SURROUND SOUND – THE CHAOS CONTINUES

Philip R. Newell, Consultant, Moaña, Spain
Keith R. Holland, ISVR, University of Southampton, UK

A very serious question needs to be asked of the music industry in general – "Is surround-sound supposed to be a high-fidelity concept, or not?" This is an important question, because if the answer is "No", and surround sound is merely an additional, sensory dimension that gives the listeners whatever they get in their listening rooms, then this needs to be made clear to all concerned. If, however, the answer is "Yes", and that surround sound is supposed to be capable of hi-fi stereo reproduction, plus and extra dimension, then in general it is failing to achieve its goal.

1 THE EVOLUTION OF STEREO MIXING AND REPRODUCTION

Two-channel stereo has achieved a very high degree of sophistication over the fifty years, or so, of its commercial existence. Within the limitations of different loudspeaker designs producing their own characteristic sounds, good stereo control rooms can produce reliable music mixes whose sounds in other environments are largely predictable. There are also things that we know about stereo which can aid the compatibility between control rooms. For example, flush-mounting the loudspeakers in a rigid wall generally leads to a flatter overall response in well-controlled rooms. The room acoustics are also, almost universally, designed with the source and reception ends of the rooms of a different nature. This could be a relatively dead front half with a diffusive rear half, or a reflective front half with an absorptive rear half. Either way, in experienced hands, the rooms can help in the creation of reliable, predictable and musical mixes.

Of course, once the commercial recordings arrive in people's homes, all things are possible. One loudspeaker behind the sofa (for the cat to sit on), and one behind the magazine rack are possible domestic placements in homes where musical fidelity is not a prime requirement. Nevertheless, the careful placement of the loudspeakers in a suitably furnished room can usually render a reproduction quality which is largely limited only by the quality of the equipment. With this simple, two-loudspeaker arrangement, a piece of music that is well recorded and mixed will tend to reveal itself both according to the quality of the system on which it is heard and the suitability of the listening room. That is, it sounds better when reproduced on a better system in a good room. The high fidelity is available from the recordings.

Some mixing personnel are known to eschew the use of very high quality monitoring loudspeakers, claiming that for their type of music – a summer pop song, perhaps – high fidelity reproduction is not the goal. They are more concerned about how a mix will sound on the radio, or in a bar or a car, because audiophiles are unlikely to buy that sort of music, anyhow. If people wish to take that approach, they are free to do so, and conventional stereo recording set-ups allow this type of flexibility of working practices. Therefore, in some types of mixing, the highest fidelity is not the object of the exercise, so mixing to the level of the most appropriate market is always an option, but mixing to the highest level is also one of the possibilities. The choice is down to whoever is doing the mixing.

2 COMPARISONS IN SOUND

Unfortunately, when we begin dealing with surround sound, we often become less limited by choice and more by circumstances; in which case the results may not be the ones that would have been chosen if more choices had been available. Firstly, let us look at the situation in the mixing rooms, which is where most recordings usually first take shape in surround, because surround recordings in studios are still quite rare.

There are two quite distinct approaches to making a surround mix – two or three-channel stereo plus ambient surround, or fully discrete 5-channel mixing. The first approach uses essentially a frontal stereo stage, with the reverberation or certain effects distributed amongst all the loudspeakers. This method is essentially like that of a cinema, where it is considered to be unwise to put any important instrument in the surround channels in order to avoid 'The exit-sign effect'. This is due to the natural tendency for people to look towards the source of any predominant sound. It is a life-saving reflex in daily life, but in a cinema it only leads to the observation of illuminated signs saying "Exit" above the emergency doors. When all the action is taking place on the screen, no cinema director wants the audience to be facing towards the rear of the theatre, hence the restriction of the surround channels to ambient sounds.

When mixing music in this manner, an arrangement shown in Figure 1 could be perfectly adapted from a very high quality stereo room. Nothing in this control room would in any way compromise the normal stereo capabilities. The only problem with standardising on the use of such a room for surround mixing is that so many music producers still want to persue the idea of fully symmetrical surround monitoring. However, many of these producers totally fail to realise the impossibility of the practical realisation of what they are asking for. Yet, despite this fact, a whole industry has developed around trying to supply such needs, even though accurate symmetrical surround monitoring is only possible, in practice, in an anechoic chamber.

3 THE EVOLUTION OF DISCRETE SURROUND SOUND

The early attempts at making quadrophonic control rooms failed badly. Many of them merely put two 'front halves' of typical stereo control rooms face to face. The differentiation of the front and rear halves of stereo control rooms had not fully developed in the early 1970s, when these first quadrophonic rooms were built, so the true repercussions of the problems with quadrophonics were initially not fully appreciated. Figure 2 shows a room of 1977 construction, still in use as a recording control room, but in which nobody has even attempted to work on a modern surround mix. Incidentally, the one room in this studio complex, (shown in Figure 3) which does work in surround is a control room designed by Sam Toyashima, where the monitoring and acoustics closely follow the concept shown in Figure 1.

As we have previously discussed, such a room optimises the stereo reproduction by the use of different acoustic surfaces for the emission and reception of the sound waves, but in a room where loudspeakers can face in all directions, and symmetrical monitoring is the goal, this concept is not an option. The fact that all of the generally accepted stereo control room designs are asymmetrical from front to back, coupled with the fact that all rooms for symmetrical surround mixing must be symmetrical, creates an obvious conflict. By definition, therefore, a room which is optimised for symmetrical surround monitoring cannot be optimised for the frontal stereo channels. Whether this is a problem, or not, depends upon the importance given to the frontal stereo panorama in a symmetrical surround mix, and also upon whether the room will also be used for any other type of mixing, such as two-channel stereo or ambient surround. Both the two-channel and ambient surround acoustics would be compromised by the symmetrical surround requirement. The two approaches to surround mixing are therefore incompatible to the degree that no room can be optimised for both forms of surround.

