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ACOUSTIC MODELLING OF FILM DUBBING AND MIXING THEATRES

AMBER NAQVI

MUNRO ASSOCIATES

1. INTRODUCTION

This paper is based on a study done on a recent Munro Associates acoustic design project involving the design of a new film mixing room at Shepperton Film Studios. The brief was to design a room with a maximum seating capacity of 100 in film preview mode, (figure 1), which should be well suited, architecturally as well as acoustically, for film post production work involving dubbing and sound mixing, (figure 2). The proposed room was to be situated in an existing structure used to house generator plants and electrical switching equipment so the internal dimensions of the new room were almost pre determined. The main acoustic design challenge was to establish the ideal target RT scale to be achieved by non variable acoustic treatment which would be suitable for film preview situations and should be carefully configured for a state of the art film mixing setup involving 3 way 5 speaker left-centre-right plus surround monitoring.

2. ACOUSTIC DESIGN

2.1. Reverberation time

Although not much documentation is available on film mixing room design, published documents from Dolby and THX concerning guidelines for cinema design were consulted. They indicated that the ideal reverberation time in relation to the volume of the room (920m3 = 32500 ft3) was found to be 450ms at 500Hz allowed to rise to 650ms at 125Hz and drop to 250ms at 4KHz as shown in figure 3 [1].

This scale is primarily based on limiting the reverberation time to preserve the intelligibility of dialogue in large cinemas [2]. However, most film dubbing and mixing rooms are a lot smaller then a traditional 1000 seat cinema and it is not only dialogue that the mixing engineer is interested in during a typical session. On an average a final film mix will comprise of 8 tracks of dialog, 8 tracks of music and 8 tracks of sound effects. It was felt at the design stage that a customised RT scale was need to accommodate the complex nature of material to be monitored in this room, more in line with the design trends in a typical studio control room.

It was agreed after a series of discussions with the engineers appointed to use this new room, that the target mid band reverberation times should be positioned around 350ms.

This was calculated to be the average between the mid band RT of a normal music studio control room of 250ms and the ideal of 450ms according to Dolby and THX guidelines. It was also agreed that the low frequency rise and the high frequency drop should follow a similar trend as shown in figure 3. This target was also considered to be suitable for film preview applications with occupancy of 100 people and with 8 surround speakers in operation, when the RT at mid band is predicted to reduce to 300ms.

2.2. Early Reflections / Initial Time Gap

It must be stated that although the room acoustic design was not based on the Live End Dead End theory, it was considered important that the early reflection pattern should be well controlled and an initial time gap of 10-15ms should be achieved in order to ensure a critical listening environment where reverberation content on the pre recorded music in large acoustic environment can be correctly preserved [3]. In order to achieve this it was considered necessary that along with highly absorptive walls and ceiling in the front part of the room, broad band diffusion in the form of curved wood panelling was also required which would reduce the level of early reflections and would also uniformly distribute the early reflection energy in the time domain.

3. ACOUSTIC MODELLING

A commercially available room acoustic prediction software namely CATT-Acoustic was used to model the room. CATT-Acoustic is based on ray-tracing method of acoustic prediction and creates numerical results, plot files for single or multiple sources. A geometry file is written in a customise editor linked with the main program, an Autocad interface can also be used to create the geometry files. CATT-Acoustic is also capable of generating room impulse response in a variety of formats to be analysed in other programs or to be used for desk top or real time auralization [4].

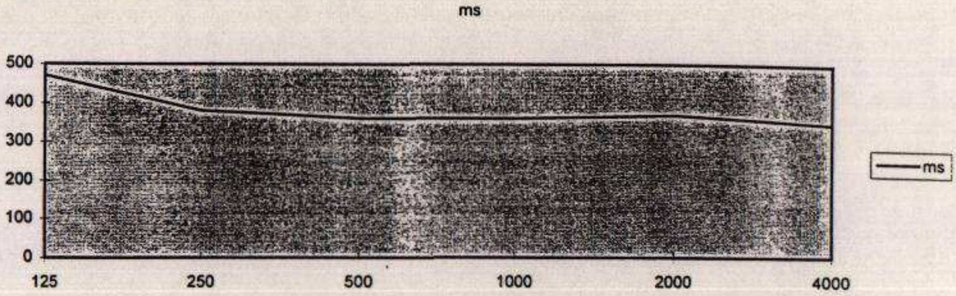
A detailed model was constructed with all the acoustic features of the room modeled to scale (figure 4 & 5). Initially the model was run for 2000 rays to check for any holes or leakage. After removing a few discrepancies in the geometry file (mainly relating to the audience plane construction) the model was ready for plane surface property selection and determination of absorption coefficients. Figures for absorption for each plane were entered in octave bands of 125Hz to 4KHz. Source and receiver positions were selected with their respective properties. Internal acoustic environment was configured for background noise, humidity and absorption of air. The model was then allowed to run for full 5000 rays which gave the following results.

4. RESULTS

4.1 Reverberation time

Figure 6 & 7 show the predicted RT (T30) in octave bands of 125Hz to 4KHz which are as follows:

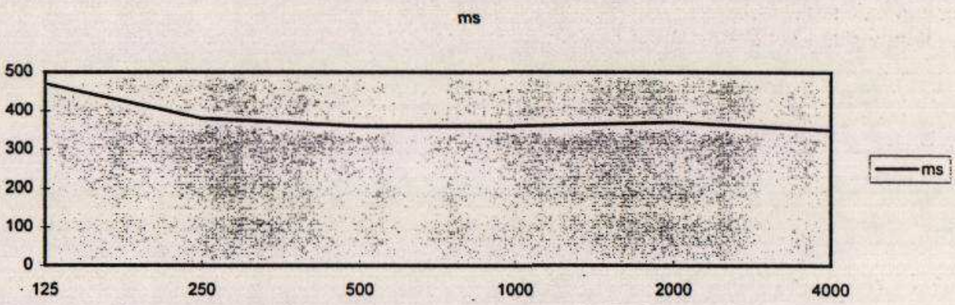
125Hz	250Hz	500Hz	1KHz	2KHz	4KHz
470ms	380ms	360ms	360ms	370ms	350ms



The slop of the above line graph was made to fit the slope in figure 3 by altering the quantity and positioning of broad band absorptive and diffusive surfaces on walls and ceiling within the room boundaries. Although the above figures do not exactly follow the slope in figure 3 and there are slight variations in lower as well as higher octaves, this was the best possible fit we could achieve. The model was also considered to be very stable as it gave the above results consistently for 2000, 3000 and 5000 rays. On the basis of these predicted results final acoustic treatment plan of the room was drawn up, in line with the surface distribution and placement in the model. Drawings were issued for construction.

