested in the later sections of Chapter 4, if an immersive mix is not considered early on in the sound production process, I question its value. The films used for the case studies of this research had immersive sound mixes created after the final mix, and failed to capitalise on the technologies to the full extent.

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[20] Binaural is a 3-D sound format that uses pan positonal data to place the sound within the 3-D space similarly to surround formats.

What is the audience awareness of emerging film technologies? Does this influence the future of film and/or the cinema?

Through conducting an online survey and by interviewing cinema managers it became evident that the audience is unaware of contemporary and emerging film technologies. Generally, participants were satisfied with the sound of the cinema where they last saw a film, although 52% of the participants did not know what sound format the film was in. Manager of Reading Cinemas Waurn Ponds, David Lovell, states 'with sound they (cinema audience) really aren't too fussed.'[21] Audiences are mostly unaware of the intricacies of emerging film technologies, so if a film looks and sounds good, then the cinema audience is happy.

The lack of audience understanding of technologies is positive for cinema managers. Without the customers applying pressure, cinemas are in no hurry to upgrade. This may also have a ripple effect, as productions will not be pressured into delivering for emerging formats. For example, studios such as Warner Bros. have taken a cautious approach to releasing films in formats other than 5.1. Although an audience may not be aware of contemporary and emerging cinema technologies, Randy Thom argues that the story should be the focus of 3-D filmmaking, not the technology. Thom notes that his biggest concern regarding industry conversation about 3-D sound 'is that once again it is focusing on technology rather than art.'[22] This is echoed by Sound Designer Erik Aadahl who points out that going to the movies is about connecting with characters and 'on the most basic level you want to create an experience where the viewer is pulled into the moment and experiences everything that the character is experiencing.'[23] The cinema is one of America's favorite and cheapest pastimes, and although the theatre of the future may be physically different, 'as long as our great filmmakers keep making movies that are emotionally entertaining, audiences will flock to them.'[24]

The introduction of 3-D is now providing the audience with more visual detail, demanding more from the sound as noted by Sics.[25] With more objects in focus along the z-axis, visual

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[21] Lovell, Reading Cinema Waurn Ponds Dolby Atmos installation.
[22] Thom, Personal Interview: 3-D Sound Discussion at Skywalker Sound, Marin County USA.
[23] Pennington and Giardina, *Exploring 3D*, 183.
[24] Film Journal International, "The Theatre of the Future."
[25] Sics, Personal Interview: 3-D Sound The Great Gatsby Location Sound Recording, Australia.

objects are utilising more space with greater depth. Sound now needs to complement this with added detail; sounds need more depth through greater layering and texturing, as suggested by Pashley.[26] Pennington and Giardina advise that 'filmmakers must maintain focus and courage because such resistance can't be allowed to thwart the potential of a technology that enables a richer and more compelling motion picture art form.'[27] Technology is providing many new opportunities for contemporary filmmakers. The balance between technology, narrative and working methodologies determines the level of dislocation between the soundtrack and the 3-D imagery. Although a good narrative has the ability to suture the audience, technical abnormalities create dislocation between the audience and the film.

With an increase in personal device usage, over half of the survey participants reported that they regularly watch films on these consumer devices. Constantly watching and listening to inferior quality media may explain why the cinema audience is not questioning contemporary cinema sound for 3-D. Compared to their devices, the cinema provides a far superior immersive experience. The survey also showed that when it comes to the quality of the cinema technology, sound is prioritised over image, and this may explain why people accept watching films on inferior personal device screens. As discussed in Chapter 5, Dolby,[28] DTS,[29] Auro[30] and the BBC[31] are currently researching and releasing headphone solutions for spatial sound. Headphone 3-D sound is a serious industry consideration with the Audio Engineering Society publishing the AES69-2015 binaural audio standard in March 2015.[32] Adapting this headphone technology for future 3-D film productions also needs to be a consideration.

