INSTRUMENTATION CORNER

# New technologies in acoustic and noise measurement

In this Instrumentation Corner article, we take a look at the future and, in particular, how our measurement systems can piggy-back on technologies ostensibly developed for other applications.

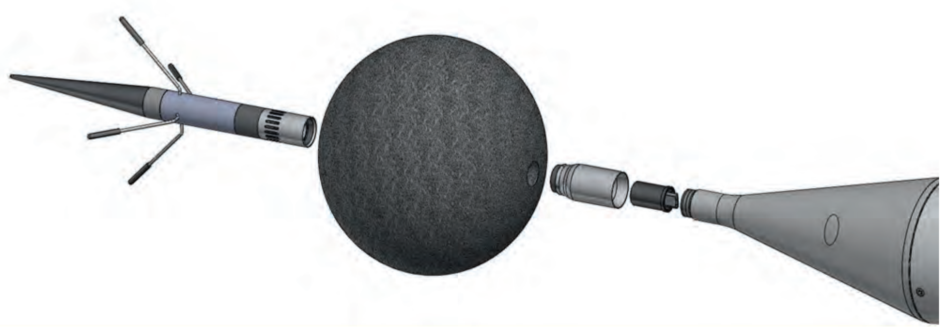
***By John Campbell and John Shelton****

## MEMS – an enabling technology

Much has been written in these pages about MEMS microphones and the performance of these tiny devices is improving all the time, driven by the mass markets in smartphones, videoconferencing and noise-cancelling technologies.

These microphones are made in their millions and the manufacturers will be completely uninterested in our tiny markets of noise monitoring and the like. As a result, the performance will be dictated by *their* end-users, not ours. However, careful selection of a MEMS microphone allows it to be used as a primary measurement transducer, as long as all the homework is also done on linearity, environmental effects, frequency response, long-term stability and calibration.

**Below:** Digital MEMS-based microphone



As a result, the technology is finding its way into noise dosimeters, calibrators and Class 1 sound level monitors, offering reduced cost but perhaps more importantly, better weather protection and handling resistance.

The low cost also allows for the use of two or three microphones to optimise noise floor, add redundancy and ensure stability. The irony is that while the microphones are cheap, the cost goes up the moment we package it into a ½" capsule, and does all the background validation and certification. Not so much of a free lunch after all!

It's also worth mentioning that MEMS technology is also used in vibration transducers – your smartphone already has these on board for simple things like screen orientation and haptic sensing, and we are starting to see MEMS accelerometers in net applications such as bridge and railway track monitoring.

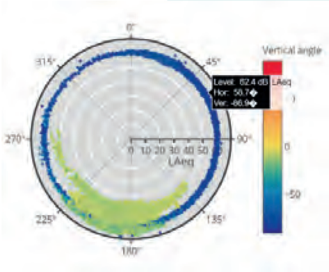
## Measurement microphones with directionality

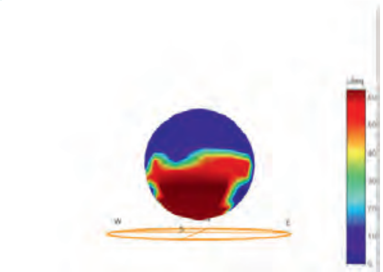
It is not cost-effective to make manned measurements for durations of longer than a few hours, and this often raises the question; "*How do you know if you have a good measurement and you are measuring the sound you thought you were?*"

To assist with this, audio recordings are often recorded in parallel with sound levels to help identify the source of the noise. However, it is time-consuming to listen to and analyse these recordings and they can also be inconclusive.

Advances in signal processing have meant that sound level meters can process far more information than previously possible. Sound level meter manufacturers have recently introduced multi- channel microphones for environmental measurements to automate the location of noise sources.

Measurement channels for location are typically MEMS microphone devices, which are phase matched. The delay in the signal reaching the microphones enables a location to be identified in a horizontal and vertical P44



**Left:** Representation of source direction in software

**Below:** Geolocation of sources

orientation. This 3D functionality enables, for example, aircraft to be picked out from normal community noise.

The systems typically feature a standard Class 1 microphone, which has type approval to ensure your overall sound levels are certified with the highest levels of accuracy.

With delivered software the user can analyse data and produce reports to identify direction and contribution to the overall sound level at the measurement point. This enables efficient and accurate analysis without expensive time on site.