Figure 8 shows the measured MLSSA RT in the room as built complete with all finishes, seating and equipment in place, measured at the engineers' position. The slop of the measured RT is as follows:

125Hz	250Hz	500Hz	1KHz	2KHz	4KHz
461ms	371ms	381ms	342ms	320ms	294ms



4.2 Early Reflections / Initial Time Gap

Figure 9 ,10 and 11 show the early reflection pattern as predicted by CATT. Figure 9 shows the amplitude of the direct sound positioned at 0 ms for reference. Figure 10 shows a very early floor reflection with the first 10ms. This reflection was ignored as in the real room this reflection will be masked by the mixing console and seating at that position. It was found that by placing the curved diffuser on the side walls and ceiling the very early reflection (within first 10ms) pattern was diffused and the amplitude was shown to be approx. 20dB lower than the direct sound. Figure 11 shows the second significant reflection arrives at the mixing position around 12ms after the direct sound and is shown to be a side wall reflection. The amplitude of this reflection is approx. 15dB lower than the direct sound due to the damping in the side wall. The whole pattern shows an initial time gap of around 12ms which falls within the design target for this room.

Figure 12 shows the measured MLSSA energy time curve in the finished room. The first arrival of direct sound is at round 39ms and the arrival of the first significant reflection is at 52ms showing an initial time gap of 13ms.

5. CONCULSION

The prediction results from the model were very similar to the actual MLSSA measurements both in reverberation time and early reflection pattern prediction. Although this example covers the very basic parameters of room acoustics mainly due to the nature of the project, design being based on mainly absorptive surfaces, it was established that reliable results can be obtained from computer models of small rooms with RT of less than half a second.

6. REFRENCES

[1] Technical guidelines for Dolby Stereo Theatres - Sept 1992
[2] THX Sound System Program - Instruction Manual - Architect's and Engineer's Edition - Oct 1987.
[3] Sound System Engineering - second edition - Davis & Davis
[4] A New Model For Room Acoustic Prediction And Auralization
Bengt-Inge Dalenback - Nov 1995.

