Realising a New Approach to Air Quality Monitoring

There is a growing body of evidence from organisations such as the World Health Organisation to suggest that poor air quality can lead to detrimental effects on health; including respiratory infections and cardiovascular health issues. As a result, many countries have implemented legislation which demands air quality monitoring to a very high standard, generally using monitoring systems that are approved and conform to regulations for measurement methods and uncertainties. These traditional monitoring stations are effective, but are expensive to set up and to maintain. The size of these stations also limits where they can be deployed. As a result of this, data gathered is accurate but limited to a few places within any given area, creating a reliance on modelling techniques to determine the spatial impact and sources of pollution.

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There is a strong drive to develop effective air quality monitors that overcome the challenges faced in locating the larger, traditional systems. Aside from the difficulties in placing bulky monitoring stations in pollution hot spots or other areas of interest, there is also a cost implication if a high number of systems were to be installed in a network. This means that a sufficiently accurate, compact, reliable and low cost air quality monitoring instrument has the potential to revolutionise the sector by providing the opportunity to gather much more actual data and reduce the reliance on modelling. This is now becoming a reality.

The AQMesh from Geotech offers a new approach to air quality monitoring. Whilst not intending to replace or compete with approved air quality monitoring reference stations, the compact AQMesh monitors NO, NO_2, O_3, CO and SO_2. It can be used to provide much wider geographical coverage, thereby giving true real-time spatial determination of monitored pollution levels and assisting enhanced air quality modelling.

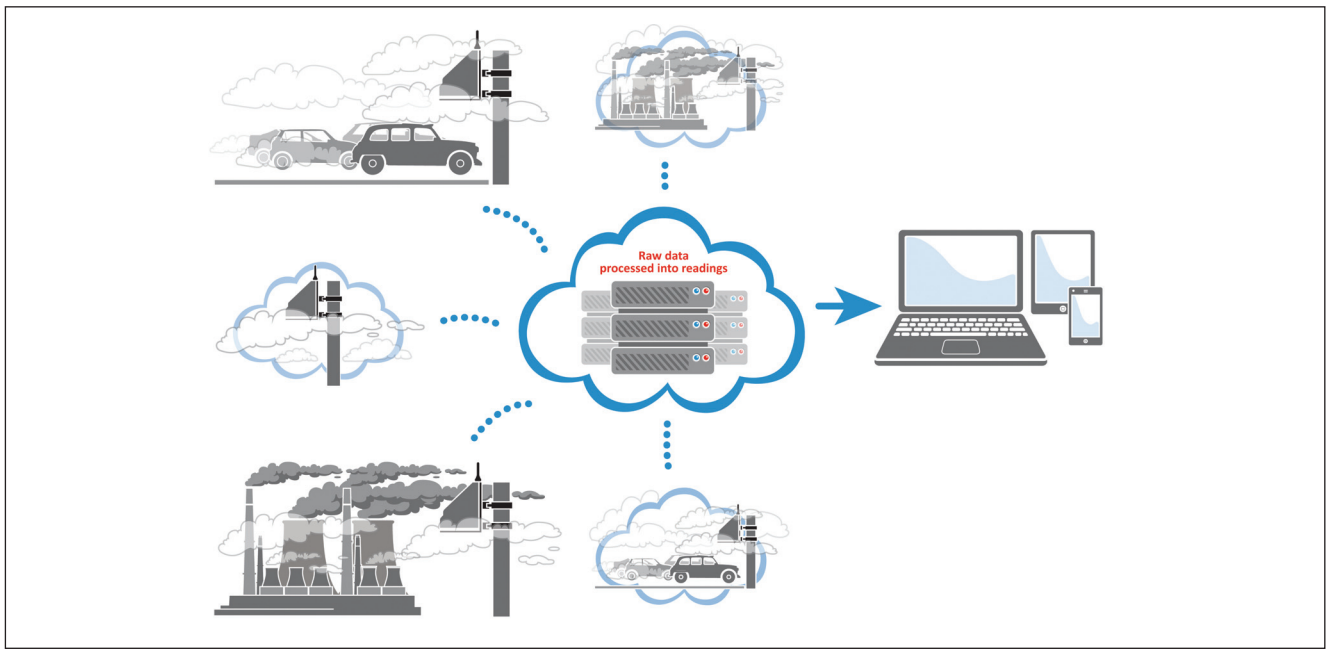
Compact system, easily deployed

Traditional air quality monitoring stations are generally quite large, often containerised systems allowing for air conditioning and control of the environment in which the analysers are operating. This tends to be important to ensure the analysers perform optimally and to the required high standards. Due to the mains power requirements and sheer physical size, the location of these monitoring stations is naturally limited.

