Wembley Stadium - Sound System Design - A Description of The Brief, Design Criteria, Implementation And Results of The First Two Project Phases

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The Client is Wembley Stadium Plc., and the site includes the Wembley Arena, Wembley Conference Centre, the Exhibition Centre and other peripheral areas.

The first two phases of the project had the following brief:-

a) To provide a life-safety evacuation sound system.

b) To provide a music quality sound system to improve the sound for many parts of the Stadium and to reduce the Environmental Noise normally associated with such coverage.

c) To provide top quality sound reproduction for commentary and other sounds associated with sporting events.

d) To provide high quality sound reproduction for the other areas of the stadium e.g. Tours and staff paging.

The first two phases were to encompass the Stadium audience area in terms of electroacoustic systems, but a Central Processing System for the whole building.

The electroacoustic systems for the concourses, turnstiles and bar/restaurant areas were to be addressed at a later date. So too was the interlinking and coverage of the other site venues such as the Arena, Conference Centre, Exhibition Halls and the Car Parks.

Even though the initial phases of the project only served the main Stadium areas, the concept of the systems design had to take into account the eventual coverage.

Life Safety Sound requires that the announcement can be directed at a particular exit route - i.e. from seat to safe area via staircases, concourses, gates etc.

Pop concert delay sound requires indisputably top quality components in both transducers, and signal processors. It also requires extreme flexibility and individuality of control.

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Sports application of a sound system are basically subtended by the aforementioned requirements, but must be included in the foremost thoughts of a systems designer since these events represent more than 90% of the use of the Stadium.

This analysis of the Clients brief leads to the following list of parameters:-

a) Multiple loudspeaker location - effectively low level distribution.

b) High quality transducers - predominantly driven at low impedance.

c) Local amplifier rack locations to reduce the line losses of a low impedance system.

d) Individual delay times for every loudspeaker group according to:-

   i) Source location.
   ii) Source selection.

e) Zone by zone equalisation for optimum intelligibility .

f) Automatic change of signal processor parameter dependant upon source, but independent of other zone requirements.

The resultant 125 zones of loudspeakers requires some detailed effort on behalf of a systems designer in order to provide a "user friendly" human interface.

To this end, the prospect of an announcer (or a concert sound engineer) operating a large metal panel filled with a myriad of push buttons would be so intimidating that the flexiblity of the system would be diluted into insignificance.

Despite the designer's healthy disrespect for the reliability or ergonomic usefulness of traditional computer systems, the practicality of the job demanded a computer based system.

"User Friendliness" was specified to take the form of a touch screen on a graphical representation of of the areas.

Reliability was built into the structure by networking the operations computers, thus allowing any outstation to be capable of emulating another.

Furthermore, the central computers were built to be able to handle the basic selection process of the whole system from any one of the two or three central computer stations.

A healthy 800% redundancy was built into the life safety applications of the computing section.

Despite all this back-up, the systems design included a facility to electro-mechanically change the input to every amplifier from the digital input to a straight-forward audio signal down a copper cable. The end result is currently 55kw of audio amplification on the end of a single microphone. This is known as the "All Call Back-up Microphone" and is only accessed by a "break glass" emergency switch.

Signal distribution is an area which has hitherto been passed over. The search for ultimate quality and immunisation from the plethora of nasty signals such as thyristor dimmers, air conditioning units, lift motors etc, lead the system designer to look very carefully at the way in which signals were to be distributed to the 12 local racks of amplifiers.

The sources for the sound system fall into three main categories:-

a) Crowd control & general announcements.

b) Operator controlled music and speech mixers

c) Direct injection music and/or speech.

In the case of crowd control, all areas must be capable of being accessed either individually or in a group. This is achieved by means of a touch screen on a computer monitor which gives a graphical representation of the areas. Due to the density of the zone representation, the software provides a zoom facility in order to be able to quickly select a particular zone either alone or as part of a group. Where groups of zones are likely to be repeated, the selection can be stored as one of three presets. These presets can be recalled at any time.