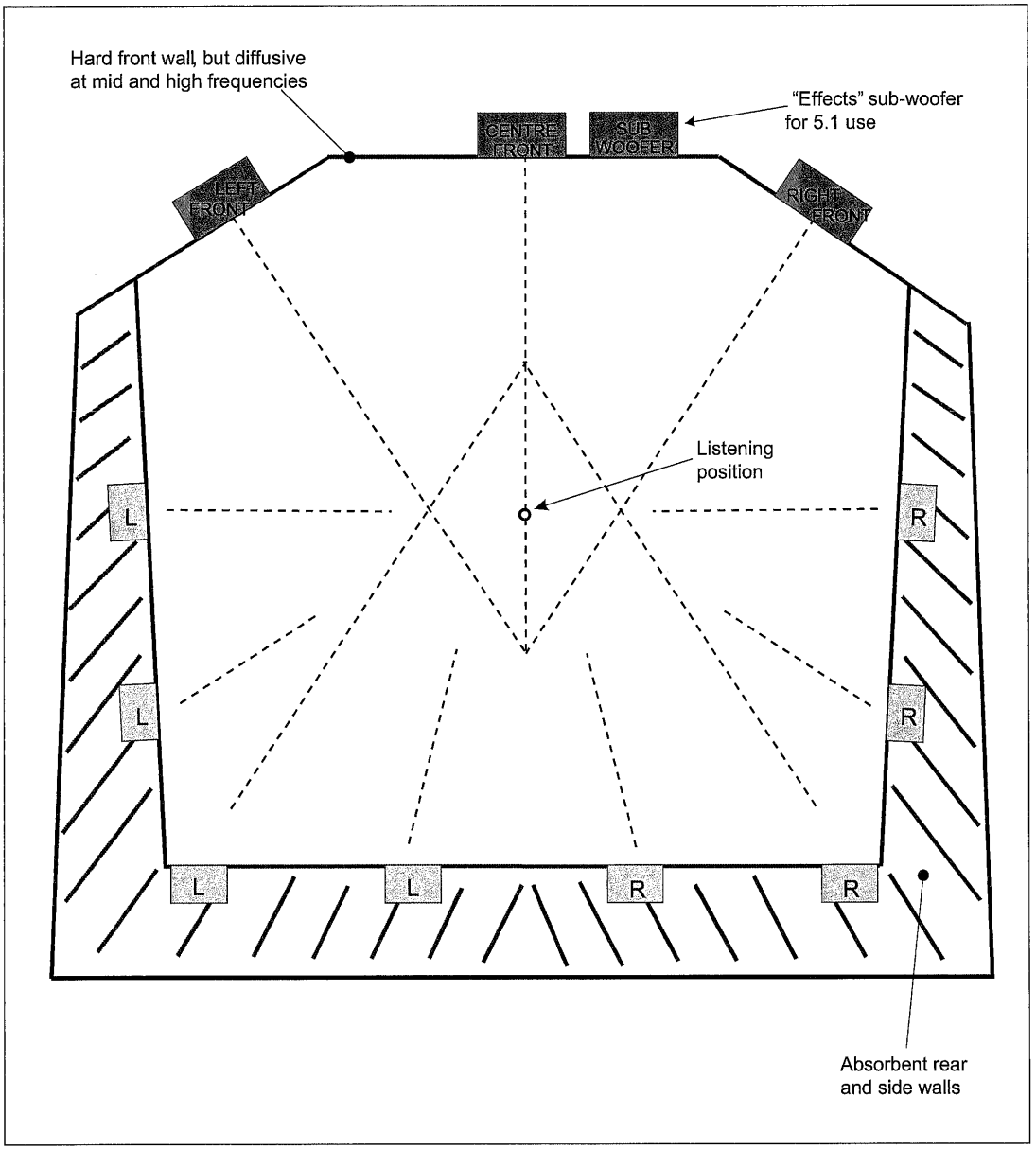


Figure 1 A Typical Stereo Control Room with Addition of Multiple, Small Loudspeakers for Diffuse, Ambient Surround

For two-channel stereo reproduction, the flush-mounting of loudspeakers is always desirable, so that the flattest in-room response can be achieved over a good-sized working area. Unfortunately, with loudspeakers pointing towards each other, they are also pointing towards the solid walls in which the opposing monitors are flush-mounted, as clearly shown in Figure 2. These plane surfaces, which are necessary to flatten the response of the loudspeakers which are mounted in them, are very disturbing to the responses of the loudspeakers which are pointing at them. There is no obvious solution to the problem, other than to use large, full-range loudspeakers in an anechoic chamber, or at least a hemi-anechoic chamber, with a hard floor but all other surfaces maximally absorbent. However, this would seem to be a rather extravagant solution, and it would certainly not be to everybody's liking to work in such a dead, general acoustic. The effective free-standing of the loudspeakers could also require up to two or three times the amplifier power than would be needed

with loudspeakers mounted in a front wall, which could lead to higher distortion and thermal compression unless the loudspeakers were also suitably enlarged. Smaller loudspeakers would suffice if the monitoring distance were reduced, though the siting of mixing consoles and equipment racks may limit how close the loudspeakers could be placed. Unfortunately, though, smaller loudspeakers tend to have reduced low frequency responses, which usually then leads to the use of a sub-woofer, or sub-woofers.