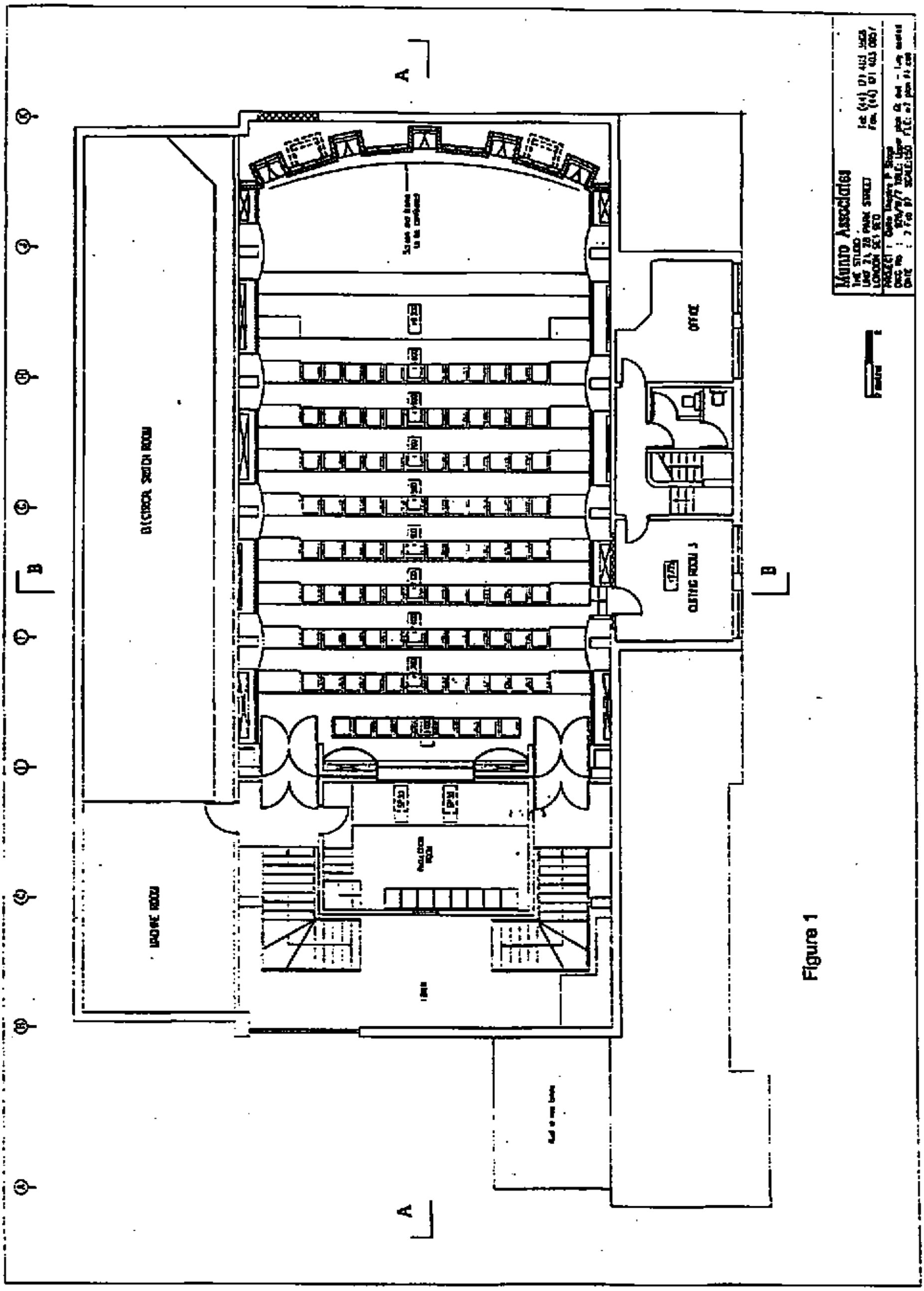


Figure 1

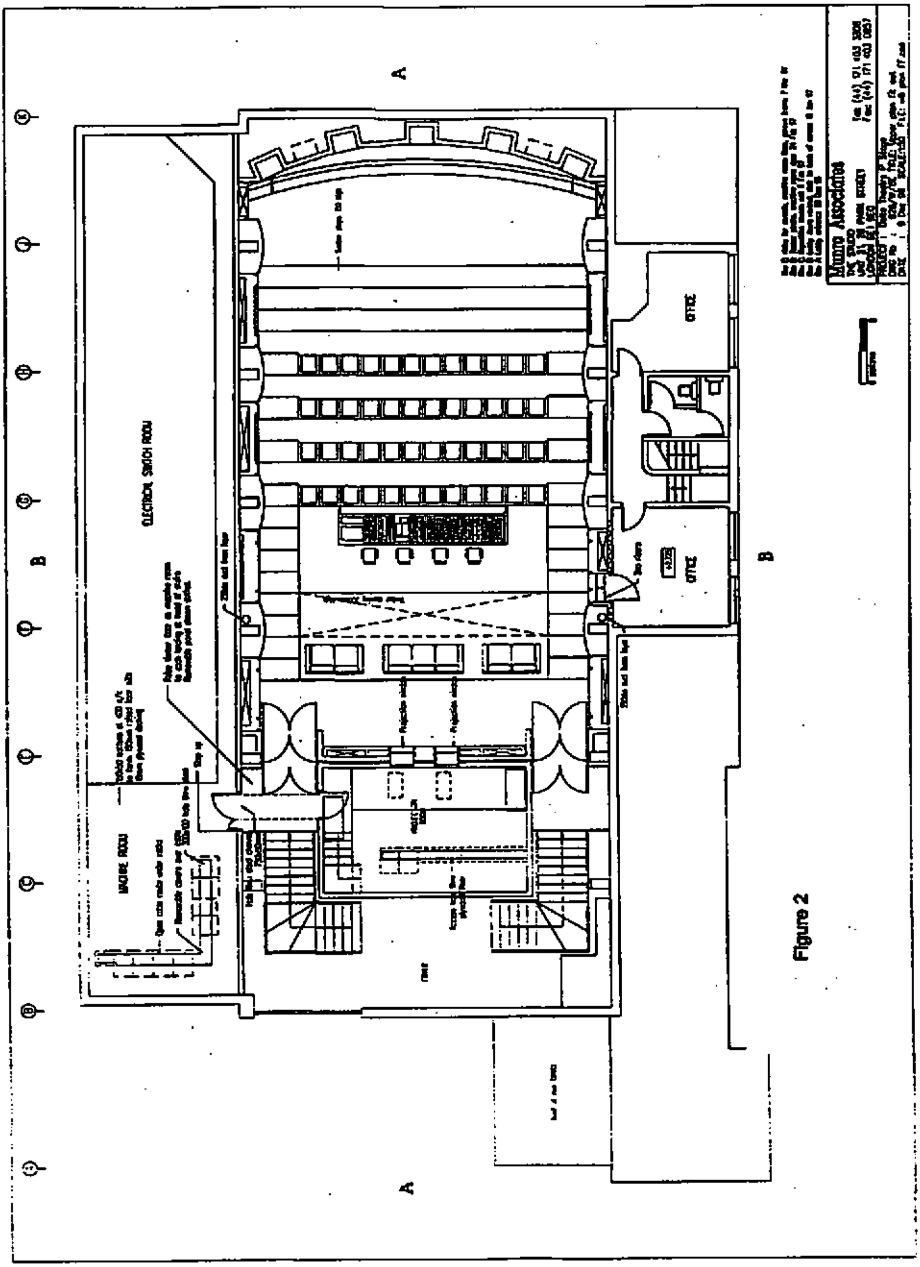
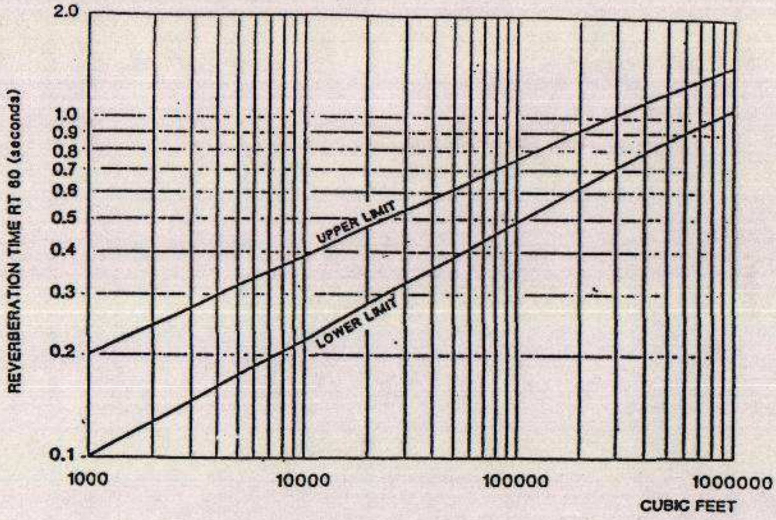

