Take it to the Max

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The World Health Organization (WHO) Environmental Noise Guidelines and the IOA, CIEH and ANC ProPG: Planning & Noise guidance documents both stress the importance of LAS and LAF Max values.

We have recently been asked about possible issues concerning the prediction or mapping of Max values so this article simply offers some thoughts on the subject, but we would be very keen to hear other people's advice and experience!

The starting point is to review how LAF Max is used to help describe noise events and how these events are linked to the standards.

The use of health-related standards for long-term exposure to noise are based on LAeq, as mentioned in the WHO guidelines on Community Noise. However, WHO also recommends an LAF Max approach 'where noise is principally composed of a small number of discrete events, the additional use of LA Max or SEL is recommended'.

WHO further describes how LAF Max should be interpreted, recognising that some LAF Max events are unavoidable, but repetitive high LAF Max events will tend to cause disturbance. It states that 'for good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45dB LA Max more than 10-15 times per night…'

LAF Max is therefore quoted as a 'not to exceed' environmental standard in the WHO guidance for night-time. It is normally referenced by acoustic consultants using both the external level of 60dB LAF Max not to be exceeded more than 10 times per night or a corresponding internal level of 45dB LAF Max.

The table below is an extract from Table 1 – Guidelines on community noise:

Specific environment	Critical health effect(s)	LAeq [dB]	Time base [hours]	LAmax fast [dB]
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening.	35	16	45
Inside bedrooms	Sleep disturbance, night-time	30	8	
Outside bedrooms	Sleep disturbance window open (outdoor values)	45	8	60

Figure 1 (below) shows a typical assessment of LAF Max events for a night-time period, marked up to show the 10th highest LAF Max (74dB). In this case, it can be seen that the external measured levels routinely exceed the external standard between 4am and 7am, and that additional mitigation is required.

By identifying the 10th highest LAF Max, a consultant can identify a need for at least 29dB of additional mitigation required to ensure that internal sound levels do not exceed the internal LAF Max standard of 45dB.

In effect, it is not possible to have an open window *and* comply with the health-related WHO guideline level. This all assumes that the measured levels for LAF Max are reliable and accurate and that they describe the noise sources accurately. It becomes even more important when we try to predict LAF Max levels using noise models or other techniques.

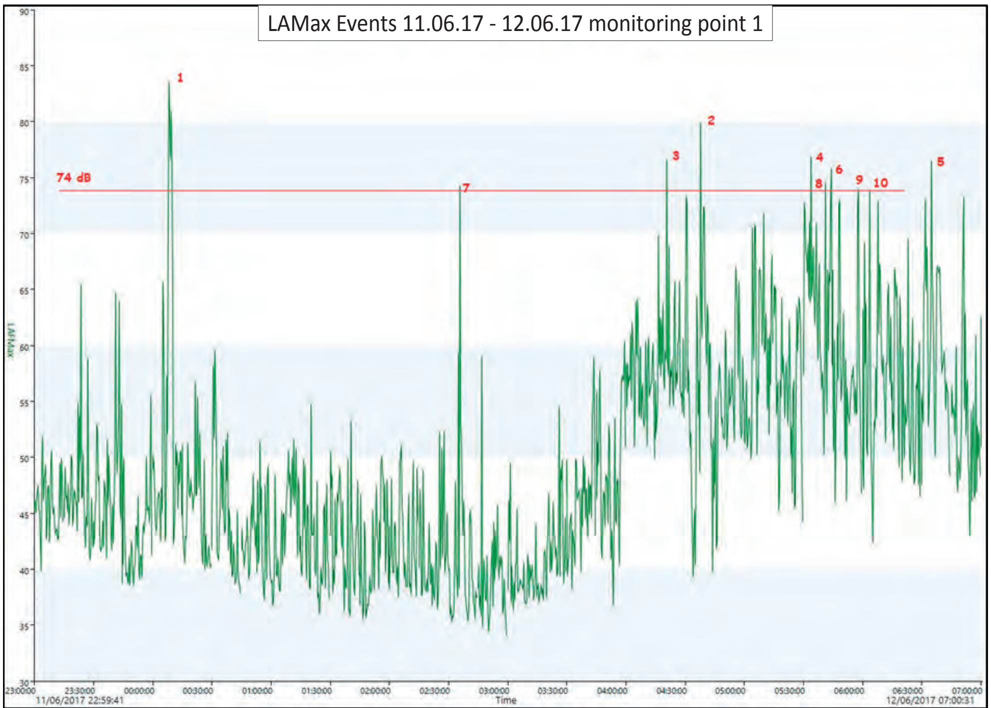

Figure 1. External LAF Max time history from 11pm to 7am

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LAF Max values are useful to determine the impact of short-term events against the baseline LAeq values. The WHO guidance and ProPG are particularly interested in the effect of Max values on the quality of sleep, but there are numerous sources that may be best evaluated with a Max. Dogs barking, rail movements, clay pigeon shooting, industrial processes and scrap yards all have different characteristics both in the time and frequency domains but does this effect the propagation?

