Help I'm Surrounded

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A dimly lit auditorium, the smell of popcorn and hot-dogs accompanied by the sound of fizzy drinks slurped through straws; the lights dim and a hush of expectation descends, sound fades in from all around, drawing the audience into the illusion of another reality. This is the world of the cinema, but is it possible to recreate this cinematic surround sound experience in the home? In order to address this question it is necessary to understand what is meant by "cinematic" surround sound and to consider some of the challenges faced by those seeking to translate it to the home environment. This article examines these issues through an exploration of the development of surround sound in the cinema and its transference to the home and concludes with a tentative look towards possible future developments.

Early Experimentation

The commercial promotion of surround sound systems in the market place today might lead one to assume that multichannel sound is a recent phenomenon, but this is not the case. A demonstration of stereophonic transmission by Clement Ader can be traced back to the Paris Exhibition of 1881, but the 1930s really mark the beginning of our exploration of multichannel sound (Rumsey, 2001: 10). In 1931 Alan Blumlein was granted a patent specification for his work exploring improvements in sound recording, sound reproduction, and transmission. Blumlein's system attempted to convey spatial attributes of sound but his work was forgotten for many years. In 1958 his work was rediscovered in a British paper entitled, "The 'stereosonic' recording and reproducing system: a two-channel system for domestic tape records," written by Clark, Dutton and Vanderlyn of EMI (Rumsey, 2001: 12).

In 1934 Bell Laboratories began to experiment with stereophonic sound, using three channels (left, centre and right). The results were published in a paper entitled "Auditory perspectives - physical factors" (Rumsey, 2001: 10-12). Their research was directed towards sound reproduction in large auditoriums, spaces in which sound from the front channels would reverberate around the listener, creating a greater feeling of envelopment. For listeners seated off centre of the left and right channels, the centre channel assisted in anchoring the sound image towards the centre. Three front channels are still the norm in the cinema today, largely because of the size of the front screen and the necessity for wide seating layouts. The conductor Leopold Stokowski showed great interest in this research, so much so that he conducted the Philadelphia Orchestra in a live demonstration of Bell Laboratories' three channel system, in which the sound was transmitted from the Academy of Music in Philadelphia across telephone lines with a bandwidth of fifteen kilohertz, in three-channel stereo, to an audience in Washington's Constitutional Hall. (Jordan, 2004)

Fantasia and Fantasound

Fantasia (1940) was the first multichannel format cinema release. The decision to explore the possibility of a multichannel cartoon feature was partly forged during an impromptu meeting between Stokowski and Walt Disney at a Hollywood restaurant. Stokowski was the driving

force behind ensuring that Disney's engineers explored Bell Laboratories' experimental stereophonic recording system. Disney extended the challenge still further; in thinking about the "Flight of the Bumblebee" segment, he decided to give his engineers an additional brief, to move the sound around the audience as well as in front. It is for this reason that Tomlinson Holman, a leading figure in the development of surround sound, credits Disney as the inventor of surround sound (Jordan, 2004).

The work of the engineers resulted in a format called "Fantasound." From the years 1938 to 1941 the format appeared in various permutations, numbered as "Mark I" through to "Mark X" (Garity and Hawkins, 1941). In developing "Fantasound," the Disney engineers developed supporting technologies such as multitrack recording, pan potting and overdubbing which are still in use today. The "Mark I" system was not dissimilar to current surround sound configurations, featuring left-front, centre-front, right-front, left-rear and right-rear speakers. Despite the number of speakers only two channels were used, one fed the centre-stage, the other fed the remaining speakers under selective manual control (Garity and Hawkins, 1941).

The "Mark II" expanded on this design by adding three speaker sources, each placed halfway back from the stage, one on each side and one on the ceiling. Unlike the "Mark I," three channels were used and were operated under manual control. The side speakers enabled sound to be moved side to side in any plane between the screen and rear of the cinema. Despite the benefits of this version, the controls proved rather complex for one man to operate and introduced an unwanted performance element, ensuring that no two screenings were entirely alike (Garity and Hawkins, 1941). The "Mark III" was a more experimental system designed to explore technical elements of the "Fantasound" design. The "Mark IV" was similar in format to the "Mark II," but eliminated manual control. "Mark V" incorporated greater flexibility. However, its inherent flexibility meant that some of those operating the equipment found it difficult remembering the sequence of operations from one rehearsal to the next, and so the "Mark V" was confined to the history books after only one day in operation (Garity and Hawkins, 1941).

Not surprisingly, the engineers sought to simplify the design with their next version ("Mark VI"), returning to three speaker sources and three channels. This was the system used for the first serious dubbing of *Fantasia*. "Mark VII" used for the first of the RCA-manufactured systems, closely resembled its predecessor with some technical alterations. "Mark VIII" was also similar in essentials but the equipment was rearranged physically. This was the system installed in the Broadway Theatre in New York for the world premiere of *Fantasia* in November, 1940 (Garity and Hawkins, 1941). "Mark IX" modified the layout again and incorporated the addition of two sets of rear speakers which were manually switched in at certain points throughout the film to supplement or to replace the left and right screen speakers. "Mark X" automated the switching process and was installed in the Carthay Circle Theatre in Los Angeles, where *Fantasia* ran for forty-five weeks (Garity and Hawkins, 1941).

The cost of installing a "Fantasound" system proved prohibitive. Only two were ever sold to theatres, at a cost of eighty-five thousand dollars and requiring the installation of fifty-four speakers positioned around the auditorium (Chumney et al, 2004). Disney's solution was to send out a *Fantasia* road show with a scaled down version of "Fantasound" based on the "Mark IX" system, but without surround speakers. The road shows only survived a limited run for a number of reasons: whilst equipment was being installed in the theatres they had to close for a few days, losing valuable revenue; the road show itself was very expensive to put on and failed to receive wide enough exposure; space was at a premium in some projection

rooms, making it difficult for some theatres to accommodate the additional equipment necessary and the coming of wartime conditions did little to encourage the manufacture of further "Fantasound" equipment (Garity and Jones, 1942).

Fantasia had cost in excess of two million dollars (Aldred, 2004). Disney's investment in technical and creative innovation had not been rewarded at the box office and the film also failed to win critical appraisal. Despite various re-releases in different formats, including mono and stereo, Disney never lived to see the film go into profit shortly after 1966 (Aldred, 2004). The advent of war and the commercial failure of the film did little to promote "Fantasound" within the film industry. Josef Stalin however did show some interest in the format and so most of the equipment began a journey across the Northern Atlantic, bound for the Soviet Union, a destination it would never reach. Somewhere at the bottom of the ocean lie the remains of the first chapter in the story of cinematic surround sound, the victim of a German U-boat (Jordan, 2004).

Post-World War II

The Second World War may mark the end of chapter one, but the life and death struggle of opposing wartime forces would result in technological innovation on an unprecedented scale; technologies that would lead us into the next chapter of our history. German magnetic recording technology was one such innovation. It offered better sound quality at an affordable price and was also relatively light in weight, making it mobile and easy to use. Amateurs quickly embraced magnetic sound, but cinemas were slower to adopt it because of the initial financial outlay required in converting from earlier optical formats (Altman, 1985: 48). The advent of the television and its increasing availability in the late 1940s, shattered the complacency of the film industry. The battle lines were drawn, and as cinema audiences began to fall, the film industry attempted to claw back its waning appeal by offering technological extras, or in some cases gimmicks which were unavailable in the home, such as 3-D film (*The Creature from the Black Lagoon* [1954]). Magnetic sound was soon claimed as part of the film industry's arsenal, and by 1951 an estimated seventy-five percent of Hollywood's productions were issued in this format (Altman, 1985: 48).

Magnetic sound technology resurrected the possibility of multichannel sound reproduction and enabled the production of better quality theatre speakers. There were a number of competing magnetic systems for multichannel sound. 3-D films were associated with a multichannel sound format called Cinerama, first introduced in 1952. Despite attempts to simplify the format, it quickly became obsolete, proving too cumbersome and expensive to be practical. Warner Brothers introduced a simplified alternative format of their own called "WarnerPhonic Sound," featured in the film *House of Wax* (1953). 20th Century-Fox revisited an older French invention, CinemaScope, and combined it with four-track magnetic recording to produce a multichannel format comprising four channels; left, centre, right and one mono surround channel (Handzo, 1985: 420). This was the first multichannel format to be released in multiple titles and was premiered in *The Robe* in 1953 (Marmorstein, 1997: 228). Both formats were well suited for wide screen presentation.

The other main multichannel format was six-track, "70mm Todd-A0," with five screen channels and one surround. The format was derived from the earlier Cinerama experiment and was named after Mike Todd, one of Cinerama's original investors (Handzo, 1985: 419). It was reserved largely for special presentations, those in which sound had a more prominent role within the film, such as musicals; examples include *Oklahoma!* (1955), and *South*

Pacific (1958). Unfortunately, magnetic sound technology could not rescue the film industry from the downturn in audience attendance figures: multichannel releases were expensive to produce and they tended to have a short shelf life compared to optical prints; maintaining the playback equipment was also costly and so the number of cinemas capable of playing magnetic releases fell and fewer titles were released in multichannel format (Handzo, 1985: 421). From the mid-1950s until the 1970s, the home consumer market became the focus for the development of new technologies. Cinema audiences seldom enjoyed multichannel magnetic releases; these were generally reserved for a limited number of big budget feature films in their first run.