With the AQMesh, Geotech engineers take an entirely different approach to monitoring, complimenting the centralised more accurate monitoring stations. Being roughly the size of an average bird box (170 x 180 x 140 mm) and weighing less than 2kg, an AQMesh pod can very easily be deployed on a lamppost, fencepost, signpost or a wall. It is also wireless, powered by high capacity batteries and has a built-in wireless GPRS connection.

Flexible modular network

The compact physical design of this type of monitoring device means that it can easily be located at any potential pollution hotspot. This might be on a major traffic junction, a busy roadside or an industrial site perimeter. By using a small and easily deployed device such as this, a network of remote sensor modules can be created to monitor a wide urban area or around a whole industrial area, thereby giving a true indication of the spatial and temporal distribution of gaseous pollutants.



Author Details:
Tom Burniston, Geotech
Sovereign House, Queensway
Leamington Spa, CV31 3JR, UK
Tel: +44 (0)1926 338111
Email: sales@geotech.co.uk
Web: www.geotechuk.com

Sensitivity and precision

A new generation of electrochemical sensors has been specifically designed for high precision monitoring in air quality applications. Traditionally, electrochemical sensors have not been suitable for this type of monitoring as they have not had enough sensitivity or precision. As well as a variety of other proprietary technology advances, the new type of sensor used has an additional fourth electrode which is used to provide this stability and help combat long term drift, along with a number of other new developments including optimised catalyst loading and improved stack structures for stable operation at low concentrations.

By continuously measuring the status and performance within a monitoring device such as the AQMesh, correction factors can be applied to the measured data from the sensors. Information specific to each sensor used in AQMesh is recorded at the time of manufacture and uploaded to the Geotech cloud computing network for data processing.

To maintain detection levels in low parts per billion (ppb), careful electronics design is needed to ensure that the level of electronic noise in the circuit is very low. The AQMesh maintains this precision with noise levels less than a few ppb within the circuit, allowing the low detection limits needed in air quality monitoring. This vital element is an important challenge to overcome in order to achieve an acceptable level of sensitivity.

