Sound level sample intervals and context

Have you ever felt that the sound you are listening to, is actually not well described by the available acoustic parameters?

By Tony Higgins

Obviously we have plenty of choice as to how to describe measured sound; sound pressure, sound intensity, and a heap of measurement parameters such as L_{Peak}. L_{Max} L_{eq}, not to mention statistical measures, dose standards, A, C, Z weightings, frequency spectra, etc. and that is before we start talking about reference time intervals, measurement periods and averaging!

All provide measured descriptions of sound that can be, and often is, suitable for the intended purpose, but there is sometimes something lacking…some nuance, some descriptive metric that isn't quite matched by the available metrics in describing the sound. Something that really doesn't quite reflect what it is we actually hear!

One of the issues may be that the way our ears process sound might not always reflect the way instrumentation can measure it, or the manipulations we use to compartmentalise the measured data into manageable chunks. The question therefore is simple, does the reported sound level parameter, actually reflect what the receiver hears? Or are we simply providing an indication of sound as a level, that may not be reporting the actual perception of the sound under investigation? This in turn leads to whether our measured levels are actually truly representative or whether they should be reported with greater levels of uncertainty where the key feature of any sound is 'missed' by too high, or too low a sampling rate.

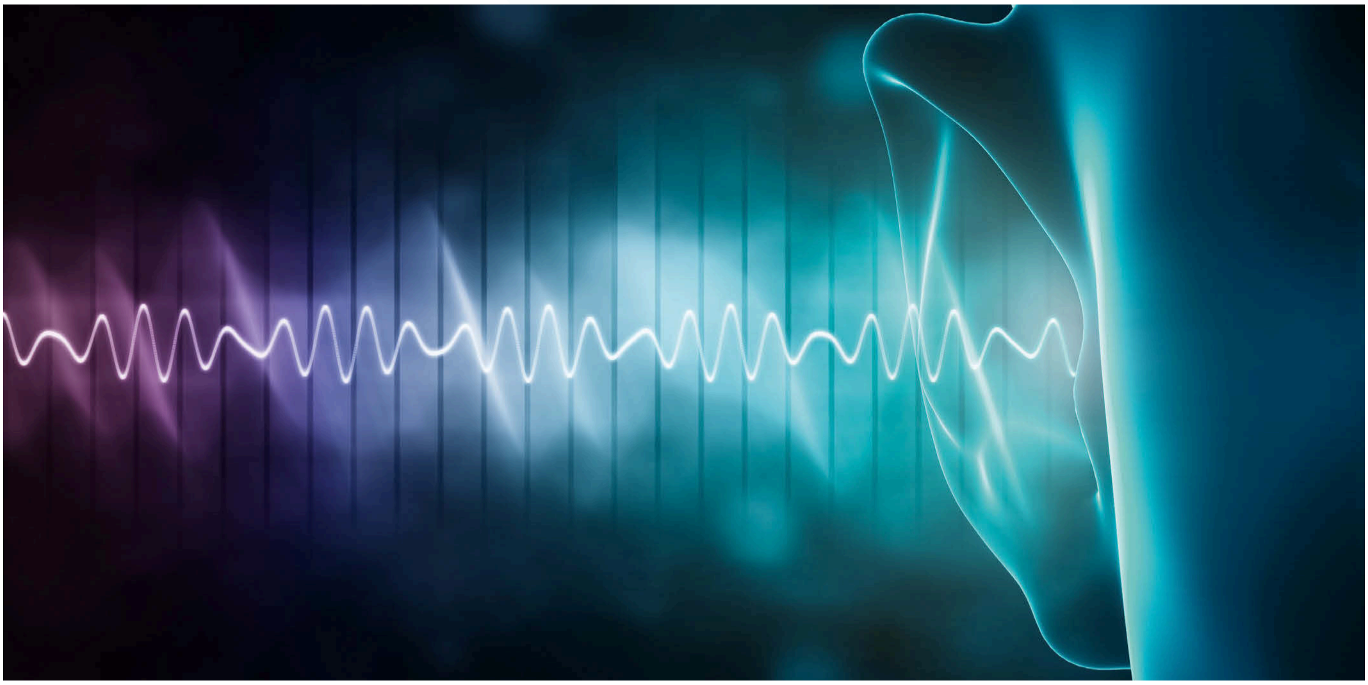
Before we get to that it may be worth evaluating the starting point, what parameters do we have and how to they work in terms of describing the sound we are evaluating?

