New Dimensions in Sound

The 5.1 Surround Revolution

Table of Contents

1.0
Introduction

This essay is presented as an introduction to surround sound for the studio professional working in smaller (20 m^2 – 60 m^2) control rooms.

Although originally developed for film, multi-channel surround formats offer unique creative opportunities for music mixing and many other applications. Creative minds and critical audiences are beginning to understand that surround is not just about explosive action effects. It is also about creating a credible illusion of the sonic landscape of an open field, or of the din of an industrial workplace or of the ambience of a concert hall. In short, it is about creating sound with a level of realism, immersement and involvement that is impossible with only two audio channels.

A rapidly expanding consumer base has already been exposed to the pleasures of surround sound for movies, music, computer games, television programming, etc. In light of the substantial investments in 5.1 audio equipment for the home, it is reasonable to expect a growing disenchantment with two-channel audio and strong demand for multi-channel software

Throughout the latter half of the twentieth century, the primary focus in audio and video development has been on the evolution and refinement of transmission media (FM, television, cable, satellite, DAB) and software media (LP, open reel tape, cassette tape, 8-track, Elcaset, compact disc, laserdisc, DAT tape, DCC, Minidisc, CD-R, CD-RW, DVD).

Constant throughout this period is the one thing which all of these media have in common: Two-channel stereo audio capability.

However, recent years have seen major steps taken towards breaking through the two-channel sound barrier as all branches of the entertainment industry have come to recognize the creative potential of multi-dimensional sound. Millions of homes worldwide are already equipped with multi-channel surround systems and these systems are outselling two-channel stereo by a rapidly increasing margin.

A multi-channel amplifier/loudspeaker configuration normally consists of three front channels (left, center, right), a pair of left/right surround channels and an optional subwoofer. This set-up can reproduce matrixed surround sources (Dolby Stereo, Dolby Surround), which retain backward compatibility with stereo and mono, or fully discrete, digital surround sources (Dolby Digital, DTS). A discrete, digital surround configuration is usually referred to as “5.1” channels, with the “.1” representing the bandwidth-limited Low Frequency Effects channel.

In the early years of the new millennium, the two-channel paradigm will fade away as stereo gives way to multi-channel surround sound for transmission and storage of music, movies, computer games and television, providing unprecedented creative opportunities for producers, directors, recording engineers and performers.

The future is discrete, digital, multi-channel surround sound.

And that future is now.

2.0
From Mono to Stereo and Beyond

From the single monophonic channel of information provided by the earliest audio systems of the first quarter of the twentieth century (crystal radio, talking pictures, the phonograph), progress was slow in the move toward more realistic, natural “stereophonic” sound. While the term “stereo” is now generally taken to be synonymous with “two-channel”, the Greek word actually means solid or three-dimensional, with no specific commitment to how many channels are used to achieve this goal. It is interesting to note that the earliest stereo experiments were usually based on ***three*** independent front left, center and right channels.

In a historic experiment in 1933, Bell Telephone Labs transmitted a performance by the Philadelphia Orchestra over telephone lines to Constitution Hall, Washington, D.C. using three microphones placed across the front of the stage. The concert was reproduced using three specially developed amplifiers and loudspeakers.

In 1940, Bell Telephone filmed a concert on 35 mm with three-channel audio and a fourth track containing control signals to regulate expanders, filters and gain. Audiences were then challenged to determine if they could actually hear the difference between a live orchestra and

As late as 1958, three-channel stereo experiments were broadcast in Boston, Massachusetts, with audiences being invited to set up two FM mono radios and a TV for the center channel!

While it was the general consensus that three channels was the ideal number for optimum music playback, two-channel stereo became the standard mostly for reasons of cost, convenience and commercial practicality in connection with the introduction of the LP and FM Stereo.

With Cinemascope and 70 mm film presentations in the fifties, a stripe of magnetic tape down the side of the film carried high quality multi-channel audio. Unfortunately, only first-run theaters in major urban markets were equipped to play the surround track. And with the growth of television, interest in developing theatrical surround technologies faded.