ELECTRICAL SWITCH ROOM
MACHINE ROOM
OFFICE
OFFICE
Munro Associates

Figure 2



Acceptable Reverberation versus Room Volume at 500 Hz

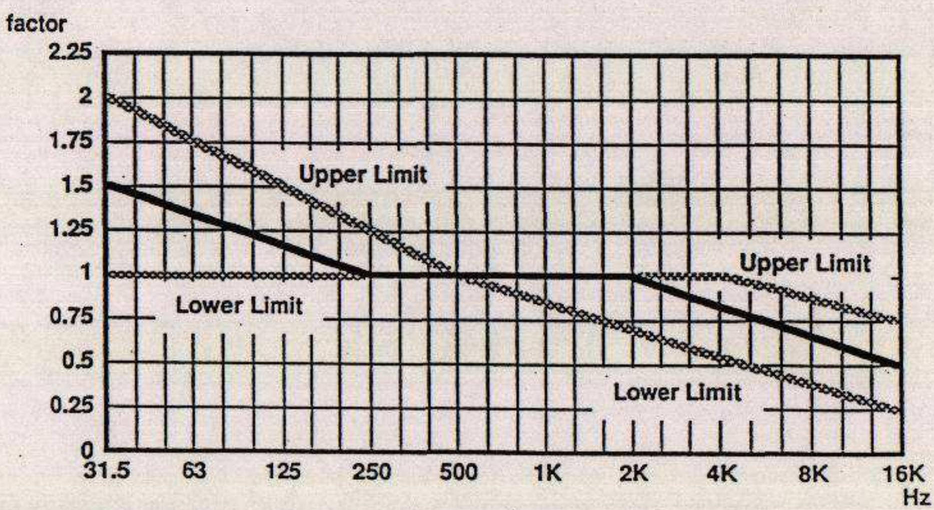


Figure 3 Reverberation Scaling Curve for Audio Bandwidth

