NOISELESS RASTI - SPACE OR SYSTEM

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1. INTRODUCTION

Most intelligibility measurements are made with the space or building in an unoccupied stated and hence normally under quiet conditions.

The noise of occupation is normally accounted for at the post-processing stage and mostly comprises the addition of a random noise signal with a spectral content that approximates the noise of occupation.

RASTI or full STI measurements are or should be treated in the same way. The question is, do noiseless RASTI or STI measurements fully account for the system performance or are the measurements in fact measurements of the space?

2. RASTI - UNDERLYING PRINCIPLE

For the purpose of brevity the principle described here is that for RASTI but it applies equally to a full STI.

RASTI is deduced from a computation deduced from the modulation reduction factors at 4 No. modulation frequencies in the 500Hz band and at 5 No. modulation frequencies in the 2kHz band.

Each modulation reduction factor in each band is a function of modulation frequency, direct-to-reverberant ratio and signal-to-noise ratio and may be understood for the solution for a position well into the reverberant field vis:

$$m(F) = \frac{1}{\sqrt{1+\left(\frac{2\pi FT}{13.8}\right)^2}} \cdot \frac{1}{1 + 10^{\frac{-S/N}{10}}}$$

where: m(F) = modulation reduction factor for modulation frequency (F)
F = modulation frequency (Hz)
T = Reverberation Time (secs.)
S/N = Signal-to-Noise Ratio (dB).

Now under noiseless conditions S/N $\Rightarrow \infty$ and hence the second multiplicand $\dfrac{1}{1+10^{\frac{-S/N}{10}}} \Rightarrow$ unity

and hence $m(F) = \dfrac{1}{\sqrt{1+\left(\dfrac{2\pi FT}{13.8}\right)^2}}$

It should be remembered that for positions not deep into the reverberant field the m(F) remains a function of the direct-to-reverberant ratio. Fig. 1 shows the relationship between RASTI and D/R ratio for various values of RT.

Notwithstanding the foregoing, the measurements cannot be gain-related since in the absence of noise the intelligibility is not a function of output level[1]. Furthermore each audit octave band in the case of RASTI 500Hz and 2kHz is treated independently.

3. SYSTEM AND SPACE ATTRIBUTES

Any speech amplification system will have the following attributes:

1. Distortion
2. Frequency Response
3. Directivity
4. Output Capability
5. Number of Output Transducers.

The space will have the following attributes:

1. Volume/Surface Area
2. Disposition of Absorption
3. Reverberation Time
4. Reverberant Field
5. Noise of Occupancy.

A particular position in the space will have the following attributes resulting from the system and the space:

1. Direct-to-Reverberant Ratio
2. Signal-to-Noise Ratio
3. Frequency Response
4. Distortion.

The following table shows the relevant parameters that affect and cause as a consequence the position specific attributes:

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[1]This is not strictly true but objective measures not do take this into account.

Table of Parameter Relationship

Parameter	Position-Specific Attributes			
	D/R	S/N	Freq. Response	Distortion
System Distortion				X
System Frequency Response			X	
System Directivity	X	X		
Output Capability		X		
Number of Transducers	X	X		
Volume/Surface Area	X			
Disposition of Absorption	X			
Reverberation Time	X		X	
Reverberant Field	X		X	
Noise of Occupancy		X		

Table 1

It should be noted that it is assumed that S/N is in fact the ratio of the direct field to noise and not total field to noise.

4. A NOISELESS AUDIT

From the foregoing information we can now readily understand that introducing noise to the audit might affect the results both in terms of absolute magnitude but also in terms of meaning and consequence.

The nub of the matter relates to the fact that the measurements are not gain-related and further that each channel is treated independently.

To illustrate this, the following experiment was carried out.

A simple system comprising graphic equaliser, amplifier and loudspeaker was set-up in a small space RT 1.5 sec. approximately.

Fig. 2 shows the frequency response of the system with the equaliser set flat.

An MLS signal was output from the system and the RASTI value deduced.

The graphic equaliser was reset to approximately 15dB cut to each of the RASTI octave bands (500Hz and 2kHz) see figs. 3 and 4.

The table below gives the results obtained.