3.0
Reflections on Surround Sound

We are well past the point where multi-channel surround could be regarded as a passing fad or a conspiracy to make old equipment obsolete and generate sales of multi-channel encoders, decoders, power amplifiers and loudspeakers. The very simple and straightforward purpose of surround technology is to imitate as closely as possible the way we hear in real life – direct and reflected sound in three dimensions.

An understanding of the perceptual grounding of surround is crucial to our acceptance of the technology as more than a gimmick for shoot-‘em-up action/adventure movies. Human hearing is omni-directional. Cover one ear and you can still hear sounds from that side and clearly place them in space.

The three-dimensional nature of human hearing plays its part even with the most uncomplicated sound sources. For instance, when listening to a single voice in a room, the direct sound of the voice and its intricate web of reflections that reach the ears from all directions provide mental cues regarding the size, shape and construction of the room and the location of the voice in that room.

But when we listen to electronically reproduced stereo or mono sources, the brain detects the familiar reflective pattern of our own listening space and registers the absence of the reflective pattern of the original recording space, making it impossible to create a you-are-there illusion. We are not transported to the soundscape of the recording, instead, the dominant reflections from our own four walls constantly remind us that we never left home at all.

A well-produced surround recording contains more of the information necessary to fool the brain into believing that what we are hearing is “real.” This applies not only to audio-only music sources. When the sonic illusion is credible, we are more willing to suspend disbelief and accept that the visual information we are receiving is also “real.”

Surround is intuitively more realistic than conventional stereo, because, when executed properly, it more closely approximates the three-dimensional orientation of human hearing.

Other valuable advantages in having five audio channels (left, right and center front and left and right surround) reproduced by five amplifiers and five loudspeakers (plus an optional subwoofer) of action movie soundtracks and to coast smoothly through the most demanding passages in well-recorded music releases.

4.0
Matrixed Multi-Channel Formats

In recent decades, developments in the fields of matrixing, perceptual coding and digital data reduction have made it possible to store and transmit multi-channel audio in the now-standard configuration of three front channels and two surround channels with optional subwoofer(s).

4.1
The Quad Wars

The launch of Quadraphonics in the early 1970's was the first attempt to add a third dimension to the listening experience, adding surround signals to the conventional stereo front channels (no front center) using amplitude-phase matrix technology. A number of factors combined to swiftly kill the concept for music in the home. Quad was a generic term for at least three mutually incompatible systems (SQ, CD-4, QS). This forced record companies to take sides, thereby limiting the number of software titles available in any one format. Home quad equipment was made more expensive by additional technology licensing fees and more complicated by additional circuitry. The channel separation and signal-to-noise ratio of the various quad formats also represented a giant step backwards in comparison to conventional stereo.

Perhaps most important is the fact that serious consumers were not impressed in the long run by the proliferation of trick recordings featuring such unmusical pleasures as trains circling the room, sitting in the middle of a table tennis match or the artificial sound of musicians blaring from every corner.

Despite its utter commercial failure, the amplitude-phase matrix technology behind the quad formats resurfaced a few years later as the basis of Dolby Stereo in the cinema: the "matrixing" of multiple audio channels into a format which provided surround playback when reproduced via a decoder, while remaining compatible with ordinary stereo and mono playback.

4.2
Dolby Stereo/Dolby Surround

Although the term Dolby Surround is loosely used to refer to all Dolby-sourced surround technologies, the term in fact refers to a very specific stage in the development of surround. To add to the confusion, the cinema version of the Dolby Surround consumer format is known as Dolby Stereo in the professional world.

Taking its cue from the quad formats, Dolby Stereo employs matrix encoding, the "folding" of surround information into a normal two-channel stereo signal, so that it can be extracted by a decoder at the other end of the chain. This is often described as a 4-2-4 matrix system. While flawed in absolute performance terms, Dolby Stereo was readily embraced by the film industry, because it meant that multi-channel cinema sound was no longer restricted to a few releases with costly magnetic stripes playable only in a handful of theaters.