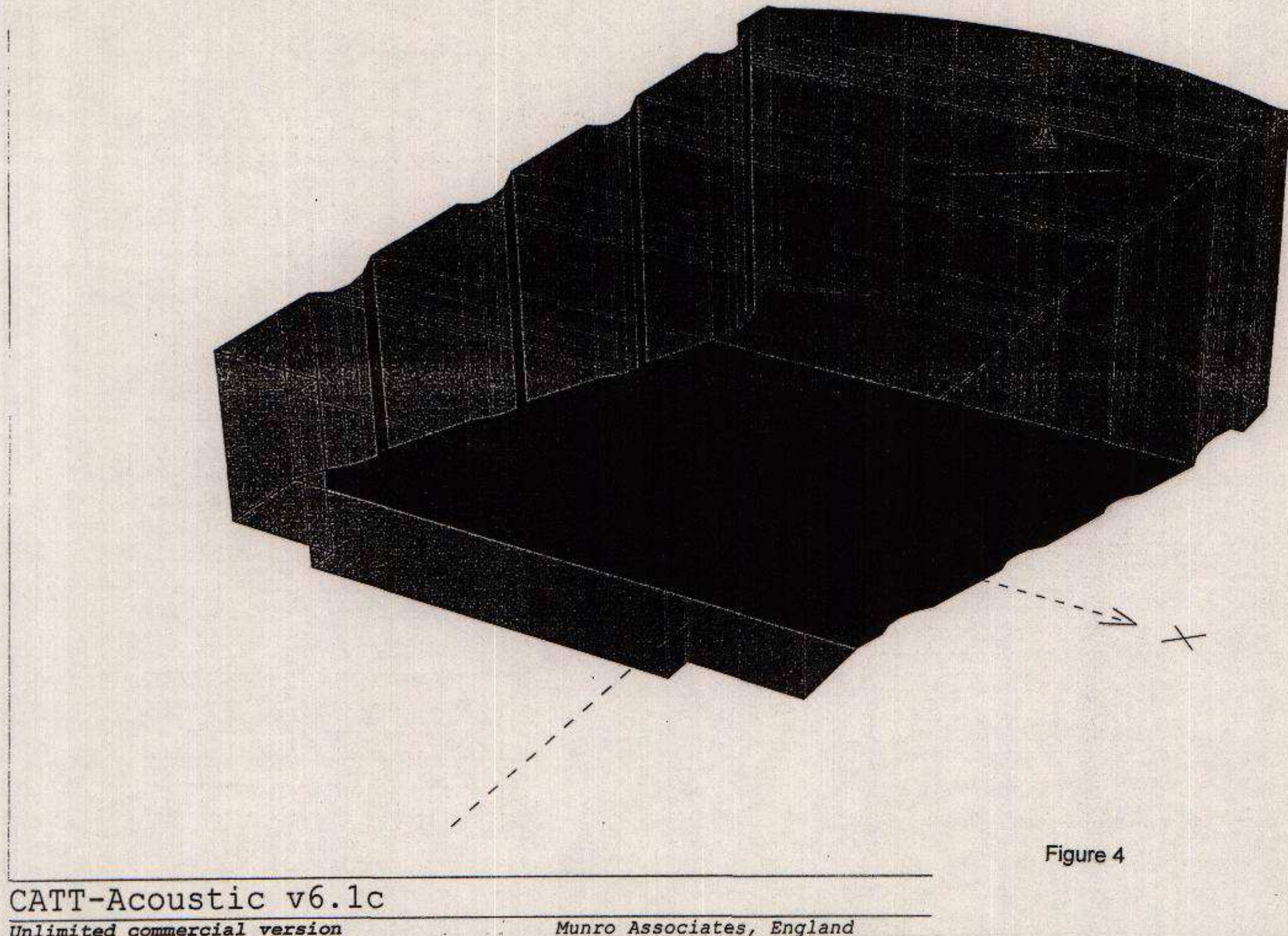

X
CATT-Acoustic v6.1c
Unlimited commercial version
Munro Associates, England

Figure 4

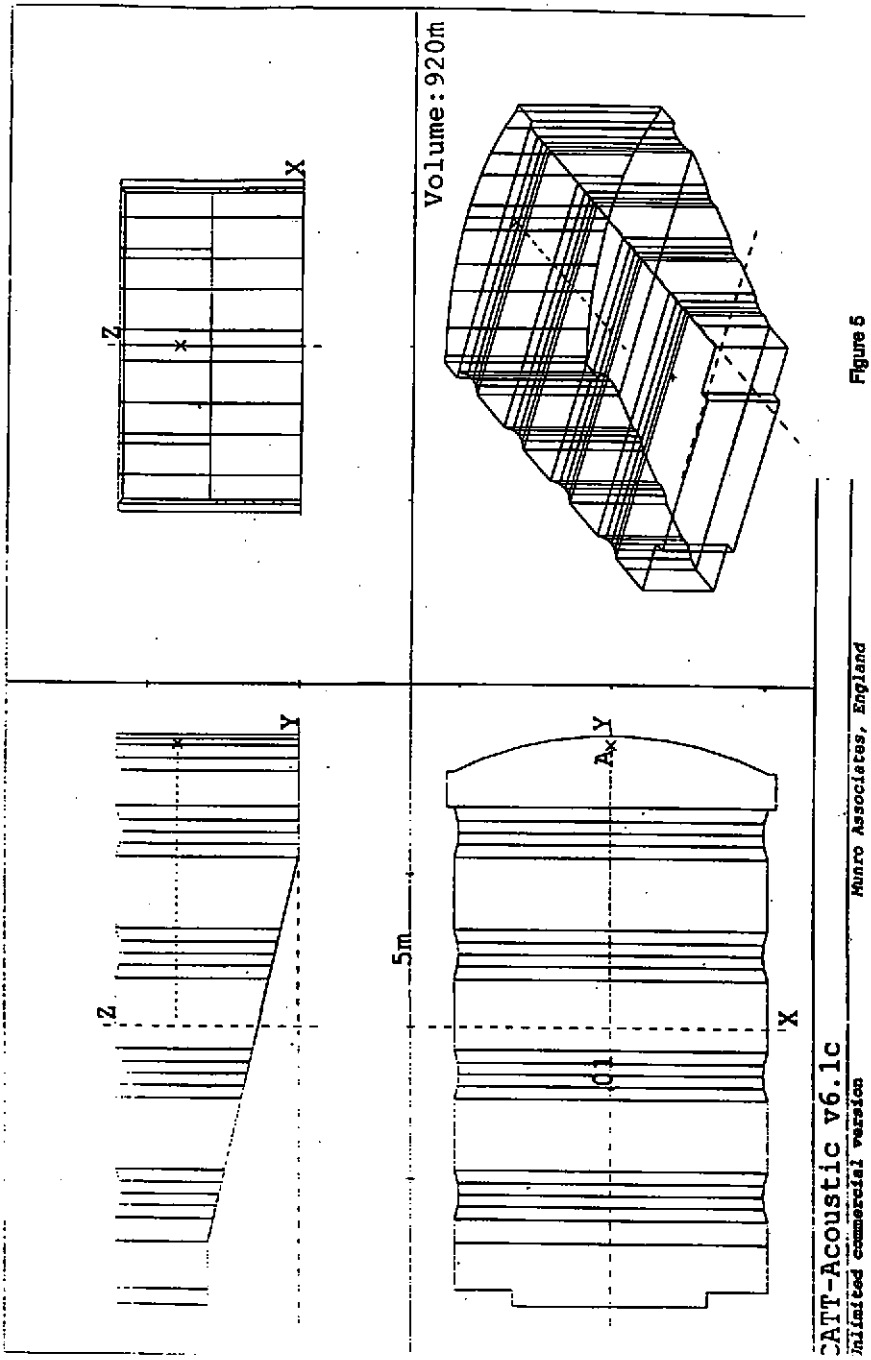
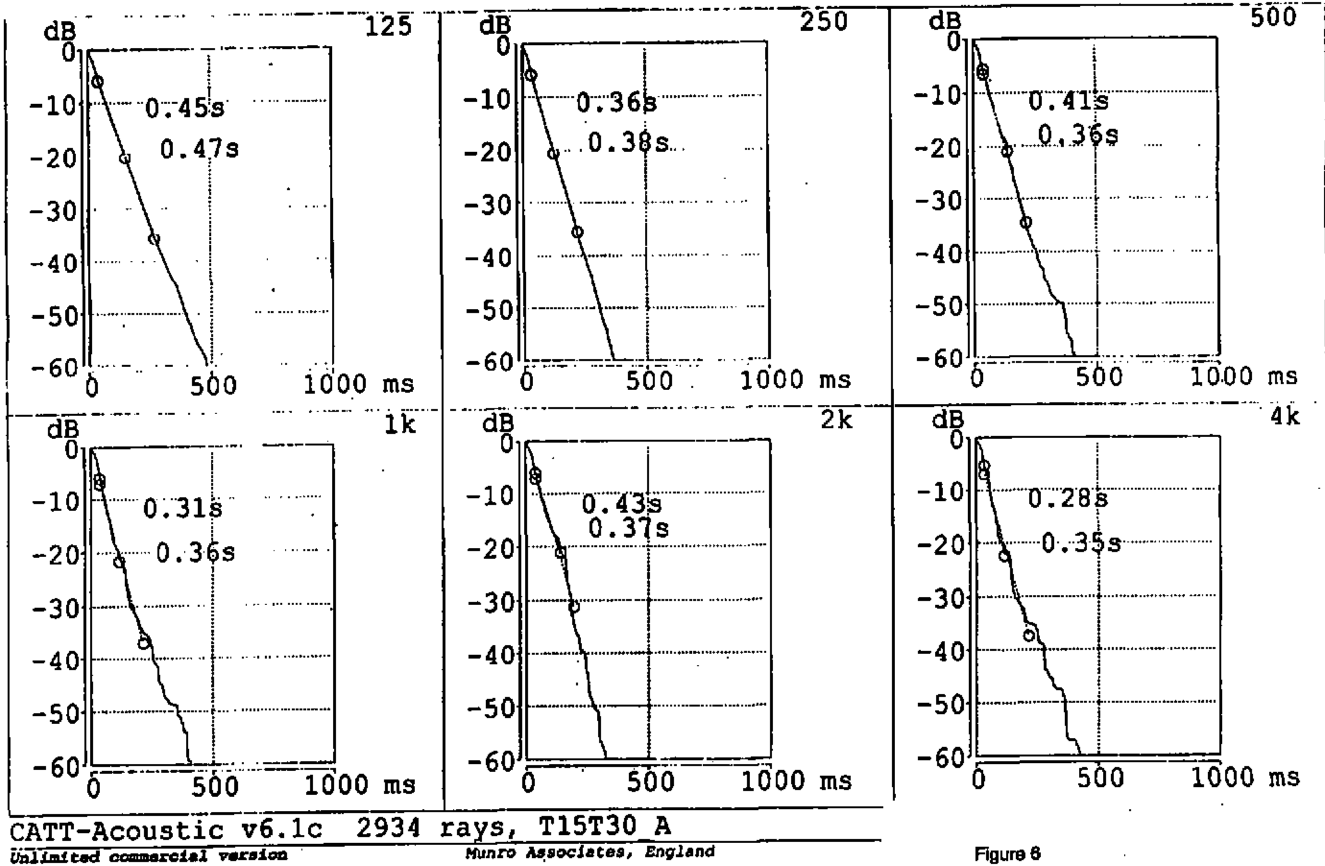
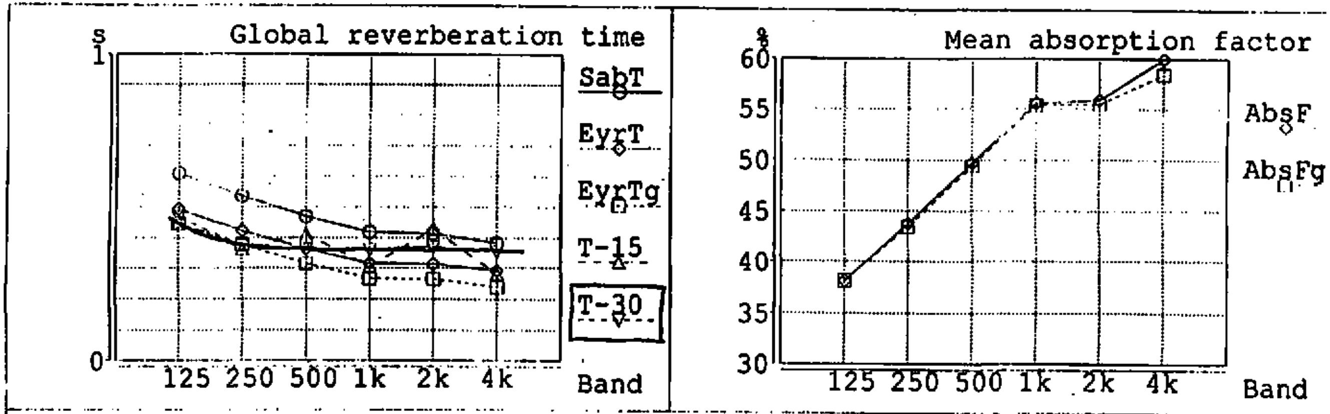