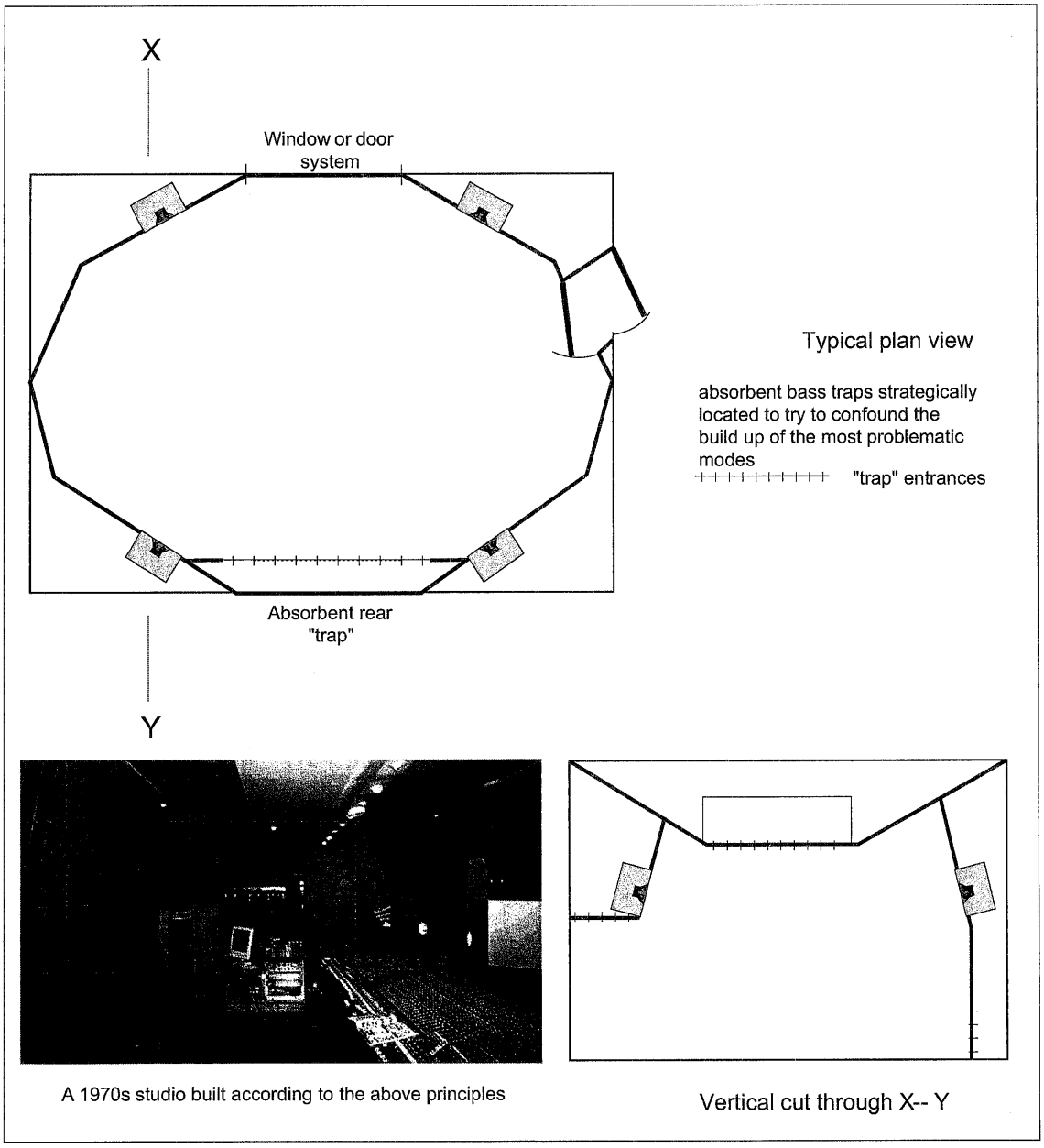


Figure 2 Quadrophonic Control Room of the 1970s Showing the Two 'Front Walls' of a Stereo Room Facing Each Other. Note the Front Speakers are Flush Mounted but the Rear ones are Mounted above the Soffits of the Machine Alcoves – Another Source of Asymmetry.

Figure 3 Stereo Control Room Adapted for Surround in the General Manner Shown in Figure 1

4 THE PROBLEMS WITH SUB-WOOFERS

If the crossover frequency to a sub-woofer is kept below about 80 Hz, the general tendency is that the direction from which the low frequencies are arriving will not be obvious. In the case of surround systems, for one person, fixed in a listening position equidistant from each loudspeaker, this could be a good solution, but for any other listeners, or any other listening position, the low frequencies will not arrive synchronously with the higher frequencies. This will give rise to a disjointed transient response and a loss of fidelity, but one reason why this effect is often not noticed is because the transient responses of the majority of sub-woofers is so poor that no position can yield an accurate transient response. Figures 4 and 5 show the response in the time domain of two different sub-woofers. Figure 4 shows the response of a typical bandpass subwoofer. The plots show that the low frequencies arrive late, continue to ring long after the drive signal has stopped, and that the ringing is at the natural frequency of the loudspeaker, which may be well away from any musical excitation frequency. The result is time-smeared bass, with a tendency to a 'one-note' boom. This, in fact, is the audible reality of so many surround sound system, both professional and domestic, but it can hardly be construed as high-fidelity bass. Figure 5 shows the response of a horn loaded subwoofer with overall dimensions nominally similar to those of the bandpass enclosure above. This subwoofer does in fact provide a rapid response, but unfortunately lacks sensitivity at low frequencies and thus cannot reproduce reasonable levels without overload.

Figure 6 shows the response of a good quality, large monitor system, flush-mounted in the front wall of a well-controlled room. Note the speed and relative uniformity of the decay (the extended response at 150Hz was found to be due to a resonant item of furniture). The important point to note is that the in-room decay of this system is much shorter than the anechoic response of the typical subwoofer shown in Figure 4. The use of satellite loudspeakers and compact subwoofer cabinets thus cannot achieve this sort of synchronised and rapid time response, at least not at the SPLs expected in music control rooms. The compact subwoofer therefore cannot be considered to provide high fidelity reproduction. They merely tend to 'fill out' the bottom end, in a way which may not be very musical at all.