## Smart sensors

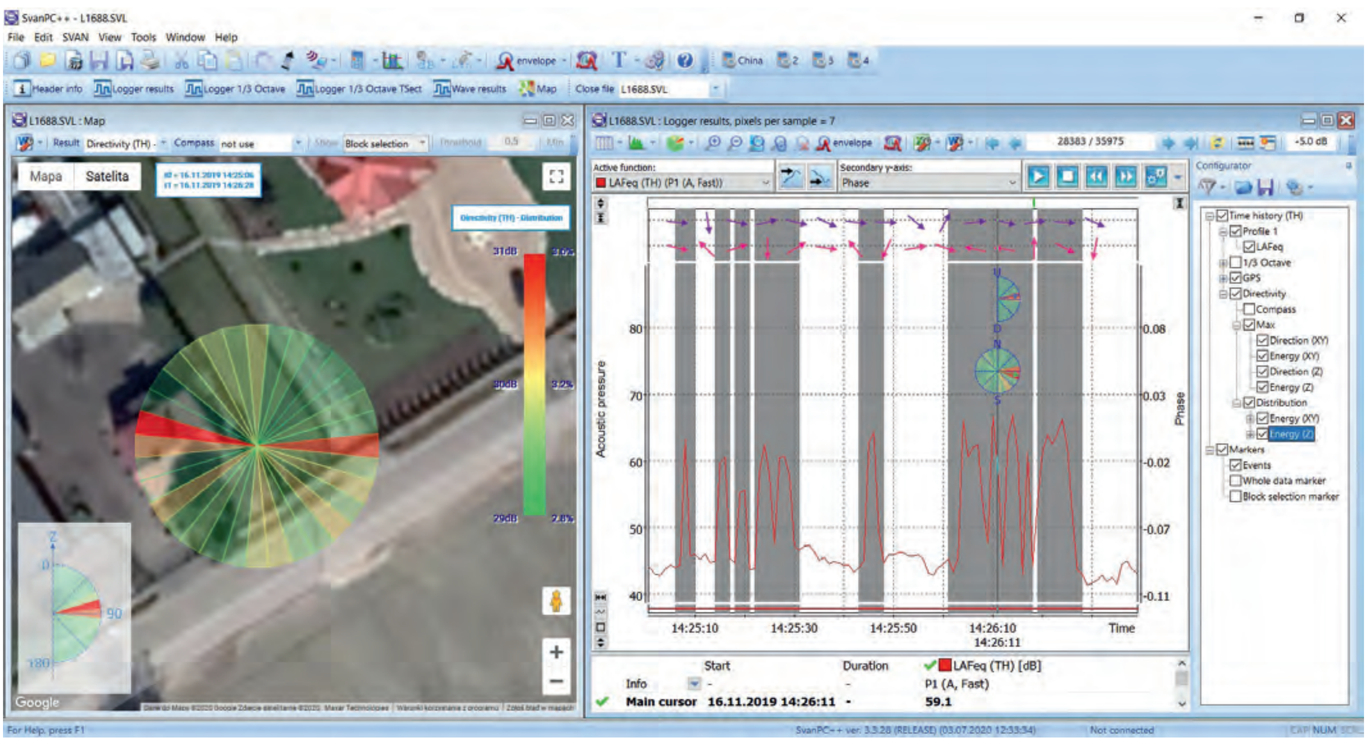
*From **Wikipedia: Smart sensor** may refer to a **Smart** transducer, an analogue or digital transducer or actuator combined with a processing unit and a communication interface.*