Public awareness and general acceptance of Dolby Stereo came with the record-breaking success of George Lucas' first Star Wars in 1977. Because Lucasfilm was based in Marin County near Dolby's San Francisco headquarters, they worked closely on the soundtrack for Star Wars, paving the way for Dolby Surround as the de facto industry standard.

Star Wars was, however, not the first feature film to include a Dolby Stereo soundtrack, as is widely believed. Earlier Dolby matrix-encoded premieres include Stardust (1974), Litsztomania (1975), Tommy (1975), and A Star Is Born (1976).

With the introduction of home video tape recorders in the eighties, consumers became gradually aware of the presence of the Dolby Surround soundtrack on many stereo video releases and began adding simple Dolby Surround decoders, a pair of surround speakers and additional amplifiers to their home systems to create a more cinematic experience. Unlike the cinema, there was still no center channel.

With stereo VHS, laserdisc and the rise of stereo television, consumers had easy access to an extensive catalog of Dolby-encoded titles right from the beginning. Another key element in the format's success was its compatibility with stereo and even mono playback. Unlike the competing quad formats, Dolby Surround immediately established itself as the uncontested standard, eliminating confusion and inspiring confidence both at consumer level and in professional circles.

The front Dolby Surround channels are mixed conventionally, left into left, right into right and center equally into left and right (with a 3 dB reduction of the center signal to maintain constant acoustic power). When played back in stereo, the entire soundtrack is reproduced, although the surround signal is not reproduced in its correct spacial perspective. The mono surround signal is divided into left and right, after first being bandpass filtered to 100 Hz – 7 kHz, encoded with modified Dolby B noise reduction and phase shifted 90 degrees to create two identical left/right signals that are 180 degrees out of phase.

Upon playback, the decoder derives the mono surround signal by subtracting the left signal from the right signal, which cancels out the mono or center signal. The surround signal is then delayed (typically 20 milliseconds), 7 kHz lowpass filtered and Dolby B decoded. The delay reduces the effect of leakage from the front channels. Lowpass filtering reduces dialog sibilance and creates a subjective impression of greater channel separation. In addition to its main noise reduction function, Dolby B also reduces signal leakage to the surround channels.

4.3
Dolby Pro Logic

While the encoding process remained unchanged, Dolby introduced an upgraded home version of Dolby Surround decoding in 1987, known as Dolby Pro Logic. This active process offered significant improvements with enhanced localization through the use of high channel separation decoding techniques. Like the Dolby Stereo cinema process, it includes a dedicated front center channel.

A Dolby Pro Logic decoder is essentially a passive Dolby Surround decoder followed by an enhancement stage to remove crosstalk by manipulating the output signals for increased front channel separation. The result is sharply focused images and directional cues across a much

This highly flexible format can be stored or transmitted in an analog or digital form using any stereo medium and can be played back in surround via a decoder or in conventional stereo or mono. A substantial Dolby Pro Logic music catalog has also been released.

For broadcast use, in some countries a stereo/surround signal plus a mono signal is transmitted simultaneously. Stereo/surround sets pick up that signal, while old televisions pick up the mono signal. The advantage being, that mono compatibility is not an issue in the production suites.

By treating the FM mono sound in a dedicated dynamics processor, and collapsing the stereo or surround encoded signal through a 90 degree mono generator, perfect mono is always transmitted regardless of the format of the original signal.

5.0
Discrete Digital Surround

As home entertainment rapidly adopted Dolby Surround/Dolby Pro Logic, the film industry was motivated to upgrade to an even higher standard, in order to continue to offer a sound experience beyond that available from broadcast television and home video. The next step up was pure digital, fully discrete, multi-channel audio which, in comparison to Dolby Surround, offered digital audio with virtually unlimited channel separation, substantially higher signal-to-noise ratio, full-range stereo surround channels and a separate Low Frequency Effects (LFE) channel which contains just what the name says. These substantially upgraded specifications add up to an expanded sense of depth, localization and overall realism.