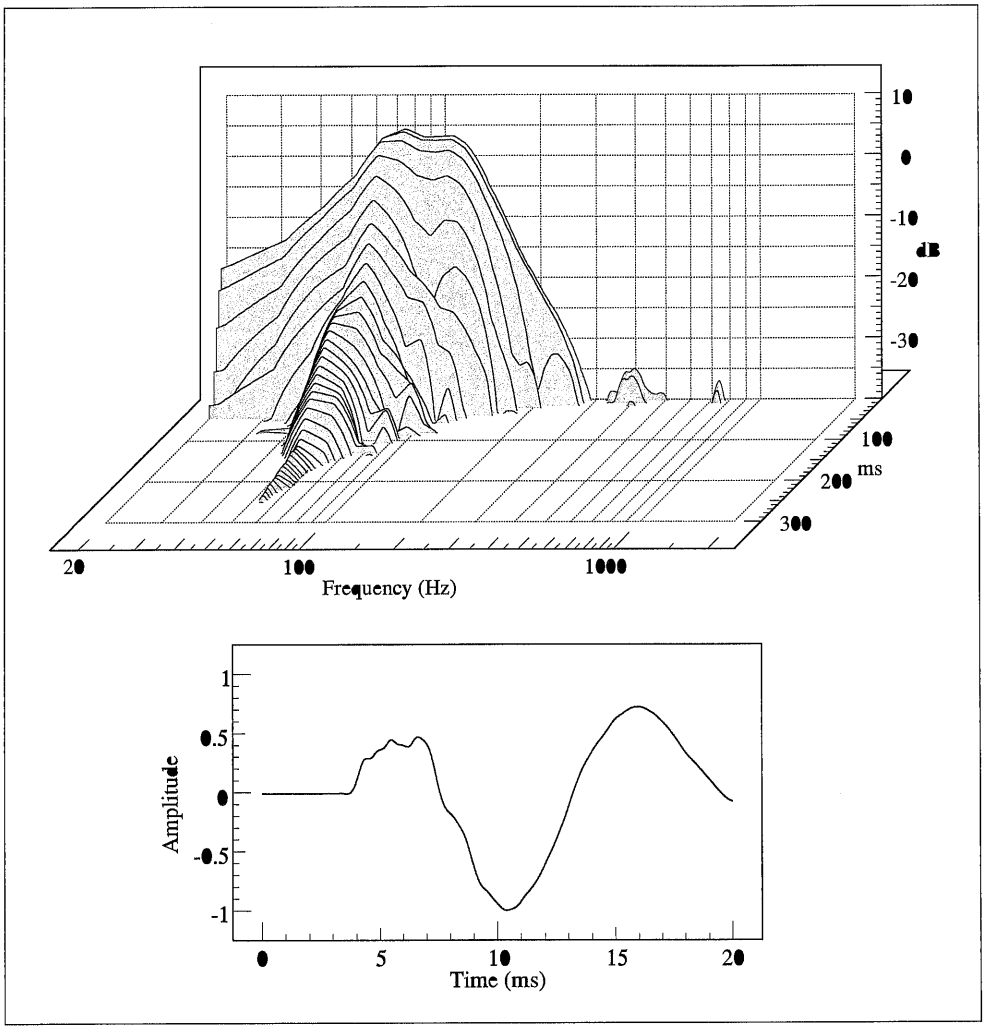


Figure 4 Waterfall Plot and Step Response of Typical Bandpass Subwoofer in Anechoic Chamber

