GETTING THE MEASURE OF REPRODUCED SOUND

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ABSTRACT

Whereas 'high sound quality' is a desirable and nowadays often a contractual requirement, is it highly subjective. The paper questions whether objective measurement techniques can be brought to bear in order to help quantify the characteristic. However, in order to do this, it is necessary to define the constituent attributes that affect sound quality. Whereas it is possible to consider a myriad of factors, the paper suggests that there are four main constituent parameters that need to be taken into account. These include the Timbre and Informational aspects together with sound localisation and distortion. The concept of an overall Sound Quality Index (SQI) is introduced.

INTRODUCTION

'Of High Sound Quality' is a phrase often used and found in audio and sound system specifications, yet what does it mean ? how do you define such an apparently nebulous phrase ? Ideally, it would be desirable to be able to objectively measure and quantify the term.

Research would suggest that there are probably four main aspects to sound quality. These can be broken down into the following broad categories which can be further subdivided as required : Timbre, Information, Spatial Accuracy and Distortion.

Timbre

The timbre of a sound relates to its tonal characteristics and potential colouration. It is therefore highly connected to spectral content and the correct spectral balance and hence the frequency response of the sound system. Clearly, the overall bandwidth and evenness of response relate to this. The low and high frequency limits are of critical importance as is the quality of the bass sound in it own right - research suggesting this to be a separately judged aspect. The main parameters therefore relating to Timbre include :

- Bandwidth
- Frequency Response
- Bass extension & quality

Colouration is a further aspect – but this can be caused by both frequency and time domain response aberrations. Objective measures exist to describe and quantify frequency response, bandwidth and bass extension – but bass quality requires a new approach.

Information Quality

The informational content of the reproduced signal is of critical importance – for both speech and music applications. Information may be lost or 'distorted' by both frequency and time domain effects. 'Clarity' is a term often used to describe information quality, either in its general sense or in its more specialist architectural (e.g. auditorium) acoustics role. It can apply equally to either speech or music signals. 'Intelligibility' on the other hand generally refers to speech. Various measures already exist that may be used to quantify intelligibility and musical definition or clarity. Information quality therefore relates to :

- Clarity
- Intelligibility

Spatial Accuracy (localisation)

Spatial accuracy is a quality that may not apply in all cases – for example in a general purpose paging or an announcement system, there is generally no sonic origin to focus on or relate to. However, in cinema, theatre or worship spaces for example, it may be extremely important to be able to accurately relate the sound you are hearing to the apparent or expected source. There is currently no standardised or accepted way of measuring spatial accuracy.

Distortion

Distortion can mean very different things to different people. Distortion in the audio engineering fraternity is generally taken to relate to the non-linear behaviour of the device or system – such as typified by harmonic or Intermodulation distortion. However, in the broader sense, distortion relates to anything that is in the output of a system that wasn't in the input. This can be observed either objectively with test instrumentation or audibly at a nominal listener position. Distortion can therefore also relate to the temporal characteristics of a sound and can include the presence of reflections, echoes or potentially reverberation – but here the line begins to blur with 'clarity' and 'intelligibility' aspects. In the days of mechanical audio reproduction and signal storage, wow and flutter and playback speed variations were another form of time domain related distortion. Distortion is therefore taken to relate to :

- Non Linear effects (eg THD / Intermodulation)
- Temporal (reflections and speed variations)

Other Quality Aspects

A further parameter, related to sound quality, but not a direct signal parameter is 'evenness of coverage'. In many instances, this will not be observed by the casual listener located at a fixed position (e.g. auditorium or sports arena seat), but there are systems where the listener is moving and needs to follow the audio signal (e.g. some theme-park rides or attractions). A further form of colouration is that produced by an unbalanced reverberation time. Whilst this is related to frequency response, the way in which the latter is measured may or may not highlight the effect. A poorly balanced or overly long reverberation time can also lead to highly undesirable waveform distortion. Examples of this are shown in figures 1 & 2. Figure 1 shows a not untypical, grossly imbalanced reverberation time characteristic for a multipurpose hall. Whilst a low frequency rise is often provided in a classical musical concert hall, it has absolutely no place whatsoever in a hall intended for amplified music. Sadly this is a far from isolated example. Figure 2 shows a poorly controlled modal response.