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[26] Pashley, Personal Interview: 3-D Sound Discussion Big Bang Sound, Sydney Australia.
[27] Pennington and Giardina, *Exploring 3D*, 39.
[28] Dolby, "Dolby Headphone," accessed January 18, 2014, http://www.dolby.com//us/en/technologies/dolby-headphone.html.
[29] Geere, "Man of Steel Soundtrack Released with Headphone."
[30] Auro Technologies, "Auro-3D® Engine," *Auro-3D*, accessed January 16, 2014, http://www.auro-3d.com/system/.
[31] Nicholas Tufnell, "3D Sound Tests Carried out by BBC," *BBC News*, April 14, 2014, http://www.bbc.com/news/technology-26958946.
[32] AES Standards Committee, "AES69-2015 AES Standard for File Exchange - Spatial Acoustic Data File Format."

Challenges of the study

This study faced several challenges. With little research having already been conducted on 3-D film sound, and the technological ground shifting in the course of this thesis, much of the research relied on online industry updates and industry peers to provide insights into their work practices. Although many participants agreed to take part in personal interviews, many did not want the discussion to be on record. As the practice-led component of the film required the creation of various soundtracks, finding suitable film material and having permission to freely create these proved difficult. It took twelve months for Warner Bros. to approve the use of *Legend of the Guardians*. The continual change in cinema technologies during the research also created challenges. Examples include the release of HFR films, the commercial release of immersive technologies, and most recently, the AES binaural sound standard.

The scope of the research topic necessitated many approaches including a practice-led investigation. The three practice-led films all showed up common concerns with sound production for 3-D. *Foxed!* proved to be the most challenging as it required many approaches to create a single successful binaural headphone mix. This included using original recordings of characters, re-recording lines of dialogue using a binaural head in an acoustically matched space, and also using a binaural plug-in. *Carwash* was the most streamlined in production as it was originally conceived to be filmed and recorded in 3-D.

Discussion on the usefulness of the theoretical framework and how to proceed

As Schön identifies, 'professional practice has at least as much to do with finding the problem as with solving the problem found; it is true that problem setting is a recognised professional activity.'[33] Although no conclusive single solution has been identified in this thesis, it has identified problems in the creation and exhibition of a soundtrack for 3-D film. The problems can be broken down to the following two attributes - positional data, and the positional rendering on playback. Terms coined by the author during the investigation, they identify limitations in positioning a sound within a 3-D space during the editing and

[33] Schön, *The Reflective Practitioner*, 18.

mixing process (input), and the positioning of sound within a 3-D space during exhibition (output).

Technology vendors are creating many software plug-in panners that provide practitioners the ability to accurately apply positional data within a 3-D space. The gap lies in reproducing this using contemporary cinema speaker formats. As a result of my research I can now make 2 particular recommendations.

Positional data recommendation

I propose the following, especially in regards to animated films. In order to provide true 3-D positional panning, meta-data needs to be introduced early in the production process. It is necessary to rethink the way film and sound are created, edited and delivered so this meta-data can be distributed and used throughout the production process. Currently, the production process is linear, with no use of positional meta-data. Introducing a meta-data workflow will allow the process to be more collaborative, and allow for greater positional data accuracy. This needs to be implemented early in the production pipeline by the visual and animation departments, as already occurs in the games industry.

Positional rendering recommendation

Further research and development are required to provide a solution for accurate positional rendering using speakers. From accounts by interviewees who have heard the IOSONO technology, wave field synthesis may prove to be the future of cinema sound. With Barco acquiring IOSONO in 2014, this may indicate a change in future cinema sound technologies.

Conclusions

This research argues that there is a dislocation and lack of homogeneity between the soundtrack and imagery of digital 3-D films. Through various research methodologies the creative, practical and technological limitations of contemporary cinema sound were investigated. The study identified that spatial dislocation can exist between the visuals and the soundtrack for contemporary 3-D films as a result of two conditions:

- Unknown positional data (not knowing the placement of a sound during the production process)
- Inaccurate positional rendering when played back (inability to accurately position a sound when it is played back in an exhibition space)

My research shows that by increasing the pan resolution through immersive technologies, adding more speakers provides greater accuracy than previous 5.1 and 7.1 formats, however a cocoon effect is almost always inevitable with the addition of height speakers. Despite increasing speaker channels, it remains difficult to accurately place sounds within the z-space. An audience does not always notice the homogeneity improvements between the sound and 3-D vision through the use of immersive sound formats and this is holding back cinema managers from implementing upgrades. This is further complicated as Dolby Atmos, Auro 3-D and the MDA format compete to set an industry standard. Beyond contemporary speaker formats, the practice-led research identified that headphone technology is capable of producing a homogenous 3-D audio-visual experience. Although not generally used in a cinema context yet, spatial audio in headphones for gaming, personal devices and virtual reality may lead to a cinema cross-over in the future. The practice-led research also highlights that adding an LFE channel to a binaural headphone mix greatly improves the immersive and haptic experience of the soundtrack. 3-D films already require patrons to wear glasses; perhaps we can also consider including small speakers in the glasses' frame arms or the wearing of headphones.

