How 21st century technology can improve sound level measurement

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Summary

We are all familiar with the relentless advance of technology. To a certain extent, sound level measurement has taken advantage of this in a number of areas. The computing power and communication possibilities in a hand-held device far surpass those which were in our desktops 20 years ago, and this has tremendously increased the flexibility of measurement applications that can be met in the field. Logging sound level meters previously capable of storing only days of processed data (e.g., broadband and 1/3-octave values and statistics) now effectively offer unlimited storage up to and including full recordings. Technology has helped right through to post-processing, where data can now be easily post-processed into different metrics and reports to ensure that the data communicates what was really happening at the measurement location.

Unfortunately there is a significant time lag. Technology developments often take years to make it through to the sound level meter and the market. This creates a mismatch between market expectations and what is available. However, this time lag is shrinking. This paper describes how the latest technology advances in wireless communications, cloud data management and smart devices are capable of not just transforming the sound level meter itself, but the way in which it is used. The next adoption cycle will deliver greater measurement accuracy and consistency as well as significantly improving efficiency enabling users to get more done with their sound level meter.

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1. Introduction

This paper aims to take a high-level look at technology and how it will affect the sound level meter and the way we work with the sound level meter in the future. But it begins with a look at the past referring to the range of Brüel & Kjær sound level meters.

1.1. A history of Environmental Measurements

The way consultants have worked over the past 60 years has changed significantly due mainly to advances in technology that have facilitated a better and easier way of working. In the early years of environmental measurements, attended measurements were the only option. Now unattended and remotely controlled measurements are equally common. The quality and shear amount of data that is now collected in the field on one instrument has tended to reduce the number of people necessary to get a measurement job done.

In those early days of environmental measurements, no legislation existed, but now national and international standards have evolved to define both the environmental legislation and the instruments we use to measure noise.

The instruments themselves have gone from barely transportable devices measuring single parameters to portable and finally to hand-held analyzers performing instantaneous measurements over long periods of time.

And back in the office, post-processing that was once done by hand and later by pocket calculator, is now performed by PC. You only have to cast an eye at your last report with colour graphs showing spectral and profile information configured quickly and easily by the user to see how far we have come from typewritten reports.

2. What happened in the 20th century?

The 20th century took the Sound Level Meter from a heavy box analyzer to a true hand-held instrument. But what were the developments in the 20th century that actually drove this evolution and influenced the way we work with our sound level meters? What influenced, among other things, ease of use, battery life, display quality and accuracy? We'll look at four advances that made a difference.

2.1. The age of transistors

Turn the clock back 50 years and we are at the very beginning of what we would today recognize as a Sound Level Meter. Before this time, noise measurements were performed with heavy equipment based on valve technology. The user would have to transport his heavy equipment to the site, setup input and output attenuators, probably adjusting the attenuators again later. Once the measurement was in progress, with no internal memory, levels would be recorded on a level recorder, the user marking events in pen or pencil on the paper roll.

In 1961, the first IEC Sound Level Meter standard was introduced (IEC 123), heavily influenced by Dr Brüel it defined for the first time what a Sound Level Meter needed to do in order to be called a Sound Level Meter.

In 1965 Bruël & Kjær launched Type 2230, compliant with IEC 123, having a conical design that was copied by all our competitors, and much smaller than its predecessors, thanks to transistors, it weighed in at just 5 kg including filters (although the level recorder was 25 kg).

Transistor technology in those days was not a precise science – it was necessary to sort transistor shipments according to their quality at the factory before using them in Production, so great was the variation in resistance.

2.2. The age of the microprocessor (and LCD)

Fast forward to the 1980s and it was time to end the era of the big sound level meters. And what drove progress was the emergence of the microprocessor? B**ruël** & K**jær** was looking for a microprocessor for their new Type 2230 sound level meter – the choice was the RCA 1802, the cost effective solution (and there weren't many to choose from back then). The result was a lightweight sound level meter, weighing in at 0,860 kg (1,31 kg with filters). Since filter sets (1/3, 1/1, infrasound and ultrasound) could not yet be made small enough to fit into the sound level meter body itself, the filter remained a separate unit. However, this had the advantage of flexibility (different filter sets could be mounted), and so was born the modular sound level meter. Users could now purchase the filters they needed without purchasing a new sound level meter. Processing power had also improved due to integrated circuits combining a lot of transistors on one chip and memory chips (RAM and ROM). Type 2230 could carry out five independent measurements in parallel (Current, Max.,Min., SPL, Leq and SEL), enabling the user to check the various parameters without interrupting the measurement. And the results were now shown on 4-digit liquid crystal display, LCD being another important 1970s technology advance finding its way into sound level meter design the following decade. So began the demise of the separate heavy level recorder.

