

# OBSERVATIONS AND EXPERIMENTS WITH SURROUND SOUND

Tony Andrews      Funktion One Research, England  
John Newsham      Funktion One Research, England

## 1 INTRODUCTION

This paper is an advocacy for surround sound as an exciting extra dimension to the sonic experience and Ambisonics as the favoured approach on which to base methodology.

## 2 IMPORTANCE OF THE AUDIO SPHERE

Although common wisdom holds sight as our primary sense, it only perceives information from less than half a sphere through a relatively narrow electromagnetic window. It can also be "switched off" by closing or covering the eyes or by darkness. Sound however, is sensed full sphere and with a much greater number of octaves. Perceived light has one octave whereas sound is perceived across 10 octaves. Hearing can never be completely avoided, even the strongest earplugs only muffle and also sound is received by the body as well as the ears. As such it is the major contributor to our feeling of where we are in space and the nature of that space, in a more complete and accurate manner than light. Sound conveys a constant stream of information about events located anywhere in our audio sphere to which the brain devotes considerable resources to achieve sound localisation. The brain would not use this much energy unless sound localisation was of major importance and is therefore intrinsic to man's survival. We propose that at an early stage in man's evolution a moving event would be prioritised because of its indication of immediate danger, such as the possibility of being eaten, or alternatively the presence of possible lunch and is therefore more stimulating to the emotions than stationary sound.

## 3 EARLY HISTORY OF SURROUND SOUND

Stimulation of the emotions implies that moving sound has high entertainment value which was recognised as far back as the late 1930s and implemented by Walt Disney and Leopold Stokowski in their collaboration to produce a surround sound system for Fantasia. Fanta Sound pioneered multi track recording with 6 tracks for sections of the orchestra, 1 for a remote microphone and 1 microphone optimised for overall balance. These 8 tracks were then mixed down to four tracks, control, screen left, centre and right by means of a "3 circuit differential junction network" based on earlier work at Bell Laboratories. This device was named "the pan pot". Screen left, centre and right loudspeaker positions had derived equivalents in house left, centre and right which in effect was 6 channel surround with screen orientation for cinemas<sup>1</sup>.

## 4 QUADRAPHONIC IN THE EARLY 1970S

During the Late 1960s it was realised that there was commercial value in bringing surround sound to the living room. No doubt the envelope expanding mood of the times was part of the driving force. Stereo was being used to its maximum effect on albums such as Sergeant Pepper and

Electric Ladyland. The stereo panning on Electric Ladyland's Voodoo Chile is astounding and made a permanent impression on our young minds. By 1971 a number of systems were on the market, the most prominent being CBS's SQ, Sansui's QS and JVC's CD4. Most of them were matrixed quad with left and right rear channels derived from extra information within the standard stereo grooves of vinyl records. JVC's CD4 system was different in the fact that it employed a high frequency component around 35kHz to carry the rear channel information requiring a special stylus as well as a decoder. Opinion has it that the Sansui QS system with its Vario Matrix decoder gave the best results. All of these systems were still restricted to four loudspeaker positions with a front and rear orientation and derived right and left rear channels although they did allow play on standard stereo setups. The Ambisonic System however, was to our knowledge, the first serious development towards a system capable of regenerating a full audio sphere with a multiplicity of loudspeakers.

## **5 DEVELOPMENT OF AMBISONICS**

A collaboration between Michael Gerzon, John Hayes, John Wright, David Brown and Professor Felgett of Reading University developed the Ambisonic system which included the well known Soundfield microphone with its 4 capsules in a tetrahedral arrangement and also a method of encoding B format (comprising reference W and axes X,Y and Z) to stereo which was known as UHJ. The collaboration was backed by the National Research and Development Corporation which later became the British Technology Group (BTG) who became the owners of over 100 patents resulting from the development work. It was extremely well received when launched in the mid 1970s but the surround sound market was declining due to the confusing number of systems, most of which were not good. Despite this the BBC broadcast UHJ encoded stereo FM radio for a number of years during the 1970s and interest was so strong in the USA that Dolby Laboratories were keen to do a deal with BTG but were unable to reach terms. It is said that this was largely because of BTG's bureaucracy and unacceptable management demands on Ray Dolby who then went on to develop his own system which is now the ubiquitous Dolby 5:1<sup>2</sup>. (It is interesting to note that Dolby Laboratories employ Michael Gerzon's lossless compression algorithms). The outcome is that Ambisonics, although brilliant and flexible has been side-lined and the World is limited to a standard employing a discrete approach to location and adherence to stage and screen orientation with a fixed layout of loudspeaker positions, so relegating sound as merely an adjunct to the visual experience. Whereas, Ambisonics allows realisation of the full potential of surround sound by affording equal importance to all directions including vertical. Furthermore Ambisonics utilises a conspiracy of more than one loudspeaker to achieve event location, it is very adaptable regarding the number of loudspeakers and their positions. Convincing event location is available over a much larger area, even perceivable from outside the sound field. Last but not least, the elegance of the B format encoding allows multi channel systems to be built with much less repetition of hardware than is the case with discrete approaches.