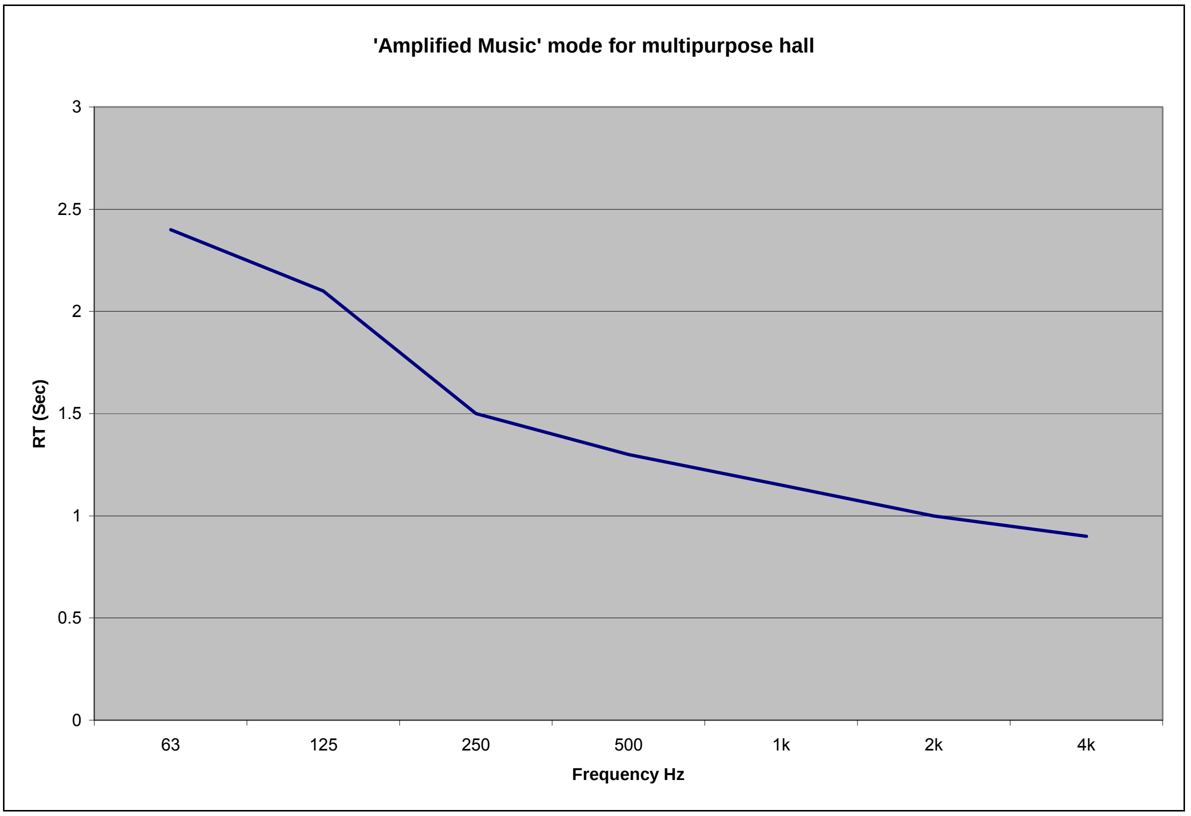

Figure 1 – Reverberation Time characteristic for Multipurpose Hall (Amplified Music Mode)

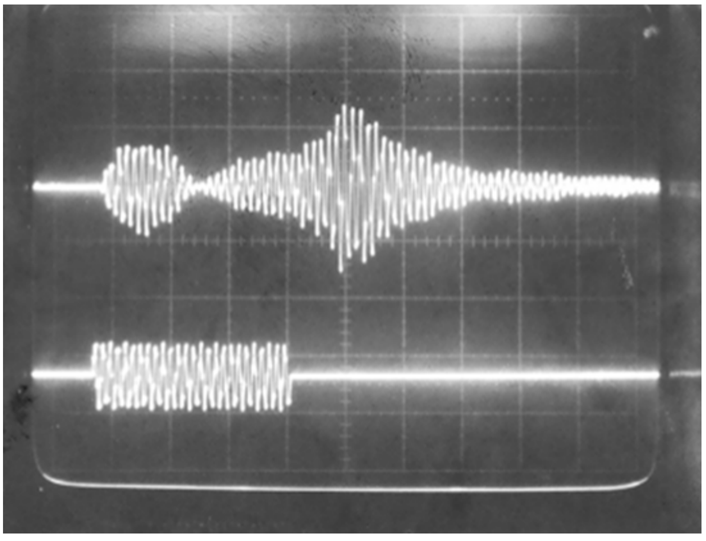

Figure 2 - Temporal (room) distortion of simple toneburst signal

The aforementioned sound quality attributes are summarised in figure 3.