One of the most interesting results of this thesis to me as an industry practitioner is that this field of research needs to be extended. Beyond this PhD I will continue research on the topic of 3-D film sound as this continues to grow as an area of discovery and debate. Ideally further research will provide possible solutions to a 3-D soundtrack that remains completely homogenous with the imagery. I will be taking various approaches to this, including further international partnerships with industry and collaborations with other academic researchers in 3-D sound. One of the solutions that I wish to pursue after completion of this PhD is a new approach to sound for animated 3-D films based on the use of meta-data and gaming technology as mentioned in Chapter 6. I am already in discussions with several commercial companies and currently investigating possible working models and financial viability for the integration of this new production solution into the film production pipeline. Through my research I have had international academic interest and collaboration requests for further joint research into 3-D sound for 3-D film. Specifically this includes Edinburgh Napier University and Hong Kong City University.

Over the coming years I foresee industry will be looking to overcome the cocoon effect that is currently experienced with immersive sound technologies. By Auro-Technologies acquiring IOSONO, perhaps this collaboration will make a breakthrough. I also believe that we will be witnessing more headphone spatialisation developments in the near future. At

time of writing, the virtual reality and gaming developments are focusing on the visuals and head tracking technology, so it will be inevitable that further headphone developments will follow.

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Appendices

Appendix A – Filmography

1612: Khroniki smutnogo vremeni. Directed by Khotinenko, V., Hollywood C.E., 2007.

A Christmas Carol. Directed by Zemeckis, R., Walt Disney Studios Motion Pictures, 2009.

Alexander Nevsky. Directed by Eisenstein, S.M. & Vasilev, D., Amkino Corporation, 1939.

Apocalypse Now. Directed by Coppola, F., Ford, Paramount Pictures, 1979.

A Star Is Born. Directed by Pierson, F., Warner Bros., 1976.

A Trip to the Moon. Directed by Méliès, G., Star Film., 1902.

Australia. Directed by Luhrmann, B., 20th Century Fox, 2008

Avatar. Directed by Cameron, J. Twentieth Century Fox Film Corporation., 2009.

Bad Boy Bubby. Directed by De Heer, R., Roadshow Entertainment, 1993.

Bad Boy Bubby. Directed by De Heer, R., Umbrella Entertainment, 2005. (DVD)

Batman Returns. Directed by Burton, T., Warner Bros., 1992.

Beowulf. Directed by Zemeckis, R., Paramount Pictures, 2007.

Bolt. Directed by Howard, B. & Williams, C., Walt Disney Studios Motion Pictures, 2008.

Brave. Directed by Andrews, M. & Chapman, B., Walt Disney Pictures, 2012.

Bwana Devil. Directed by Oboler, A., United Artists, 1952.

Candy. Directed by Armfield, N., Dendy Films, 2006

Chicken Little. Directed by Dindal, M., Buena Vista Pictures Distribution, 2005.

Citizen Kane. Directed by Welles, O., RKO Radio Pictures, Inc., 1941.

Close Encounters of the Third Kind. Directed by Spielberg, S., Columbia Pictures, 1977.

Dick Tracy. Directed by Beatty, W., Buena Vista Pictures Distribution, 1990.

Don Juan. Directed by Crosland, A., Warner Bros. Pictures, 1926.

Doom. Directed by Bartkowiak, A., Universal Pictures, 2005.

Ender's Game. Directed by Hood, G., Summit Entertainment, 2013.

Fantasia. Directed by Algar, J. et al., Walt Disney Productions, 1940.

Godzilla. Directed by Edwards, G., Warner Bros., 2014.

Gravity. Directed by Cuarón, A., Warner Bros. Pictures., 2013.

Happy Feet. Directed by Miller, G., Warner Bros., 2006.