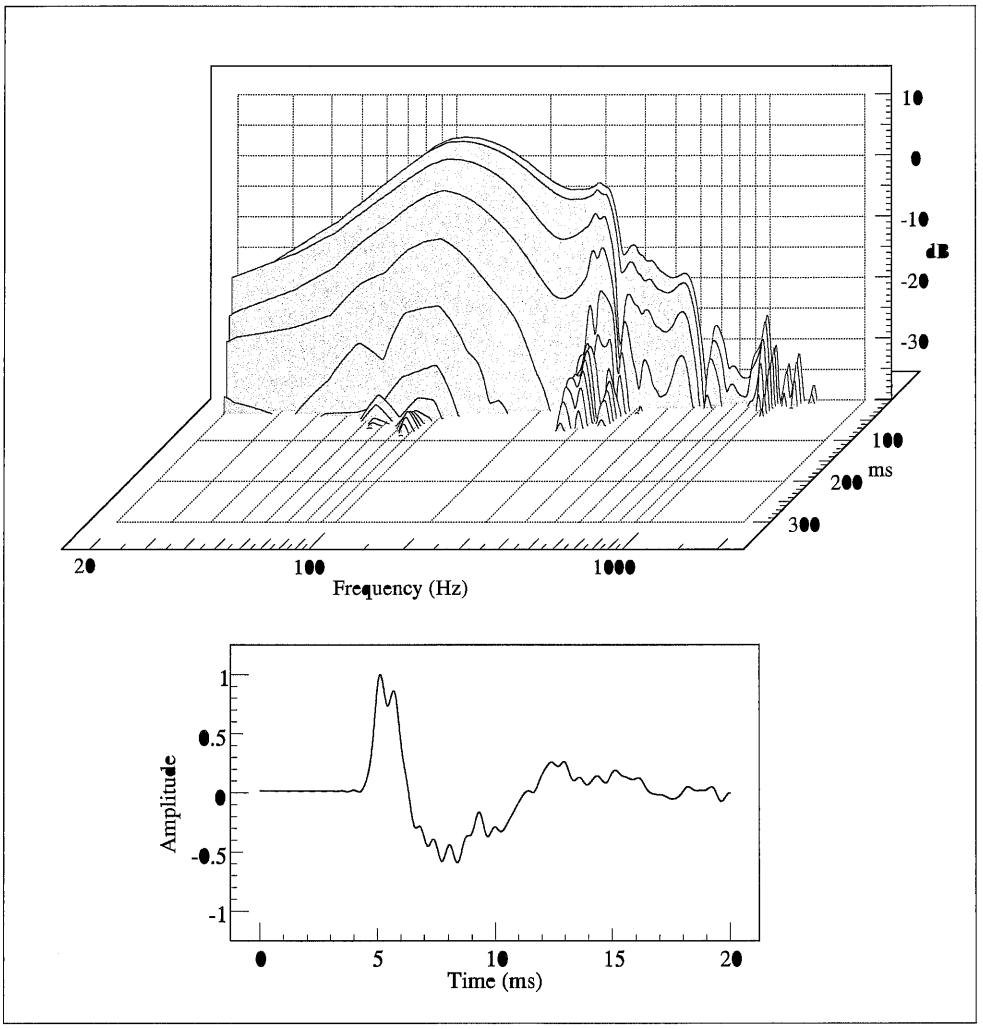


Figure 5 Waterfall Plot and Step Response of a Horn Loaded Subwoofer in Anechoic Chamber

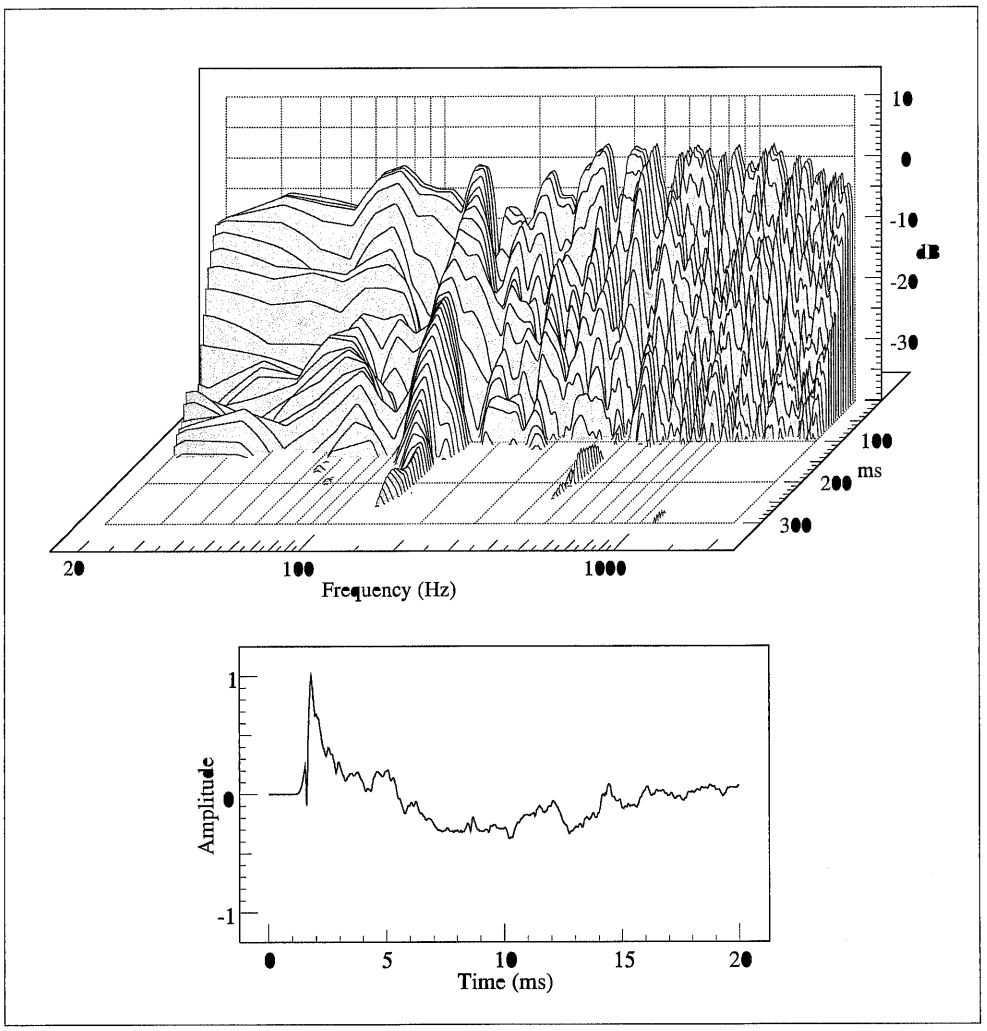


Figure 6 Waterfall Plot and Step Response of a Large, Full-Range Studio Monitor System, Flush-Mounted in the Front Wall of a Well-Damped Stereo Control Room

5 THE RESPONSE OF A TYPICAL ENVIRONMENT

It is very unusual for anybody to mix in a hemi-anechoic chamber. In the majority of cases, surround music mixes are done in rooms which have not been specially constructed for surround sound, and rather excessive use is made of close-field monitors. The result is that flat monitoring conditions are impossible to achieve, and the responses vary greatly from room to room. Uncertainty and inaccuracy in monitor set-up procedures are also much more widespread than in similar, two-channel stereo monitoring conditions, which is another reason why the mixing conditions are highly variable. The fact cannot therefore be escaped that if there is no consistency in mixing conditions, there is nothing for a 'high-fidelity' reproduction to be faithful to. What the end users hear is therefore pot luck.

The variation is also exacerbated by the use of some very different bass management systems, the appalling spacial inaccuracy arising from inappropriately located woofers, and the 'war' between manufacturers, who are endlessly trying to get more bass out of ever-smaller boxes, the resonant behaviour of which can be a travesty. The confusion in the studios about what a surround

reference should be is also very great indeed. However, if the studios cannot fix a reference for mixing, then how can domestic listeners fix a reference for playback? Again, without the reference, there can be no 'fidelity'. To be accurate in reproduction requires a reference to the production: if the production reference does not exist, then it makes a mockery of the concept of accurate reproduction, or 'high-fidelity'.