Sound pressure

Sound pressure is defined as the instantaneous level derived from the incident sound pressure differential caused by a sound wave and the ambient pressure of the media the sound wave is passing through. It is measured as the root mean square value over a defined measurement period.

Sound pressure level

Sound pressure level is defined as the above sound pressure compared to the reference sound pressure (taken to be 20µPa) and expressed as a log function multiplied by 20 (the decibel). A sound pressure level is quoted over a reference time averaging interval but may be reported as an average over the measurement period or as the variation of sound level over each reference sound measurement period.

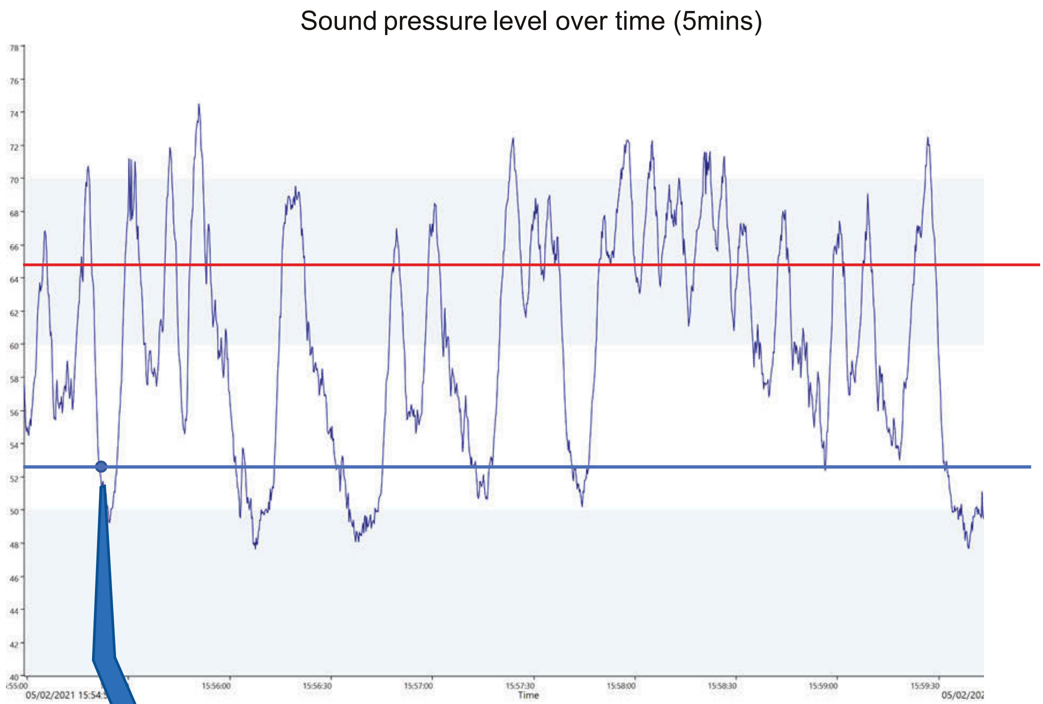


Let's take an example. The measurement Fig.1inset is a sound pressure level time history taken over a period of 5 minutes. The display at the point indicated shows an instantaneous level within that 5-minute period of 52.5 dB. This provides good detail…ordoes it? Does this actually reflect the sound as observed at the receptor location at that point in time?