The Development of Multichannel Sound in the Home

Stereo sound became available in the home in 1958 through Vinyl LP phonograph records. As more stereo records became available to the public, it was not long before stereo sound supplanted mono as the standard home consumer format. Two channel stereo FM broadcasting shortly followed in 1961, further enshrining stereo sound as the norm. Television on the other hand, still only supported mono sound reproduction (Hull, 2004). The standardisation of stereo sound led to a number of experiments which sought to enhance or augment the format in new ways (See Appendix). Ambiophony represents one such experiment in which reverberation signals were reproduced from separate loud speakers, creating a sense of greater sound envelopment. Few of these systems however were commercially viable and so alternative solutions were sought, including the ill-fated Quadraphonic format (Hull, 2004).

In order to deliver four channels of sound via two channel analogue media, manufacturers developed a form of encoding or "matrixing" by which the information from the extra channels could be folded down and accommodated on only two standard stereo channels (Rumsey, 2001: 16). To enable the reproduction of quadrophonic recordings in the home, consumers were required to purchase a range of equipment from decoders (to reconstruct the original four channels of audio) through to new amplifiers and speakers, positioned around the listener in a square configuration. The use of encoding to deliver surround sound information through stereo media points to more recent developments such as Dolby Surround. In fact, surviving quadraphonic systems dating back to the 1970s are reputed to be able to decode analogue Dolby Surround signals of today.

If quadraphonic sound was so ahead of its time, why did it fail to gain a commercial foothold? A number of reasons have been suggested in answer to this question: the square speaker configuration failed to deliver convincing surround sound effects (Rumsey, 2001: 16); the market place offered consumers a range of different encoding/ decoding systems without ensuring universal compatibility (Hull, 2004); there was no consensus of opinion amongst recording engineers and producers as to the preferred function for the additional channels (Holman, 2000: 14); the expense incurred by consumers in purchasing a Quadraphonic sound system for the home, and the perception that there were few advantages to the format did little to promote four channel sound, despite the efforts of the manufacturing industry. Perhaps most significantly of all, quadraphonic sound failed because it was not associated with visual media. The recent and dramatic commercial success of surround sound systems in the home has been triggered by the desire to recapture the immersive and escapist world of cinematic experience in the privacy of one's own home. Had surround sound systems been promoted purely for audio reproduction, it is unlikely that we would be witnessing the current commercial surround sound phenomenon.

The Importance of Standardisation

The failure of the quadraphonic experiment clearly demonstrated the need for standardisation. If the format had been marketed with standardised specifications and compatible coding/decoding formats it may have been more successful. Equally, standardisation would become increasingly important to the film industry as surround sound technology developed and as cinemas increasingly came under independent ownership. A number of different bodies would be involved in the standardisation process, standardising compatible technologies and procedures to facilitate high quality surround sound in the home and at the cinema. The selection of particular technologies was and still is based on consultation across a range of industries, testing, research, market forces and consumer preference.

In times of transition, when technology changes very rapidly, standardisation becomes increasingly important for a number of reasons: it enables interoperability and fosters innovation; it opens up global markets providing a level playing field for competitors, helping to prevent duplication by encouraging dialogue and the dissemination of information; it also tends to reduce costs for consumers and helps to assure them of product quality. However, standardisation can only be built on consensus otherwise standards will not be adopted. The standards used within the film and home entertainment industries today are largely voluntarily. For this reason different countries may select different standards, but as "front runners" emerge these become increasingly globalised. The history of standardisation runs like a subplot underlying the history of surround sound in the cinema and the home and continues to this day (See Appendix).

The Cinema Revival

Cinemas saw a return to popularity in the mid 1970s, due in large part to ground breaking films such as *Star Wars* (1977) and *Close Encounters of the Third Kind* (1977). The soundtracks to these films used a new multichannel format called Dolby Stereo which had first been introduced in 1975 in a film called *Lisztomania*, followed a year later by *A Star is Born* (Handzo, 1985: 423). Original Dolby Stereo systems offered anything from three to six channels. 35mm film formats encoded four audio channels onto two optically recorded audio tracks, giving left, centre, right and surround channels. 70 mm film formats gave six discrete tracks of magnetically recorded audio (Rumsey 2001: 96-7). In 1978, in line with the wishes of Gary Kurtz, the producer of *Star Wars*, and members of the Dolby team, the existing 70 mm magnetic format was reconfigured to give greater impact to low frequency sounds during action sequences (Holman, 2000:16). Tracks one, three and five drove the left, centre and right speakers, tracks two and four, known as the "baby boom," provided low frequency sound (below 250 Hz) which drove the left centre and right centre stage speakers. Any frequencies above 500Hz were electronically diverted to the left and right surround speakers. The sixth or "surround" channel provided frequencies below 500 Hz and was used to drive the left and right speakers at the back of the room (Handzo 1985: 423). 70mm prints of *Star Wars* provided a wonderful showcase for the new format, enveloping audiences with enhanced low frequency power, intensifying the experience of warfare in space. By the time *Close Encounters* was released six months later, some theatres introduced dedicated "subwoofers" rather than borrowing the left centre and right centre speakers for this purpose (Holman, 2000: 16). The closing sequence of the film, in which the alien "mother ship" arrives and then engages in a dialogue of musical counterpoint, provided many opportunities to showcase the adapted format, particularly when enhanced and intensified with the power of dedicated subwoofers.

The Dolby Stereo logo today is generally associated with the four channel format (front-left, front-centre, front-right and surround) in which four audio channels are encoded or "matrixed" onto two track optical soundtrack (see figure 1).

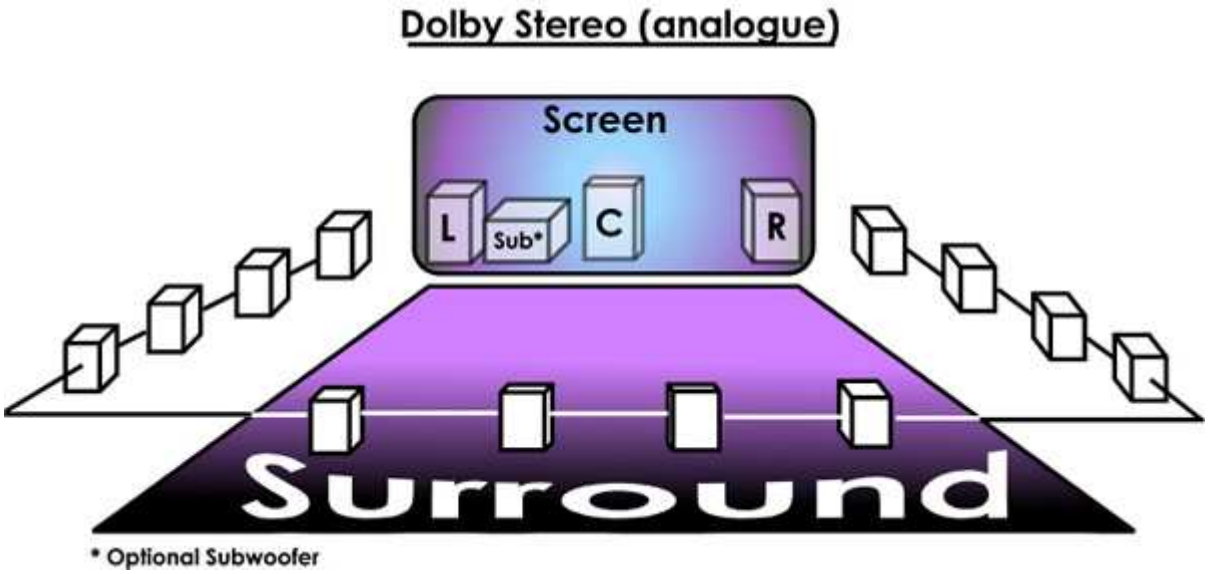

FIGURE 1

The surround channel is reserved for ambient sound and special effects and the centre channel provides the dialogue (Hull, 2004). The Dolby format owed much to the quadraphonic experiments preceding it, and was based on a matrix encoding system, derived from a 1972 patent by Peter Scheiber (Holman, 2000:15). Dolby Stereo marked a significant step forward; the soundtrack could be printed at high speed along with the picture, consequently the format was less time consuming and expensive to produce than earlier multichannel magnetic formats (Holman, 2000: 15). The conversion from magnetic to stereo optical reproduction equipment was also relatively cheap and once installed required very little maintenance. The introduction of Dolby A-type noise reduction minimised the characteristic background noise associated with optical film technology, offering cinema audiences consistently higher quality sound (Rumsey, 2001: 97). Despite these advantages, Dolby Stereo might never have become established without the success of *Star Wars*, which convinced the industry of the commercial potential of the format. Once Dolby Stereo had acquired the industry's seal of approval, Dolby manufactured cinema processors were installed in many cinemas, these provided a wide frequency response with less distortion. Cheap, reliable, high fidelity technology marked the demise of four-track 35mm magnetic film and led to the introduction of a new global, universal standard for the playback of wide-range stereo prints, the "ISO 2969" (Dolby, 2004) (See Appendix). Virtually all major titles have been released in the Dolby Stereo format.

The next development came with the film *Superman* (1978), in which the surround channel was split into two, left and right surrounds. Other releases soon exploited the dramatic potential of split stereo surrounds including *Apocalypse Now* (1979), *The Empire Strikes Back* (1980), and *Raiders of the Lost Ark* (1981) (Handzo, 1985: 423). *Apocalypse Now* (sound design by Walter Murch) is often singled out for its creative use of sound. From the quiet, ambient sounds of the jungle to the loud symphony of helicopters and explosions bombarding a Vietnamese village, the scope of the split surrounds could be fully exploited, although many cinemas were not equipped to render the soundtrack as intended.