Happy Feet Two. Directed by Miller, G., Warner Bros., 2011.

House of Wax. Directed by Toth, A.D., Warner Bros., 1953.

Hugo. Directed by Scorsese, M., Paramount Pictures, 2011.

I, Frankenstein. Directed by Beattie, S., Hopscotch Films, 2014.

Innerspace. Directed by Dante, J., Warner Bros., 1987.

Iron Man 3. Directed by Black, S., Walt Disney Studios Motion Pictures, 2013.

Jim the Penman. Directed by Porter, S. Paramount Pictures, 1915

Jurassic Park. Directed by Spielberg, S., Universal Pictures, 1993.

L'arrivée d'un train, Directed by Lumière. A. & Lumière, L., Lumière, 1896

Last Action Hero. Directed by McTiernan, J., Columbia Pictures, 1993.

Legend of the Guardians: The Owls of Ga'Hoole. Directed by Snyder, Z. Warner Bros., 2010.

Legend of the Guardians: The Owls of Ga'Hoole, Directed by Snyder, Z. Warner Bros., 2011. (DVD/Blu-ray)

Life of Pi. Directed by Ang Lee. Fox 2000 Pictures, 2012.

Lights of New York. Directed by Foy, B., 1928.

Lisztomania. Directed by Russell, K., Warner Bros., 1975.

Mission: Impossible - Ghost Protocol. Directed by Bird, B., Paramount Pictures, 2011.

Monsters vs Aliens. Directed by Letterman, R. & Vernon, C., Dreamworks Animation, 2009.

Oklahoma!. Directed by Zinnemann, F., Magna Theatre Corporation, 1955.

Red Tails. Directed by Hemingway, A., Twentieth Century Fox Film Corporation, 2012.

RoboCop. Directed by Verhoeven, P., Orion Pictures, 1987.

RoboCop. Directed by Padilha, J., Columbia Pictures, 2014.

Sanctum. Directed by Grierson, A., Universal Studios, 2011.

Star Wars. Directed by Lucas, G., Twentieth Century Fox Film Corporation, 1977.

Star Wars: Episode I - The Phantom Menace. Directed by Lucas, G., Twentieth Century Fox Film Corporation, 1999.

Star Wars: Episode V - The Empire Strikes Back. Directed by Kershner, I., 20th Century Fox, 1980.

Star Wars: Episode VI - Return of the Jedi. Directed by Marquand, R., Twentieth Century Fox Film Corporation, 1983.

Steamboat Willie. Directed by Iwerks, U. & Disney, W., Celebrity Productions, 1928.

The Avengers. Directed by Whedon, J., Walt Disney Studios Motion Pictures, 2012.

The Big House. Directed by Hill, G.W. & Wing, W., 1930.

The Dark Knight. Directed by Nolan, C., Warner Bros., 2008.

The Great Gatsby. Directed by Luhrmann, B., Warner Bros., 2013.

The Haunting. Directed by Bont, J. de, Dreamworks Distribution, 1999.

The Hobbit: An Unexpected Journey. Directed by Jackson, P., Warner Bros., 2012.

The Hobbit: The Desolation of Smaug. Directed by Jackson, P., Warner Bros., 2013

The Jazz Singer. Directed by Crosland, A., Warner Bros., 1927.

The LEGO Movie. Directed by Lord, P. & Miller, C., Warner Bros., 2014.

The Robe. Directed by Koster, H., Twentieth Century Fox Film Corporation, 1953.

The Thin Red Line. Directed by Malick, T., 20th Century Fox, 1999.

This Is Cinerama. Directed by Cooper, M.C. & Fritsch, G. von, 1952.

Thor: The Dark World. Directed by Taylor, A., Walt Disney Studios Motion Pictures, 2013.
Titanic. Directed by Cameron, J., Paramount Pictures, 1997.
Titanic (3-D version). Directed by Cameron, J., Paramount Pictures, 2012.
Tommy. Directed by Russell, K., Columbia Pictures., 1975.
Toy Story 3. Directed by Unkrich, L., Walt Disney Pictures, 2010.
Transformers. Directed by Bay, M., Paramount Pictures, 2007.
Turbo. Directed by Soren, D., 20th Century Fox, 2013.
War Horse. Directed by Spielberg, S., Dreamworks SKG, 2011.
Wreck-It Ralph. Directed by Moore, R., Walt Disney Studios, 2012.