Table of Noiseless RASTI Results

Condition	RASTI
Flat	0.83
500Hz Cut	0.82
2kHz Cut	0.83

Table 2

It can be seen that there is very little difference between the results which indicates that the system is not part of the audit chain.

The experiment was then repeated but with the addition of noise giving an overall S/N in the region of 10dB.

The table below provides the results together with those detailed in table 2.

Table of Noiseless and Noise Contaminated RASTI

Condition	RASTI	
	Noiseless	with Noise
Flat	0.83	0.67
500Hz Cut	0.82	0.46
2kHz Cut	0.83	0.40

Table 3

It can now be seen that there is a considerable difference between the flat and 'cut' conditions.

5. DISCUSSION

The foregoing is a patent demonstration that RASTI or STI measurements made under noiseless conditions do not audit the system and the results are largely a function of the space.

Clearly this is a worrying situation since most measurements are carried out under quiet conditions when the public are not present.

Furthermore, RASTI is often used as maintenance monitor to detect the onset of system failure. Clearly if noise is not present the RASTI method is largely insensitive to system changes.

6. CONCLUSIONS

From the foregoing we have deduced:

1. Noiseless RASTI does not fully audit the system and is only a direct measure of the space.

2. To provide a proper audit of the system noise compensation must be included.

Finally, we would pose the question that if RASTI under quiet conditions does not audit the system but that word scores might, then is it true to suggest that there is a unique relationship between RASTI and Word Scores?