The last significant development before the transition to digital sound was the introduction of a new recording process called Dolby SR (spectral recording). Introduced in 1986, Dolby SR provided over twice the noise reduction of the Dolby A-type process, allowing louder sounds with less distortion and a wider frequency response (Dolby, 2004). Even in today's digital world, Dolby SR analogue soundtracks are provided on virtually all film prints as backups to guarantee successful playback in all cinemas.

The Birth of Home Cinema

Mono video cassettes and recorders were introduced to the home in 1972 (Hull, 2004). Initially promoted as a means of recording one's favourite television programmes when out of the house, it was not long before their full commercial potential was realised. There was great demand for more material to be released on video to the general public, and the film industry was more than happy to satisfy the growing market. The introduction of the video cassette was one factor in successfully eliminating the necessity for competition between the film industry and its old rival television. Video cassette sales and rentals brought the film industry vital new sources of revenue. More surprisingly, video appeared to rekindle fresh interest in new releases at the cinema and cushioned the financial losses when films flopped at the box office, as many of these were recouped through video sales and rentals. Stereo video cassettes became available in 1978, followed in 1980 by the two channel laser disc, which offered higher fidelity picture and sound quality. The laser disc was the first audio-visual medium for the consumer market to incorporate digital sound and was followed by the compact disc two years later. In 1986, stereo television broadcasting was also adopted (Hull, 2004). Once films with stereo soundtracks were available and accessible within the home environment, a re-visitation of multichannel surround sound became increasingly attractive.

The consumer version of Dolby Stereo was introduced in 1982 and was called Dolby Surround. It lacked some of the technical sophistication of Dolby Stereo (it did not use Dolby A-type noise reduction for example), but the matrix encoding method, which reduced four channels into the space required for two, was essentially the same. Some later versions employed Dolby B-type noise reduction in the surround channel to reduce unwanted noise. Whilst Dolby Surround was the first commercially successful consumer surround sound format, it was not a perfect solution; sounds from the front channels would sometimes bleed into the surrounds and the centre channel was not fed to its own speaker, but created as a phantom image between the left and right speakers. Some of these technical issues were addressed in Dolby's next version, Dolby Surround Pro Logic, which first became available in 1987 (Rumsey, 2001: 97-8).

The improved format offered greater channel separation and emphasised directional sounds, whilst anchoring the dialogue in a dedicated centre channel. Dolby Surround Pro Logic proved to be a great commercial success for Dolby Laboratories, and is still built into many home cinema systems today. Its success as a surround format is due in large part to its association with film and television and perhaps more importantly Dolby's definition of hardware and software standards both within the film industry and the home consumer market. Today, Dolby Surround Pro Logic encoding features on music CDs and audio cassettes and is also found on video games and other multimedia applications. Whilst the encoding system has been universally applied, it should be acknowledged that Dolby Surround was never designed for pure audio reproduction and in many cases standard stereo music releases are preferable.

The Cinema and the Digital Age

The introduction of digital sound to the film industry would mark the next significant development for film sound. In 1987 the subcommittee of the Society of Motion Picture and Television Engineers (SMPTE) organised a number of meetings to decide the necessary requirements for digital sound on film. They agreed upon a multichannel system with a minimum requirement of "5.1" channels, in other words, five channels plus a low frequency channel. Tomlinson Holman, who was present at the meetings, has described the 5.1 system as, "a codification of existing 70mm practice" (Holman, 2000: 16) (See Appendix).

The foundations for digital sound had been laid and in 1992 when the film *Batman Returns* was released with a soundtrack encoded in a new digital, multichannel format called "Dolby Digital." Dolby Laboratories found a way to combine both analogue and digital versions of the sound track on the same optical film print (Hull, 2004); the digital information was placed on a separate optical track running between the sprocket holes of the film. The combined format was called Dolby SR-D (Rumsey, 2001:104). Those cinemas with Dolby Digital soundtrack readers and decoders could enjoy the full benefits of the new technology, offering their audiences six channels of surround sound (left, centre, right, left-surround, right-surround and a low frequency enhancement channel), whilst the same film print could be sent to cinemas with older optical equipment and reduced surround sound capabilities (see figure 2). This feature was essential in ensuring the success of the Dolby Digital format.

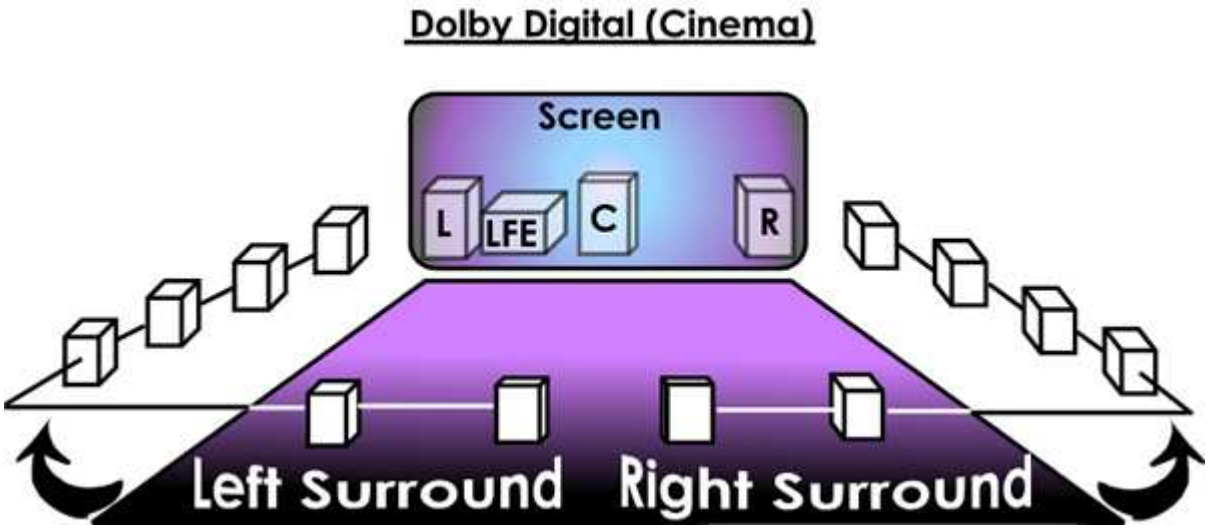

FIGURE 2

The new digital format also offered additional benefits for film sound, including wider dynamic and frequency ranges, improved channel separation, low distortion and relative immunity from wear (Rumsey, 2001: 106; Dolby, 2004). The manufacturing of prints and their subsequent distribution proved relatively easy and Dolby offered a range of support services to film producers and exhibitors world-wide, and the format soon outstripped its competitors. Today more titles are released in Dolby Digital than any other format (Hull, 2004).

A less well-known approach to surround enhancement has also been employed in cinema film and a broad range of other applications: Qsound Labs' "Qsound" for 3D audio. The developers of the technology stumbled across it by accident; in setting up a complex

arrangement of microphones they noticed that the sound appeared to be coming from an unexpected source. Following further research they developed "Qsound" to give an enriched and realistic 3D sound experience. "Qsound" made its first cinematic appearance in *Robin Hood: Prince of Thieves* (1991). Since then, "Qsound" has been used in many subsequent applications including well-known television programmes, television sets, albums, public venues, computers (games, software/hardware), mobile devices and headphones (Qsound Labs, 2005).

Dolby Digital's main competitors are Digital Theatre Systems (DTS), first introduced in *Jurassic Park* (1993), and Sony Dynamic Digital Sound (SDDS), introduced in *The Last Action Hero* (1993) and *City Slickers II: The Legend of Curly's Gold* (1994) (Miller, 2004). The differences between the three formats relate to the physical location of the digital soundtrack on the film and the way in which the digital information is encoded. All three digital systems use some form of data reduction; without this it would be impossible to fit all the required sound information onto the film. The DTS system applies time-code to the film and uses this to synchronise the footage to a CD-ROM containing the film's soundtrack. Dolby Digital uses a form of data reduction called "AC-3" (Rumsey, 2001: 103); the DTS "Coherent Acoustics" system offers another coding format with a higher maximum data rate (Rumsey, 2001: 106), whilst Sony's SDDS system uses their own "ATRAC" data reduction technology (Rumsey, 2001: 107).

Inevitably as the amount of data is reduced, detailed digital information representing the original recording is lost. One of the central challenges for all three formats is to achieve the necessary data reduction without compromising the overall sound quality. Different methods of data reduction approach this problem in different ways, but in general, methods yielding significant data reduction are based on research into the ways in which the human brain perceives and interprets sound, a field called "psychoacoustics." The aim is to lose information which would not be significantly missed, for example, soft sounds masked by much louder sounds within the mix. Opinion is divided regarding the comparative sound quality of the different data reduction methods, although the DTS "Coherent Acoustics" system does preserve more of the original audio content. Since all three formats occupy different locations on the film, it is possible to include all of them on one print (Holman, 2000: 24). Dolby Digital and DTS provide 5.1 channels of surround sound, whereas SDDS has the capacity to deliver 7.1 channels, adding two front channels (left-centre and right-centre). The "DTS XD10 Cinema Media Player" and "DTS XD10P Cinema Audio Processor" provide up to eight audio channels, with two additional channels for alternate audio available from the "DTS XD 10 Media Player" (DTS, 2005a). This system is Digital Theatre System's answer to Sony's SDDS technology, which offers up to ten channels of digital sound; in practice however a maximum of eight channels tend to be used (five screen channels, two surrounds and a subwoofer). Over twenty four thousand cinemas worldwide now have some form of DTS sound equipment installed (DTS, 2005b) and they have also made some inroads into "IMAX" features shown at special venues (DTS, 2005c).