2.3. The age of the DSP

Fast forward once more to the 1990s and the familiar shape of Type 2260 appears on the scene with its Concorde-like design that no Bruël & Kjær competitors copied. This dedicated DSP didn't drive size down; instead, performance and battery life won over weight. Type 2260 also made a number of advances possible that we take for granted today:

- Real-time octave filters
- FFT, which meant that a Sound Level Meter could now be used as a vibration meter
- Logging profiles on Sound Level Meter display

Real-time data processing was here to stay! But don't think that the same Type 2260 that finally retired in 2011 was what was the same one released in 1994; the first 2260 Investigator didn't even have 1/3-octave filters, and customers hesitated.

But it wasn't progress on all fronts. In some respects digital processing was a step backwards: the frequency range became limited to the audio range (due to the limited sampling rate of digital circuits), ruling out the ultrasonic applications of earlier designs. In addition, power consumption increased – equivalent digital instruments required an order of magnitude more power.

In some ways, Type 2260 was too far ahead of its time: Type 2260 was designed with an optical interface – at the time advanced audio equipment had an optical interface for audio transmission, but it never came into use; the interface was never needed.

2.4. The age of the hand-held computer and the touch-sensitive screen.

With the advent of Type 2260, Brüel & Kjær sound level meters used only a number to signify their identity. Then Brüel & Kjær launched the Type 2250 in 2004, the first to market with a touch-sensitive screen – the quality of the display and improved usability when compared with Type 2260 are beyond compare. Today an increased number of sound level meters have colour touch-sensitive screens, such as the Nor150.

Type 2250 is also a modular device that can expand, as the user's needs expand, through additional software licences. This is a key advantage of functionality that is provided through software rather than hardware – not only can it be provided modularly, but it can also adapt to changing standards. This makes the unit more flexible without increasing the price for customers with basic measurement requirements.

2.5. Summary of progress in the 20th century

Concluding the look back at the last century's developments, this table compares weight, size, RAM, processing power and battery life for some classic Brüel & Kjær instruments.

Table 1 Development of Brüel & Kjær instruments as a function of time.

SLM (Type)	Release	Weight[Kg]	Battery life	RAM [bytes]	External memory
2203	1960	2.7	8	None	
2230	1980	0.86	8	32 RAM	
2260	1994	1.2	5 -9	10 M	ATA flash
2250	2004	0.65	7.5 - 11	20 M	CF flash
2250 G4	2012	0.65	7.5 - 11	512 M	SD flash

3. What is meant by 21st century technology?

Having looked at the past, what do we mean when we talk about 21st century technology, even though currently is only 15 years old? We take for granted being online, having knowledge at our fingertips and being able to share information easily. Cloud services make information available in a way that would have been hard to imagine at the end of the last century. But the technology development that at present appears to be most significant for Sound Level Meter development are the advances in smart device technology. Indeed, 10 years ago how many of us would have understood the term "smart device"?

3.1. What are smart devices? When did they emerge?

The term "Smart device" was coined by Ericsson for their GS 88 mobile phone released in 1997, just after the better-known Nokia Communicator.

These mobile phones were far from the smart devices of today that can do much more. They are not only phones; they are wireless communication devices using microphones, speakers and high-resolution colour touch-screen displays. These smart devices incorporate an ever-increasing array of additional capabilities, such as cameras, light and motion detectors, accelerometers, near-field communication, and fingerprint readers. Third party companies provide sensors that range from measurement-quality microphones to seismographs, heart rate monitors, pedometers, blood pressure – pretty much anything you might want to measure.

3.2. Trends in smart devices

Many of us are now permanently attached to a smartphone, and tablets are starting to take over from laptops. The global number of smartphone users is rapidly increasing, and these devices look like they are here for the foreseeable future in some shape or form.

Will all of us need a desktop in the future? Not according to Chipmaker ARM who believe that we can go phone by only 2016 [1]. Whether this statement is true or not (and being able to and actually doing are two different things), developing software only for the PC is no longer sustainable for sound level meter manufacturers.

4. The age of the smart device and cloud

We've already seen that smart-device technology is available for use by anyone with a mind to use them. So where are Sound Level meter manufacturers now in 2015? How have the major players in this professional niche market segment responded so far?

The first thing to note is that our work dependency on the PC is not yet over – most would rather use a 20” monitor for their post-processing than a tablet or smartphone – but for in-the-field applications, the smart device comes into its own. And currently Sound Level Meter manufacturers are looking for ways to use smart devices in their applications. Why are they doing this? Because the very nature of smart devices makes them well suited to field measurements. What makes smart-device technology so suited for measurement applications?