Combining three discrete left-center-right front channels, two stereo surround channels and an LFE channel, this layout is most often referred to as 5.1 channels, since the bandwidth-limited LFE only operates in the deep bass. 5.1 is merely a general description, not a specific audio format. As a result of the popularity of the term 5.1, matrixed formats are now sometimes referred to as “4.0” for three front channels plus one mono surround channel and no subwoofer.

5.1
5.1 Audio Formats

5.1 channel mixes are typically monitored in standard dubbing stages that meet the ANSI/SMPTE 202M specifications. Decisions on sound placement, levels, tonal character and spaciousness are all based on what the mixing engineers hear over the sound system in these rooms. Once a 5.1 channel sound mix is completed, it can then be encoded in any of the available formats.

The first 5.1 format to be presented to the general public was CDS (Cinema Digital Sound) from Kodak and Optical Radiation Corporation with Dick Tracy (1990). Dolby Digital debuted in 1992 with Batman Returns. DTS (Digital Theater Systems) launched their 5.1 format with Jurassic Park in 1993, the same year as Sony introduced SDDS (Sony Dynamic Digital Sound) with Last Action Hero. Of these formats, Dolby Digital and DTS are the most prominent, largely because these independent technology licensing companies are not perceived as competitors to the film studios and also because they are the only 5.1 discrete digital formats presently available to the consumer (Dolby Digital on laserdisc and DVD, DTS on laserdisc, DVD and CD).

quality and versatility. Reductive algorithms based on psychoacoustic models of human hearing determine which information can be discarded without – in theory - significantly affecting final sound quality.

5.1 allows precise placement of sound at any location and precise pans in any lateral direction. While the channel layout is the same as matrix surround (with the addition of the LFE channel), the higher fidelity of digital audio places far greater demands on the playback system's dynamic headroom, frequency response and dispersion control.

5.2
Reference SPL

Designed to create average sound pressure levels of 85 dB (C-weighted, slow reading, each channel) and peak levels of 105 dB, 5.1 digital audio formats demand a system capable of massive power handling, yet subtle enough to render the quietest layers of low-level detail or ambient sounds. Each amplifier/speaker must be precisely calibrated for the 85 dB reference level using pink noise.

The system must offer clean, undistorted performance without amplifier clipping at levels in excess of 105 dB.

It is important that listening be done at the 85 dB reference level. If the volume is set too low, the studio engineer will not catch low-level noise or other sounds that will be audible in the end product. If the level is set too high, low-level sounds which were clearly audible in the studio will be too soft in the end product.

With a reference SPL, the level-dependent non-linearities of human hearing are also taken out of the equation. (Equal loudness contours at different sound pressure levels are normally referred to as Fletcher-Munson curves).

Monitoring at too low levels will normally result in excessive low and high frequency energy in the final mix, while the opposite is true if mixing is done at a high sound pressure level.

When mixing specifically for television, average and peak levels are typically limited to 78 dB and 100 dB, although this is not standardized.

The existence of a standardized reference level for multi-channel audio recording and playback is a unique advantage in comparison to stereo music recording, where the end user's playback level is unknown. THX are currently preparing a proposal for a reference level for multi-channel music recording.

5.3
Speaker Set-Up

While it might seem to the casual observer that five identical speakers would constitute the ideal 5.1 system, it is important to look critically at the very different functions of the front and surround speakers. With three speakers up front, careful attention should be paid to directivity. Wide horizontal directivity provides good coverage of the listening area, while restricted vertical increasing the ratio of direct sound to reflected sound, localization and dialog intelligibility are significantly enhanced.

Early reflections should not exceed –15 dB spectrum level for the first 15 ms. –20 dB is a more ambitious goal, but may not be possible in most rooms.