In 1999 George Lucas' *Star Wars: Episode I – The Phantom Menace* introduced Dolby Digital's successor, Dolby Digital Surround EX (Miller, 2004). The improved format was developed jointly by Lucasfilm THX and Dolby Laboratories. Gary Rydstrom, the director of Creative Operations at Skywalker Sound wanted to be able to move or "pan" sounds directly behind the audience and so a third rear surround channel was added to the existing Dolby Digital format, through a process of matrix encoding between the left and right surrounds (see figure 3).

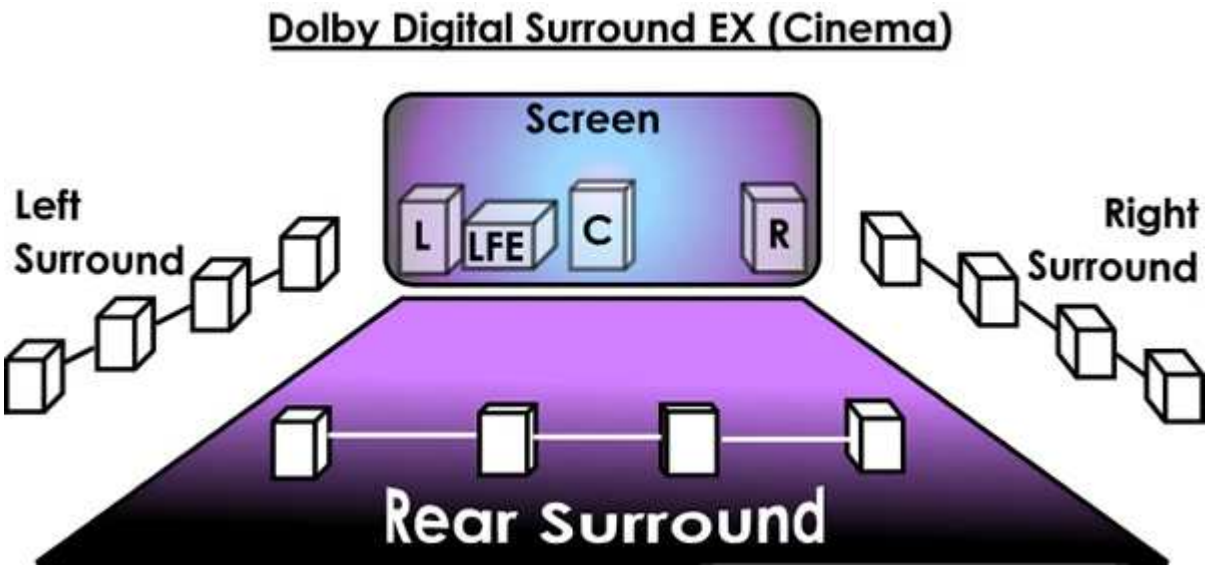

FIGURE 3

The benefits of Surround EX include more realistic "flyover" and "fly around" effects as well as more accurate sound placement (THX 1, 2004); a stable sound image for music and ambient sounds and a more consistent surround sound effect regardless of seating position. The "pod race" sequence represents one of a number of scenes which showcase the effectiveness of the new format. Dolby Digital Surround EX has enjoyed considerable success; many films have been released in this format, including many international films and thousands of cinemas are now equipped with Dolby EX technology (Dolby, 2005a; Dolby 2005b).

A more recent collaboration between Dolby, Disney and Industrial Light & Magic, a Lucasfilm Ltd. company, has resulted in a new technology, "Disney Digital 3D," which provides a three-dimensional digital experience in movie theatres. *Chicken Little,* released in November 2005, was the first film to use the new technology. The film has been rendered to play on Dolby Digital Cinema servers and Dolby plans to install these systems in high-profile cinemas. Viewers will be required to wear special 3-D glasses to watch the CGI animation. Despite the failure of earlier 3D film formats, Disney Digital 3D could mark a new chapter in film history (Dolby, 2005c).

Digital Home Cinema

The success of digital multichannel formats within the film industry promoted the development of consumer versions for use in the home. In 1993 Dolby's AC-3 coding method was selected as the coding system for digital television. Consequently Dolby Laboratories gained a significant advantage over their competitors (ATSC, 2005) (see Appendix). The first Dolby Digital laser discs were introduced in 1995, and by 1997 Dolby Digital 5.1 was available on DVD-Videos and DVD-ROMs, followed a year later by digital television broadcasting of Dolby Digital 5.1 in America (Hull, 2004). Digital Theatre Systems (DTS), have made increasing inroads into the home cinema market place despite Dolby's initial monopoly. Hot on the heels of Dolby, they introduced their first version of DTS for the home in 1996 (Miller, 2004). An increasing number of laser discs, surround CDs and DVD-Video releases contain DTS coding. Dolby Digital and DTS Digital Surround both provide 5.1

channels of sound (left, centre, right, left-surround, right-surround and low frequency enhancement channel) (see figure 4).

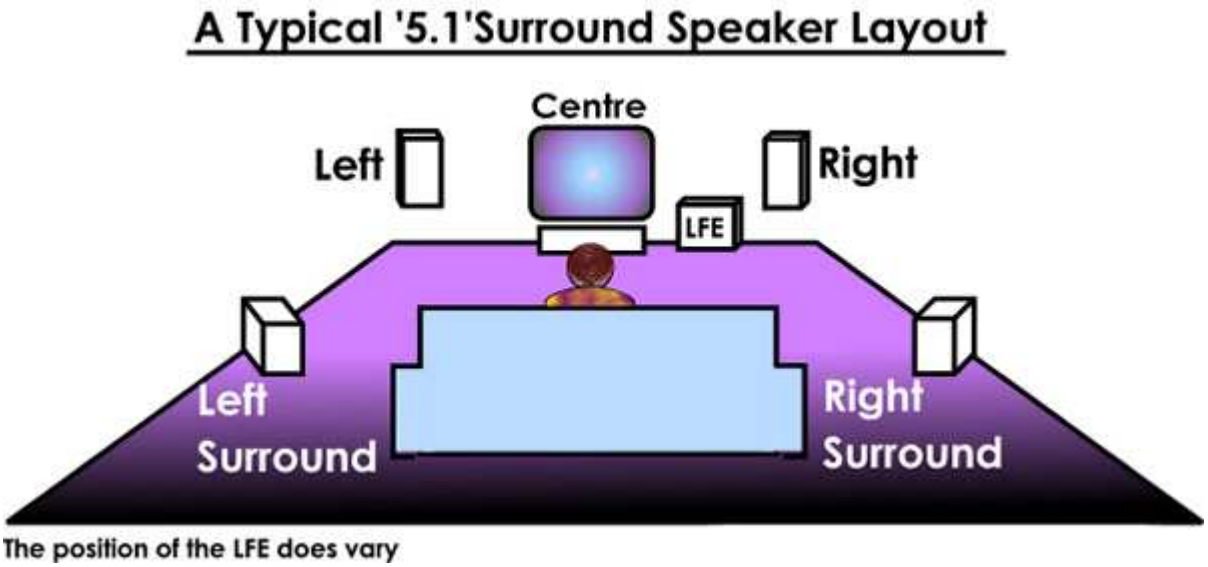

FIGURE 4

Dolby Digital has now become the digital audio standard for "High Definition Television" (or HDTV) in North America and has also been used in digital video broadcast (DVB) applications world-wide (See Appendix). In France, M6 broadcasting have begun broadcasts in Dolby Digital 5.1 via the new Digital Terrestrial Television (DTT) network and the TPS network satellite service. In Britain subscribers to Sky can enjoy Dolby Digital 5.1 broadcasts, and a number of other countries including Germany, Sweden, Italy, Austria and Poland also provide Dolby Digital broadcasting (Dolby, 2005j). "MPEG Surround" is an alternative audio format, used in US satellite broadcasts, personal computers and some DVDs (in PAL areas) (Meridian, 2005a). Despite the standardisation of the 5.1 format, the growing success of digital surround sound has encouraged the drive towards increasing the number of channels still further.

"Dolby Digital EX" or "THX Surround EX" is based on the same technology as Dolby Digital but offers an additional single or stereo rear surround channel, for 6.1 or 7.1 surround sound (see figures 5 and 6).