The frequency characteristics of the source will change with distance due to ground effects and air attenuation. Air attenuation is far more significant at higher frequencies, see Figure 2.

The effects of ground absorption are more complex and depend on too many factors to summarise in a sentence, although it is the high frequencies that are attenuated the most.

With this in mind, the character of each type source should be considered individually as it will affect the level at the receiver.

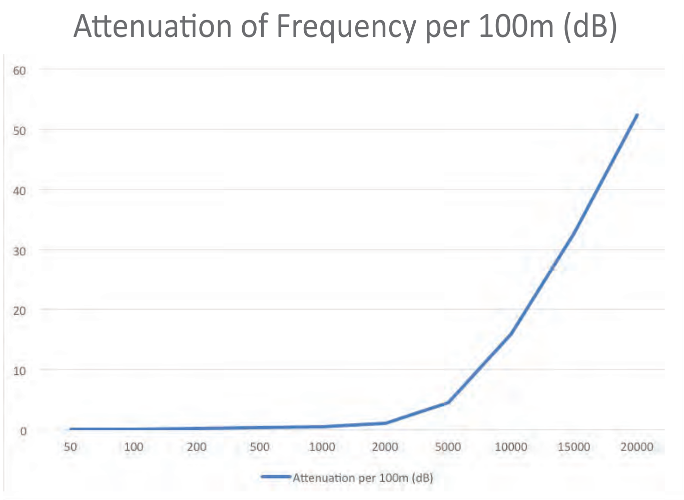

Figure 2. Frequency attenuation in air at 100m at 50 percent humidity and 20°C

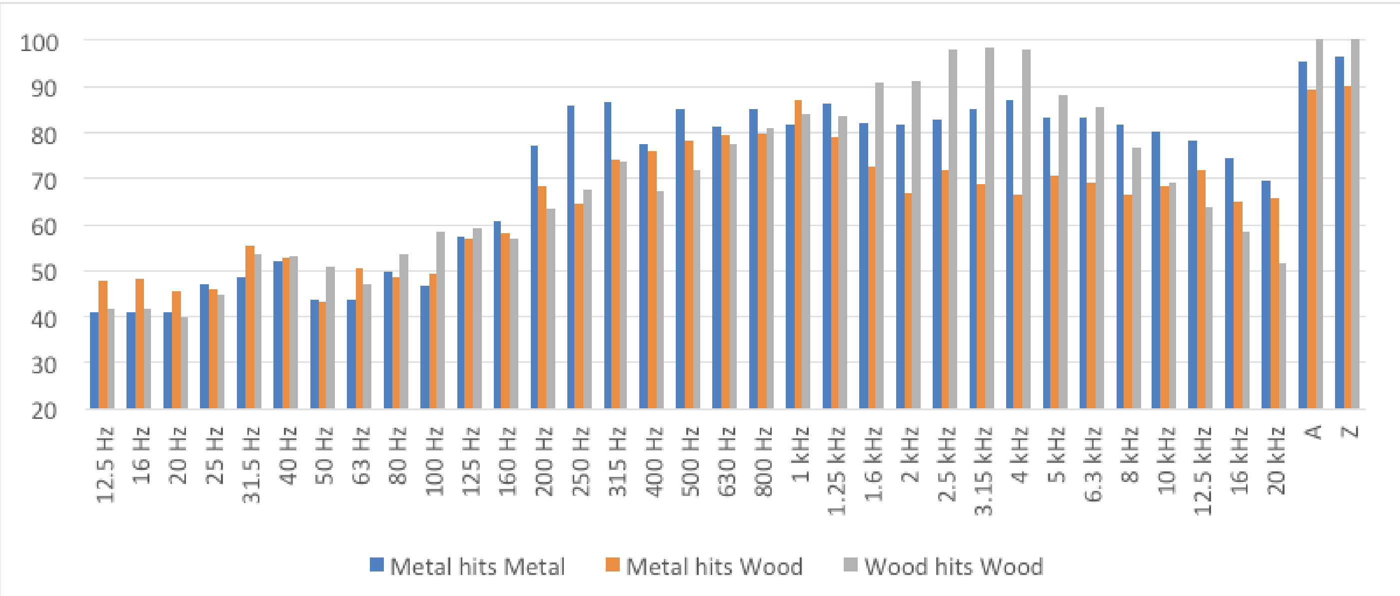

Figure 3. Frequency content of impacts at 1m measured in LZF Max

There is a common misconception that impulsive sounds contain an even amount of all frequencies. Figure 3 shows three impacts measured at 1m. The metal on metal impact produces quite a flat frequency output while, somewhat surprisingly, the wood on wood impact has considerably more high frequency content in the 1.6 to 5 KHz range. Therefore, in this example, the attenuation due to air will be more significant on the wood on wood impact than the metal on metal.

It may also be worth considering which parameter is best suited to measuring impulsive sounds. ProPG and WHO Guidelines refer to broadband LAF Max, which makes sense as it relates to the human perception but if you want to predict a level at the receiver, it would be more thorough to measure the frequency bands at source.