Looking more closely (second image) the single point reference (one second) for that same point in that same five-minute graph is obviously an average. The measurement sample rate is much faster, (actually 1/100thsecond), the levels recorded within that one second vary between 49 dB and 55 dB.

So, is the measured sound level for that one second actually representing what is perceived at that second? Or is it artificially simplifying something our ears have a much greater ability to detect and resolve? What effect does the change in sampling rate actually have other than to provide greater resolution on the data that may or may not be helpful? And how does all of that relate to the perception of the sound where we average periods of five minutes, 15 minutes, or an hour?

Maybe it would help to display the data in a different format? And maybe the fine resolution at 1/100thsecond is not actually needed and what is required is something representative of perception? P64



Left:
Figure 1: Time History (1/.100s)

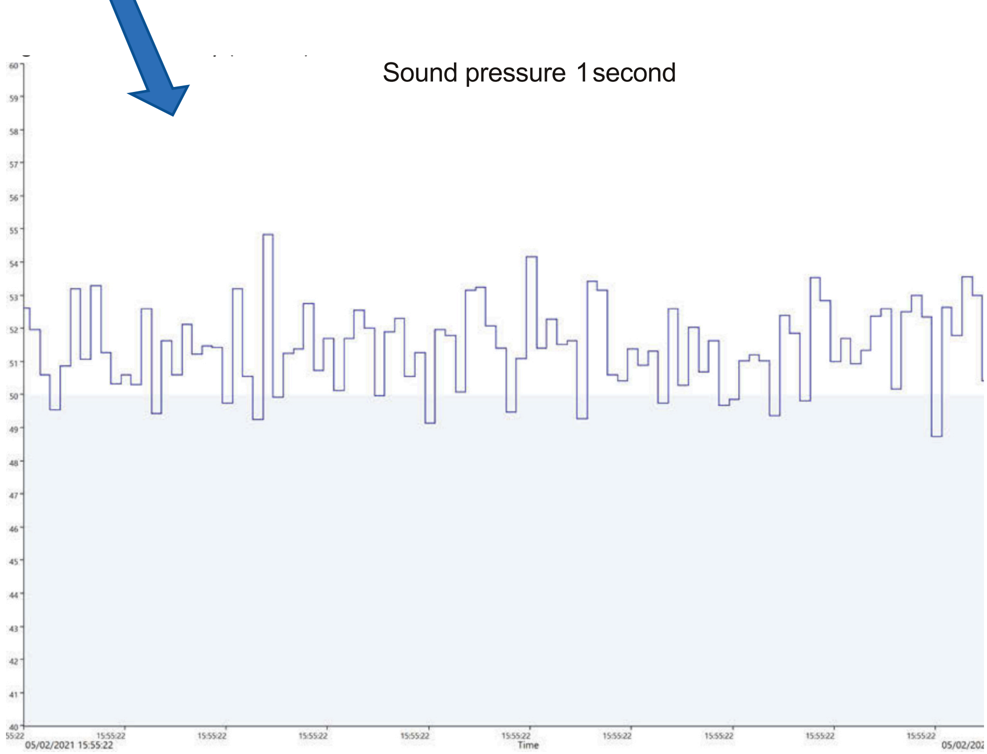


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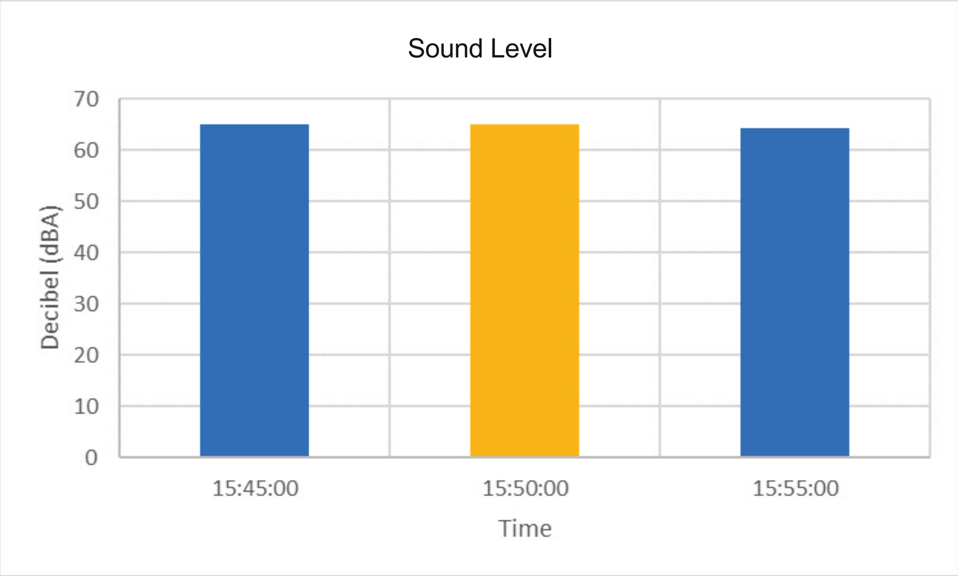
Figure 2: Time History (1/.100s)



Left:
Figure 3

How about the data presented in Figure 3? Perhaps it is time to use an average…cue L_{eq}, the levels representing an average had the sound been constant throughout the measurement period. The graph shows the five-minute measurement, (and the two adjacent measurements to help provide context). Is this helpful? Clearly with less detail there is less to interpret but we are no closer to evaluating the source and determining how that source will be perceived. Do we need something more detailed, more nuanced and generally more helpful?

So, what about this? (See Figure 4). The image provided shows the same five-minute period. It shows frequency and sound levels varying over time, with level – surely this will provide all we need to identify the source and provide appropriate context? It certainly provides additional granularity and an ability to see variation in the sound over time. We may even hazard a guess at what the source sound actually is based on this sort of data, or at least be able to describe the changes in level, pitch, tone, and variation over time.

So, we come back to the original question, we need a measurement criteria or method that represents the nuance of a sound, provides a full and frank explanation without compromising the usefulness of single figure data. We need to know that we can rely on the data presented and processed by the sound level meter and that the results are robust for all measured sampling rates.

It seems clear that a single parameter, isn't going to provide that, and neither are multiple, increasingly detailed measurements going to help.

Additional understanding about how the human ear comprehends sound may help. Data to establish what sampling rates the ear uses to identify and recognise sounds might be helpful. I looked but failed to find any robust literature on the subject, research project anyone? So ultimately where does that leave us in interpreting sound level data?