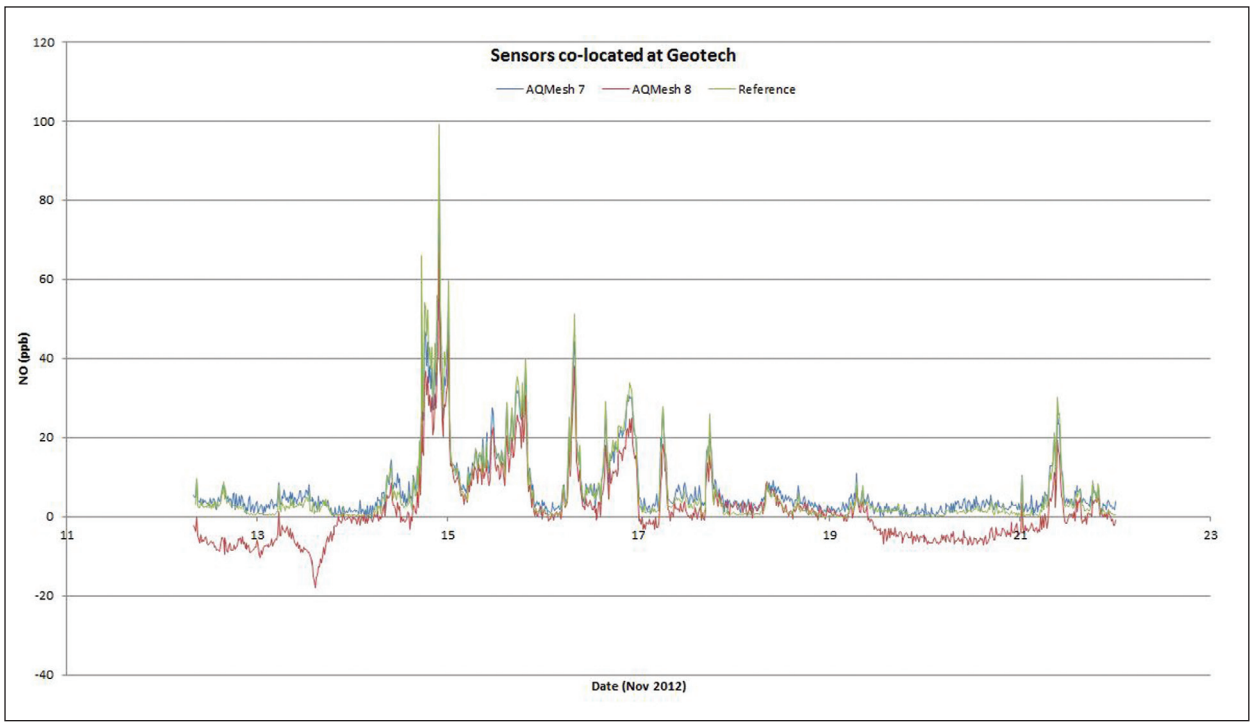
Wireless, low power design

For any compact air quality system to achieve such ease of deployment, two further design considerations become important:

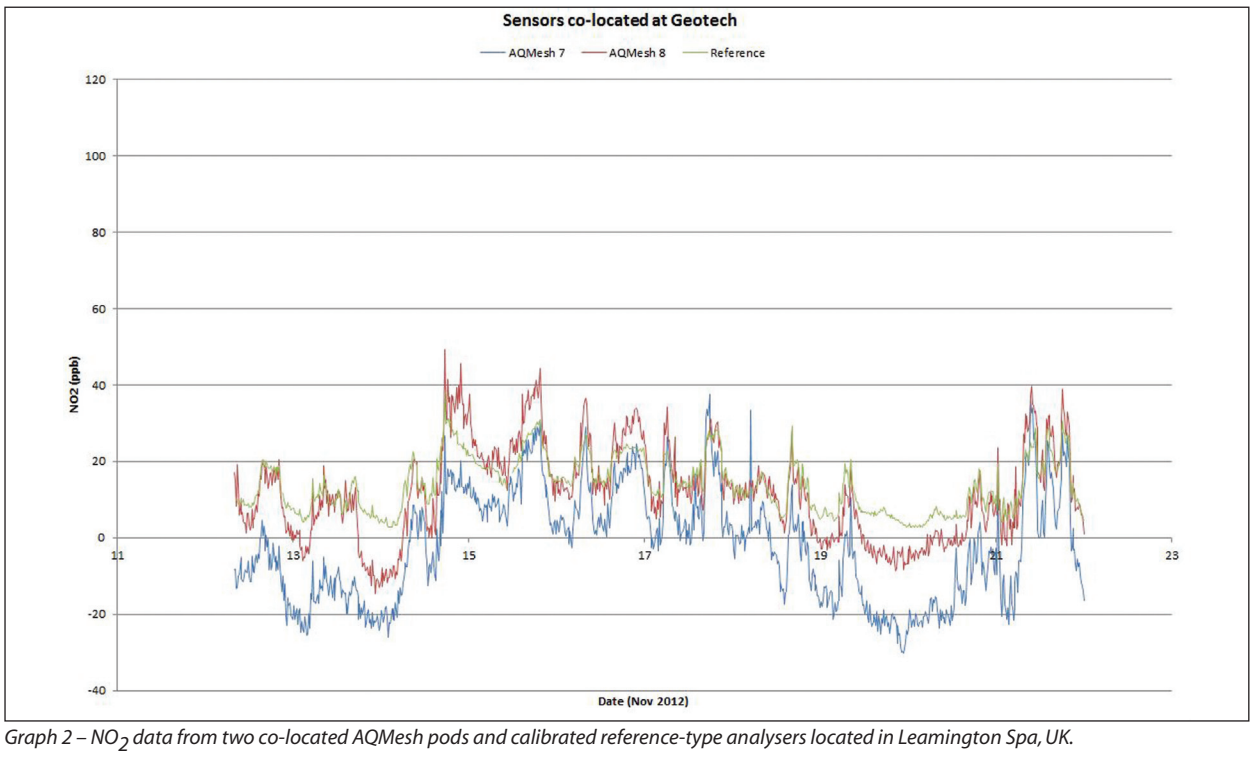
- It must communicate without hardwiring.
- It must be powered without the need for a mains power connection.