My preference is to use LZF as it provides a better indication of low frequency content and most analysis software will have a post weight option to apply the A-weighting curve. It should also be noted that we may not hear LAF Max events but we may still perceive/feel them, so low frequency events measured using LAF Max may underestimate the actual perceived impact.

Modern sound level meters will make more measurements per second than are actually displayed or stored, LAF or LZF values will be typically be analysed every 5ms. The 'F' stands for 'fast', which is 125ms so there is plenty of overlap on each of the measurements, this makes it possible to pinpoint the event and capture the Max level of each frequency band within a measurement period.

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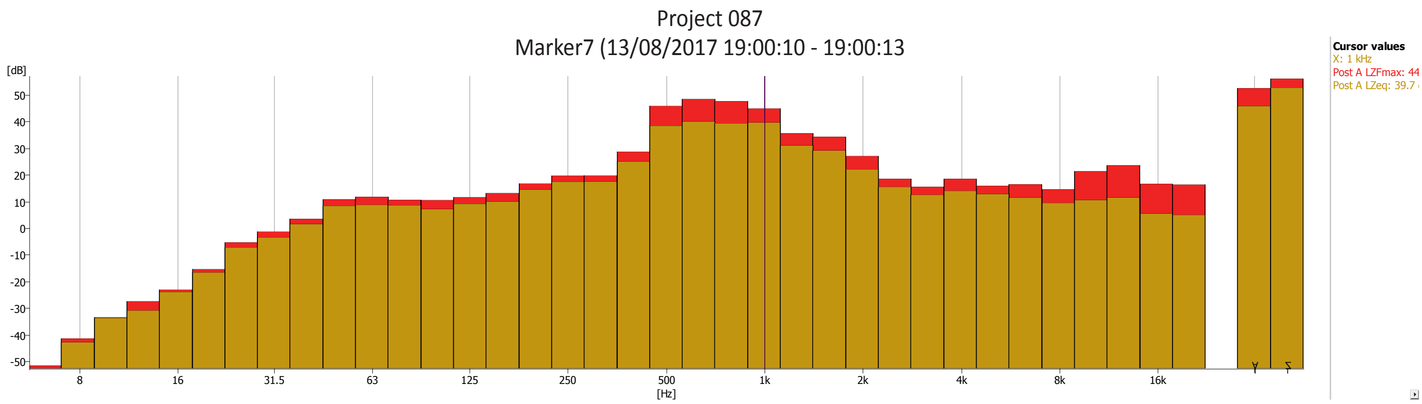

Figure 4. Single dog bark at 300m – one second LAF Max vs LAeq

If you are logging every second then you may find the Max values are close to the Leq values but would be significantly different over a longer period. Figure 4 shows one second LAF Max and LAeq of a dog bark at 300m from the kennels, there is a still about 5dB difference so even one second LAeq does not give an accurate representation of Max.

The impact on the receiver of an impulse event is due to the number of occurrences – not just the level or frequency content. Using the fast logging function on your sound level meter saves multiple measurements per second and can be useful to count and visualise impulse events.

Figure 5 shows that fast logging, in this case, 10ms LAF, can be used to demonstrate the intensity of impulsive events that would be missed with the one second LAF Max.