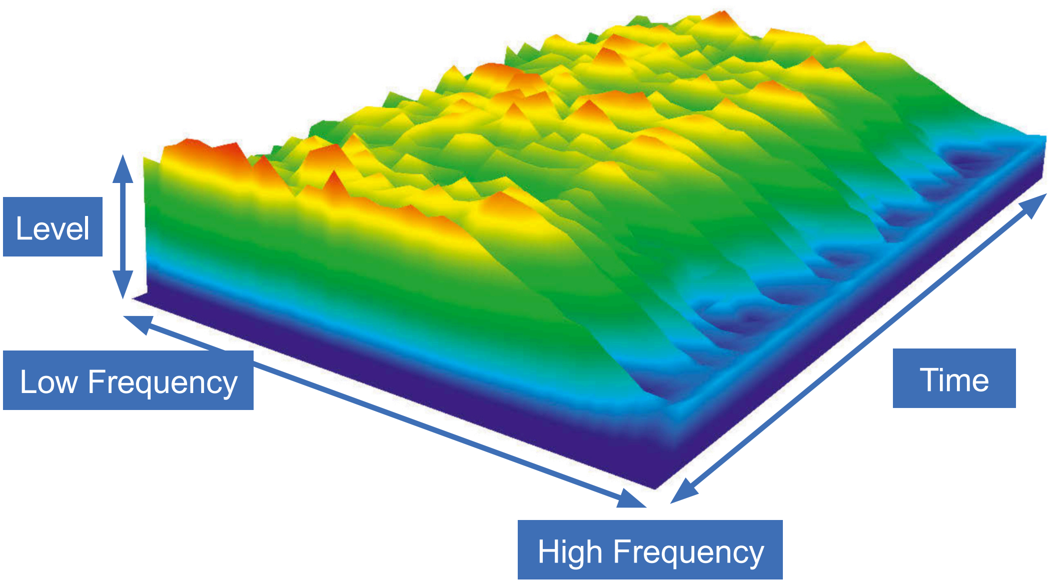
Reflection

Instrumentation has the capability to store and display huge quantities of data. The sheer volume of data invites analysis and commentary, but reporting needs to reflect the impact on the receiver, or if we prefer, the context of the perception of the sound.

As measurement parameters get closer to reflecting the human response, sound standards determining the acceptability of particular measured parameters that represent this will arise.

We already have one example; we use a reference A-weighting to reflect a standardised human response to frequency (and its drawbacks are well known). Currently, for environmental noise, the measurement parameters used reflect the standards (and particularly the health-related standards) available, e.g. long-term averages L_{Aeqs} for occupational noise, and most environment noise, short duration or Peak or L_{AMax} for event noise, but they don't provide a true indication of the perception of that impact.

Below:
Figure 4



The Planning Practice Guidance Table Noise Exposure Hierarchy Table (ref:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820957/noise_exposure_hierarchy.pdf), provides a useful link between observed levels of impact and practical effects on receptors, that in turn links to measurement standards such as BS4142:2014+A1(2019) terminology and the sound level measurement results that inform the assessment outcome (adverse and significant adverse impacts).

The simple example provided in this article, shows that the sample rate for collating these highly detailed results does vary significantly from the 'average levels' used in standards such as BS4142, the greater granularity offered by sampling very quickly, may or may not be the significant key issue that a receptor picks out, but clearly the variation in level is every bit as distinct for a particular sound as the frequency components, and these variations are lost when we average the results as required by some of these standards currently in use.

Whether the standards should change to reflect the human response to sound is perhaps something that will emerge more fully over time but what is clear is that the data alone cannot identify the source, no matter how much of it is presented. Identification of sources, and appropriate representation of that source in terms of measured levels, is solely down to the acoustician's preferred reporting metric.

We state what the source is (in this case road traffic – full marks if you guessed!), in order to provide context. That in turn aids the recipient to review the report based on a common understanding/description of that source, using well recognised acoustic descriptions, e.g. road noise, rail noise, barking dogs etc, but would it be as easy to describe a new industrial source, or entertainment noise where music varies over time? Clearly recorded rock music at a level of 70 dB will be perceived differently than observing live choral singing at the same level. I suspect that this nuance of perception, and we can extend that to our collective enjoyment for the sound in question, will be a key factor in determination of context.

Minimising uncertainty

While we know the recorded levels are accurate, and they may even be relatively consistent, perhaps it is time to consider not just describing sources, but presenting recorded sounds so that the recipient of reports can appreciate the nature of the sound, and therefore minimise the uncertainty in reporting by offering a common starting point. It may be that this is a necessary precursor for truly understanding context, and it may also be that this is the next big area of difficulty in predicting the impact (in context) of sounds yet to exist in the acoustic environment, and may be simpler (and/or aid) the ISO 12913methods for assessing soundscape.

This article should remind you that:

- The way our ears process sound might not always reflect the way instrumentation can measure it.
- Data to establish what sampling rates the ear uses to identify and recognise sounds might be helpful.
- As measurement parameters get closer to reflecting the human response, sound standards determining the acceptability of particular measured parameters that represent this will arise.