Both could limit how easy the device is to install and initialise, and where it is possible to locate a monitor.

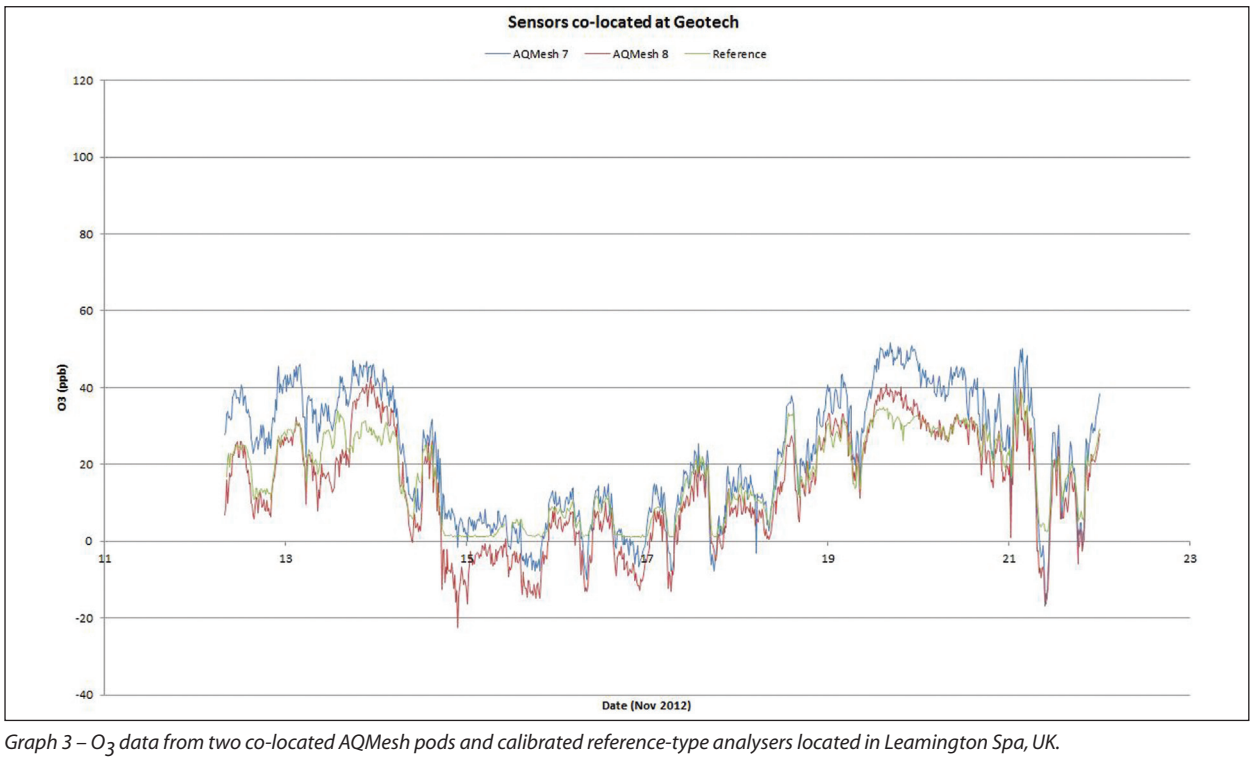
Wireless communications can be achieved via the use of mobile GPRS technology. Although limited to where a signal can be accessed, this gives great scope for deployment in most urban and industrial areas. Where necessary, modern telecom networks will allow roaming to access a suitably strong signal and transmit data to a centralised cloud-based server. Data can then be accessed at any time from any location with suitable connectivity.



