National Physical Laboratory

A new approach to sound-in air measurement

Distributed noise measurement exploiting MEMS microphones

Richard Barham
National Physical Laboratory, Hampton Road, Teddington, Middlesex, UK, TW11 0LW
E-mail: richard.barham@npl.co.uk

New approach:

Our vision:

To address a number of today's major noise measurement challenges through the development and application of an entirely new generation of acoustical measuring instruments

In response to a National Measurement System remit to embark on innovative research aiming to have significant impact in the medium to long term, NPL identified MEMS microphone as a disruptive technology, offering significant benefits for measurement application.

Why is a new approach required?

- Noise has become a significant and high-profile social issue with well understood impacts on health and wellbeing
- New legislation focuses on environmental noise, particularly in urban areas, but also aims to preserve quiet spaces
- Modern measurement instrumentation does not always proved economical ways of dealing with noise issues
- Modelling and prediction are often used in-lieu of measurements because suitable instrumentation is not readily available
- The role of measurement is often reduce to short-term validation of predictive models with limited spatial sampling

How does this approach fit with the NMS?

- Leading edge measurement science – scientifically challenging and innovative
- Leading to step change in measurement capability for sound-in-air
- Clearly identifiable impact across a range of industrial sectors and through society
- UK in forefront of new technology and applications
- Internationally leading

What will the new technology enable?

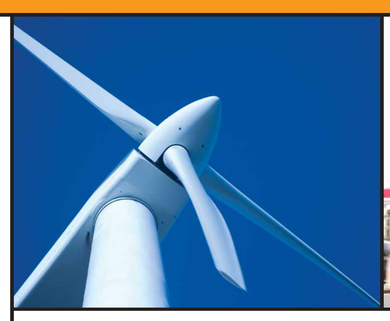
- Measurement where this is not possible at present
- Cheap options for many applications, challenging existing practices
- New measurement solutions and on-going monitoring

Key impact areas

Applications in:

- Workplace
- Transport
- Built environment
- Urban planning
- Renewable energy
- Entertainment

with resulting economic benefit and improved quality of life, both within the UK and worldwide



The huge potential impact of distributed measurement has led UK industry and the Technology Strategy Board to co-fund the NMS investment in this technology through the DREAMSys Project. Significant steps towards the vision of creating the next generation of measurement instrumentation have been made, culminating in the production the distributed noise measurement system, utilising one hundred MEMS microphones in its first incarnation.

Key scientific measurement challenges

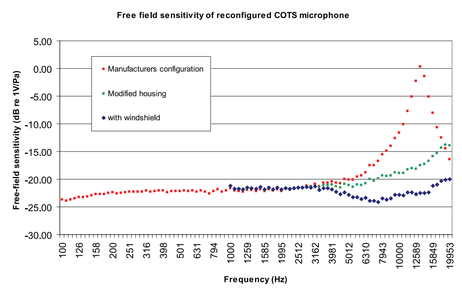
To meet industry needs there are several key measurement challenges to be addressed to overcome limitations in this readily available MEMS hardware. NPL, supported by the NMS has been responding to these challenges.

Key challenges for MEMS technology are:

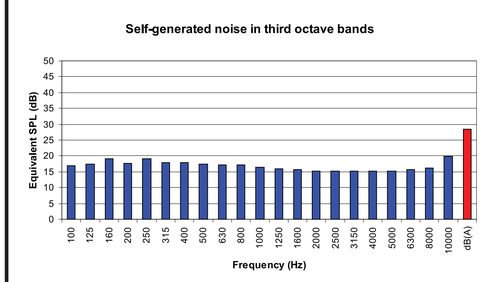
- Frequency response and bandwidth
- Dynamic range and self-generated noise
- Environmental dependencies
- Accuracy of measurement
- Wireless external deployment and concerns over environmental effects

NPL - recent research

NPL has been investigating innovative ways of solving these challenges, so extracting maximum performance from commercially available MEMS microphones, enabling future generations to be modified for improved measurement grade performance



Frequency response improvements of microphone with modified packaging showing NPL is collaborating with a commercial supplier to develop a production version with such characteristics



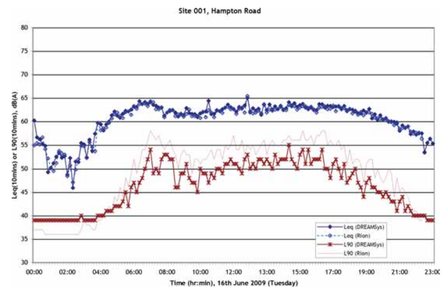
Self-generated noise of a small microphone array illustrating the benefits of using multiple sensors showing a decrease in the noise floor. MEMS fabrication is readily suited to producing such arrays in a single structure.

Accuracy of measurement

Initial comparisons with type 1 sound level meter systems, measuring traffic noise shows excellent agreement. Measurements were made outdoors, over prolonged periods and in a wide range of sometimes extreme weather conditions.

Environmental characteristics

NPL has developed a suite of tests to characterise the dependency of MEMS microphones on temperature, atmospheric pressure, humidity, condensation and frost and wind



Wireless external deployment and environmental effects

DREAMSys

MEMS based noise measurement instrumentation is being deployed in large numbers, in a series of pilot studies to investigate the role of the system in validation of noise maps. DREAMsys is already deployed and performing well at two locations, and is currently being introduced to the larger main survey site.

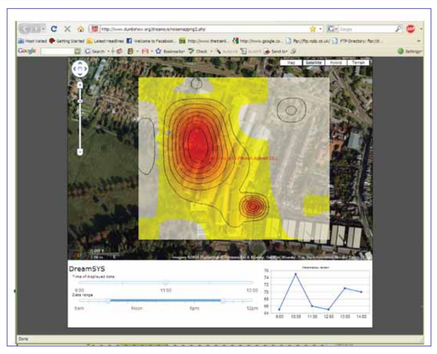
NPL Number of units: 10; deployment start date: 1 May 2009

Wraysbury Reservoir (Heathrow Airport & M25)

Number of units: 6; Deployment start date: 27 July 2009

Silvertown Quay (City Airport)

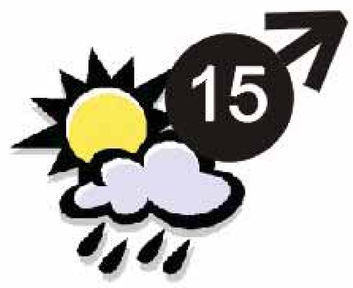
Number of units: ~90; Deployment start date: 2 September 2009



Software

The large volume of data generated by DREAMsys requires a convenient means of visualisation. maps have been adapted and augmented with additional functionality to overlay DREAMsys noise data as well as plot time histories, with full user control over the area and time period to be examined.

To date the system has been exposed to the full range of British weather and is showing excellence resilience while maintaining stability.



Conclusions and forward look

- MEMS microphone are proving valuable in tackling existing and emerging noise measurement challenges
- Their performance is moving towards that of traditional measurement microphones
- Initial trials indicate that they have sufficient durability for long-term use outdoors
- NPL has made significant steps forward to realising the vision
- There is strong interest from industry, government and academia in adopting these novel systems for a wide range of applications
- Other NMIs are also known to be preparing to follow NPL's lead in carrying our MEMS microphones research

Other demo systems

To address the wide range of interest in the developments at NPL, MEMS microphone have also been developed into very low form factor devices to serve as general purpose demonstrators. NPL is planning a showcase event to demonstrate all of the systems in the near future.

8593/REP/0909