To ensure a uniform acoustical environment, the room should be symmetrical about the center loudspeaker axis. Acoustic room treatments to reduce first reflections should be a high priority. Absorption and diffusion techniques approach this problem in very different ways. The choice between absorption, diffusion or a combination of both should be based on experience and the characteristics of the specific room.

Room treatments should be applied symmetrically throughout the room. Mixed Live End/Dead End environments should be avoided. The acoustics of the control room space should be consistent throughout the room.

Ideally, the three front monitors should be placed with their high-frequency drivers at ear level. If placement above or below ear level is necessary, the monitors should be tilted and aimed at ear level. The bottom edge of the surround monitors should be placed approximately one meter above ear level. Always maintain a free, unobstructed line of sight from all monitors to the main listening position.

In connection with 5.1 audio for video, the center monitor should be positioned along the center axis of the picture and the left/right monitors just outside the picture. If an acoustically transparent perforated screen is used, the left/right monitors should be placed just inside the edges of the picture.

Monitors should be de-coupled from surfaces either via spikes to channel energy away from the cabinet or via soft, rubbery damping devices to dissipate vibrational energy as heat. Effective acoustic isolation of all five monitors can tighten image focus, improve dynamic contrast and increase resolution of low-level detail.

5.4
Front Center Channel

The center loudspeaker must be identical to the left/right front pair in any serious system in order to ensure consistent timbral characteristics and smooth lateral pans.

Often inaccurately referred to as the dialog channel in movie applications, the center channel also carries the center-stage part of the music and sound effects, roughly any sound which is related to activity in the central one-third of the picture. How much a music producer wishes to center the front image is a creative decision which will vary from project to project, and sometimes from track to track.

In the cinema, the center channel is required to preserve the illusion of sound emanating from the same point as the visual image for audience members seated well off-axis, closer to the left or right speakers. Without the center channel, actors' voices would be heard coming from a different direction than the picture.

Because extreme off-axis seating is rare in domestic applications, the need for a center channel “acoustic crosstalk” occurs as the sound from one monitor reaches the opposite ear slightly behind the sound from the monitor on the same side as the ear.

The use of a phantom center creates clearly audible frequency and temporal aberrations, which are eliminated entirely by the implementation of a true center channel. Research conducted at the IRT in Munich actually demonstrates that a front center speaker almost doubles the stereo “sweet spot” before imaging distortion is experienced.

A dedicated center channel, whether for music or movies, also offers benefits such as improved clarity, a more solid, focused center image, independent level adjustment of the center channel, as well as the increased dynamic range and power handling made possible by an additional power amplifier and loudspeaker.

Since the center channel generally has more work to do than all of the other channels combined, these are not trivial concerns.

Still, many music engineers and producers hesitate to take full advantage of the center channel, partly in fear of exposing e.g. a lead vocal too much or because they fear that an active center channel will narrow the soundstage. These attitudes will probably change, as 5.1 room simulators and effects become more readily available.

In setting up the front array, the three monitors should be equidistant from the main listening position. Placing the monitors along a line does not achieve this goal, since this positions the center monitor somewhat closer to the listening position. The ideal array is an arc with the center monitor recessed relative to the left and right monitors.

Since this is difficult with in-wall or on-wall arrangements, the mixing console should allow digital delay of the center channel to compensate.

5.5
Surround Channels

The surround channels represent an entirely new use for loudspeakers: nearfield listening with monitors positioned behind the listening area or to the sides. Clearly, such a configuration requires a re-think of loudspeaker design in order to function optimally.

Conventional direct radiators, bipoles and dipoles all have their supporters for this application. Some prefer surround monitor placement directly to the sides for film and to the rear for music. The final choice will, as always, come down to room acoustics, the facility’s main areas of business, practical compromises and personal tastes.

In any event, the surround monitors should be selected for the closest possible acoustic match to the front array. Comprehensive blind tests have demonstrated that a low-cost matched system will out-perform significantly more expensive systems based on poorly matched products.

The most recent development in 5.1 mixing is the addition of a rear center channel to enhance the solidity and pin-point placement of center rear images such as fly-overs, voices, effects, etc.