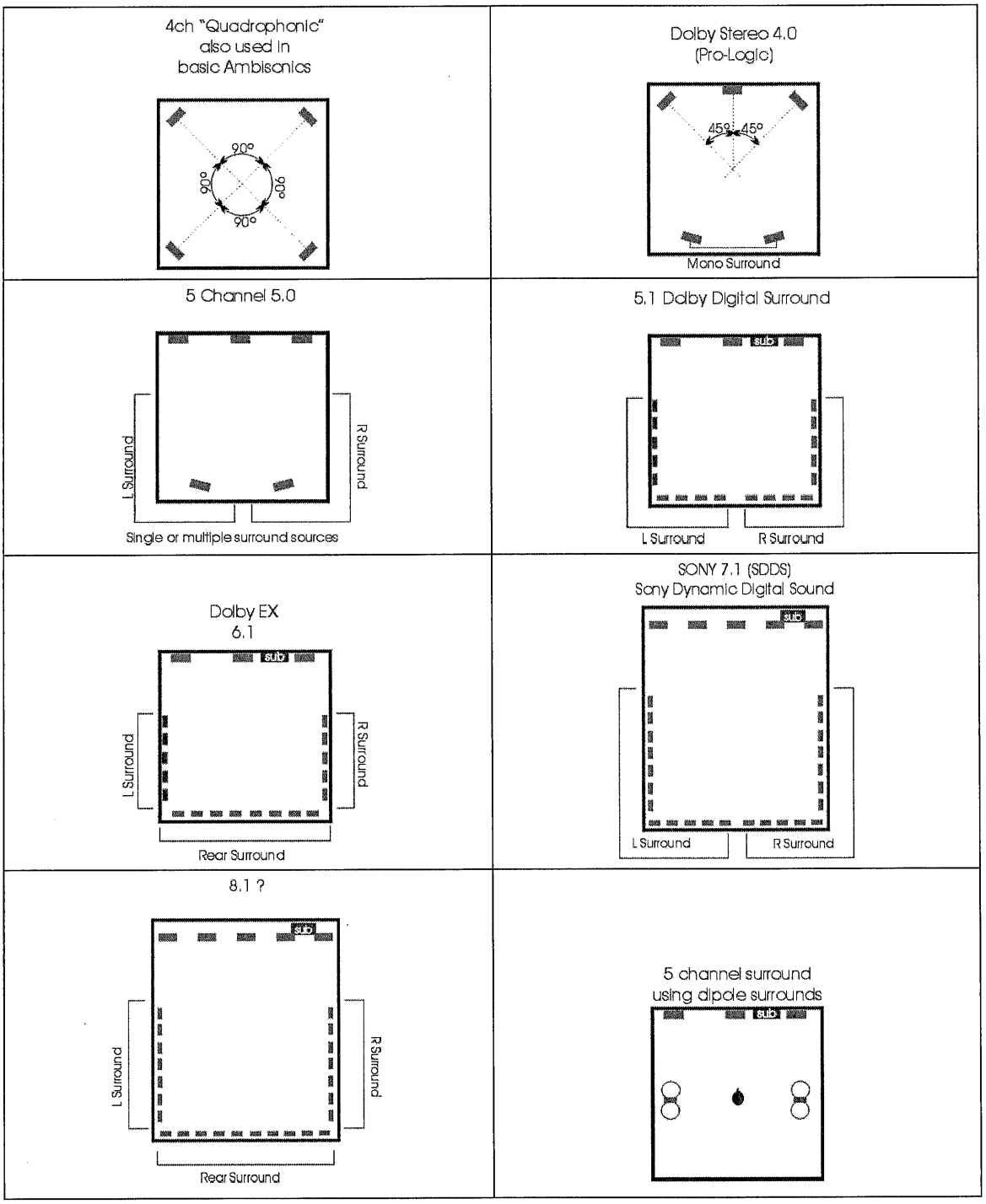
This point was highlighted by a pair of articles in the January/February 2004 edition of Resolution magazine. Christophe Anet [1], of Genelec, argued the case for flush-mounted, full-range, low distortion loudspeakers. He also offered the alternative of following an ITU-R/BS775-1 standard in the placement of the loudspeakers at 1.2 metres from the ground, at least 1.1 metres from any wall, and in a well damped room. In the same issue of the magazine, George Shilling [2] had been interviewing Greg Penny, who had just been re-mixing some of Elton John's work into surround. Penny said that he did not want to monitor on anything that was too 'high-end', because for him, the high-end was not reality. Were that statement true, then the question would beg to be asked "In that case, what is reality? Mid-fi?" He was also monitoring in a small room, which did not meet the ITU/BS recommendations, and was then asked what his recommendations would be to a novice at 5.1 mixing. His reply was "I think you've just got to find your own way, everybody's got their own way of doing it. There are no rules....." and this was from a supposedly professionally respected producer.

Well, with luck, as Greg Penny is a very experienced music mixer, and the multitrack recordings of Elton John are usually excellent, it will probably largely be a question of balancing the levels of the instruments, but this is surely no way to approach surround sound mixing in general.

6 TOO MANY STANDARDS

Figure 7 shows an assortment of layouts for various surround-sound formats. These are all formats which have some claims to reasoned existence. They are not 'crank' ideas. A quick glance over the layouts will lead to the obvious conclusion that sonic compatibility between most of the systems is not to be expected. For example, the option of the dipole loudspeakers for the surrounds, although giving good diffusion in an appropriate room, would be entirely inappropriate in a room with an absorbent rear wall, as shown in Figure 1, or in any relatively dead room. To be fair, this system was proposed by Tom Holman, as far back as the 1970s, for domestic use – not professional use – but it could never be expected to give workable results from a 5-channel discrete (symmetrical surround) mix: it is clearly intended for ambient surround, only.