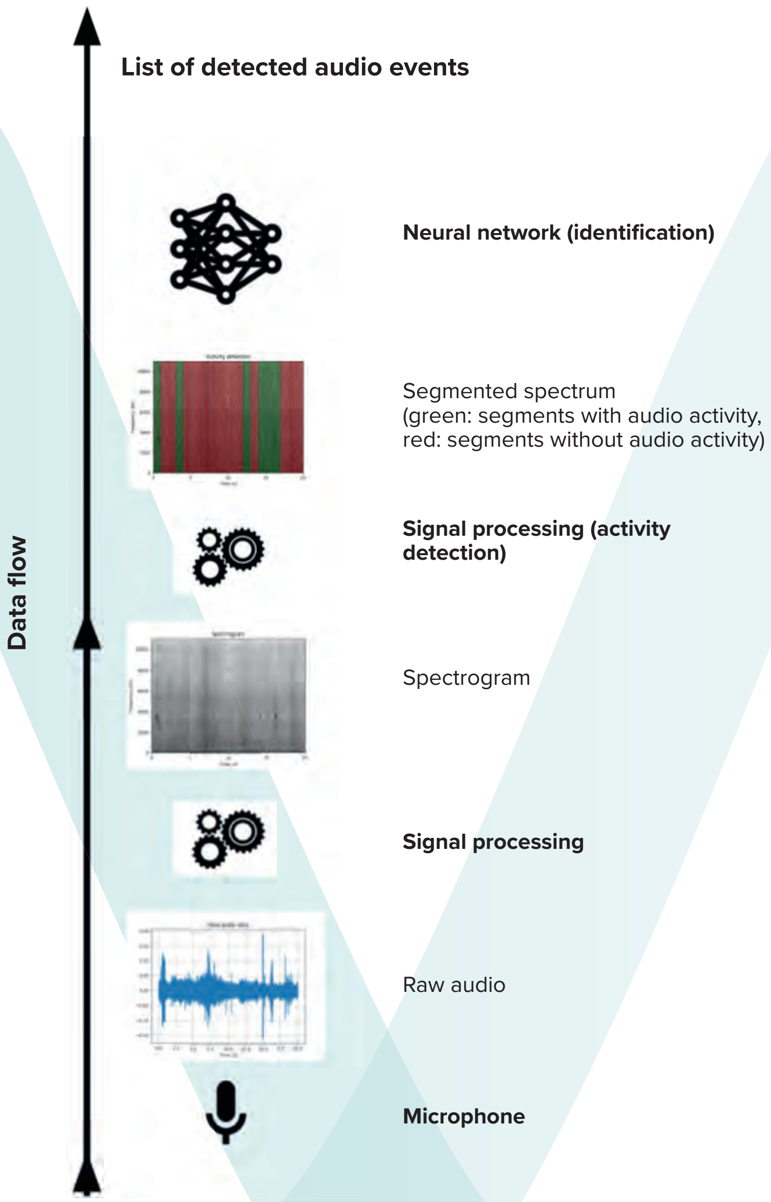
Acoustic measurements have been made with sound level meters connected to modems for many years, to provide users with data from remote locations. It could be argued that this is a smart sensor system, but it is generally accepted that smart systems are designed specifically for remote operation, with communication modules built into the hardware, as a single piece of instrumentation.

Smart noise monitoring systems are widely available featuring integrated communication modules in the sound level meter. Having convenient access to web-based data, with alarm functions, offers the project manager significant cost savings compared to attended measurements on site. This makes it a popular solution for most noise monitoring applications.

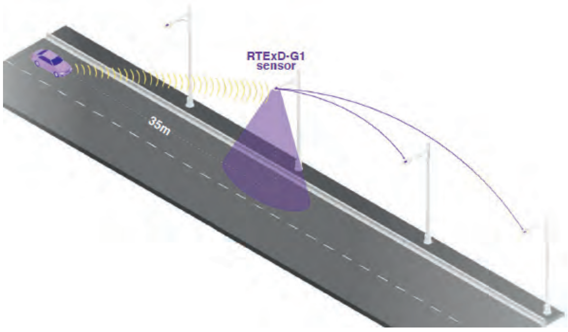
In recent times, technology in this remote monitoring field has moved forward quickly with interesting and potentially useful features becoming available, such as source identification.

Voice recognition is commonplace in mobile phone technology and this is extending to home technology such as Amazon Alexa and Google Assistant. These devices are listening to our voices constantly, waiting for commands and P48






**Below:** Acoustic traffic counter




instructions and perhaps more information than that (check your privacy settings!). The devices can also be set to listen for acoustic events such as breaking glass and forced entry to a property, which can be used to trigger alerts.