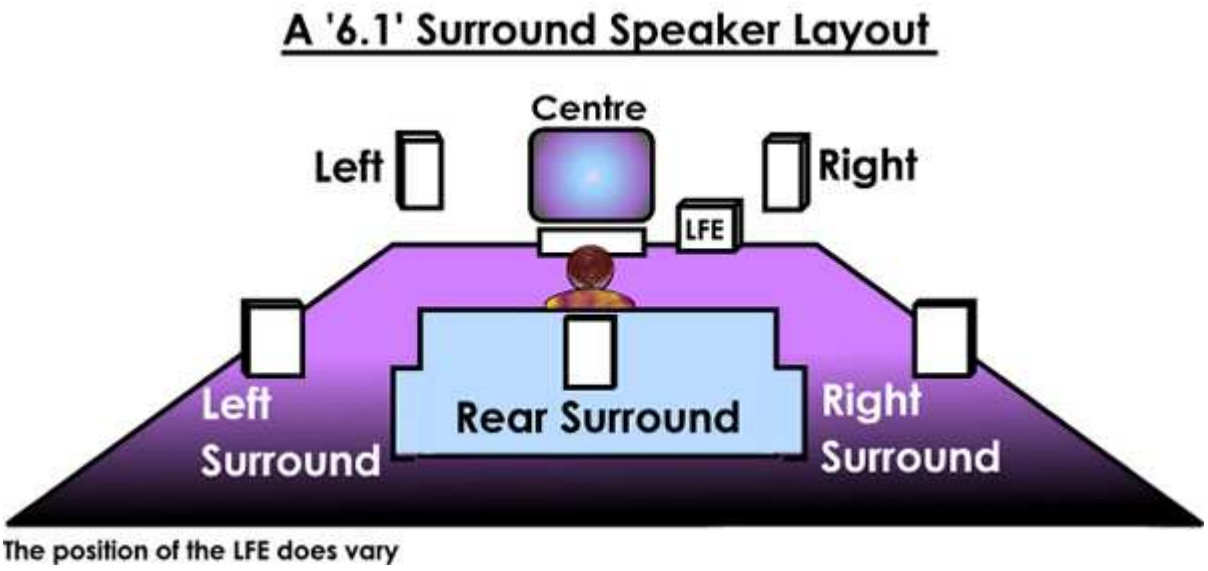

FIGURE 5

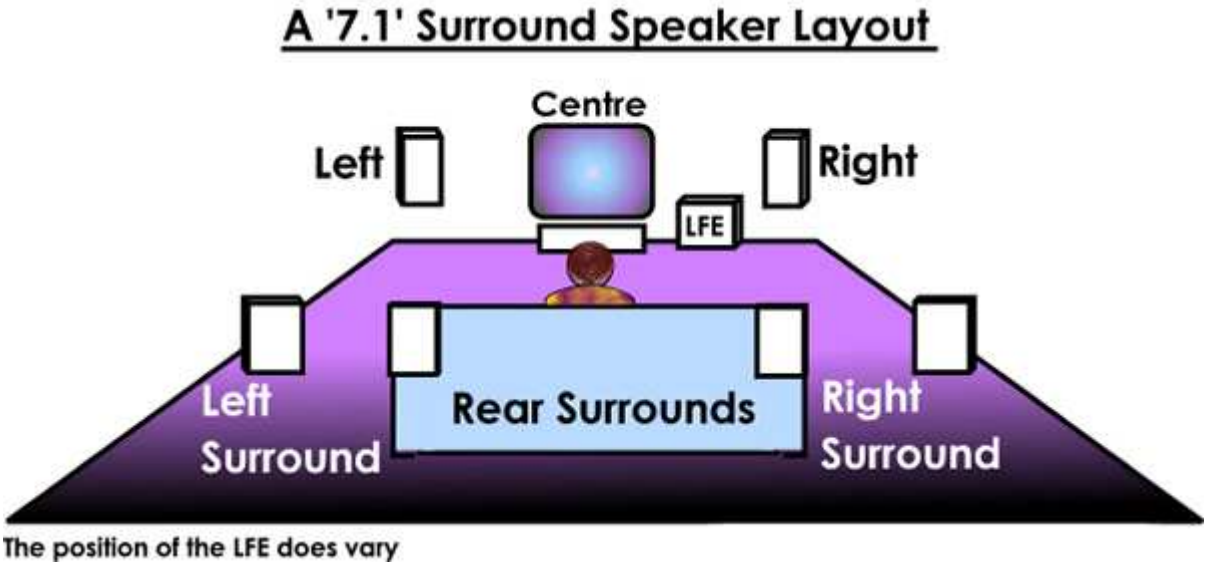

FIGURE 6

The surround "EX" signals are matrixed within the Dolby Digital 5.1 signal (Rumsey, 2001: 103), allowing "EX" encoded titles to be played back on existing Dolby Digital equipment. However, to access the additional surround channel information one would require a Dolby Digital EX decoder to reconstruct the encoded information, a suitable amplifier and one or two rear surround speakers. THX (Tomlinson Holman Experiment) Ltd, have also enhanced their "Surround EX" format with the "THX Ultra2." The format is configured for three front speakers plus four surrounds and a subwoofer with a range extending to twenty hertz (THX, 2004b).

Digital Theatre Systems have parallel technology in direct competition with Dolby Digital EX. "DTS-ES Matrix" extracts a centre rear channel from existing 5.1 material encoded in the DTS format. For those wanting to hear genuine non-matrixed 6.1 soundtrack releases, DTS offer an alternative, "DTS-ES Discrete 6.1." Titles must be DTS encoded for 6.1

surround sound in order to enjoy the benefits of the extra channel, however "DTS-ES Discrete 6.1" is designed to be "backwards-compatible". Unfortunately, for those investing in expensive systems of this sort, fewer DVD titles are available in these enhanced formats, however this does appear to be changing (Time For DVD, 2005). Some DVD titles and receivers offer a high resolution encoding audio format, "DTS-96/24" which provides better audio resolution (24 bit, 96kHz).

The Confusion of Transition

Despite the drive towards digital multichannel sound and its undeniable success in the market place, many peoples' homes only contain stereo playback equipment. A significant number of people still watch television accompanied by mono sound piped directly from their television's internal speaker. Despite the strong arm tactics of retailers who appear to be making it increasingly difficult for consumers to purchase the latest film releases on video, a significant number of people still do not own a DVD player, let alone a surround sound system. Consumers are increasingly encouraged to trade in their existing home entertainment systems for the latest DVD player/recorders, set-top boxes, surround sound systems, and High Definition-ready LCD and plasma television sets (the bigger the better). This transition will be resisted by some. Manufacturers and developers of technology face a paradoxical challenge; designing, implementing and promoting new technologies whilst preserving older technologies in the interests of backwards compatibility, so ensuring broad market appeal. Their answer to this challenge endeavours to provide for the transitional and uneasy mix of analogue and digital technology and seeks to take into account the need for new technologies to be compatible across a range of different home cinema and television sound systems, consequently new or adapted surround formats have emerged.

SRS (Sound Retrieval System) Labs represent a leading force in the development of home cinema. They appear particularly aware of the need to develop surround technologies for consumers who would like to experience the effects of surround sound without upgrading from their existing stereo systems. SRS Labs' "TruSurround XT" delivers a virtual multichannel 5.1 surround effect from surround encoded material over a two-speaker system (SRS Labs, 2005a). Dolby have also developed "Virtual Speaker" technology which simulates a surround sound effect from just two stereo speakers and is used in conjunction with Dolby Pro Logic and Dolby Digital. The technology is really designed for those without the space for multichannel systems or for applications in which the distance between the two speakers is quite narrow. The success of the 5.1 surround sound effect depends largely upon the listener's position relative to the speakers. Dolby provide online demonstrations for people to audition which may be accessed from Dolby's home web site (Dolby, 2005f). Yamaha have launched a virtual surround sound system of their own called, "Virtual Cinema DSP" to be used in conjunction with Dolby and DTS encoded audio. A surround sound image is created from only two speakers, but if a centre speaker is present, Yamaha's software will generate a virtual rear channel (Yamaha, 2005a). Totally virtual surround systems answer very specific consumer needs but inevitably involve an element of compromise.

Simulated surround sound has also been applied to the humble headphone. Dolby, SRS Laboratories, Yamaha, Recoton and a number of others have all developed their own surround sound headphone technologies (Dolby, 2005d; SRS Labs, 2005b; Yamaha, 2005b; Qsound Labs, 2005). They appear to place the enveloping sound field farther away from the listener, creating a more natural, less claustrophobic listening experience. Whilst a virtual

surround system might be considered a compromise, the appeal of this approach, particularly within a transitional market place, cannot be underestimated.

For those who have expanded their systems to five or six speakers plus a subwoofer, SRS Labs have developed "Circle Surround II" or "CS II". The format has been designed to emphasise the sensation of sound immersion and has the added benefit that it can create up to 6.1 channels of audio from older mono and stereo sources, as well as reproducing Circle Surround or matrix encoded material. Circle Surround is gaining a significant foothold in the world of television and radio broadcasting, particularly in America (networks using Circle Surround encoded programming include TNT, Fox, Paramount Television, ABC Sports, NBC, ESPN and others) (SRS Labs, 2004). Circle Surround has also made inroads into radio stations in Japan ("Tokyo FM") and China ("Guangdong Radio") and is incorporated into a wide range of consumer products by well known manufacturers. In April 2005, SRS Labs' Circle Surround Technology was awarded the "Radio World 'Cool Stuff' Award" at the National Association of Broadcasters (NAB) Convention in Las Vegas (SRS Labs, 2005d).

Dolby Laboratories' Surround Pro Logic II can be seen as an enhancement of Dolby's original Pro Logic technology. It can create a simulated 5.1 surround sound effect from two-channel stereo recordings or from Dolby Surround encoded material and also offers improved channel separation compared to its predecessor. (THX Limited also produce an enhanced version of Pro Logic called "THX Cinema" [Meridian, 2005a].) Dolby Pro Logic IIx expands the capabilities of Pro Logic II by simulating up to 6.1 or 7.1 channels of sound (Dolby 5, 2005). Digital Theatre Systems have designed their own answer to Dolby Pro Logic II and IIx, the "DTS Neo:6." The "Neo:6" decoder extracts up to 6.1 channels of sound from two-channel analogue material (Silva, 2005).

