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DESIGN AND IMPLEMENTATION OF P.A. SYSTEMS FOR DIFFICULT CONDITIONS

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INTRODUCTION

The general availability of high quality sound sources and innovations in other areas of audio such as domestic Hi-Fi, personal 'walkman' type stereo cassette players, the compact digital disc and improvements in the fields of theatre and cinema sound reproduction are producing both greater expectations from PA and Sound Reinforcement systems and a demand for improved sound quality and intelligibility.

However, whilst there is certainly scope for major improvements in this field, the atrocious acoustic conditions under which many such systems are often expected to perform are frequently neglected or little understood by the system user. An example of this is a recent case where the author was called in to advise on a sound system installation which was expected to provide conference or lecture theatre type use and quality in a building where the initial survey revealed a reverberation time of 5.9 seconds and an ambient noise level of 60 to 65 dBA!

The aim of this paper and presentation is to look at some of the factors affecting modern Sound Reinforcement and Public Address design for difficult conditions such as overlong RTs or high ambient background noise levels by looking at three recent case histories. These include two temporary conference type systems for audiences of 2,000 and 5,000 respectively and a new P.A. system design and installation for British Rail at Waverley Station, Edinburgh, which incorporates a number of novel design features.

The two main parameters for successful P.A. and Sound Reinforcement design are sound quality and intelligibility. These two are quite separate entities - it being quite possible to achieve high sound quality (e.g. in terms of frequency response, harmonic distortion etc) but total unintelligibility and vice-versa. As other papers being presented at this conference will be discussing the more theoretical aspects of speech intelligibility - this will not be dealt with here in detail, instead the ways in whih this was achieved and the problems encountered will be highlighted. It is interesting to note that the temporary systems require the same design input and calculation as an equivalent permanent installation but suffer from the disadvantage of little or no time being available to set and commission them optimally.

Case History No.1
Temporary system for 1985 Eisteddfod - Cardiff

The Eisteddfod was held at the National Sports Centre Cardiff with the main sports hall being used as an auditorium to seat an audience of 2,000. An initial site meeting was held to establish the Sound Reinforcement and P.A. system requirements and to conduct a preliminary investigation into the acoustics of the Sports Hall which measured some 120 x 120 x 45 feet.

Subjectively the Sports Hall was found to be very reverberant with considerable flutter and long delayed echo paths - all surfaces being essentially hard and sound reflecting. Reverberation time measurements were therefore made, showing the space to have an average reverberation time of 4.0 to 4.5 seconds - the long delay path echoes being clearly discernible from the decay trace and recordings - hardly the ideal acoustic conditions for encouraging highly articulate speech and music! (An RT or around 1.0 to 1.2 seconds would have been optimum for speech).

In agreement with the Eisteddfod's acoustic adviser, it was agreed to treat the rear and side walls with heavy drapes - bringing the predicted Reverberation Time down to approximately 2 seconds and controlling the majority of the problematic echoes.

Fore-armed with this knowledge, the P.A. system was evolved and based on a central cluster arrangement comprising a dual drive 15 cell multicell horn to cover the front and centre sections of the Hall, together with two skewed 3 cell multicell horns to provide infill to the front and sides. The rear part of the Hall was covered using suspended dual cone cabinet loudspeakers set on a digital signal (time) delay and synchronised with the multicell and stage sound to give correct sound localisation. In order to achieve a controlled low frequency sound coverage, two 5ft column loudspeakers and active cross-over unit were employed. Microphone feeds were taken via splitter boxes from a BBC feed.

The loudspeaker positioning was in part fixed by the available suspension points but was also governed by T.V. lighting and camera sight lines - a number of compromises therefore inevitably had to be made.

The P.A./Sound Reinforcement system also had to provide feeds and remote monitors to other pats of the building. (A delayed monitor was used at the rear gallery camera and sound mixing position.) A show relay and paging system to backstage areas together with an on-stage music reproduction system and a comprehensive intercomm system completed the installation. All loudspeaker signals were via a 100V line high impedance distribution system and all low level signal feeds were fully balanced.

Case History No.2

Temporary P.A. system for 5,000 seat conference in temporary structure

This project, apart from the size of the audience, (few permanent conference venues in this country can handle this number) was unique for a number of reasons including the fact that the conference venue itself was a totally temporary structure, measuring some 125 by 25 metres with a roof height varying from 2.8 to 7.0 metres. A time synchronised (delayed) distributed system was employed to provide an even sound coverage throughout the area - (the max variation being 5dBA) with particular care being taken to ensure no long path echoes were produced off the highly reflective structure. A comprehensive foldback system for the stage (over 30 metres in length) together with microphone coverage of the stage, two rostra and floor microphones together with battery power back-up were required. Comprehensive signal processing and equalisation were utilised, system equalisation being carried out with the aid of a computing Real time 1/3 octave spectrum analyser. Wind noise, which at times reached over 70 to 75dBA, was a major problem though by careful equalisation and loudspeaker positioning and control, adequate gain before feedback was achieved. The correct selection, positioning and equalisation of the microphones was essential, shock mounted, studio quality, cardioid types being used throughout.

Case History No.3

Permanent Installation for Waverley Station Edinburgh

Following complaint over the poor intelligibility of the existing P.A. system, the author was asked to design and specify a new system of considerably improved quality and intelligibility.