Crowd control and general announcements are performed from three areas:-

Police Control
Wembley Control
Front Desk Reception

The latter being a first line back-up in case anything untoward should happen to the main control rooms.

Operator Controlled music and speech mixes also require zone selection and grouping.Multiple inputs to the matrix from Sound Control allows one operator to feed different sources to particular areas simultaneously.

In addition to the Sound Control Room mix position there is a socket box at the Royal Tunnel which allows either direct injection at high priority (as used for pop concerts) or multiple injection via tie-lines back to the Sound Control Room.

The third category of direct injection music and speech sources is represented by a facility known as "Tours". The tours are a visitor attraction telling the tales of the sporting legends and the magic which the name Wembley conjures up for them. The audio visual controller accesses the appropriate channels and the audio signal is fed to the matrix input port.

During Greyhound racing the commentary and betting prices are announced from the Steward's Room. While this has traditionally been controlled via the sound desk, it is now possible for the steward's microphone switch to enable a high priority input. Thus the necessity to continuously man the sound control room is diminished considerably.

Schematically, the control system is very simple. There are:-

12 inputs with individual signal processing in the analogue domain.

A 12 in 128 out digital matrix.

88 channels of digital signal processing.

128 output channels spread around the stadium.

Having decided to run the loudspeakers at low impedance, the amplifiers required to be as close by as possible. This then posed the problem of audio distribution with interference immunisation and physical security. It was the latter which brought forward the case for fibre optic distribution of the audio. Indeed, the concept of digital signal processing was forced upon the contractor because the consultant did not wish to leave the digital domain, only to return to it after the processing.

Initial acoustic tests were carried out to assess the uniformity of the frequency response and the sound pressure level with respect to coverage. In general, after adjustments in terms of speaker orientation the results are as follows:

Location	Frequency Response over 1/3 octave bandwidths	Sound Pressure Level (dB) 20Hz-20kHz	'A'weighted
Main Terrace Area	100Hz-10kHz ±3dB	99 ±4	96 ±3
Olympic Gallery (Executive Suite)	250Hz-10kHz ±3dB	97 ±3	95 ±3
Main Pitch Area	250Hz-10kHz ±3*	95 ±4	94 ±4

*assessed over octave bandwidths

The results in the main met the receiver criteria used in the design which were specified in terms of the source sensitivity, frequency response, etc.

It was interesting to note, that music amplified through the system at sound pressure levels given above (over the frequency ranges quoted) matched the average levels generated by the crowd during the FA Cup Final. This was demonstrated when the sound of chanting supporters was rapidly curtailed by the start of the band amplified to generate levels typically 99dB. Breaks in the band's performance were soon followed by the audience chanting once again quickly to be curtailed by the start of the music.

A major challenge on the use of the sound system was its acceptance by the touring bands/production companies coming to the Stadium. Extensive tests were performed throughout the acoustic space to set the delay times prior to the arrival of the tour. Further tests were then carried out with the touring sound system to fine tune the delayed sound to the engineers acoustic tastes.

The original design concept of the multiple delays required for this distributed system was met with scepticism by some sound engineers due to the delay times between adjacent speaker clusters and the range of delay time within each speaker coverage. The tests carried out in conjunction with three major sound rental companies have shown these potential

problems to be minimised due to:

i. The use of high quality devices giving a controlled coverage over a defined bandwidth This frequency range is where the major sound reinforcement is carried out during concert events.

ii. the acceptability of up to +50 milliseconds for a secondary source (Wembley System) over the arrival of sound from the primary source from the stage. In a large reverberant space, the sound from a secondary system for most contemporary popular music adds to the quality of sound, producing at worst, an artificial reflection not too long to be an 'unwanted echo'.

As well as improving the sound during concerts for a major sector of the audience, the sound system has reduced the need for such high sound levels from the stage system. This in turn has generated lower external sound levels compared with previous years, and reduced complaints from 189 in 1987 to 121 in 1990 (in both years eleven concerts were held).

So far this year the system has been used successfully for some 100 Greyhound meetings, over 20 sporting events and 10 pop concerts. Further additional features and uses of the system are being planned for future events.

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