Ambisonics is the best surround system we have experienced and Michael Gerzon and his fellow collaborators are to be commended for their vision.

## **6 EVOLUTION OF EXPERIMENTAL SOUNDFIELD**

Our first foray into surround sound was with Jonny Rotten's Public Image back in the 1970s employing the eminently simple approach of using the difference between the two normal stereo channels to derive a third rear channel as per Haffler [see *Figure 1*]. It was reasonably effective and drew the apparent sound away from the stage and into the audience. Signals panned hard to either side would be more present in the rear channel. We also built an 8 channel Haffler system for Steve Hillage's Rainbow Dome Music at the first Festival of Mind, Body and Spirit in 1979.

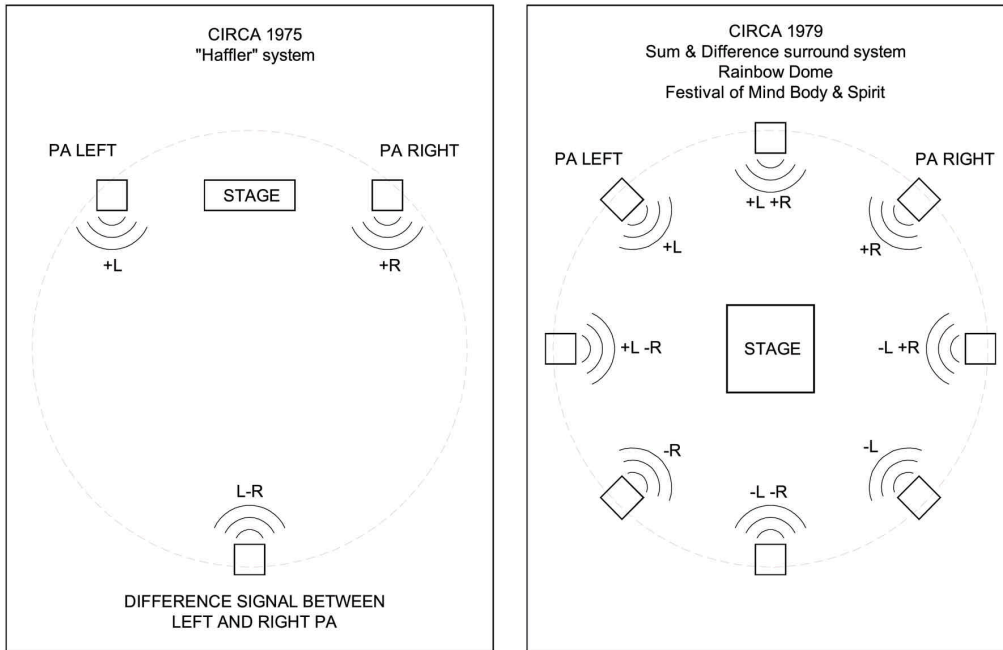


Figure 1

After discovering Ambisonics in the Late 1970s we acquired a Minim decoder with which we attempted enhanced stereo at the early Glastonbury Festivals. We knew that as Ambisonics relied on subtle phase information it was important that the loudspeakers were as accurate as possible in terms of time coherence and fidelity. To avoid upsetting the Bands with delayed percussive information we avoided aiming any of the loudspeakers at the stage and so restricted ourselves to the arrangement as shown below in *Figure 2*.