Other:

Carwash. Directed by Damian Candusso, 2013 (Short Film)
Farscape. The Jim Henson Company, 2002 (Television)
Foxed!. Directed by Stewart, J.E.D. & Bezaire, N., 2013. (Short Film)
Grand Theft Auto V. Rockstar Games, 2013. (Game)
Half-Life 2. Valve, 2004. (Game)
Muriel Lake Incident. Cardiff, J., 1999. (Mixed Media)
Niagara Falls. General Film Company, 1914. (Documentary Short Film.)
Papa Sangre. Somethin' Else, 2011. (Game)
Red Dead Redemption. Rockstar Games, 2010. (Game)
Souviens-moi. Directed by Derobe, J., 2013. (Short Film)
Virtual Barber Shop. QSound Labs. 2007. (Soundscape)

Appendix B – Figures

Appendix C – Author's Screen Credit List

2014 **The LEGO Movie** (sound effects editor)
2013 **Backyard Ashes** (additional sound)
2013 **The Great Gatsby** (sound effects editor)
2011 **Happy Feet Two** (sound effects editor)
2011 **Sanctum** (sound effects editor)
2010 **Legend of the Guardians: The Owls of Ga'Hoole** (sound effects editor)
2010 **Primal** (sound effects editor)
2009 **Daybreakers** (sound designer) / (sound effects editor)
2008 **Australia** (sound effects editor)
2007 **1612: Khroniki smutnogo vremeni** (sound effects editor)
2006 **Happy Feet** (sound effects editor)
2006 **Catch a Fire** (dialogue editor)
2006 **Like Minds** (dialogue editor)
2006 **Checkpoint** (Short) (sound mixer)
2006 **Candy** (sound effects editor)
2006 **Gloomy Valentine** (Short) (sound designer) / (sound mixer)
2006 **RAN: Remote Area Nurse** (TV Mini-Series) (sound effects editor)
2005 **Little Fish** (sound effects editor)
2005 **The Magician** (dialogue editor) / (sound effects editor)
2005 **Deck Dogz** (ADR editor)
2004 **The Cooks** (TV Series) (dialogue editor)
2004 **Farscape: The Peacekeeper Wars** (TV Mini-Series) (ADR recordist) / (dialogue editor) / (sound editor)
2004 **Anacondas: The Hunt for the Blood Orchid** (ADR editor)
2004 **Blinky Bill's Extraordinary Balloon Adventure** (TV Series) (sound effects editor - 2004)
2003 **Farscape** (TV Series) (dialogue editor - 23 episodes) 2001 **Tabaluga** (TV Series) (sound effects editor - 2001)
2001 **Old Tom** (TV Series) (sound effects editor) / (sound re-recording mixer)
1999 **Flipper & Lopaka** (TV Series) (sound re-recording mixer) / (supervising sound editor)

Appendix D – Interview Consent Form

Interview Consent Form
'Sound Design and the 3D film: New dimensions in sound'

1. I ..... (please print) consent to take part in the '*Sound Design and the 3D Film: New dimensions in Sound*' Project. I have read the information sheet for this project and understand its contents. I have had the nature and purpose of the research project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is freely given.

2. I understand that while information gained during the research project may be published in academic journals or books, my name and position title will not be used in relation to any of the information I have provided, unless I explicitly indicate that I am willing to be identified when quoted.

3. I understand that if I agree to participate in the research project I will be asked to take part in an interview, which should last for no more than hour; and that in preparation for the interview I will be sent a list of questions indicating the matters to be discussed.

4. I understand that any personal, sensitive or potentially incriminating information will be kept confidential so far as the law allows. This form and any other data collected throughout the duration of the interview including digitally recorded media (audio or visual) will be kept on a computer accessible only by password and accessible only by the researcher.

5. I understand that although any comments I make will not be attributed to me in any publication it is possible that others may guess the source of information, and I should avoid disclosing information which is of confidential status or which is defamatory of any person or organisation.

6. I understand that I may withdraw from the research project at any stage, without providing any reason and that this will not have any adverse consequences for me. If I withdraw, the information I provide will not be used by the project.