"Lexicon" is another competitor in the surround sound market place and have developed a range of home theatre products, some of which include their "Lexicon Logic 7" matrix encoding/decoding technology. "Logic 7" can generate a surround effect from ordinary two-channel material, creating up to seven channels (7.1) of audio (left, centre, right, two side speakers and two rear speakers). "Logic 7" was developed by Lexicon to be incorporated into its more expensive range of products and has been marketed as an alternative to Dolby Surround decoding (Rumsey 2001: 101). Despite this "Lexicon Logic 7" will reproduce Dolby Pro Logic and any "Logic 7" encoded mix can also be played back on a Dolby Pro Logic decoder (Lexicon, 2005a). Such an approach broadens Lexicon's potential market base and indicates a recognition by members of the industry that compatibility of technology, even between competitors, is important within a diverse and transitional market place (See Appendix).

Lexicon's "MC-12 Music and Cinema Processor" extends the number of audio channels still further, whilst maintaining compatibility with Logic 7, Dolby and THX decoding and also holds THX Ultra certification. It offers twelve channels in all; left-front, right-front, centre, low frequency enhancement (LFE), left-subwoofer, right-subwoofer, left-side, right-side, left-rear, right-rear and left and right auxiliaries. Scaled down versions are also available, such as the "MC-8" for eight channel audio, the "MC-4" and the "MC-1" (Lexicon, 2005b).

With an eye to the future, Dolby have introduced "Dolby Digital Plus", an audio codec based on Dolby Digital, but designed to adapt to changing future demands whilst retaining backward compatibility. Dolby Digital Plus allows for more than 7.1 fully discrete surround sound channels. Additional technical benefits such as higher coding efficiency and high data

rate support, have resulted in Dolby Digital Plus gaining selection as the standard format for High Definition DVDs or "HD-DVDs" (Dolby, 2005g), an optical disc format developed by Toshiba and NEC (Blu-ray, 2005) (See Appendix). Also of interest is "Dolby Digital Live," a real-time coding technology designed to enable the conversion of audio from PCs and game consoles in real-time for 5.1 surround sound playback through a home cinema system via one digital connection. Game players are immersed in sound, placing them in the centre of the action (Dolby, 2005h).

Having outlined a number of the surround sound options available in the market place today, it is not difficult to see why many people are confused. The right to free choice is certainly precious to most of us, but in the absence of sufficient information or understanding, making the right choice becomes increasingly difficult. The transitional nature of the market place further compounds this problem; we are becoming bewildered by choice and the rate of change. Against this backdrop it is understandable that many people are not prepared to upgrade from their existing stereo systems or willing to invest large sums of money in surround sound systems that could quickly become out dated. Of those who have plunged their hands into their pockets, would their money have been better spent at the cinema?

Home Cinema Systems vs. the Cinema

The success of the home cinema experience depends upon a number of factors: the quality and correct installation and configuration of the equipment; the production quality of media titles for the consumer market; and the suitability of the home environment for effective surround sound rendering. The same criteria could also be applied to cinemas, though perhaps to a lesser extent. There is a direct correlation between product price and product quality; you get what you pay for. It is possible to purchase surround sound home cinema systems relatively cheaply, but the sound quality of the systems can be very poor and "tinny" and would certainly not be comparable with true cinema sound. At the other end of the spectrum, a growing number of audio specialist companies are now providing products for the home cinema market place which offer better sound quality than many cinema sound systems. A number of these companies provide the very equipment used in professional recording and film studios.

For those working within tighter budget constraints, purchasing a good quality home cinema surround sound system is more difficult. The same kind of money that would have bought a perfectly reasonable two-speaker system is now expected to secure anything up to seven speakers plus a subwoofer. This inevitably dilutes the quality of the equipment available at that price. In addition, the tailoring of surround sound primarily for the home cinema market as opposed to pure music reproduction has led to a number of compromises. Consequently, some see the current developments in home cinema surround sound in a negative light.

The surround sound experience in cinemas can also be compromised by the quality of the sound systems installed. The development of multichannel cinema sound has always been subject to financial constraints of one sort or another and these persist today. Whilst multiplex and city cinemas may have the technology necessary to take full advantage of recent developments in film sound, other more provincial cinemas may not. Just as in the home, standards of sound reproduction vary and may fail to live up to the director's vision for the film.

The THX trademark (derived from the "Tomlinson Holman eXperiment" at Lucasfilm) has been developed in answer to this problem. Any cinema displaying the THX logo complies with certain parameters for cinema sound systems and acoustics which should ensure that the sound is faithful to the intentions of the film's production team (THX, 2005a). Once installed, THX licensed systems are periodically tested to ensure continued compliance with the required specifications. Following further research, THX Ltd. engineers applied similar principles to the home cinema arena, providing a workable standard to maximise the performance of a variety of audio-visual components and systems (THX, 2005a). The THX logo certifies that a particular product complies with the THX standard, effectively acting as a guarantee of quality. THX certified products tend to be in the mid- to upper-range price bracket (THX, 2005b). There are a number of leading audio specialists however who have chosen not to be constrained by the THX guidelines. The absence of the THX logo cannot, therefore, be taken as an indication of poor performance.

Qsound Labs have approached the challenge of audio quality from a different perspective, designing a small hardware unit, the "UltraQ," which works in conjunction with consumers' existing audio systems to improve performance. The unit connects easily to any home stereo or multichannel system enriching the quality of the audio and enhancing the listener's perception of three-dimensional sound. The appeal of this approach is twofold; it is easy to install and inexpensive to acquire. A demonstration is available for people to audition via Qsound Labs' website (Qsound Labs, 2005).

Yamaha's "Cinema DSP" technology seeks to recreate the quality of the cinematic experience in the home by enhancing the surround sound image of Dolby and DTS encoded audio still further. "Tri-Field Cinema DSP" (for 5.1 surround sound) creates three independent surround sound fields, "Quad-field Cinema DSP" (for 6.1 surround sound) creates four sound-fields. This technology is designed to enhance sound immersion regardless of room acoustics (Yamaha, 2005c).

SRS Labs offer a range of technical enhancements of their own, designed to improve the performance of audio systems in the home: "Dialog Clarity" technology increases the intelligibility of dialogue in soundtracks originally mixed for cinema playback; "FOCUS" repositions and elevates the sound image for non-optimally positioned speakers; "SRS 3D" expands mono or stereo material to create a three-dimensional sound image; "TruBass" heightens the sensation of low bass tones and "WOW" enhances the quality of any mono or stereo source, improving the dynamics and bass performance (SRS Labs 1, 2005). Additional enhancements are provided for mobile systems and headphones. Consumers may audition some of these enhancements by accessing online demonstrations available through SRS Labs' home web site (SRS Labs, 2005c). These developments are significant because they clearly show recognition from the industry that success in the home cinema sphere may require some degree of compromise.

Naim, a company well respected for the performance of its audio products has tackled the issue of compromise from a particularly intriguing angle. Their DVD player ("DVD5") has been developed with an unusual feature; "its audio decoding board is physically separated from the DVD boards and its video processors," and it also incorporates a design element from Naim's CDS3 CD player. These refinements allow the DVD5 to outperform many CD players designed exclusively for audio playback. The player is also suitable for DVD Audio discs, and with an upgrade, will render DVD Audio in 7.1. Naim, in line with a growing number of other companies, are designing their AV systems with future developments in

mind, allowing for future upgrades in response to the rapid rate of change in the industry (Naim, 2005).

Meridian's "Ultimate Theatre" system exemplifies an uncompromising approach. It incorporates their "800 Series" source products and their finest range of DSP speakers (the DSP 8000 and DSP6000), the first speakers of this type to be developed. The DSP 8000, a four-way active model, contains five power amplifiers, three digital to analogue converters, three digital crossovers and advanced distortion cancelling computers all built within an elegant casing. These speakers allow the sound to be steered and adapted to the room in which they are placed. Other DSP speakers in the Meridian range are scaled down in size for smaller living spaces (Meridian, 2005b).

A "music first" approach, which prioritises audio quality and "future proof" technology, is characteristic of the more prestigious companies. The element of compromise, commonly associated with home cinema surround sound systems, is reduced if not eliminated. Whilst cheaper products constantly evolve and fall out of favour, high end products may remain unchanged for years with only occasional, minor upgrades when research dictates that an improvement may be made.

The success of the surround sound experience in the home rests not only upon the technology employed but also upon the acoustics of the physical space. It is difficult for domestic spaces to compete with cinemas in this regard. Recommended speaker layouts must adapt themselves to the demands of the home and family. Enthusiasts may be able to set aside a dedicated home cinema space, with a large projection screen and perfectly positioned speakers, but this is the exception rather than the rule. For most of us, installing a surround sound system involves some degree of compromise. There are however a number of commercial solutions which reduce or eliminate this element of compromise. Retailers of mid to upper range home cinema surround sound systems and Hi-Fis tend to offer installation services, ensuring the best performance potential for the equipment in the space available. In addition, a significant number of companies manufacture technologies designed specifically for custom installation in the home (RGB Communications, AMX, Living Control, Crestron, Cyrus Electronics, KEF Audio, Linn, CSE Solutions, Russound, SpeakerCraft, Meridian and others). Seemingly technology free spaces may disguise hidden wall and ceiling speakers, drop down projection screens and hard disk recorders, all available at the touch of a small keypad (Audio T, 2005: 58-65). Custom installation allows a fundamental change in approach; technology is selected for and adapted to the needs of a particular space in order to achieve the best possible sound quality and spatialisation. This eliminates the practical and aesthetic struggles usually encountered when seeking to adjust a living space to the demands of surround sound technology. The advantages of custom installation are clear, but for financial reasons they are not within everybody's reach.