To maintain compatibility with current 5.1 technology, the rear center signal has not been allocated a discrete channel to itself. Instead it is “matrixed” into the left and right surround channels, much like the front center channel in Dolby Stereo/Dolby Surround.

Designed to improve the stability of the rear center image across a wide listening area in large cinema spaces, this technology will probably only be noticeable in loud, action/adventure movies with very active soundtracks. Its relevance to home installations and music listening, where a very smaller audience enjoys more optimal seating much closer to the loudspeakers, is certainly questionable. Naturally, this has not stopped manufacturers from announcing Dolby Digital-EX home decoders in anticipation of the availability of appropriately encoded software at some point in the future.

5.6
Low Frequency Effects

The “.1” Low Frequency Effects channel was devised following the observation that systems such as linear PCM and 35 mm magnetic film tend to overload first in the bass. A dedicated low-frequency channel resolves this problem and addresses the tendency of low frequencies at high levels to intermodulate with higher frequencies in the same channel.

The isolation of low frequency effects in a dedicated channel also provides new opportunities for sound mixing and new options for equipment set-up both in the home and in the studio. The options available in the handling of low frequencies during playback (crossover frequency, roll-off, number of subwoofers) are commonly referred to as “Bass Management”, a phrase trademarked by THX in connection with the launch of consumer digital 5.1 formats.

Depending on the size and quality of the main monitors, the LFE may be distributed equally among the five main monitors. Alternatively, the main monitors may be run full-range, but with a separate subwoofer for the LFE. Finally, taking advantage of the fact that human perception of direction decreases with frequency, it is possible to feed the lower octaves (below 120 Hz) from all five main monitors to one or more subwoofers along with the dedicated LFE signal without compromise.

This permits the use of smaller “satellite” main monitors and allows placement of the subwoofer for optimum bass (typically near a wall or corner) and placement of the main monitors for optimum imaging (typically away from walls or corners). The actual upper cut-off frequency for the LFE channel varies depending on the 5.1encoding format.

An independent bass source provides enhanced flexibility of placement and level matching for optimal performance. Careful attention should be paid to subwoofer placement, so that it blends in seamlessly with the upper frequencies. Room boundaries exert profound influence on bass performance. Placement near floor and wall adds 12 dB of bass reinforcement, relative to the subwoofer’s free-field response. Moving the subwoofer into a corner adds a further 6 dB. Correct subwoofer positioning is the difficult art of finding the best possible compromise between bass quantity and quality.

Note: The level in each 1/3 octave band in the operating range of the subwoofer is 10 dB above the level of each of the 1/3 octave bands of one of the main channels, but the wide bandwidth main channels carry more overall energy. If you measure your speaker system with a sound

5.7
Dolby Digital

With the viability of matrix multi-channel surround for consumer formats so well established by the rapid acceptance of Dolby Surround for broadcast TV, VHS and laserdisc, it was only a matter of time before the more advanced discrete digital technologies with enhanced spacial realism also migrated to the home.

Originally known as Dolby AC-3 (**A**coustic **C**oding format **3**), Dolby Digital is well-established as the basis of the Dolby SR.Digital cinema surround system and has been selected as the standard format for High Definition Television via cable and satellite in the USA. Dolby Digital appeared on laserdisc in 1995 and on DVD upon its introduction in 1997. Every DVD must contain either a conventional two-channel PCM audio track or a Dolby Digital track, although the Dolby Digital track does not have to be full 5.1 channels.

Designed to be a flexible audio data reduction technology capable of encoding from one channel (mono) up to 5.1 channels, Dolby Digital is based on a transform filter bank and psychoacoustic principles.

Dolby Digital can process at least 20-bit dynamic range digital audio signals over a frequency range from 20 Hz to 20 kHz (-3 dB at 3 Hz and 20.3 Hz). The Low Frequency Effects channel covers 20 to 120 Hz (-3 dB at 3 Hz and 121 Hz). Sampling rates of 32, 44.1 and 48 kHz are supported. Data rates range from as low as 32 kb/s for a single channel to as high as 640 kb/s. Typical applications include 384 or 460 kb/s for Dolby Digital 5.1 DVD and 192 kb/s for two-channel audio tracks.