7. In any publications produced as a result of this research I consent to be identified by (check one):

- My full name
- My position and organisation (if you tick this box it is possible that you could be identified)
- None of the above (complete confidentiality)

Signed ..... Date ..... .

Audio Recording

I consent to be audio recorded by the interviewer. I understand that the media will be stored securely by the researcher. I understand that documentation of this kind raises the likelihood of being identified. I consent to the researcher storing my data including this

consent and any audio interview(s) indefinitely for as long as the data is relevant to any further research conducted by the researcher.

Signed ..... Date ..... .

Researcher to Complete

I, Damian Candusso certify that I have explained the nature and procedures of the research project to ..... and consider that she/he understands what is involved.

Signed ..... Date ..... .

Appendix E – Survey Questions and Results

New Summary Report - 23 May 2014

Film Futures Survey

1. Do you work in the film industry?

Yes	73	36.3%
No	128	63.7%
Total Responses	201	

2. If so, in what area primarily:

Vision	13	7.3%
Sound	48	27.1%
Other	16	9.0%
I don't work in the industry	100	56.5%
Total Responses	177	

	3
Directing/actors	1
I am a sound graduate of AFTRS, now a Uni Lecture	1
N/A	1
Post	1
Post Production Supervisor	1
Producing/Production	1

Production / Direction	1
R&D primarily, Music Production privately	1
Set, props, costume and sound	1
analyst	1
both	1
director	1
visual storytelling (combined emaphsis on vision and sound)	1

3. When was the last time that you went to the cinema to watch a film?

Less than 1 month	102	51.0%
1-3 months	57	28.5%
3-6 months	26	13.0%
6-12 months	6	3.0%
1 year or more	9	4.5%

Total Responses	200
Sum	180
Average	1.8
StdDev	1.4
Max	6

4. How often do you go to the cinema?

At least once a month	69	34.7%
once every few months	82	41.2%
a couple of times a year	35	17.6%
no more than once a year	13	6.5%

Total Responses	199

5. Do you regularly go to the same cinema?

Yes	146	73.4%
No	53	26.6%

Total Responses	199

6. Out of the last few films that you have seen at the cinema, would you say that they have mostly been 3D (stereoscopic) or 2D?

3D	34	17.1%
2D	165	82.9%

Total Responses	199
Sum	432
Average	2.2
StdDev	0.4
Max	3

7. If you have the option, do you prefer to see the 3D film version or 2D film version?

3D	72	36.6%
2D	125	63.5%

Total Responses	197
Sum	466
Average	2.4
StdDev	0.5
Max	3

8. Do you regularly watch films on a personal device? (eg. iPad, laptop)

Yes	110	55.6%
No	88	44.4%

Total Responses	198

9. Do you prefer to watch (and listen to) films on a personal device using headphones or speakers?

Headphones	64	33.9%
Speakers	125	66.1%

Total Responses	189

10. Generally, when listening to music do you wear headphones?

Yes	70	35.2%
No	129	64.8%

Total Responses	199

11. Given the choice, do you prefer to listen to music through headphones or speakers?

Headphones	32	16.0%
Speakers	168	84.0%

Total Responses	200

12. When going to the cinema, do you select a cinema based on it's technical capabilities or do you select it on the convenience of the cinema. (For example it is close to you, it has good parking)

Technology	57	28.6%
Convenience	142	71.4%

Total Responses	199

13. If you had to choose a cinema based on quality, would you pick good sound over good image or good image over good sound?

Good sound over good image	106	54.1%
Good image over good sound	90	45.9%

Total Responses	196

14. The last time that you went to the cinema, were you content with the image quality?

Yes	175	87.9%
No	24	12.1%
Total Responses	199	

15. The last time that you went to the cinema, were you content with the sound quality?

Yes	157	78.5%
No	43	21.5%
Total Responses	200	

16. Did you notice the sound being particularly good, or particularly not good?

The sound was good	110	55.3%
The sound was NOT good	35	17.6%
I didn't notice sound	54	27.1%
Total Responses	199	

17. Do you know what the format of the sound was for the film that you last saw?

No	104	52.0%
Stereo	7	3.5%
5.1	46	23.0%
7.1	27	13.5%
Dolby Atmos	15	7.5%
Barco Auro	1	0.5%
IOSONO	0	0.0%
Other	0	0.0%