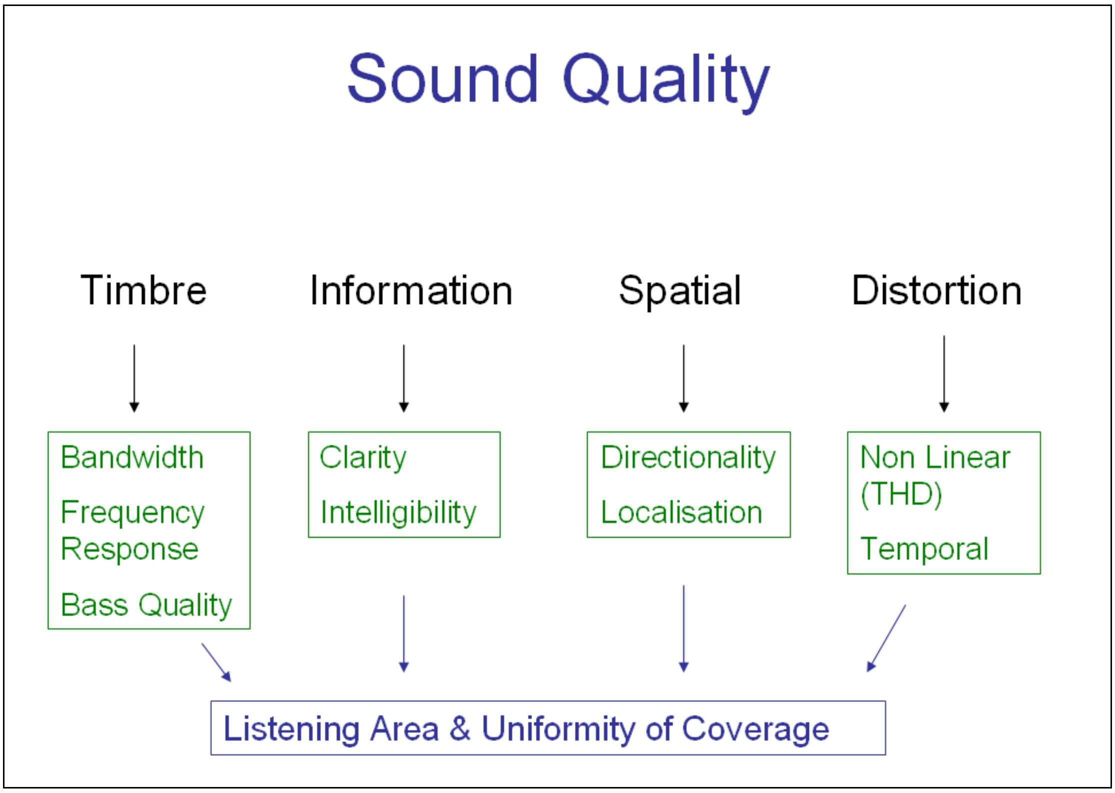

Figure 3 – Sound Quality attributes

SOUND QUALITY INDEX (SQI)

A method is required by which measures of the individual factors that go to make up ‘Sound Quality’ can be combined into a single rating scale.

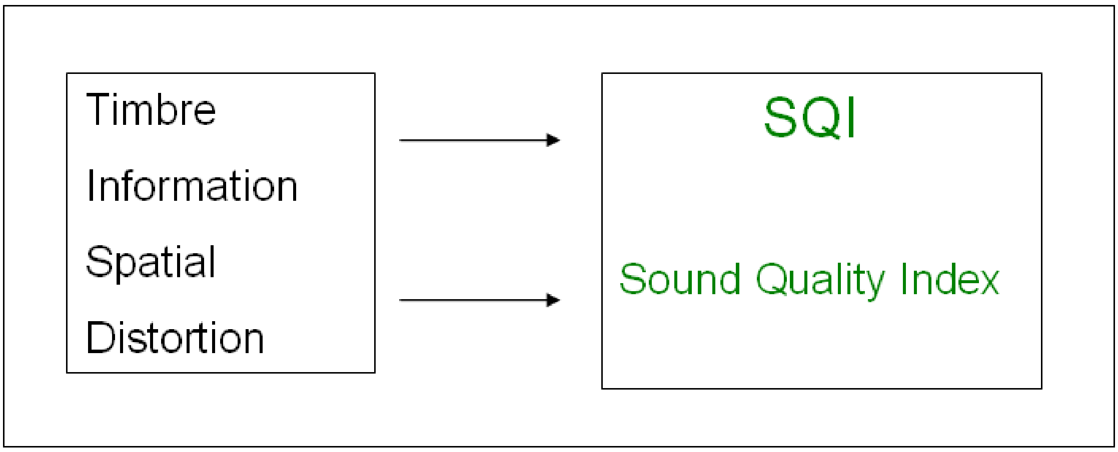

Figure 4 Sound Quality Index

There are several ways that this could be achieved which are currently being investigated by the author.
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The simplest would be in the form of a simple weighted product such as :

$$\mathbf{SQ} = \alpha(\ \mathbf{T}\ ) + \beta(\ \mathbf{I}\ ) + \gamma(\ \mathbf{S}\ ) + \delta(\ \mathbf{D}\ )$$

Where α, β, γ & δ are weighting factors that relate to the importance of each attribute and T, **I**, S & D are the Timbre, **I**nformation, Spatial and Distortion attributes discussed above. The equation could be normalised or computed as an r.m.s. value and then expressed as a single SQ**I** rating scale ranging from 1-10 say or maybe better still as a percentage. Whilst the weighting factors could change with situation, it would be better to keep them constant and instead adjust the overall rating score to relate to various applications. For example an overall score of 40 % might be suitable for an industrial paging / announcement facility, whilst 80% plus might be the recommendation for a theatre or high quality auditorium system and 90 % plus for a home theatre etc.

Considerable further work is required to make the concept into a viable measure and rating system.