Volume:920m
X
Z
Y
Z
5m
Y
A
01
X
CATT-Acoustic v6.1c
Unlimited commercial version
Munro Associates, England

Figure 5



125
dB
0.45s
0.47s
250
dB
0.36s
0.38s
500
dB
0.41s
0.36s
1k
dB
0.31s
0.36s
2k
dB
0.43s
0.37s
4k
dB
0.28s
0.35s
0 -10 -20 -30 -40 -50 -60
0 500 1000 ms
CATT-Acoustic v6.1c 2934 rays, T15T30 A
Unlimited commercial version
Munro Associates, England

Figure 6



	125	250	500	1k	2k	4k	
EyrT	0.49	0.42	0.36	0.32	0.31	0.29	s
EyrTg	0.45	0.38	0.32	0.27	0.26	0.24	s
SabT	0.61	0.54	0.47	0.42	0.42	0.38	s
T-15	0.45	0.36	0.41	0.31	0.43	0.28	s
→T-30	0.47	0.38	0.36	0.36	0.37	0.35	s
AbsF	38.09	43.75	49.69	55.58	55.89	59.96	%
AbsFg	38.12	43.44	49.42	55.40	55.47	58.44	%
MFP	5.31	5.33	5.31	5.29	5.34	5.45	m
gam2	0.41	0.42	0.42	0.42	0.42	0.44	
Diffs	9.88	24.94	34.59	23.84	21.62	10.19	%

Trunc 1000.0 ms
Rays 2934 (used/oct)
Rays 0 (lost/oct)
Angle 3.75 deg

Figure 7

CATT-Acoustic v6.1c RT A

Unlimited commercial version *Munro Associates, England*

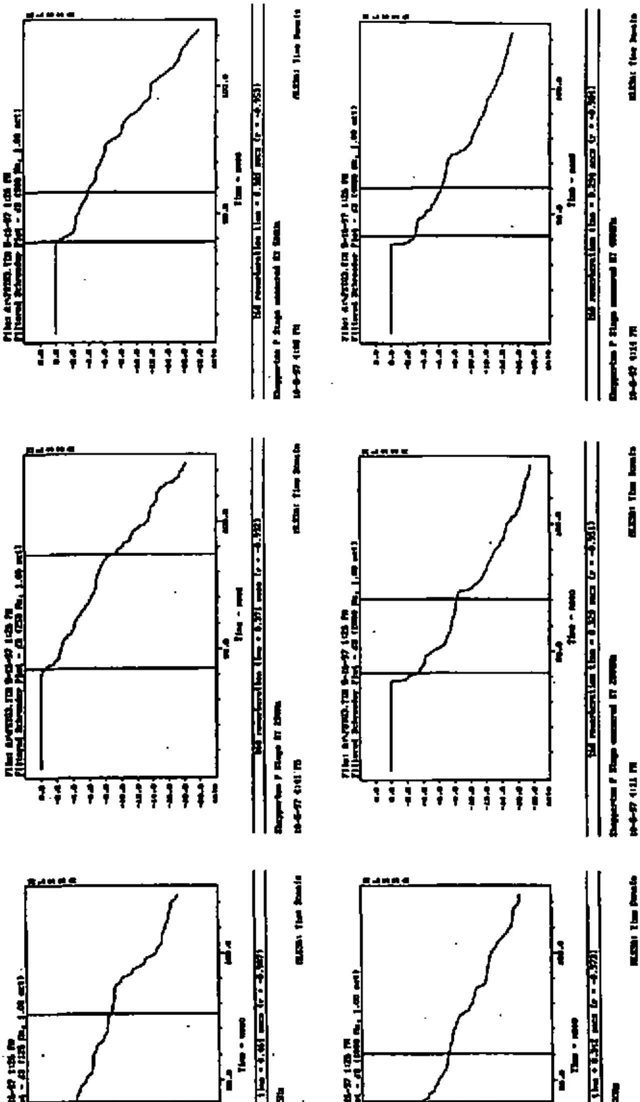
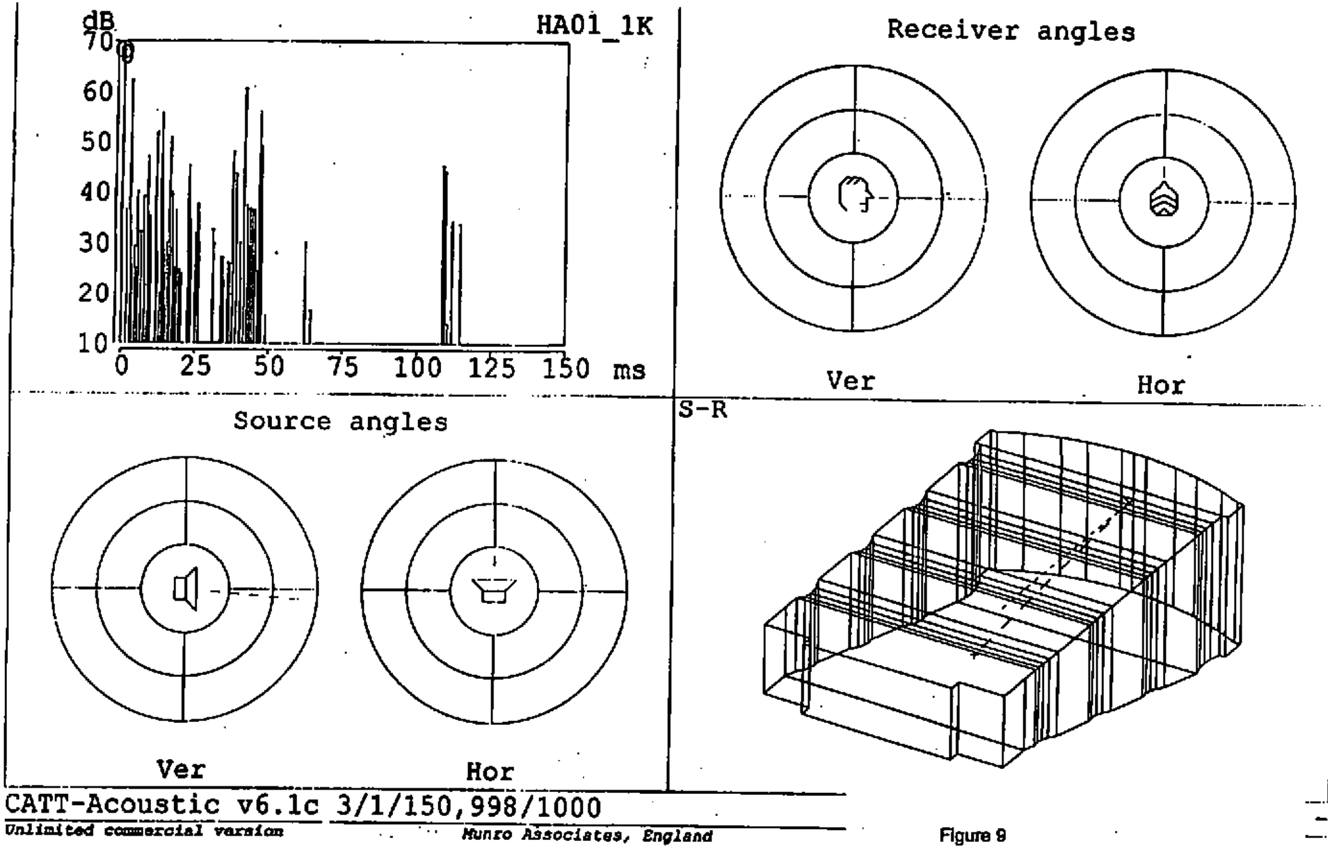


