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SPECIAL CONFERENCE SYSTEM - BUSTAN, OMAN

V.W. Dobbs

Spectrum Audio Ltd., Garman Road, London, N17 0QP, U.K.

INTRODUCTION

The Special Conference facility represents the focal point of the Bustan Hotel complex in Bustan, Oman. Its prime function is to host the 1985 meeting of the Gulf General Council.

This paper is intended to define the conference system that has been installed and to explain some of the thinking behind the design. The special conference system differed from a conventional system in that it was required to provide reinforcement to other areas in the room as well as inter-delegate. Fig. 1 shows a plan view of the conference room; seven heads-of-state are allowed access to the system, reinforcement is provided to the entourage seated behind the delegates and to the audience seated around the perimeter of the room.

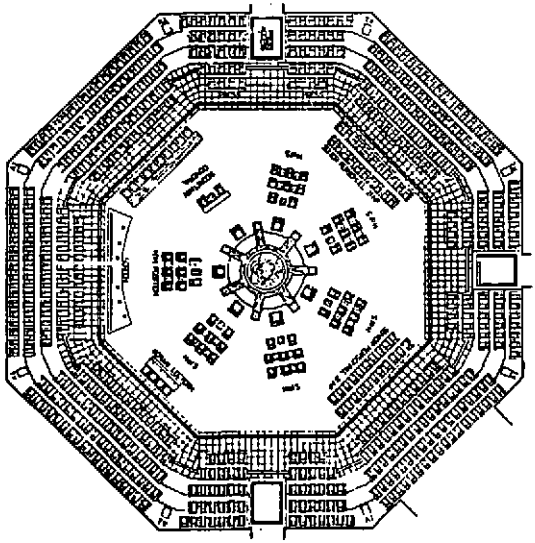

Fig. 1

System Specification

No definitive specification was provided, except that the system had to be unobtrusive, and provide good intelligibility without undue colouration to all areas. There were however some conditions that would apply. Firstly that the delegates microphone would be secreted in the table approximately 1 m from each delegate. Secondly that with the exception of the delegates loudspeakers, all loudspeakers must be placed in the ceiling.

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System Design

In a large room with an expected reverberation time of around 1.5 seconds (500 H_3) the biggest problem, especially with the delegate microphone distance of 1 m would be feedback. It was therefore paramount that the best possible advantage should be made of the intrinsic absorption in the room and that at all costs the loudspeakers should not direct sound onto reflecting surfaces. To this end the audience areas are covered by eight constant-directivity horn loudspeakers each with a bass unit. The entourage areas are covered by seven constant-directivity loudspeakers situated immediately above in the ceiling. The delegate units comprise a hyper-cardiod microphone and a high quality loudspeaker drive unit in a purpose-built enclosure. The system employs signal delays referenced to the table, the routing, gain values and switch functions are microprocessor controlled. Fig. 2 shows a block schematic of the system.

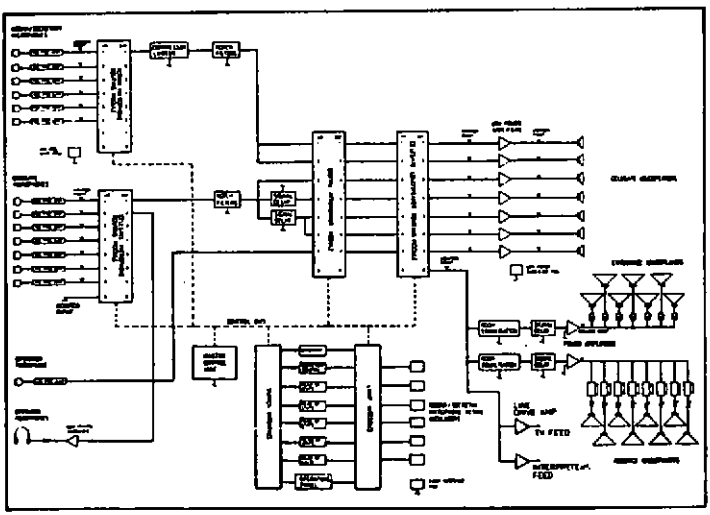

Fig. 2

ROOM ACOUSTICS

The room is octagonal in shape with hard walls and ceiling but with a carpeted floor. The volume is in the region of 4900 m3 and the RT_{500} was expected to be in the region of 1.0 seconds. To ensure an adequate margin, for the purposes of all calculations a value of 1.5 seconds was used.