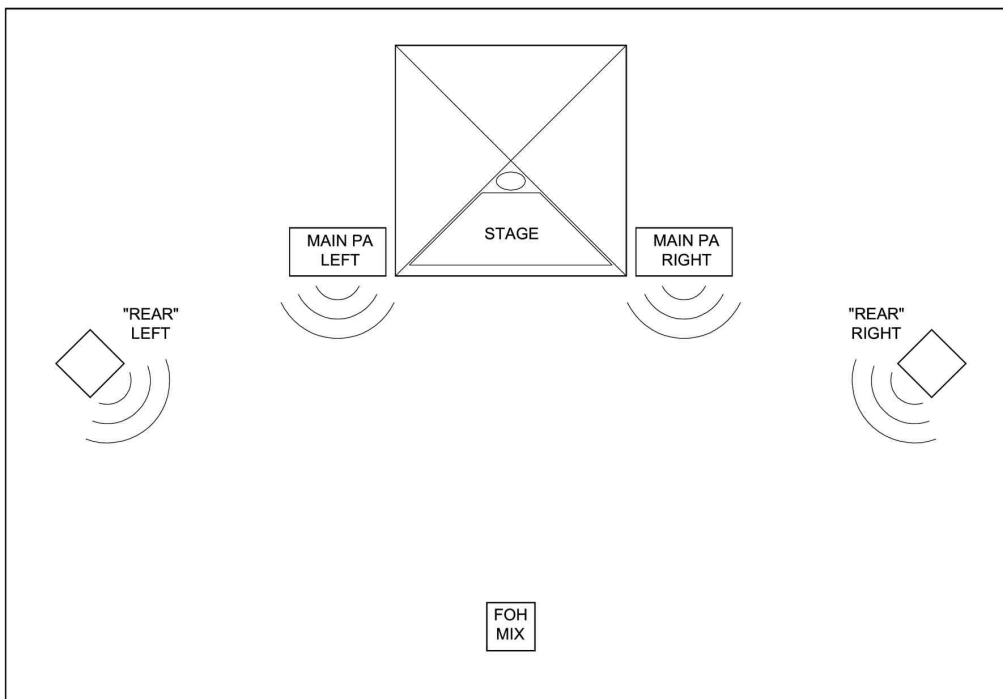


Figure 2

There was definitely stereo enhancement but this was not full surround sound. Our options for further experimentation in conjunction with live bands were limited by the effects of the slow speed of sound. We had become involved with the emerging House Music Dance Culture and found it to be more compatible and exciting than the conventional set up of band on stage with a stack of loudspeakers either side.

### 6.1 Music without stage orientation

With the advent of the microchip, dance music and djs we could tap into programme material that would not be disturbed by delayed sound. Electronic music had no specific directional orientation and was very suited to the geometrically balanced approach of Ambisonics. If we put the control position in the middle of the sound field [see figure 3] we would not only halve this distance but it would put all those involved, musicians (Underworld), djs (Danny G and Darren Emerson) and engineers (us) in the same sound field as the audience in close proximity to each other so removing the separation of the stage with its dedicated monitoring system. Live input could be monitored on headphones to overcome the delay issues and Trevor Morais played live drums on a direct inject electronic kit which was quiet enough locally not to distract from the sound field. Our goal was to transcend the normal "shoebox full of lights and sound" at one end of the hall with all the audience facing in the same direction.

In 1992 we set up what we termed the Experimental Soundfield in a field at Glastonbury. We performed continuously by moving between musicians and djs for 14 hours on the Saturday with the old Pink Floyd Quadraphonic add on desk for rotating selected inputs. [See figure 4]. It was a very powerful experience for all concerned and we are advised that it is in a list of the top 100 best dance events ever. The experience of the sound so immediate and encompassing coupled with the moving events was a major part of the experience.