Figure 8



dB
HA01_1K
70
60
50
40
30
20
10
0
0 25 50 75 100 125 150 ms
Receiver angles
Ver
Hor
Source angles
Ver
Hor
S-R
CATT-Acoustic v6.1c 3/1/150,998/1000
Unlimited commercial version
Munro Associates, England

Figure 9

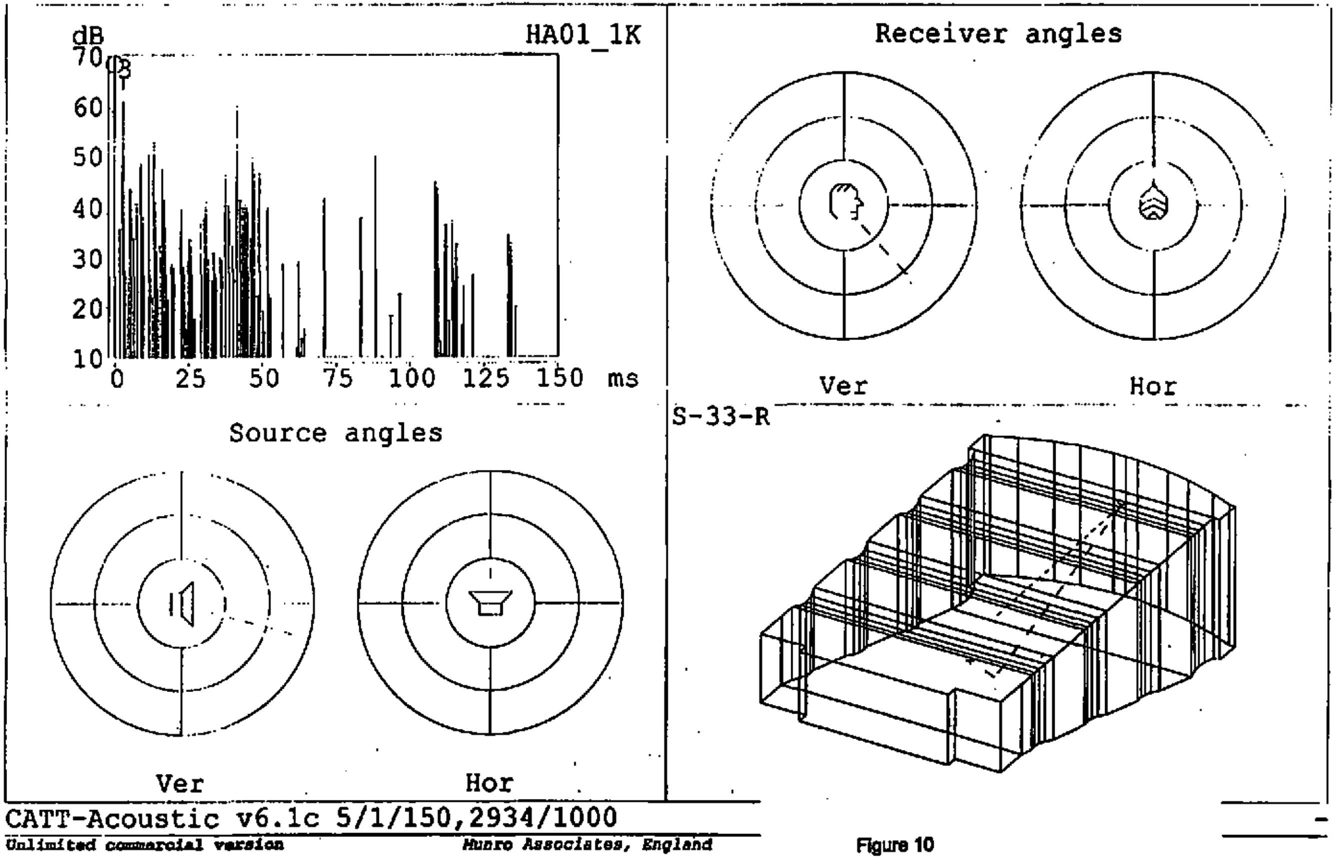

dB
HA01_1K
70
60
50
40
30
20
10
0
25
50
75
100
125
150
ms
Receiver angles
Ver
Hor
Source angles
Ver
Hor
S-33-R
CATT-Acoustic v6.1c 5/1/150,2934/1000
Unlimited commercial version
Munro Associates, England