Graph 1 – NO data from two co-located AQMesh pods and calibrated reference-type analysers located in Leamington Spa, UK.



Graph 2 – NO_2 data from two co-located AQMesh pods and calibrated reference-type analysers located in Leamington Spa, UK.



Graph 3 – O_3 data from two co-located AQMesh pods and calibrated reference-type analysers located in Leamington Spa, UK.

The use of wireless technology can often be relatively intensive in terms of power usage. Sophisticated GPRS management techniques can be used to take a trickle charge from the batteries and is then used to give the short bursts of power needed to connect the wireless GPRS link for data transmission. This avoids taking large peaks of current from the battery which would shorten its life. Combining this approach with the use of high capacity cells means that a battery powered air quality monitor can be deployed with a lifespan of up to two years before batteries need to be replaced.

Innovations in data processing

Traditionally most monitoring instruments perform data processing on-board. This can require high power, high capacity

processors for complex data. It is possible to take a new approach by doing the required data processing on servers hosted on a cloud network. This has two primary benefits:

- Maintaining the low power design through use of a low power processor.

- The ability to integrate sensor-specific parameters in the processing.

An example:

Geotech has developed a number of intelligent data processing techniques in collaboration with the University of Cambridge to ensure that readings from an array of AQMesh pods are accurate. The complex algorithms used require significant processing power and also include a number of factors specific to each sensor, including its sensitivity to temperature changes, calibration coefficients and a variety of other factors. This is all uploaded into the cloud-based server and referenced to each individual sensor pod. The processing also takes into account additional data gathered in the field, meaning readings can be corrected accurately.

Cross-sensitivity of sensors to gases that they are not designed to measure is a common challenge faced when using electrochemical sensors. This can also be overcome by measuring the cross sensitivities for each sensor and uploading this data to the cloud-based server. This can then be compensated for in data processing.

Prototype test data

Based on the principles detailed above, Geotech has been working on the development of the AQMesh air quality monitoring system. Now prototype monitoring devices have begun to be tested in real-life environments and in comparison to reference-type air quality monitors. Some examples of this early test data are shown in graphs. These show data from two co-located AQMesh pods and calibrated reference-type analysers located in Leamington Spa, UK.

This early test data clearly shows excellent correlation between two monitoring pods co-located with a set of reference-style analysers, with trends and pollution events clearly comparable between all three.

The data shows the need for continued development. Data offsets are common with many reference station instruments, with readings drifting off zero. A correction factor can be applied to correct readings or calibration checks can be used to provide baseline correction. Geotech is currently investigating both of these approaches for AQMesh, with promising results, as a means to further improve the already impressive performance being seen from this new type of air quality monitoring device.

Realising the concept

Driven by a growing demand of the air quality market, manufacturers of instrumentation and sensors have developed new technologies and new approaches to air quality that are now being practically demonstrated and are delivering good results.

This type of compact, easily deployable, wireless monitor is not designed to and will not replace the highly accurate, approved reference monitoring stations that are mandatory in some regulated environments. What is possible is a revolution in the amount of genuine spatial and time-stamped data that can be collected within any urban or industrial environment.

This type of networked sensor array gives the opportunity to identify more accurately the sources of air pollution and thereby develop strategies to combat the problem. Inevitably further development will continue as manufacturers strive to improve the sources of monitoring available to the sector.

Observers can now conclude that achieving greater density of valuable air quality monitoring data using a networked array of low cost sensors is becoming a reality.

The Geotech AQMesh is being launched at the AQE Show (13-14 March, Telford) on stand 43 by Geotech partner for UK customers, Air Monitors enquire@airmonitors.co.uk, Tel: +44 (0)1684 857530.

Customers in other countries are invited to contact Geotech direct at: sales@geotech.co.uk or +44 (0)1926 338111. More at: www.geotechuk.com