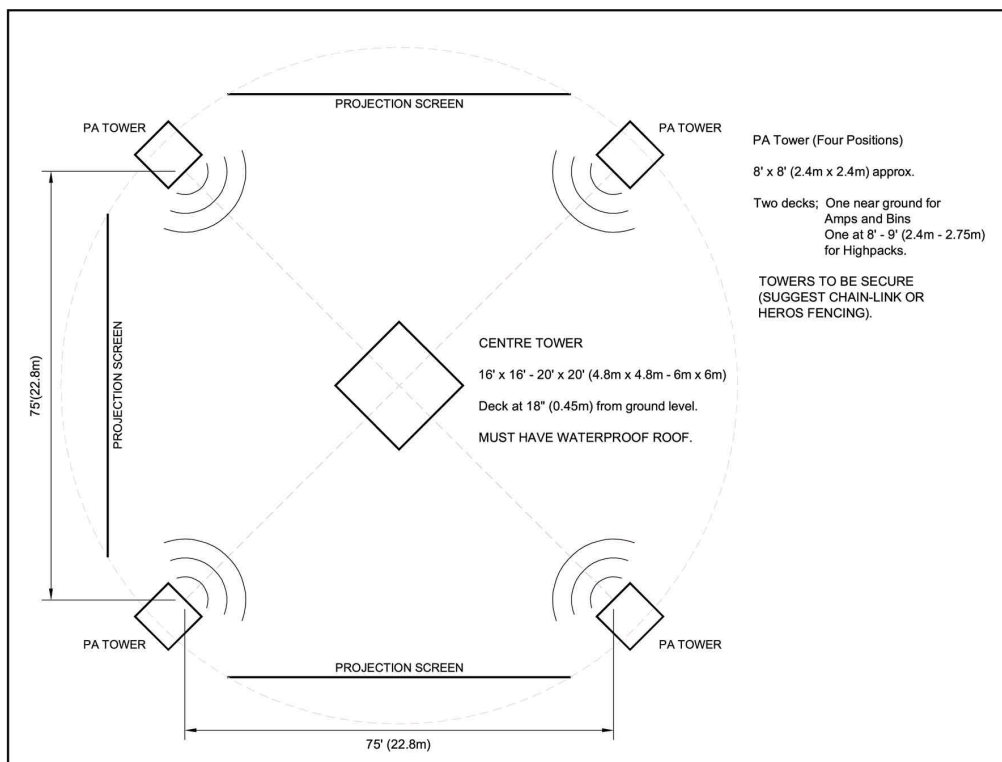


Figure 3

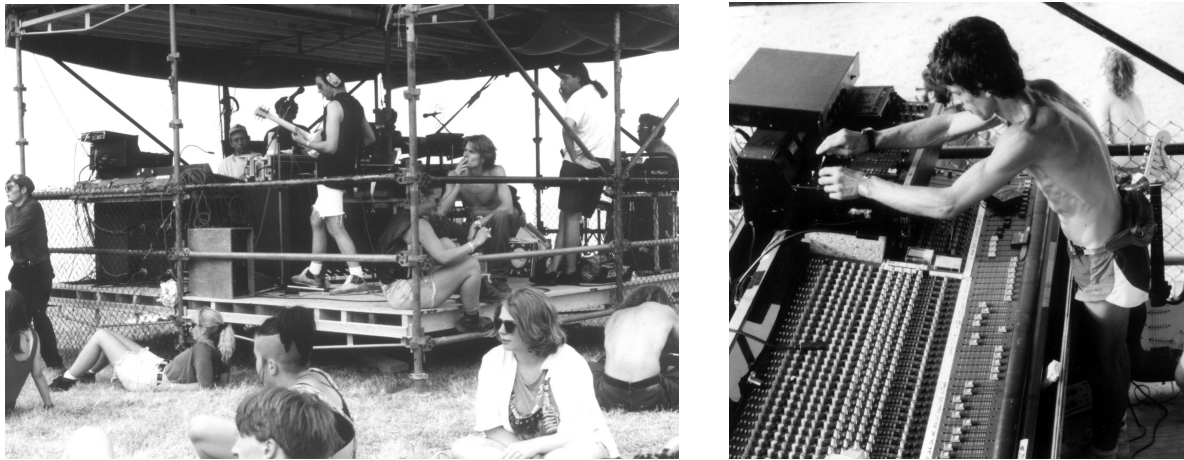


Figure 4 - Experimental Soundfield Central Tower at Glastonbury 1992

## 6.2 Implementation of Computer Control

A chap called Chris Blythe came forward with the determination to use computers and a programme to facilitate moving events. This was a great relief concerning the amount of wrist strain we suffered from operating the quad joysticks during the Glastonbury experiment. Over the next few years Chris and his partner Bill Croston (Audio Dimensions) built 8 channel VCA controlled hardware with input from Ben Duncan (Ben Duncan Research) who was also present at the Glastonbury Experiment. Bill wrote a comprehensive DOS programme to control the hardware. The signals from the 8 VCAs were mixed Ambisonically into B Format without the height information (Z axis). Chris Richards then of Cepiar supplied the 8 channel Ambisonic decoder with the addition of a UHJ decoder for enhancement of stereo material. [See Figure 5].