Figure 10

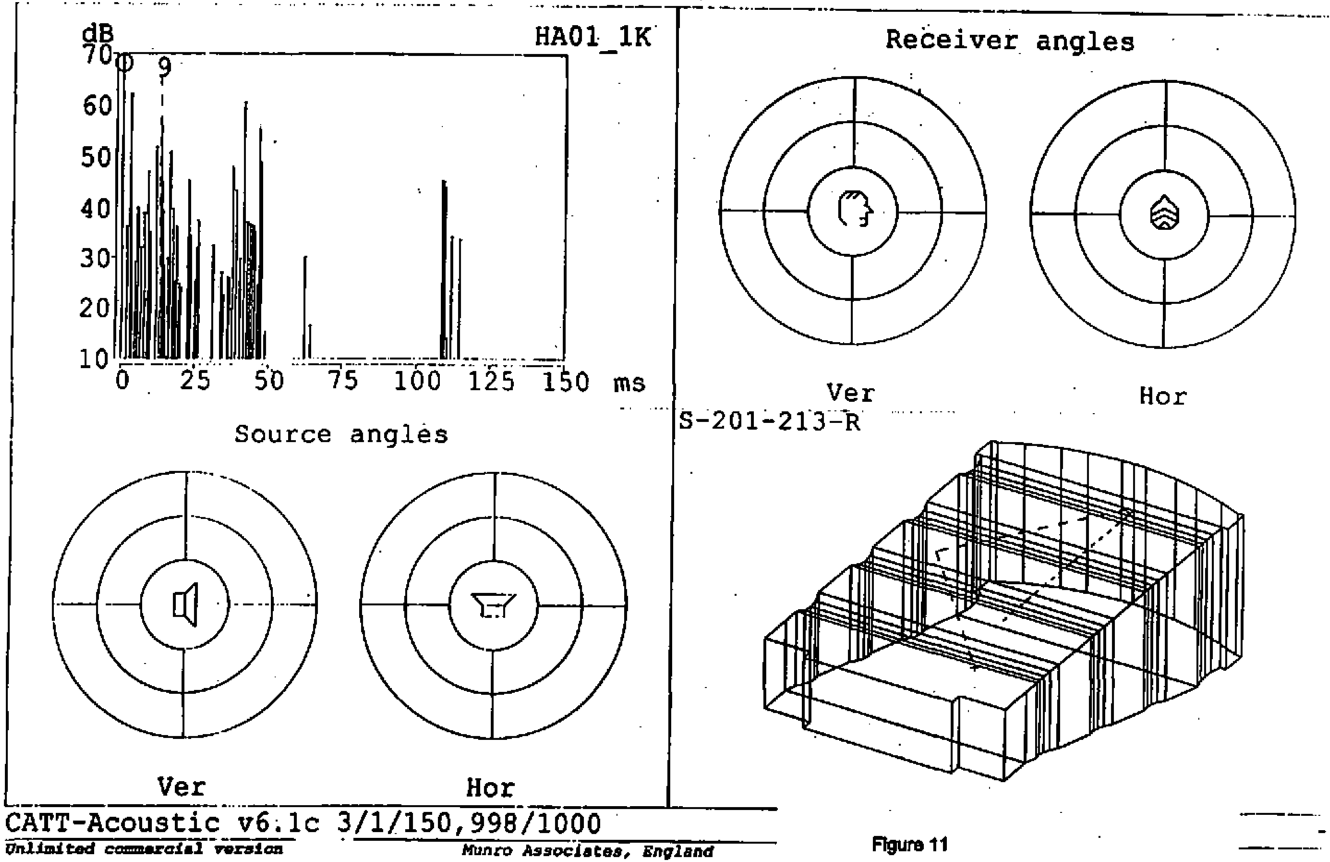
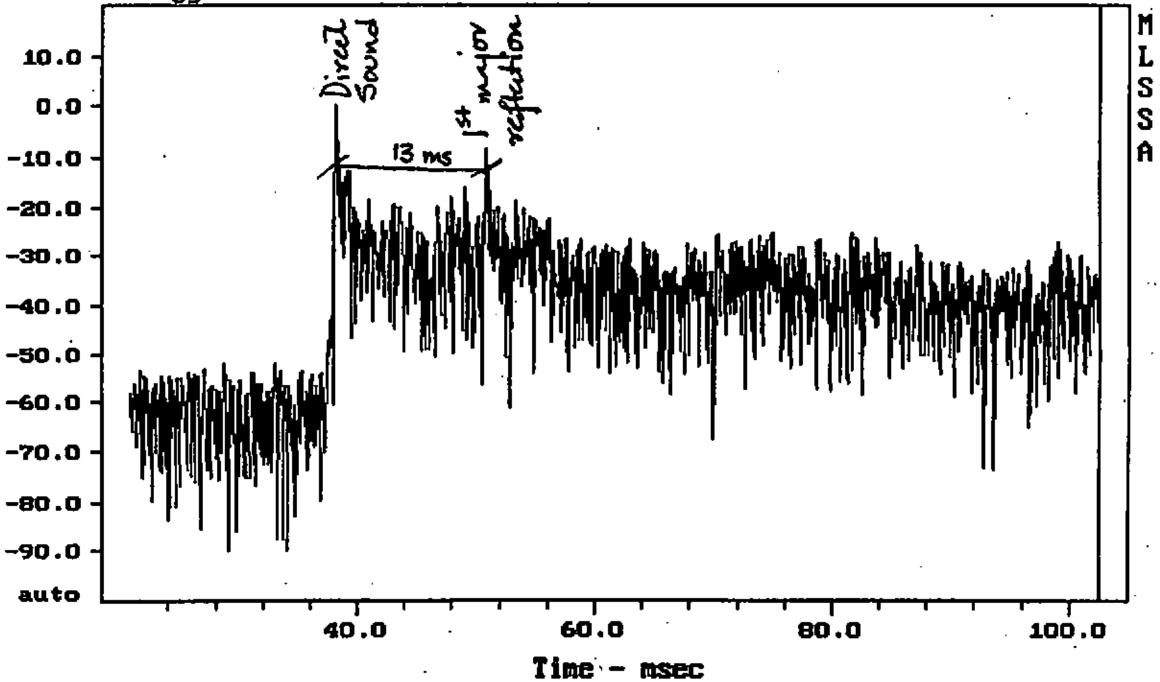

dB
HA01_1K
70
60
50
40
30
20
10
0
9
0 25 50 75 100 125 150 ms
Source angles
Ver
Hor
Receiver angles
Ver
Hor
S-201-213-R
CATT-Acoustic v6.1c 3/1/150,998/1000
Unlimited commercial version
Munro Associates, England

Figure 11

File: A:\PSTG3.TIM 5-16-97 1:26 PM

Energy-Time Curve - dB (Blackman-Harris window)



CURSOR: y = -36.8836 x = 102.5145 (6213)

Shepperton P Stage centre spk

10-6-97 5:38 PM

MLSSA: Time Domain

Figure 12