Whilst the cinema world largely controls its own environments for mixing and public reproduction, the reality of what happens in people's 'home cinemas' is largely out of their control. The cinema formats of surround sound are necessarily using diffuse surround sources, because there is no other way to avoid huge level differences between different seats in a public theatre if only single sources were used for each channel. Clearly, though, such systems are not appropriate for discrete, 5-channel music mixes, because the timbral differences between the front and rear channels can be considerable.


4ch "Quadrophonic"
also used in
basic Ambisonics
90°
90°
90°
90°
Dolby Stereo 4.0
(Pro-Logic)
45°
45°
Mono Surround
5 Channel 5.0
L Surround
R Surround
Single or multiple surround sources
5.1 Dolby Digital Surround
sub
L Surround
R Surround
Dolby EX
6.1
sub
L Surround
R Surround
Rear Surround
SONY 7.1 (SDDS)
Sony Dynamic Digital Sound
sub
L Surround
R Surround
8.1 ?
sub
L Surround
R Surround
Rear Surround
5 channel surround
using dipole surrounds
sub

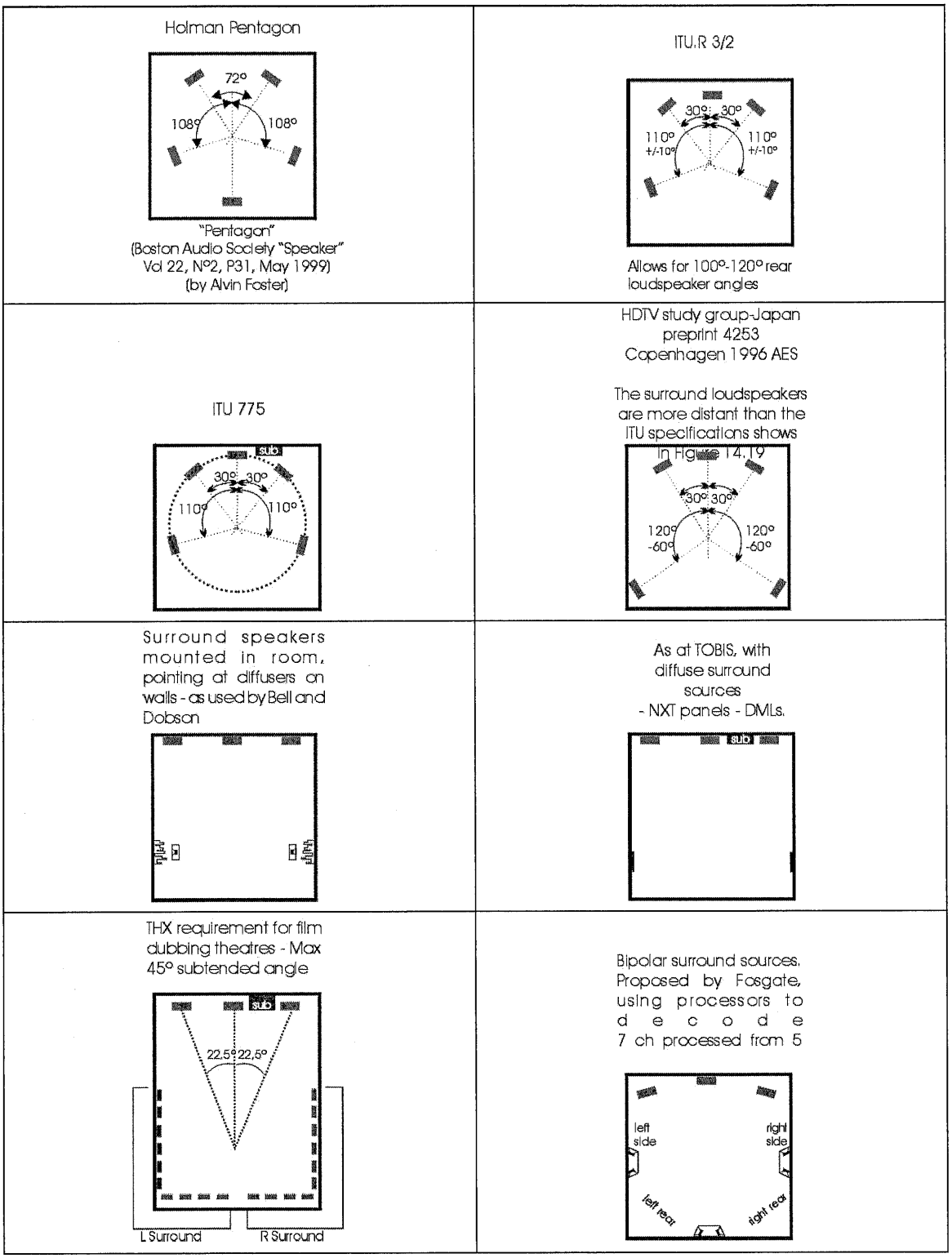


Figure 7 Layouts for Various Surround Sound Formats

Nevertheless, many people will use their home cinema systems for music-only surround, simply because they will not want to have 10 or 12 different loudspeakers in their lounges, which would be what they would need if they wished to have optimum systems for both the cinema and music styles of surround. Not only would it not be practical from a space point of view, but also because, ideally, some of the loudspeakers for each system would be required to occupy the same positions, which they clearly could not do. Furthermore, there are level differences in the rear channel set ups between home cinema and music-only surround. Almost certainly, in over 90% of cases, people would not re-adjust these levels according to what they are listening to, and indeed, experience has shown that so many home systems are not correctly set up for any type of reproduction.