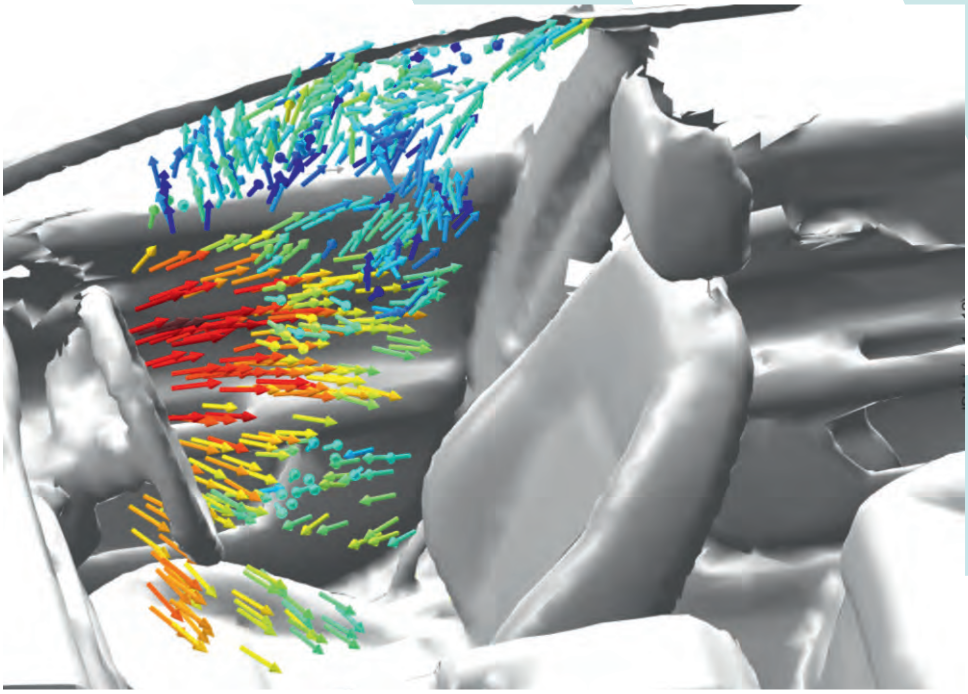
This technology is now appearing in smart city acoustic sensors in order to give more information from the same measurement node. Active trials are under way for such a system, which in addition to measuring the sound levels, will also count and classify traffic passing the microphone. This works by monitoring raw audio to detect activities, it then identifies the event from spectrograms and neural networks, which is the core technology of such systems.

For the process to work effectively it requires a little time to train the sensor to match the noise source to the inbuilt database. This training is required as the local acoustic environment (background noise and reflection effects) will introduce specific artefacts to the source. The corrections to the established algorithms are in-built and ongoing to improve the accuracy of the traffic counter. The systems on trial will classify traffic as cars, motorcycles and HGVs, it can handle wet roads with additional learning and also estimate traffic speed. Traffic of 10kmph or less is a problem for counting, but we know radar and other methods have issues counting very slow traffic. P50

Smart algorithms mean that classification and counting can be performed locally on a simple processing board. This reduces the data transmission requirements of sending raw data for processing. In the future with 'super-fast' 5G networks it may even be possible to move processing to the network, thus enabling even lower cost hardware in the measurement node.

Transportation is a major source of noise in communities and having traffic data with your sound levels from the same sensor will be useful to many. The same technology can be used for detecting accidents to quickly alert emergency services. It can also detect gunshots, crowd disturbances, wildlife and more.

For unattended noise measurements in the future, perhaps this will be a standard feature with an automated estimation of source contribution with your sound level data.



**Above:** Acoustic path identification in a vehicle

## Acoustic imaging

The use of acoustic beamforming and acoustic holography is maturing rapidly, but on the way, both techniques have acquired the reputation of large, expense arrays and data acquisition systems. This may be true when using condenser measurement microphones in arrays, with front ends designed for general purpose analysis, but the advent of digital MEMS microphones is bringing down the size and cost dramatically. It is now possible to have hand-held 'acoustic cameras', so that source location is a matter of point-and-shoot with a tablet display.

But, as Montgomery Scott was wont to say: *"I cannae break the laws of physics, Jim"* so imaging at low frequencies will still require large arrays and high frequency sampling will be required for good time and spatial resolution, both of which will increase cost. However, for the majority of field applications, the 'starter' systems are still adequate without extending to applications such as partial sound power and 3D vector presentation.

Particle velocity transducers are also maturing, offering unique measurement capabilities for source location, in a more robust package. Being able to measure particle velocity directly, rather than deducing it from pressure gradient, gives many more possibilities in field sound power determination, source location and acoustic path analysis.

To infinity and beyond!

**Having traffic data with your sound levels from the same sensor will be useful to many.**

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