Directivity is another factor that must be considered when working with impulses. High level impacts such as munitions testing or demolition can have significant low frequency content that will spread equally in all directions until it meets a substantial structure. However, for sources with more high frequency content, directivity must be considered.

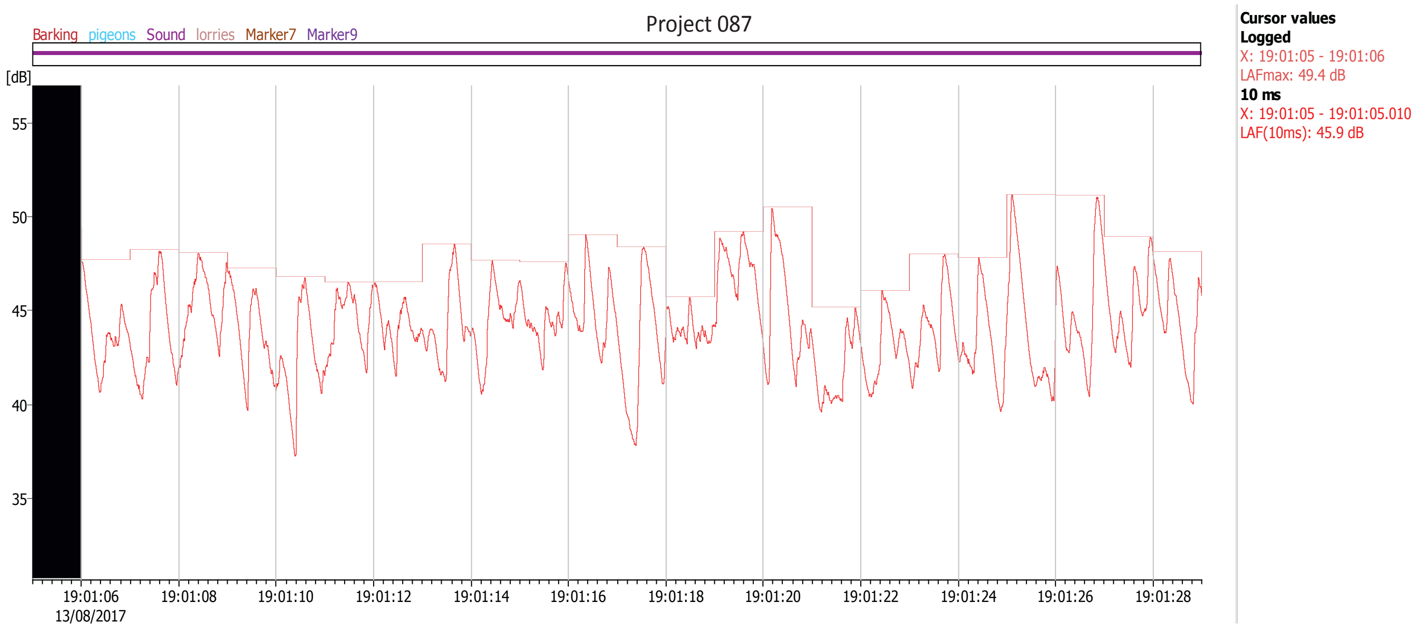

Figure 5. One second LAF Max and 10ms LAF data showing numerous dog barks in a 20 second period at receiver

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As an example, in a rail freight terminal, two carriages are shunted together and the metal buffers hit. As the carriages are blocking the sound path to the front and back the sound is only emitted to the sides and vertically making receptors to the sides of the train more susceptible to noise impacts.

Shotguns, such as those used for clay pigeon shooting, are also quite directional. It is difficult to measure a shot directly in front of a gun so in this example source measurements are made at 20 meters at an angle 135 degrees from direction of the shot. Figure 6 shows that the source and receiver measurements have different frequency content

The indirect source measurement gives a false impression that the high frequencies (>2KHz) are attenuated less by the ground and air effects at the receiver than the lower frequency range (125 to 630 Hz).

While this is not necessarily a comprehensive method, it hopefully demonstrates some important considerations when predicting levels of impulsive sounds. It is critical that when we characterise event noise (and impulsive event noise in particular), that we do so having regard to the perception of those events and then relate that to the way the instrumentation will display that data.

Low frequency event noise (particularly loud thumps) will be underestimated where LAF Max is used as a metric for measurement, while barks from a dog may be better represented.