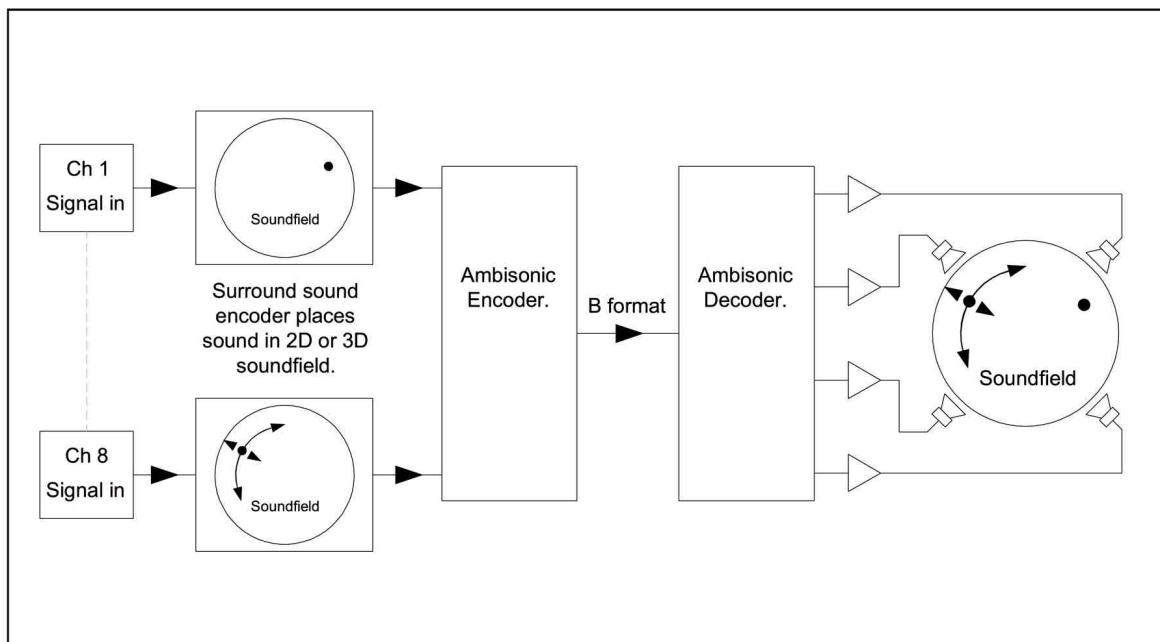


Figure 5

We tried all this out at another Experimental Soundfield at Burgess Park, Lambeth. Despite hardware and software teething troubles the audience reaction was astounding and we were encouraged to continue the evolution. From this event we learned that 4 stacks of loudspeakers placed equally on a 100 foot diameter circle was too large a spacing. Despite using Ambisonics a person located close to an individual loudspeaker would get the impression that the loudspeaker was turning on and off when the entire programme material was rotated. We decided that in future we should use 6 positions, as shown below in *figure 6*. We also aimed the loudspeakers with more declination than necessary to avoid too large a level from one side of the circle to the other which helped us mitigate being outside the 40 foot Haas window with the size of our Soundfield.