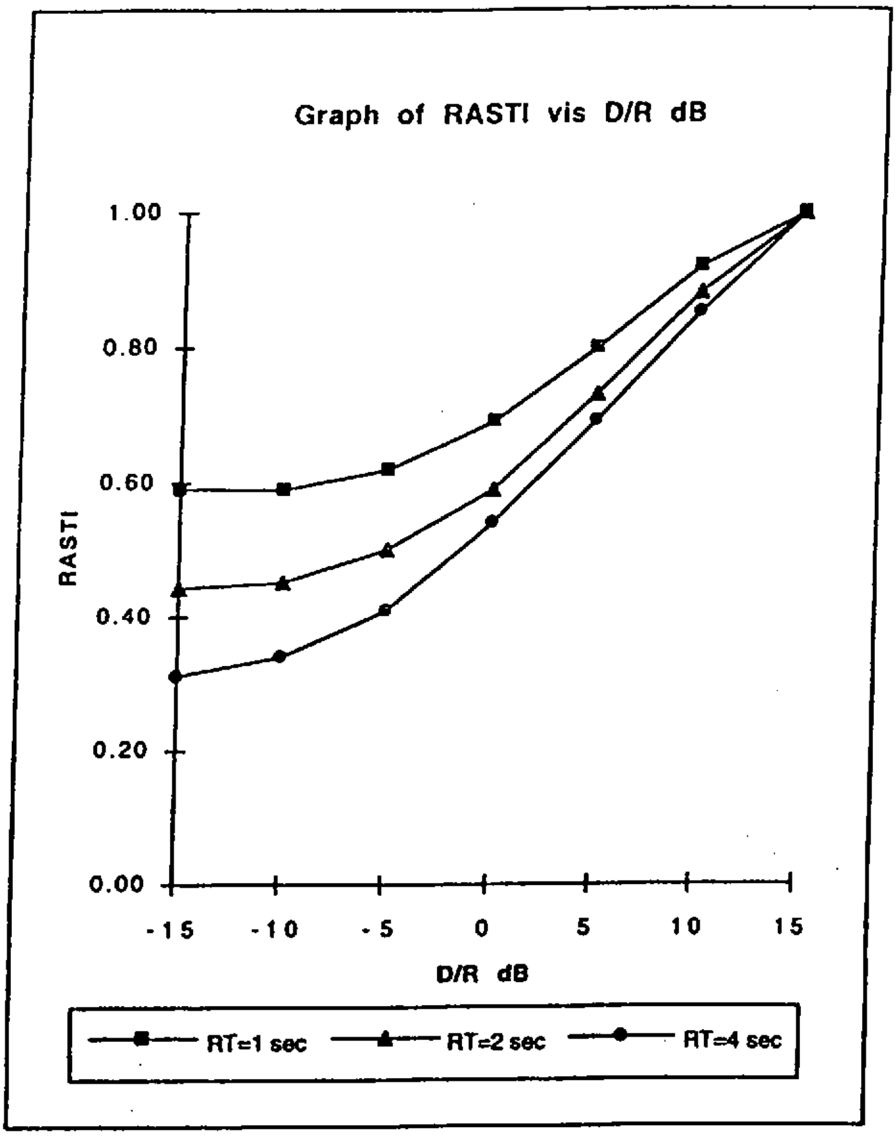
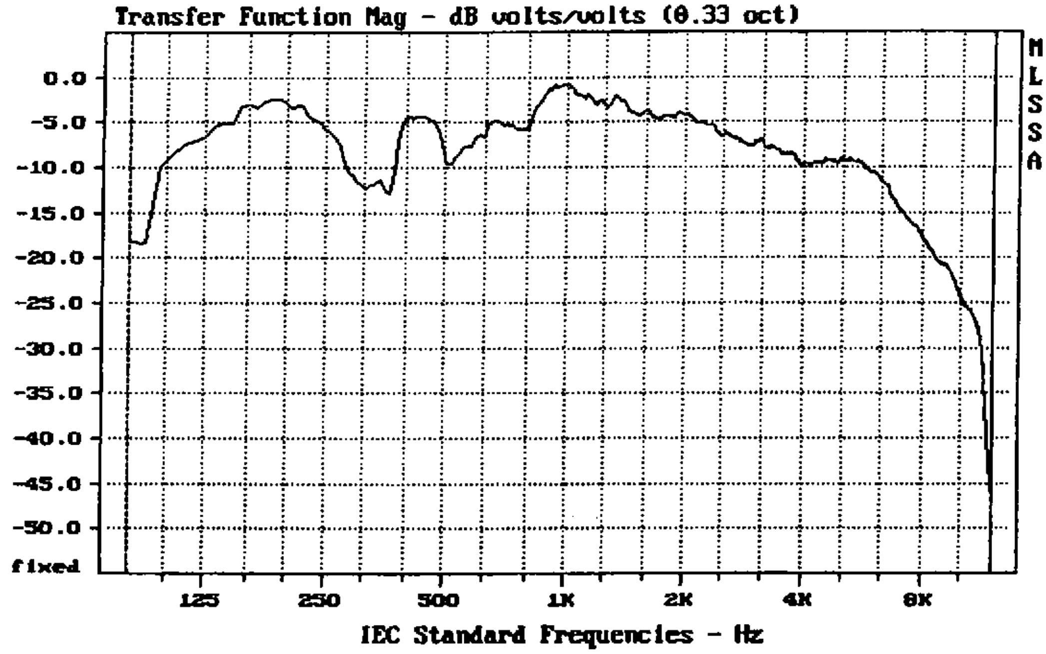

Graph of RASTI vis D/R dB
RASTI
1.00
0.80
0.60
0.40
0.20
0.00
-15
-10
-5
0
5
10
15
D/R dB
RT=1 sec
RT=2 sec
RT=4 sec

Figure 1



mean: -10.96, rms: -9.00, std: 4.88, max: -0.76, min: -46.33

MLS: Flat. Noiseless.