- Mobility – small, light, battery powered
- Flexibility – many functions (camera, GPS, recorder etc.)
- Display – generic, familiar
- Connectivity – hotspot on smart device, linked to cloud

Those are the advantages, these are some challenges:

- Battery life
- Developing software for multiple platforms (IOS, Android, Windows phone)

One of the main benefits of companion apps becomes clear when you consider that modern Sound level meters are simply computers tailored to perform the highly specialised task of sound measurement. They contain many of the elements also in smartphones: processing, storage, display, and communications. Smartphone technology in the 21st century has progressed beyond that needed to operate a sound level meter, so rather than repeating all that in the sound level meter, just use a smartphone, which are made in much greater volume than sound level meters and are, therefore, lower cost and engineered for more rigorous environments, like your back pocket. Expect these companion apps to transform usability, increase flexibility and reliability as well as reduce cost.

4.1. Where are instrument manufacturers now?

Instrumentation manufacturers have started to make use of the benefits of the smart-device platform by producing companion apps that sit alongside their established offerings. These apps enable the collection of measurement metadata including photographs and ad hoc notes and use the built in GPS for recording location. Some enable remote control of the instrument, which means measurement control can be done from a safe position out of the sound field(often in a more practical and comfortable setting for the operator).

Two examples are the SvanMobile from Svantek and Measurement Partner Field app from Brüel & Kjær. We can expect other examples to emerge in the future.

4.2. What are the limitations of using a smart device for measurement?

The apps mentioned in the previous section do not make measurements, they supplement the measurements taken by an instrument. However, the processing power in a smartphone surpasses by many times that needed and available in most sound level meters. So the next logical step is to use the smartphone as a sound level meter and hereby do away with an expensive sound level meter.

Currently what the market can offer the sound & vibration professional is a companion app, or webserver support. The logical conclusion of this development is to use a smart device to perform the measurement itself (data acquisition and all) so that the smart device becomes the sound level meter.

We all know of free or cheap smartphone apps to measure noise using the internal MEMS microphone; these are fun for the amateur acoustician unconcerned or unaware of measurement accuracy. But what it is that prevents Sound level meter manufacturers from moving there entire development on to the smart device platform? Why do noise and vibration professionals need to buy an expensive sound level meter for certified and legally verifiable measurements?

It’s mainly about the transducer: Smartphone microphones are optimized for speech and rejecting background noise. They are not designed with any attention to measurement accuracy, linearity, temperature stability, high dynamic range, high frequency range and definitely not Omni-directional. Currently it is not possible to fulfil IEC 61672 with a smart device.

5. Where are environmental measurements and instrumentation heading?

And what is driving them? Some factors change very slowly, others by comparison, fairly quickly; but we can be sure that the next generation of instruments will deliver even greater efficiency, enabling users to get even more from their sound level meters.

5.1. Noise sources

A good place to start is what we actually measure;. after all, without noise sources, environmental noise measurements would not exist. With a few obvious and important exceptions, such as wind turbine noise requiring the new metric amplitude modulation, noise sources are developing fairly slow. Legislation also has to take account of any new metrics before they can be used in a legal sense. In general, we can say that the same laws of physics will apply to building acoustics and that traffic noise from road, rail, air and industrial noise sources will remain largely unchanged for the foreseeable future. What may change is the way we assess them i.e. the legislation.

5.2. Standards

Historically one of the primary drivers of instrumentation has been the sound level meter standard. The recent revision of IEC 61672 requires all sound level meters to be updated before Type approval is possible, and this is still the case. But the sound level meter standard moves slowly.

After its establishment, the first priority of the Working Group of IEC/TC 29 for sound level meters was to prepare a document with recommendations (not a standard) for the characteristics of a general-purpose sound level meter. The recommendations were given in IEC Publication 123 [5], issued in 1961 with design goals for measurements of frequency-weighted sound levels.

Replacing the IEC 123, IEC 179 and IEC 179A was IEC 651:1979, which was revised in 1993 and 2000 and later replaced by IEC:61672–1:2002, revised in 2013. So since 1961, relatively few revisions have been made.

5.3. Technology trends

Sound level meter development has moved from merely fulfilling the requirements of IEC 61672, to developing the environment (the features and functionality) that surround display, data acquisition, sharing and post-processing of data. This development is technology driven, and to some extent the technology advances are following consumer goods such as cameras.

5.3.1. Bigger, brighter, touch-sensitive displays

Market expectations for quality and size of display are, thanks to smart device technology, greater than ever. Earlier generations of sound level meters, with their primitive monochrome displays are no longer marketable. We want large, colour displays.