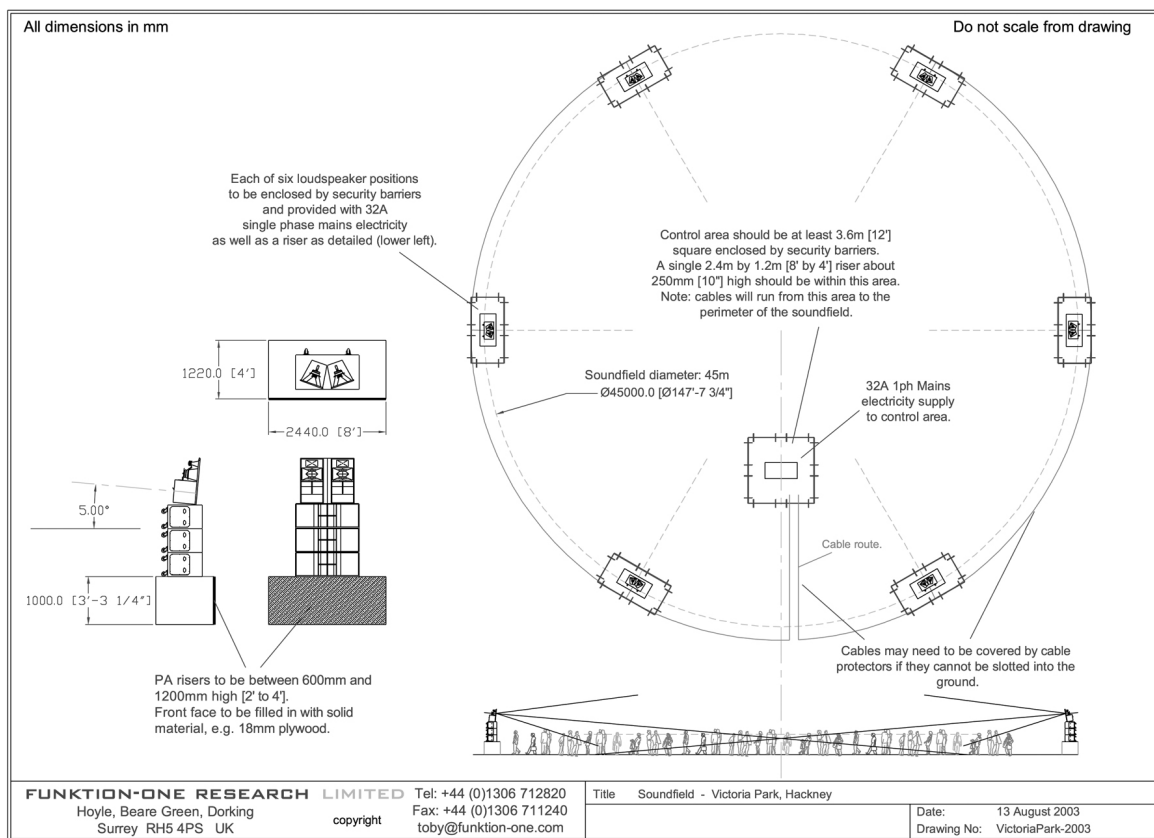


Figure 6

### 6.3 Feature Extraction

The need arose to derive moveable events from standard stereo material. With Ben Duncan's help we built a specialised parametric EQ which allowed us to extract chosen frequencies which would more or less encompass the bandwidth of a particular instrument or voice that could then be reintroduced to the normal stereo landscape as a moving or stepping event. We undertook several more Experimental Soundfields and advanced our hardware which is still in use with The Chemical Brothers to this day. [See *Figure 7*].

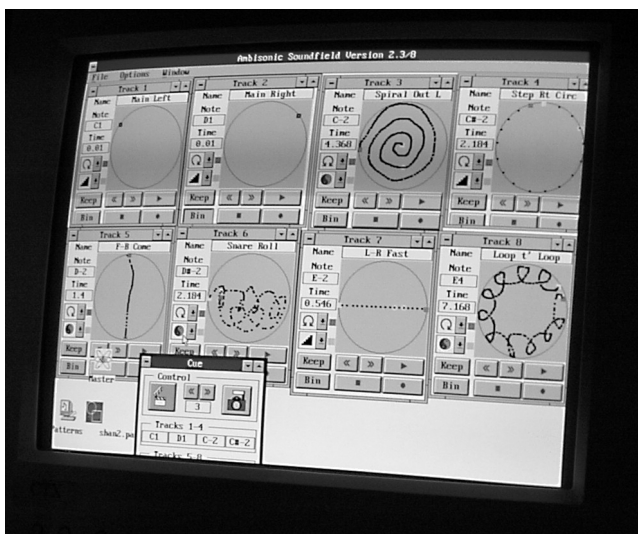


Figure 7 – Screen Shot from recent Chemical Brothers tour of Japan

We are currently converting the frequency manipulation to digital with a view to providing a more precise and enhanced event channel. We successfully tested a prototype with Sancho Panza at The Glade Festival, Aldermaston in July 2004. [See figure 8].



Figure 8 - The Glade Festival, Aldermaston in July 2004

## 7 CONCLUSION

In conclusion we have satisfied ourselves that surround sound is viable in arrangements with a diameter in excess of the Haas window. In fact we have had good results with circles over 30 metres in diameter. The most effective approach for localisation and moving events is Ambisonics. It is an effective enhancement to the music and dance experience as borne out by the many enthusiastic comments and communications we have received from people who have attended our Experimental Soundfields. The extra dimension and ability to generate moving events afforded by surround sound can be truly said to improve the listening experience.

## 8 REFERENCES

1. Middle Tennessee State University Society of Motion Picture and Television Engineers [History of Film Sound]  
<http://www.mtsu.edu/~smpte/forties.html>
2. History of IMF – email from John Hayes published on the Internet  
<http://imf-electronics.com/history/>

Further Reading on Ambisonics

[http://www.york.ac.uk/inst/mustech/3d\\_audio/welcome.html](http://www.york.ac.uk/inst/mustech/3d_audio/welcome.html)