Because the data blocks of the Dolby Digital optical soundtrack are placed in the unused space between the sprocket hole perforations along one side of 35 mm film, its theatrical bit rate is limited to 320 kb/s.

When preparing a mix for Dolby Digital encoding, studio engineers should note that Dolby specifies that the LFE channel be recorded 10 dB lower than the five main channels, in order to gain an extra 10 dB of headroom. This is then compensated for in the playback chain to restore correct balance. The Dolby Digital Professional Encoder Manual can be downloaded from their website.

Acknowledging the fact that Dolby Digital market penetration is at present minimal compared to Dolby Surround and desiring total backward compatibility, DVD incorporates an automatic “downmixing” which can create in real time a matrixed two-channel mix based on the 5.1 audio elements on the disc. This two-channel signal is compatible with any Dolby Pro Logic matrix decoder or with plain stereo playback. Studio engineers should note that downmixing does ***not*** include the LFE track in the new mix, but ignores this information entirely. This may be a consideration when preparing the original mix.

5.8
DTS

Two-channel compact disc 16-bit PCM digital audio offers a dynamic range of 96 dB, achieved by taking 16-bit samples 44,100 times per second for each channel. This yields a data rate of 1,411 kb/s for only two audio channels. At the present state of technology, it is impractical to employ a similar data density for transmission or storage of 5.1 multi-channel audio. For this reason all current 5.1 formats employ high levels of data reduction, but they do so in very different ways.

We have seen how the low 320 kb/s data rate (approximately 12 to 1 data reduction) for theatrical Dolby Digital was limited by the available space between the film sprocket holes. DTS, finding such a low bit rate unacceptable on performance grounds, sought an alternative placement for their audio tracks. By employing an interlock system with only the time code printed on the film, theatrical DTS utilizes dual CD-ROM drives synced to the film for up to 3 hours and 20 minutes of 5.1 audio at a bit rate of 1,411 kb/s (approximately 3 to 1 data reduction). As an incidental advantage, the DTS soundtrack is not subject to the wear and damage that will inevitably occur when a film copy is played hundreds of times.

DTS offers 96 dB dynamic range, flat 20 Hz to 20 kHz frequency response for the five full-range channels and flat 20 Hz to 120 Hz frequency response for the LFE channel.

Introduced on laserdisc in 1997 with the theatrical bit rate, DTS on DVD was launched in 1999 with a slightly higher 1,536 kb/s bit rate, although no audible difference is claimed. Whether the much higher data density of DTS results in any audible improvement compared to Dolby Digital is the subject of ongoing discussion and heated debate.

5.9
Music in 5.1

It may be significant to note that only DTS has actively promoted its system for use on audio-only CD. Since most of the 20-bit 5.1 DTS CD titles are readily available on stereo CD, the collection represents a useful crash course in various approaches to 5.1 music mixing. The mixing decisions involved may at times seem bizarre, artistic, puzzling, bold, annoying, amusing or inspiring, but they are always enlightening.

The major point of contention here is whether to go for “concert hall realism”, i.e. musicians and vocalists in a focused, natural perspective across a front stage with only the reflected sound of the original recording space in the surround channels or to take a more “creative” approach with effects, instruments or voices placed wherever you choose, sometimes actually moving among the channels.

There are no rules carved in stone and each individual project will dictate a particular approach to the many opportunities and temptations of 5.1 surround mixing.

There is also a selection of concert performances and music video compilations on DVD in 5.1. However, due to the perceived need for the audio to “track” the image, there is usually far less “playfulness” in 5.1 audio mixing for music with accompanying video.