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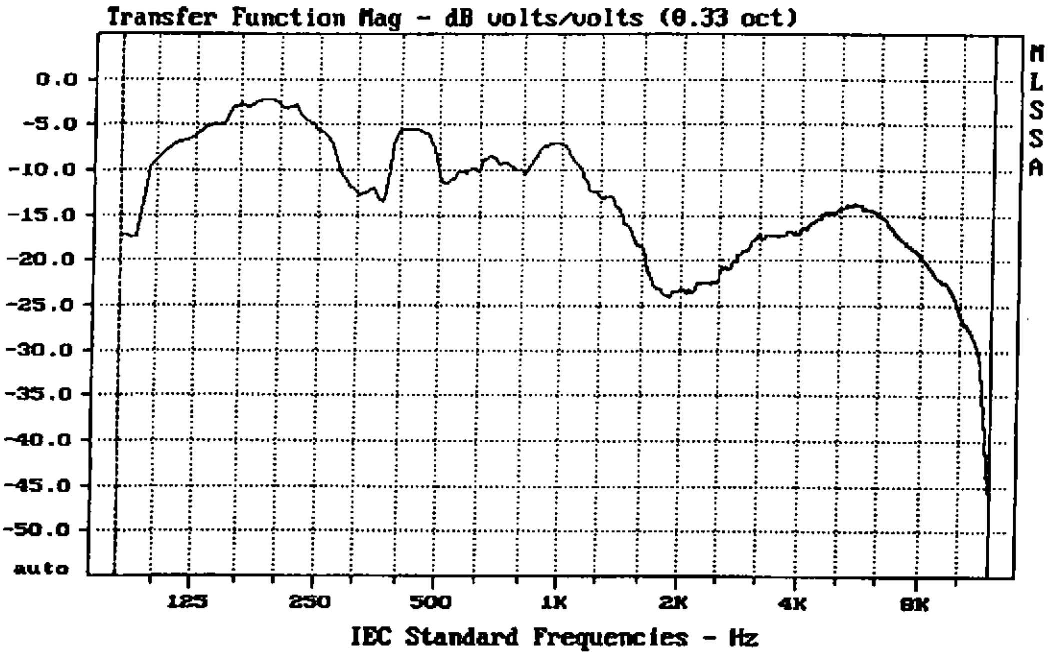
MLSSA: Frequency Domain

Figure 2



mean: -17.30, rms: -15.22, std: 5.82, max: -2.12, min: -46.19

MLS: 2kHz cut(-20dB). Noiseless.

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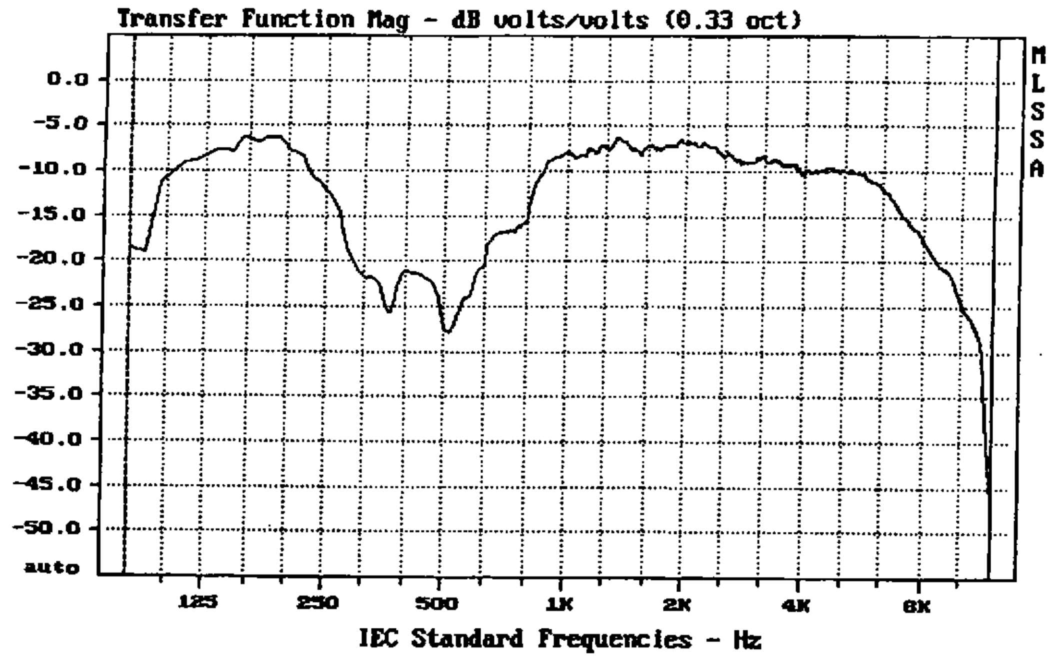
Figure 3



mean: -13.16, rms: -11.66, std: 4.30, max: -6.26, min: -46.16

MLS: 500Hz cut(-20dB). Noiseless.

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MLSSA: Frequency Domain

Figure 4