FEEDBACK CALCULATIONS

Feedback or howl round occurs in a public address system when a signal or sound pressure level perturbation or fluctuation from an outside influence results in a larger signal at the microphone caused by the loudspeaker output.

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The key to the problem is, therefore, the loudspeaker/microphone transmission characteristics which within the context of electro-acoustic systems in enclosed spaces is extremely complex. It is important, therefore, to understand that any such attempts at quantifying this phenomenum must be subject to conditions and limitations.

For the purposes of these calculations we assumed that feedback would be caused by the total reverberent component output by the system.

Delegates' Loudspeakers
Type Jordan 2 inch; sensitivity = 80dB re 2 x $10^{-5}Nm^{-2}$ @ 1 watt @ 1 m; directivity (Q) = 5.

For any talker position there will be two listeners at approximately 2.5 m, two listeners at 4.5 m and two listeners at 5.5 m.

We are able to calculate the direct sound pressure level produced at each of the listening positions.

To achieve the criterion that the perceived level at each listener shall be 65dB re 2 x $10^{-5}Nm^{-2}$, the deficit shall be provided by the individual loudspeakers. Table 1 details these results.

Table 1

Listener @	Direct Spl dB re 2 x 10^{-5} Nm^{-2}	Required Level	Received extra from L/S	Sound Power Level of L/S dB re $10^{-12}w$
2.5m	62.5	65	61.4	65.3
4.5m	58.4	65	63.9	67.8
5.5m	57.2	65	64.2	68.1
Total Sound Power Level to Reverberent Field dB re 10^{-12} watt				75

The total reverberent sound pressure level caused by the delegate loudspeakers is 53.8dB re 2 x $10^{-5}Nm^{-2}$.

Audience Loudspeakers
Type Electrovoice constant directivity horn HR120; sensitivity = 109dB re 2 x $10^{-5}Nm^{-2}$ @ 1m; directivity Q = 8.7.

The total acoustical power to produce 65dB @ the listener (6m) is 80.7dB re 10^{-12} watt.

Due to the directional properties of the HR120 and its interaction with the audience area we can assume that only a small fraction of the primary radiated energy is reflected to enhance the reverberent component.

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Entourage Loudspeakers
Type Electrovoice HR40; sensitivity 115dB re 2 x $10^{-5}Nm^{-2}$ @ 1w @ 1m; average directivity Q = 50.

The total acoustical power to produce 65dB at the listener may be calculated as 74.3dB re 10^{-12} watt.

Table 2 gives the calculated values of Pwl and Spl for each unit.

Table 2

Position	L/S Type	Directivity Q	No. of units	Target distance m	Req. Spl @ Target	Total Pwl to Rev. Field dB	Total Rev. Spl
Delegate	Jordan	5	6	1	65	75	53.8
Audience	HR120/ MC8A	8.7	8	6	65	82.7	61.6
Entourage	HR40	50	7	6	65	79.3	58.1
TOTALS						84.8	63.6

Table 2 gives the results of these calculations.

It can be seen that the overall reverberent level caused by all loudspeakers will be in the region of 64dB re 2 x $10^{-5}Nm^{-2}$. This should be compared with 70dB re 2 x $10^{-5}Nm^{-2}$ expected at the microphone as a result of the delegate talking. Hence the system may be expected to operate 6dB below feedback. It should be noted that in our experience these calculations produce a pessimistic result and in fact we would expect the margin to be closer to 12dB. With regards to the presence of room modes included in the electronic package are high Q notch filters to deal with this problem. In addition no account was taken of the directional characteristics of the microphone.

INTELLIGIBILITY CALCULATIONS

The intelligibility afforded by the system may be considered from two standpoints.