6.0

THX, a division of Lucasfilm, are the acknowledged guardians of excellence in film presentation at all levels. While the specifics of each THX program are zealously guarded, the various THX programs cover certification of theaters and dubbing and mixing stages and equipment for them, film print quality control, theater evaluation and approval of home audio/video equipment and software.

When George Lucas discovered the poor state of some of the theaters in which his films were presented, he set out to develop and implement a set of quality control criteria for theaters. The very first THX theaters were certified in connection with the premiere of Return of the Jedi in 1983. The THX Theatre Alignment Program offers on-site technical alignment of projection and sound equipment and evaluations conducted during normal public screenings.

The Home THX Program from 1986 sets minimum standards for surround components, in such areas as focused vertical directivity, diffuse surround envelopment, broad dynamic range, smooth, extended frequency response, amplifier gain and sensitivity. Some aspects of the Home THX standards are now virtually general industry standards, such as the 80 Hz, 24 dB/octave Lowpass filter and 12 dB/octave highpass filter specified for the subwoofer crossover in home THX systems.

It should be noted that there is some widespread confusion among many consumers who believe that Home THX is a separate, incompatible surround audio format. This is not the case.

Originally, there was one Home THX standard for rooms up to 6,000 ft^3. That standard has now been re-designated THX Ultra and a second standard, THX Select, has been created in 1999 for products intended for smaller spaces up to 2,000 ft^3.

THX also offers pre-release review and approval of 35 and 70 mm film prints and of laserdisc and DVD home software.

THX are presently working on standards for electronic, non-projection cinema presentation.

6.1
THX PM3

Of particular interest to the studio professional, is the launch in mid-1999 of a new certification program to approve smaller control rooms and equipment for them. The program is entitled THX PM3 for **P**rofessional **M**ulti-Channel **M**ixing and **M**onitoring.

As demand for multi-channel audio for television, music, computer games and other non-cinema applications grows, these mixes are often created in smaller control rooms which present their own unique set of problems. THX addresses these issues with the THX PM3 program to create rooms with consistent bass response throughout the monitoring area, wide dynamic range and smooth, extended frequency response.

The first PM3 certified sites include 4 rooms at 20th Century Fox post-production, Los Angeles, Tape Gallery, London, Berliner Synchron, Germany and a multimedia computer game audio suite at Origin Systems in Austin, Texas.

Appendix: ITU Recommendations
Cinema vs. Domestic Speaker Set-Up

Currently, at least two different speaker configurations are widely used for 5.1 reproduction:

1. The cinema approach with multiple surround speakers on the side walls
2. The ITU-R BS.775 recommendation with only two surround speakers

<INSERT ILLUSTRATIONS>

1. Front speakers behind screen with multiple surrounds down the side walls
Multiple surround speakers are harder to localize, and can be adjusted for a constant ratio of screen sound to surround sound from the front to the back of the room.

2. Center (0 degrees), Front (± 30 degrees) and Surround (± 110 degrees, tolerance ±10 degrees). Speaker distance: 2-3 m. LCR height: 1.2m. Ls, Rs height: 1.2m or more.

Note that the sound in a theater from multiple identical surround speakers carrying the same signal is very different from the ITU recommendation. In theaters, the surround channels are colored by comb filtering as a result of multiple arrival times of the same signal.

The ITU recommendation, on the other hand, is a compromise between maximum lateral envelopment (achieved with surrounds at ± 90 degrees as in the theater) and the ability to position sources behind the listener, which is not possible in the cinema approach.

If the goal is to achieve well defined, interchangeable results, the ITU recommended speaker positions for the studio should be preferred. Whether the surround speakers should be direct radiators or dipole is a matter of taste, and might be made flexible to suit different mixing situations.

It is important to obtain first-hand experience of how a mix in an ITU environment translates to a theatrical situation if the same mix is to be used both in domestic environments and with a big screen. If theater is your main goal, you should be able to mimic a theater configuration when mixing.

8.0
Resources

Technical papers, background information and late-breaking news are available from the following web sites:

www.dolby.com
www.dtsonline.com
www.soundpro.com
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