Total Responses	200
Sum	426.3
Average	5.8
StdDev	1
Max	7

18. Have you seen a film in the Dolby Atmos format?

No	113	58.6%
Yes - with a 3D film	26	13.5%
Yes - with a 2D film	19	9.8%
I Don't Know	35	18.1%

Total Responses	193

19. Have you seen a film in the Auro format?

No	135	70.0%
Yes - with a 3D film	6	3.1%
Yes - with a 2D film	10	5.2%
Don't Know	42	21.8%
Total Responses	193	

20. Have you seen a film in the IOSONO format?

No	141	73.4%
Yes - with a 3D film	2	1.0%
Yes - with a 2D film	5	2.6%
Don't Know	44	22.9%
Total Responses	192	

21. When watching 3D films, are you happy wearing the 3D glasses?

Yes	100	51.3%
No	95	48.7%
Total Responses	195	

22. Since you already need to wear 3D glasses, would it bother you if there were

tiny speakers enclosed within the rear of the glasses frame arms?

Yes	59	29.7%
No	140	70.4%
Total Responses	199	

23. When watching a 2D film, does surround sound enhance the movie going experience for you or does it make no difference?

Yes it enhances	186	93.9%
Makes no difference	12	6.1%
Total Responses	198	

24. When watching a 3D film, does surround sound enhance the movie going experience for you or does it make no difference?

Yes it enhances	179	91.3%
Makes no difference	17	8.7%
Total Responses	196	

25. Do you think surround sound does a good job of supporting 3D visuals or is there room for improvement?

Surround sound does a good job	81	40.5%

It could be better	101	50.5%
Don't know/ Never thought about it	18	9.0%
Total Responses	200	

26. Do you think that 'surround sound' is the same as '3D sound'?

Yes	18	9.1%
No	96	48.5%
Don't know/ Never thought about it	84	42.4%
Total Responses	198	

27. Do you think that sound for 3D films can be called '3D sound'?

Yes	56	28.3%
No	71	35.9%
Don't know/ Never thought about it	71	35.9%
Total Responses	198	

28. When an object 'comes out of the screen' in 3D, does the sound do an adequate job of 'being connected' to the image?

Yes	64	32.5%
No	79	40.1%
Don't know/ I have never thought about it	54	27.4%

Total Responses	197

29. Do you accept paying a premium surcharge for 3D films?

Yes	97	48.7%
No	102	51.3%

Total Responses	199

30. With cinemas charging a premium surcharge for 3D films, would you happily pay a surcharge for a new sound format offering 3D sound, or do current surround sound formats do an adequate job?

Yes I would pay for even better sound	85	42.9%
No I wouldn't pay as surround sound is good enough	78	39.4%
Don't know/ I have never thought about it	35	17.7%

Total Responses	198

31. Where do you live?

Australia	161	80.5%
Azerbaijan	1	0.5%
Belgium	1	0.5%

Canada	2	1.0%
Colombia	1	0.5%
France	1	0.5%
Germany	2	1.0%
India	2	1.0%
Italy	1	0.5%
New Zealand	1	0.5%
Singapore	2	1.0%
Spain	1	0.5%
Sweden	1	0.5%
Switzerland	1	0.5%
United Kingdom	5	2.5%
United States	17	8.5%

Total Responses	200

32. What is your age?

under 18	0	0.0%
18-24	31	15.5%
25-34	48	24.0%
35-54	94	47.0%
55+	27	13.5%

Total Responses	200
Sum	6,533.0
Average	32.7
StdDev	10.8
Max	55

33. Are you a male or female?

Male	126	63.0%
Female	73	36.5%
Other	1	0.5%

Total Responses 200

Source Countries

Australia	162	80.6%
Belgium	1	0.5%
Canada	2	1.0%
France	1	0.5%
Germany	2	1.0%
India	3	1.5%
Italy	1	0.5%
Mexico	1	0.5%
New Zealand	1	0.5%
Singapore	1	0.5%
Spain	1	0.5%
Sweden	1	0.5%
Switzerland	1	0.5%
United Kingdom	5	2.5%
United States	18	9.0%

Total Responses 201