In fact, can the general public really be criticised for incorrectly setting up their systems when music such as that of Elton John is being mixed with a flagrant disregard for tightly following any accepted surround monitoring standards? Just what are the public to make of this free for all? And what are the manufacturers to make of this free for all? Unfortunately, the manufacturers seem to be able to make almost whatever they like; to sell to a general public that is lost in confusion. So we must return to the question which was asked in the opening sentence of this paper, "Is surround supposed to be a high-fidelity concept, or not?" From the evidence here presented, and the situations that we encounter so frequently in the recording studios, the answer would seem to be a resounding "No!"

It would seem that the idea of domestic surround sound has been almost force-fed to a public that was not particularly asking for it. It is now very common to see very small loudspeakers in use, heavily processed and protected, and used with some rather dubious bass-management and sub-woofer systems; all these things being necessary to overcome the domestic resistance to mounting five relatively large loudspeakers in a living space. Two loudspeakers of considerable size can usually be accommodated for use with a two-channel system, but the centre-front and two surround locations can lead to great domestic disturbance if large loudspeakers are used in these channels. There is also a financial disincentive to the purchase of five very high quality loudspeakers for domestic use. In fact, many people do use a higher quality stereo pair on the front left and right channels. This gives them good reproduction for conventional stereo, and adequate reproduction of videos and home cinema in surround, even when lesser loudspeakers are used on the centre-front and rear channels. Despite not being ideal, this arrangement can again give quite creditable reproduction of ambient 5-channel surround, but it is not compatible with 5-channel discrete mixes. Nevertheless, people will play their discrete mixes on such systems, simply because they will have no other practical options. However, they would hardly be enjoying the full potential of the music, but to some degree this mix-and-match approach is the result of a lack of clear direction and co-operation on behalf of the professional side of the industry.

In fact, the professional studios, almost as much as the consumers, are having to deal with the confusion resulting from the marketing wars which have themselves resulted from the surround concept being driven into a reluctant marketplace. Few people, either professionals or domestic users, are keen to commit themselves to big expenditure on systems which show no sign of having any significant life-spans before the marketing people decide that the whole thing is redundant. Even as this paper is being written, NARAS, the organisation which gives the Grammy awards, is discussing a modification to the ITU 775 recommendation, to push the rear loudspeaker back to 135 degrees from the centre front, for music mixing. The entire concept of surround sound for music appears to have been badly conceived and badly implemented. In the previously referred to Greg Penny interview, he concedes that much rock music works better with a frontal sound stage, then explains how he put the bass guitar in the front, rear and sub channels. And all of this was done on a non-standard monitor system in an untreated room.

The low frequency response, even given identical loudspeakers for domestic playback to the ones which were used for the mix, could never be expected to be consistent from room to room. The low frequency interference patterns between the three sources of low frequencies would be entirely dependent on the distances that the loudspeakers were from each other, and the distances from, and the nature of, the room boundaries [3]. As the number of common sources goes up, the

complexity of the interference fields increases rapidly, but so many music mixers neither seem to know nor care about this. Of course, once the real-world variables of different sub-woofer, different crossover frequencies and bass-management systems are added to the equation, any hope of fidelity of reproduction becomes a question of nothing more than luck. Spurred on by a music industry that looks for ever more new sensations, the music mixers are also under pressure to produce the goods, whether they are accurately reproducible or not. If this is truly the case, even with top level surround sound mixes in 2004, and now over thirty years after the advent of quadrophonics, then the title of this paper would seem to be fully justified. So, where do we go from here?

7 AN IMPROBABLE SOLUTION

There is a real chance of good compatibility between music surround using ambient rear channels, home videos, and home cinema reproduction. A system which was optimised for such use would also readily lend itself to two-channel stereo reproduction. In this way, a good sensation of ambience can be achieved, along with a reliably reproducible frontal sound stage. However, the record companies, in their endless search for the re-use of old material, have deemed that surround mixes with an ambient stereo format are not 'sexy' enough to stimulate a mass market into renewing much of its music collections. The record companies have, in isolation, opted to go for a discrete, 5-channel music mixing regime which makes not only its own impossible demands on an otherwise compatible world of surround, but also makes demands which are not even compatible with the concept of high fidelity reproduction; at least not in any way that could be realised in practical circumstances. The fact remains that the 5-channel, fully discrete surround concept, if optimised, will compromise the achievable quality of the left/right/frontal stereo sound quality.

In the opinion of the authors, 5-channel, fully discrete, high-fidelity, surround-sound music mixing is an unattainable goal, primarily because of the difficulty of interfacing it with real rooms, but also because of its incompatibility with other domestic surround requirements. In many ways, the concept of discrete 5-channel surround is blocking the development of the better implementation of more appropriate systems, both professional and domestic. The problems involved in 5-channel, discrete, symmetrical surround mixing are not realistically solvable, and the compromises which must be made to its reproduction lead to a reality that can hardly be considered to be high-fidelity. A standardisation on 3-channel frontal stereo plus ambient surround would solve most of the problems. For classical music, it is already almost the de facto situation.

8 ACKNOWLEDGEMENTS

The authors would like to thank Julius Newell for assistance with the subwoofer measurements and Sergio Castro for the artwork.

9 REFERENCES

1. ANET, Christophe; 'Multichannel Control Room Acoustics and Calibration', Resolution, Vol 3, No 1, (V3.1) pp58/9, UK, (January/February 2004)

2. SHILLING, George; 'Greg Penny' Resolution, Vol 3, No 1, (V3.1) pp 44-6, UK, (January/ February 2004)

3. HOLLAND, Keith R; NEWELL, Philip R; 'Mutual Coupling in Multi-Channel Loudspeaker Systems', Proceedings of the Institute of Acoustics, Vol 19, Part 6, pp 155-162 (1997)