We want more space to do stuff and explain what is needed and what is measured. Indeed, the size of modern displays allows for the on-screen display of historical data. And as usability improves, sound level meters become easier to understand and more intuitive, so operators make fewer mistakes, use less time and get a better measurement. This trend will eventually see the primary display of the sound level meter moving to the smart device as there is little point in implementing an expensive full-featured display on a sound level meter if you carry one in your pocket on a smartphone.

5.3.2. Cloud storage and service

In the future, having performed a measurement, users will expect data to be automatically uploaded to the cloud, where a carefully administered group of users have access to the data. Users may indeed soon expect data to be streamed to the cloud, removing the necessity for device memory. Once in the Cloud where the specific application allows, cloud services will process data automatically. Although, removing the expert user completely from environmental measurements looks a long way off. When in the cloud, data can be processed in new and different ways, ways that are not possible on a sound level meter or even on a desktop PC.

5.3.3. Web-based applications

The days of downloading and installing software on a PC are numbered. Web-based applications are machine independent, operating on PCs, MACs, linux, tablets and anything else in the future. These applications are easier to use and easier to maintain.

5.3.4. Companion apps

And as mentioned above, the age of the Smart device is already here, heralding the use of companion applications to the sound level meter operating on smartphone or tablet. These apps supplement the features and functionality of the sound level meter, in some cases making functionality on the instrument redundant. They complement the measurement capability of the sound level meter adding the additional capabilities of the smartphone that will probably never be completely replicated inside a sound level meter.

5.3.5. Miniaturization

Instruments are getting smaller and lighter. Highly desirable of course for a hand-held instrument, and we've come a long way from early instruments mentioned in the first section. Today the smallest class 1 sound level meter we could find weighed less than 300 g. The trend for sound level meters to get smaller will continue, driven by the migration of features and functionality to companion apps.

5.3.6. Communication

Remotely connecting to a sound level meter is actually nothing new. The more progressive consultants out there have been doing it for years with dialup modems and telephone lines. What has changed is that communication is now much simpler to setup without the compatibility problems that were common among equipment even 10 years ago. Transfer is much faster, there are no data transmission errors and failed downloads are very rare. The future will be plug-and-play remote communication – or maybe just play.

5.3.7. Battery capacity

Battery capacity equals operating time in the field. While other technology trends are moving quickly, innovations in battery technology have lagged behind advances in processing power. For outdoor-attended measurements in the field, battery life is of prime importance. In 2015 and onwards, we are talking not just about the battery life of the sound level meter, but the smart device that companions it. And the more functionality that is implemented in the smart device, the more important this limitation becomes.

The battery power available to sound level meter manufacturers is largely constant. As mentioned for Type 2260, there is rather a trade-off between the desired power usage and battery capacity – so reduce power consumption or make the internal components of the sound level meter as small as possible, freeing up space for the battery pack.

In respect to the battery capacity in Smart devices [2] since 2000, battery capacity has only doubled, while processing speed has increased 12-fold. Even though battery power is being used more efficiently and battery makers are experimenting with new technologies, capacity will continue to constrain the day-long use of smart devices in the short term.

Battery capacity development has been driven by the mobile phone market, so it has improved significantly. However it remains a limitation for high-end instruments that provide the flexibility needed by the multi-disciplined consultancies of today. Although still improving, the problem is that battery capacity does not follow Moore's law like disk, CPU and RAM do.

5.4. Environmental measurements 2025?

In conclusion, it will be interesting to speculate on where environmental measurements will be in 2025, ten years from now. Future predictions can tempt one to exaggerate, so maybe what is described here will be longer coming. Will the consultant still exist in 2025? Yes, but fewer of them. The technology advances mentioned in this paper will better leverage the time of experts, reducing the need for assistants to help with measurements. There will always be a need for expert validation and approval in planning projects, but what we may see is a reduction in the need for attended measurements, particularly outdoors. So fewer attended measurements, but still some – where background noise levels make identifying the noise source difficult or impossible noise calculations will be needed, based probably on sound power measurements.

What we will see is an increase in networks of cheap, low-power sensors monitoring urban noise levels, calculating averages and making reports automatically [3]. The cost and availability of these sensors will aid in theft-proofing, one of the main issues today – who wants to leave a Type 2270 unprotected in the field. Background noise will always be a problem for noise measurements where it is close to noise source levels, but the advent of effective automatic noise source classification techniques will minimize this issue, marking noise sources automatically and alerting police in the case of crashes or shootings. In 2025 we may be approaching "the monitored city". Public access to noise maps will, of course, be the norm ("Google Maps > Google Sound Maps") increasing awareness of noise issues and the public debate.

References

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