Architectural constraints ruled out the option of using a low level distributed system - a high level, 'long throw' system was therefore devised employing constant directivity horn loudspeakers, set on appropriate signal delays to synchronise sound arrivals in order to improve speech intelligibility and overcome annoying long delay echo effects.

A total area of some 17 acres required P.A. coverage - the station comprising 21 platforms.

The system was designed to provide minimum variation in sound pressure level throughout the main concourse and platform areas together with comprehensive signal processing equipment to automatically compensate for variations in the background noise level and to optimise and match the speech signal to the difficult acoustic conditions of high noise and reverberation. Considerable headroom was built into the system, a total audio power capability of 5KW being provided. A number of novel features to improve speech quality and intelligibility such as comprehensive microphone equalisation, signal compression and delayed feedback have been incorporated into the design.

The high level loudspeaker system consisted of 29 de-centralised clusters and 1 main central cluster system to cover the main indicator board and concourse. The majority of clusters were made up from a Constant Directivity long throw horn and a short throw Compound Diffraction re-entrant horn to cover the area local to the cluster. A number of variations on this basic scheme were also employed - the main central cluster, for example, comprising a long and medium throw C.D. Horn, together with two Compound Diffraction units. The main ticket hall, a large highly reverberant area (approx 20m x 20m x 10m with a reverberation time in excess of 3 seconds) was covered using a central cluster made up of two C.D. horns and a bass unit, located within the ceiling/roof structure due to architectural constraints. Despite this, a high direct to reverberant ratio was achieved with minimum overspill resulting in a high quality, highly intelligible signal.

Each loudspeaker cluster was served by its own 100V line marching transformer filter network and level adjustment controls - allowing each cluster to be set up for optimum performance.

A number of ancillary loudspeakers were used to provide coverage or infill coverage in low headroom areas, such as under the main entrance canopy, and bridge areas (The station is traversed by two main roads on overhead bridges) and external platform canopies.

Six ambient noise sensing microphones detect the ambient noise level throughout the complex - automatically adjusting the level of the P.A. system to optimise the signal to noise ratio - the ambient noise was found to vary by more than 30dBA throughout the day.

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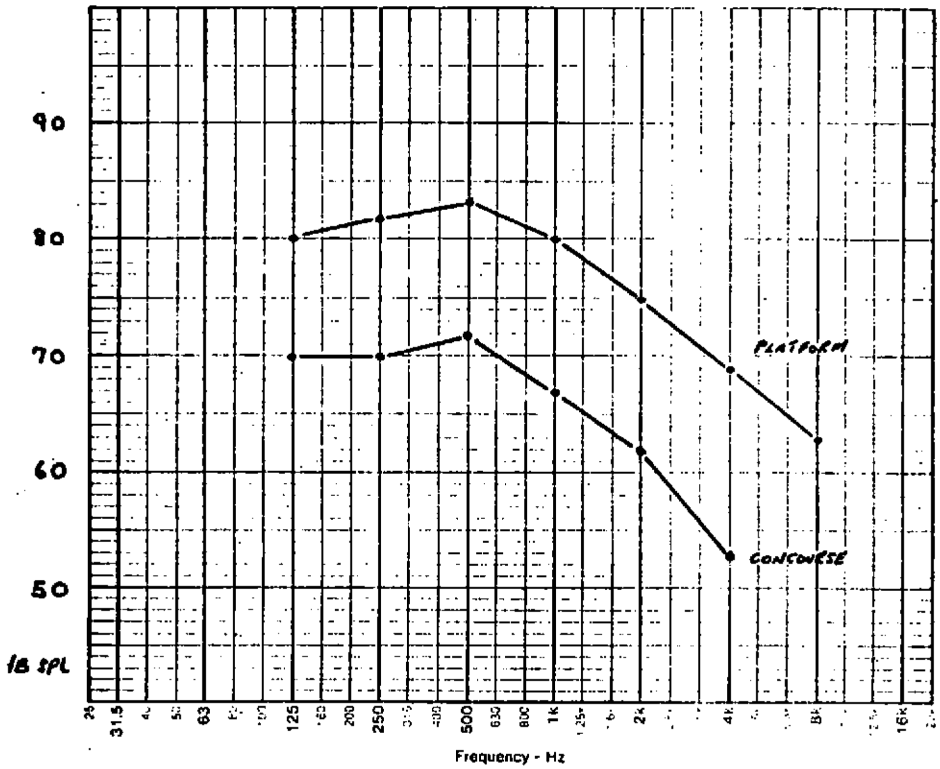
Due to the complexity of the physical zoning and time delay zoning, the automatic ambient noise control circuitry had to be specially developed - and incorporates a total of 26 controllable VCA circuits.

The system employs a total of nine time delay zones, 1 with signal delays ranging from approximately 100 to 600 milliseconds.

The average distance between the main loudspeaker clusters was 30 to 40 metres, which together with the cluster design and horn characteristics allows the maximum spl design target of 85 to 90dBA to be met.

Although not fully completed, the system has been found to achieve a high level of intelligibility throughout the design coverage areas with minimal reverberant excitation or production of long delayed echoes. Further test data will be reported at a future date.



Typical background noise levels - Waverley Station