Wireless surround sound technology reduces the complexity of surround sound installation for those who choose not to opt for custom installation, but wish to preserve the aesthetic appeal of their home. Systems of this type are becoming more common, such as Sony's "Wireless DVD Dream System" (Sony, 2005). The facility to be able to arrange speakers around the room without worrying about the usual "spaghetti junction" of cables, is a tremendous advantage and encourages flexible speaker positioning to suit different situations and room layouts. A number of audio specialists have approached the problems of small or awkward domestic spaces from alternative perspectives. "THX Select" technology delivers all the usual features of THX home cinema but optimised for small spaces of two thousand

cubic feet or less. THX Select-certified products tend to be available in the midrange price bracket (THX, 2005c). Other companies such as Bose and Mission have focused on developing a range of innovative small speakers designed to defy their size in terms of performance. Mission's small "M-CUBE," designed for 5.1 surround sound, exemplifies this trend and boasts one other level of aesthetic sophistication, namely interchangeable fabric wraps to suit the decor. Bose's small speakers are incorporated across a range of their home entertainment systems. Their innovative "direct/reflecting cube speaker arrays" swivel, allowing the user to adjust the speakers to achieve the best possible sound reflection from the walls of their particular room. Another particularly interesting technological development has been incorporated within Bose's "Lifestyle" range of DVD home entertainment systems; the "AdaptiQ Audio Calibration System." During set up, the calibration system figures out the position of the speakers and the shape and size of the room, before self-adjusting for optimal performance (Bose, 2005a). Systems of this sort, designed to learn and adapt, point to intriguing future developments across a range of applications, not necessarily restricted to the home cinema arena.

NXT- New Transducers Ltd. have developed a very different solution, "Distributed Mode Loudspeakers" (DMLs) or "SurfaceSound" (NXT, 2005a; NXT, 2005b). These generally opaque, flat panel loudspeakers can be disguised as paintings and are currently being produced in a growing range of different sizes (NXT, 2005a). The German company ELAC uses DML technology in their flat panel picture speakers. Arranging five or more speakers around the room for surround sound becomes much easier when the only aesthetic consideration is whether to place Van Gogh next to Duret or Lombarte (ELAC, 2004: 28). Theoretically, any images could be applied to panel surfaces, including prints of family photographs. This technology has also been explored by General Motors, IBM and others, across a range of applications (NXT 1, 2005).

A more recent development of "SurfaceSound" is NXT's "SoundVu Technology," which "enables the design and construction of completely transparent, ultra-thin loudspeakers that bring sound and vision together" (NXT, 2005c). This development is particularly interesting since it allows the television screen itself to become the sound source, potentially removing the requirement for separate loudspeakers, or enabling the user to invisibly supplement their existing surround sound system. There are many possible applications for this technology in many different areas of our lives, the repercussions of which are likely to be with us for some time to come. Other companies have also developed flat panel technologies which are not derived from NXT's particular approach. Artcoustic loudspeakers are true dynamic loudspeakers based on a proprietary technology called "QPC" which allows the speakers to provide as much bass performance as a speaker with twice the internal volume. Electrostatic flat panel speakers represent yet another approach. These designs radiate sound from the front and the back, and so must be placed at some distance from the wall (Artcousticusa, 2005).

KEF Audio's "KIT 100 Instant DVD Theatre" represents an intriguing, hybrid exploration of flat panel technology. It incorporates flat panels to produce virtual surround sound from only two speakers and a bass unit. Behind each speaker front, at right angles to it, is a small flat panel. Surround sounds from the panels are reflected behind the listener from the walls on either side, effectively creating a rear surround effect. KEF incorporate technology from their "Reference Series" line of audiophile products within their home cinema ranges, including a development called "Uni-Q" technology, known for its "wide dispersion characteristics,"

perhaps explaining why the "KIT 100" has received so much positive feedback (Audio T, 2005: 40; KEF, 2005).

Given the growing shift towards plasma and LCD televisions within the market place, flat panel speakers have an obvious aesthetic appeal. The jury may still be out regarding the performance of some flat panel technologies, particularly amongst audiophiles, but the manufacturing industry are taking the new technology very seriously and are investing significant sums in associated research and product development. The adoption of flat panel technology by companies such as Bowers & Wilkins, demonstrated in their "Flat Panel Monitor" or "FPM Series" (Bowers & Wilkins, 2005), KEF and ELAC, all known for their uncompromising "music-first" approach, reinforces this trend. More familiar high-street names also utilise flat panel technology, often advertised under user friendly headings such as "super slim" or "ultra compact." A contrasting space-saving approach can be seen in Nirotek's "Niro 1.1 PRO II" which incorporates five precisely angled speakers, all within one case. An onboard computer processes the signal to each speaker to create surround sound imaging (only the left and right surrounds are virtual). Unlike some of its competitors, Nirotek have developed technologies which do not rely upon the reflection of sound from walls to create the illusion of surround sound. The compact design of Nirotek home cinema systems is in tune with the demands of modern living. Different Nirotek systems are designed to perform in particular room sizes, from quite small (two hundred square feet floor space or less), through to large (six hundred square feet plus). The demarcation of room size makes it easier for consumers to select the correct model for their home and the scale and simplicity of design facilitate easy installation. Even Nirotek's discrete 6.1 systems (NIRO TWO6.1 and NIRO TWO6.1-C) are remarkably unobtrusive in appearance, with three speakers housed in a small front unit with a similar rear unit behind the listener (Nirotek, 2005). Bose, a company known for their ability to deliver impressive sound quality from diminutive looking hardware, have made significant inroads into this area of research, producing a 3.2.1 multichannel system called the "GS DVD Home Entertainment System." From only two visible speakers and a hideaway "Acoustimass" module, the system delivers a surprisingly wide and effective multichannel presentation. The speakers are based on U.S. patented "Gemstone" speaker array technology, which works in conjunction with "TruSpace" digital surround processing to expand the sound image (Bose, 2005b).

For those without the space, budget or inclination to place any surround sound speakers in their living rooms, or for those who wish to enjoy their surround sound entertainment in private, there is the option of surround sound headphones. Recent developments suggest that manufacturers are beginning to explore ways of translating true 5.1 surround sound to the headphone as the next logical step on from virtual or simulated surround sound. "Mentor Surround Sound Headphones," designed with individual chambers surrounding each ear in the headset, exemplify this shift in emphasis and indicate possible future trends (Gizmag, 2005).

Some aspects of the home cinema experience are beyond the control of the consumer. Film soundtracks are remixed before they are transferred to consumer media. Cinema sound systems always have a subwoofer channel, this is not the case in many home systems. For this reason special low frequency content derived from the original cinema subwoofer channel is remixed to the main audio channels. This ensures that any low frequency sounds will still be heard despite the absence of a low frequency enhancement channel. In addition, the gain of the surround channels is normally boosted by three decibels during the remix process. The gain of the centre (dialogue) channel may also raised by one or two decibels to

preserve the intelligibility of the dialogue amidst competing sound effects and music (Holman, 2000: 172-174). These adjustments are made to enhance the home cinema experience, but production quality does vary. Some surround sound music media releases can be particularly disappointing. Even the best consumer media releases can sound unsatisfactory if rendered through a poor system.

The range and diversity of home cinema solutions available in the market place, reflects the inherent diversity of the target consumer group. Balancing the constraints of budget, physical space, aesthetics and consumer preference against sound quality or spatialisation is something of a challenge. The extent to which any particular home cinema system succeeds in meeting this challenge and recreates the feeling of "being there," is largely subjectively determined. The evidence suggests that it is possible for home cinema sound systems to compete with and even to surpass those found in cinemas but these may not be within the financial reach of most.

"Into the Future and Beyond"

The transition from analogue to digital technology is likely to continue through to completion and should help to reduce the confusion within the market place. Some predict the completion of this process within the next decade (Gessler, 2004). "Blue laser technology" ("Blu-ray Disc" or BD) and HD-DVD discs, which enable more data to be stored on a single DVD, are already being promoted by the DVD forum (Blu-ray, 2005). Blu-ray discs offer the highest specification of the alternative formats. Higher density DVDs allow increased sample rates and more channels of audio information, offering better sound quality, more detailed information for sound rendering and multiple metadata streams. Blu-ray products are already available in Japan (Blu-ray, 2005) (See Appendix).

Higher rates of data compression are likely to emerge, allowing higher definition within current DVD formats. Microsoft's VC-1 video codec based on their "Media 9 Suite" exemplifies this trend. Research may produce superior lossless codecs for next-generation technologies. Alternatively, developments such as Sky+, TiVo and the ubiquitous iPod point to a "solid-state" future with no need for storage units piled high with our favourite film and music titles (Haikin, 2005). Our entertainment systems may be linked to "super-broadband" pipes, delivering our favourite films direct to our homes where a high powered processor will recreate a three dimensional sound field best suited to our particular speakers and room layout. Long-term, new bandwidth for contemporaneously-emerging new media would be required (Elen, 2004). The introduction of "Broadband" appears to confirm this trend. Removing the need for consumers to store media on disc may help to alleviate concerns within the music industry about "Digital Rights Management" or "DRM." Currently, to stay one step ahead of "pirates," the industry is constantly having to change and adapt, creating an unstable technology platform. High resolution digital media is a valuable commodity, hence the desire by some in the movie and music business to slow down developments in this area. Copy protection represents a significant, ongoing technical challenge to the industry (Stidsen, 2004). The convergence of technologies seems set to continue as our television sets become more computer-like. Alternatively, as personal computer technologies develop and become more orientated towards entertainment applications, our conventional home entertainment centres may become redundant. The world of virtual reality and interactivity could transform the home cinema experience beyond all recognition.