From Table 2 the overall reverberent sound pressure level is given as 63.9dB. This figure should be compared with the target sound pressure level 65dB. The difference between these two values indicates the relative position of the listener in the sound field. For example if the overall reverberent level is equal to the direct level from the loudspeaker then the listener may be considered to be at one critical distance from the source.

It is generally agreed and understood that in the absence of obtrusive reflections and other unwanted acoustic effects

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intelligibility is good (can be very good) if the listener is not more than one critical distance from the source. In the case of special conference the direct to reverberent ratio is 1dB, hence the listener is at a distance less than one critical distance, from which we may infer that the intelligibility will be at least 'good'.

The second method is quantitative and involves the calculation of %ALcons of the system, from the following formula:-

$$\%ALcons = \frac{200D^2RT^2(N+1)}{VQM}$$

where: D = distance to the listener in question; RT = reverberation time of the space in seconds; N = number of loudspeaker groups identical to the prime group; V = volume of the space in cubic metres; Q = directivity of the loudspeaker; M = a modifier, generally chosen as unity relates to audience absorption.

In order to understand the calculations it is necessary to inspect the above equation in some detail. The terms RT and V are intrinsic to the space and require no explanation. The term D (distance from the source) and Q (directivity of the source) imply that at different listening positions the intelligibility varies and hence we should calculate the %ALcons at the three critical locations; delegate, audience and entourage.

The term M relates to an improvement produced by the whole or partial containment of the sound on an absorptive area, e.g. audience. In fact this has already been taken into acount when calculating the reverberent sound pressure level and, therefore we shall assume M = 1. The term N refers to the number of like sources in the space (in excess to the prime source). In a simple system we generally find that all sources are set to have identical outputs. In the special conference system this is clearly not the case. Three sets of loudspeakers are involved and further each set has a different output power.

Taken at a delegate's position, therefore, it would be incorrect to assume that the N was in fact the sum of five delegates, eight audience and seven entourage = twenty loudspeakers since the acoustical output of the audience and entourage units is in itself dissimilar and also different from that of the delegates. Hence a weighing factor should be applied to the term N and a new value N equivalent (N_E) should be determined and used. It does not seem unreasonable to weight the value of N in relation to the relative acoustical output of each unit.

For example, if a system uses two loudspeakers, both identical in power output, then N = 1 (i.e. one additional like source). If, however, the extra loudspeaker had a relative output of +3dB then in terms of power output it is equal to two sources, hence $N_E = 2$.

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The following calculations are based on the above principle:

Calculation of %ALcons at Delegate's Position (Taken at furthest delegate, delegate No. 1) Delegate No. 7 speaking.

Position	No. of sources	Power Level of Source	N_E
Delegate (2)	1	68.1	1
Delegate (3,4)	2	67.8	1.9
Delegate (5,6)	2	65.3	1
Audience	8	73.7	29.0
Entourage	7	70.8	16
TOTAL EQUIPMENT N_E			48.9

This exercise was repeated for each listening position.

The table below gives a summary of the %ALcons for the three listening positions:

Position	%ALcons
Delegate	1
Audience	5
Entourage	1-2

Within the definition of the term the calculated values of %AL would indicate that the system would provide excellent intelligibility.

As stated earlier, however, a favourable %ALcons does not necessarily guarantee good intelligibility. Consideration also has to be given to the reduction of unfavourable reflections and the time of arrival of the various signals. The system uses loudspeakers specially selected to ensure that the overspill of sound onto hard surfaces is minimised, thereby reducing the likelihood of strong reflections and in addition signal delays are employed to assist in the realism of the system and to ensure that the intelligibility is optimised.

Conclusions

The Special Conference facility is due to be commissioned during early October. At this time measurements will be taken which will hopefully corroborate the theory as outlined in this paper. The system design was a very careful blend of acoustics and sound system engineering. The success depends wholely on the interface and matching of the loudspeakers to the space to minimise the reverberent sound field. We believe that the use of constant

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directivity loudspeaker units was mandatory to minimise overspill onto hard surfaces. Of necessity, little has been said about the operation of the system and its associated engineering. It does however, represent state of the art in respect of routing and control functions.