We will no doubt continue to use LAF Max as the approved metric for measurement of event noise, mainly because WHO is a long-established standard using that metric, but increasingly, we are seeing that new research is identifying other methods and/or setting lower standards (WHO Guidelines for Europe 2009, Environmental Noise Guidelines for Europe 2018) perhaps to reflect the uncertainty in using LAF Max, moreover, LAS Max has been quoted in some research as a metric for sleep disturbance and may better reflect health-related impacts for long-term exposure than the more traditional LAeq.

Whichever standard or method is used to help describe event noise, it should be remembered that the character of the noise should be described and the results placed into context.

Please feel free to get in touch if you have any comments as this may become the topic of a presentation:

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The WHO Guidelines refer to LA Max, LAF Max and LAS Max. An LAS Max (‘S’ for slow) will be loudest one second within a measurement period and will be an equal or lower value than the LAF Max for the same period. LAS Max is used in connection with air traffic measurements. LA Max appears to be used as general description of both A-weighted Max parameters.

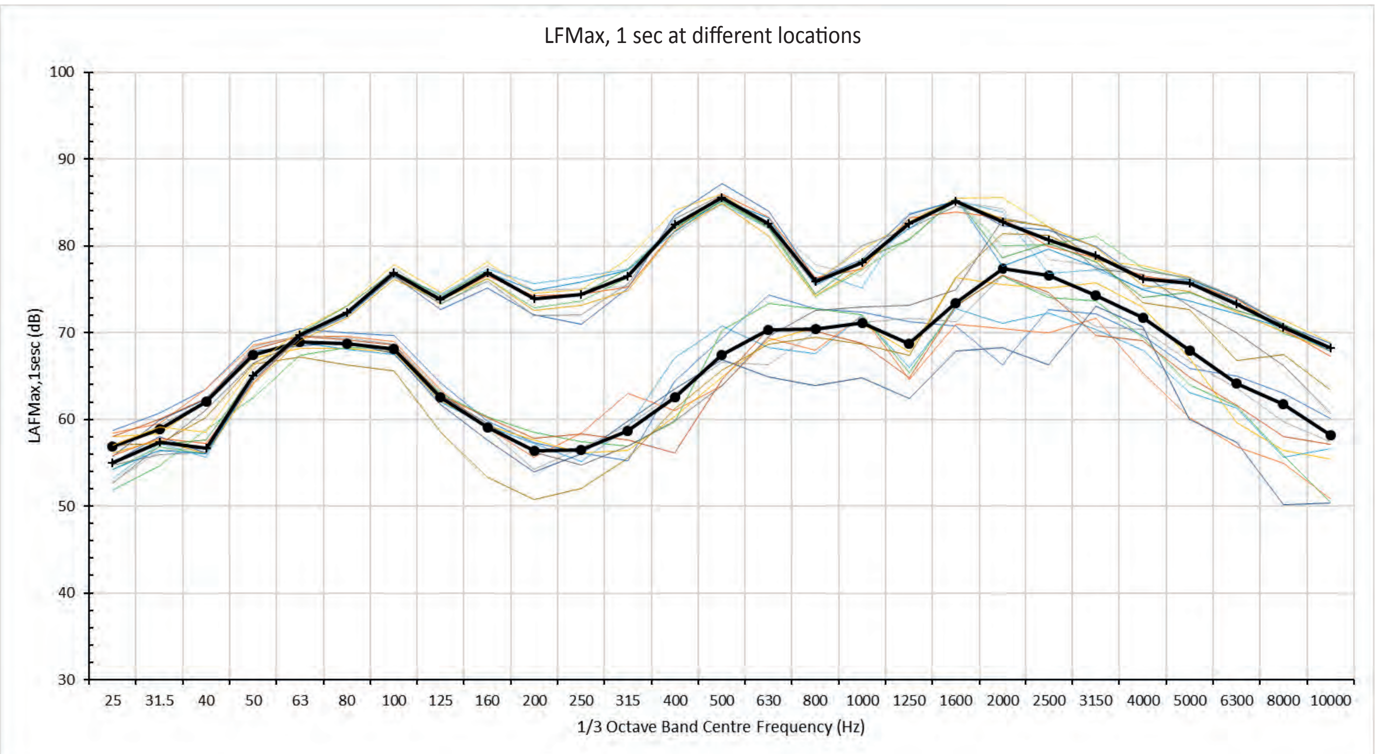

Figure 6. Clay pigeon shots at 135 degrees from the line of the barrels at a distance of 20m and at 150m in front of the gun