The complexity of home cinema surround sound systems may necessitate a move towards custom installation. As the home environment becomes increasingly automated and new technologies converge in synergy with one another, custom installation could become the norm rather than the exception. We may see further developments in flat panel technologies, such that the listener would literally be surrounded by walls or even windows of sound. As surround sound technology becomes increasingly invisible and cheaper in price, consumers may become increasingly interested in systems offering further audio channels. Tomlinson Holman is keen to promote a 10.2 channel system (five front speakers, two ceiling speakers, three surrounds and two low frequency enhancement channels). Over twenty such systems have been installed, some of which are permanent, including a number of cinema installations. The film industry, though aware of the format, have not embraced it as yet. Several companies already produce equipment suitable for production of 10.2 channel soundtracks which, once installed, would add little to production costs or post-production schedules (Holman, 2004). The drive towards further audio channels does seem inevitable however; it is just a question of time, money and incentive. Audio manufacturers will probably continue to debate whether or not higher sample rates should be prioritised instead. Advances in technology could silence such debate in future.

There are some who argue that the best approach is to encode the 3D sound field in a way that is independent of the replay system before transferring the data in a "hierarchical way" so that the same data stream may be rendered by all replay systems, from the simplest mono or stereo equipment to the most sophisticated surround sound system (Elen, 2004). This is similar to Holman's own position, who in promoting 10.2 audio sought to encourage the accommodation of a variety of playback environments. He argues that one audio mix-down could accommodate a variety of surround sound configurations, including 10.2 surround, if multiple metadata streams were included in the mix. As higher density formats emerge, information of this type could easily be accommodated (Holman, 2004). Such an approach would take account of the inherent diversity within the marketplace.

We may find that home cinema systems evolve in unexpected ways which cannot be described in current categories. Developments in the field of artificial intelligence, for example, could have a role to play in advancing intelligent systems with the capacity to learn and adapt from the data they receive to suit the changing needs and preferences of consumers. Sound diffusion and spatialisation is a vibrant area of research and practice in many Universities. The pathways taken by University researchers and practitioners can be very different to those chosen by their commercial counterparts. Collaboration between both communities is likely to trigger the development of new approaches or a return to older ones, such as "Ambisonics" (Ambisonics allows the creation of three dimensional sound fields, including a height dimension, and can involve a varied number of reproduction channels and loudspeaker arrangements). Interestingly, Meridian's "861 Reference Surround Controller" provides ambisonic decoding and accordingly is capable of running "height" speakers (Meridian, 2005a).

It seems likely that home cinema systems of the future will continue to shadow new developments as they are introduced to cinemas and new film releases. This symbiotic relationship points to a lucrative future for the film industry and also for the home cinema market. The development of surround sound in the home will probably continue to be driven by visual applications and the need for backward-compatibility. Hopefully we may see home surround sound systems optimised for pure audio reproduction. If audio was prioritised more, many believe that the home cinematic experience would also be enhanced dramatically.

Currently developments are significantly based upon surround sound's cinematic heritage. If DVD-Audio becomes more prominent within the market place we may see a shift away from this emphasis, but whatever happens commercial surround sound is here to stay, with or without popcorn.

Appendix One

Industry Associations and Standardisation

Provided below is a list of a few of the key players responsible for the standards governing the film and home entertainment industries today; those whose decisions govern the technologies of the present and shape the technologies of the future.

The Advisory Committee on Advanced Television Service (ACATS) was established in 1987 by the FCC to advise the commission about advanced television systems. Their reports and recommendations influence the selection of particular standards by the FCC. In arriving at their recommendations, the ACATS seek advice from a number of organisations including laboratory testing facilities and the ATSC. ATSC's selection of Dolby Digital 5.1 as the digital television standard was adopted by ACATS (ACATS, 2005).

The Advanced Television Systems Committee Inc. (ATSC) is an international organisation which develops voluntary standards for digital television. Its members include representatives from a range of industries; film, home entertainment, semiconductor, computers, cable, satellite and broadcasting. It was founded in 1982 by member organisations of the Joint Committee on InterSociety Coordination or (JCIC), these included, EIA, IEEE, NAB, NCTA, SMPTE. Its membership has since grown internationally. Their standards for digital television include high definition television (HDTV) and also standard definition television (SDTV). The FCC have adopted major elements of ATSC's digital television standard (ATSC DTV). In 1993, ATSC were instrumental in standardising Dolby Digital for 5.1 digital television (ATSC, 2005).

The Blu-ray Disc Association

The Blu-ray format was developed jointly by the "Blu-ray Disc Association" comprised of a group of leading consumer electronics and PC companies, "to enable recording, rewriting and playback of high-definition video (HD), as well as storing large amounts of data." (Blu-ray, 2005) The discs can be single or dual layer.

The European Committee for Electrotechnical Standardisation (CENELEC) is a non-profit technical organisation working in the interests of European harmonisation. They seek to create and harmonise voluntary standards in accordance with market needs and European legislation (CENELEC, 2005).

The Digital Cinema Initiative (DCI) is a joint venture of the major film studios (Disney, Fox, MGM, Paramount, Sony Pictures Entertainment, Universal and Warner Bros. Studios). Their aim is to "establish and document voluntary specifications" and to facilitate the deployment of digital cinema systems in movie theatres. (DCI, 2005)

The Digital Television Group (DTG) was formed in 1995 to set the technical standards for digital television in the UK. Its role has since expanded to address convergence issues and all digital television platforms on a world-wide basis (DVB, 2005).

The Digital Video Broadcasting Project (DVB) was established to design global standards for the delivery of digital television and data services. It is an industry led consortium made up of members from many industries and regulatory bodies. The specifications developed by the DVB project are turned into international standards by international standards bodies such as CENELEC, ETSI and ITU. Standards are developed according to the needs of the market and consumer requirements. They are also considering how they might develop further specifications and support for converging technologies (DVB, 2005). They are responsible for designing the Multimedia Home Platform or "MHP" (MHP, 2005).

The DVD forum, founded in 1995, is an international association of hardware manufacturers, software companies and others with an interest in Digital Versatile Discs. With a membership of over two hundred and thirty companies, their purpose is twofold; to "exchange and disseminate ideas and information about the DVD Format and its technical capabilities, improvements and innovations" and to "promote broad acceptance of DVD products on a world-wide basis, across entertainment, consumer electronics and IT industries." (DVD Forum, 2005)

The Electronic Industries Association (EIA) is a trade organisation made up of U.S. manufacturers whose aim is to promote U.S. high-tech industries through domestic and international policy efforts (EIA, 2005).

The European Telecommunications Standards Institute (ETSI) is an independent organisation who work to produce telecommunications standards by consensus. The institute is also responsible for standardisation of "Information and Communications Technologies" (ICT) within Europe. Their prime objective is "to support global harmonisation by providing a forum in which all the key players can contribute actively." (ETSI, 2005)

The Federal Communications Commission (FCC) was established in 1934. It is an independent US government agency "charged with regulating interstate and international communications by television, wire, satellite and cable" (FCC, 2005). They have played a significant role in standardising formats for digital television in America.

The International Electrotechnical Commission (IEC) is a global organisation which focuses on preparing and publishing international standards in the electronics industry and related fields (IEC, 2005).

The International Organisation for Standardisation (ISO) is a global network which identifies, develops, and promotes international standards across a broad range of industries. Each ISO member acts as the principle standards organisation in its own country (ISO, 2005).

The Institute of Electrical and Electronics Engineers Inc. (IEEE) is a technical professional association made up of more than 360,000 members from many different countries. It produces "consensus-based standards," nine hundred of which are currently active with seven hundred under development (IEEE, 2005).

The International Telegraph Union (ITU) was founded in 1865 primarily to "standardise equipment to facilitate international connection" and to adopt "uniform operating instructions which would apply to all countries." Their role has changed little over the years and ITU standards are in place across a range of audio applications, including surround sound. They continue to standardise emerging systems and foster global policies. Hundreds of experts regularly gather at ITU meetings (often competing market players) to assist in drawing up recommendations. These standards protect consumers "from incompatibility problems between rival systems" and they enable manufacturers to compete within a solid global marketplace with fewer technical barriers. Global standards can also reduce costs for manufacturers, so reducing prices to consumers (ITU, 2005).

The National Association of Broadcasters (NAB) is a trade association representing the interests of radio and television broadcasters (NAB, 2005).

The National Cable and Telecommunications Association aim to provide its members with a "strong national presence" and to speak with a "unified voice" on issues directly concerning the telecommunications and cable industries in America (NCTA, 2005).

The Society of Motion Pictures and Television Engineers (SMPTE) can be traced back to 1916. Originally the "T" for television was not added until 1950 to recognise the emergence of the television industry. The original mission statement of the society was "to develop standards in the burgeoning motion picture industry." At the time there were no standards regulating film industry practices. "Today, SMPTE is recognised as the global leader in the development of standards and authoritative practices for film, television, video and multimedia." The society were responsible for the standardisation of 5.1 surround sound, and have been involved in many other developments within the film industry (SMPTE, 2005).

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Figures

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