NEW PARADIGM FOR ENVIRONMENTAL NOISE MEASUREMENT

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1 INTRODUCTION

Historically, environmental noise measurement has required specialised instrumentation and engineering skills, and a working knowledge of acoustics to produce robust and reliable data. The growing use of handheld devices like smartphones, puts processing power sufficient for most noise measurement applications in the hands of the non-specialist, but generally the quality of this data, and just as importantly, the knowledge to interpret it are lacking. Nevertheless, significant sustainability benefits can be realised through effective noise planning, which in turn benefits from the richness of the data upon which action planning can be based. In an urban context this requires a greater distribution density and longer periods of temporal sampling in noise data collection, to enable the noise scenario, or the effectiveness of mitigation to be monitored. As sensors become more pervasive and connected to wireless data networks, the prospect of a fully instrumented city where environmental parameters, including noise can be assessed in real time becomes a realistic proposition.

2 MEASUREMENT SYSTEMS FOR THE NEW PARADIGM

2.1 Measurement system pre-requisites

At a basic level, the components necessary to make a noise measurement are a microphone connected to a suitable processing system to interpret the electrical signals in terms of acoustic parameters, and some means of presenting the results to the user. At first glance, a modern smartphone or tablet computer, that a large percentage of the population already possess, would seem to fulfil these basic requirements. The prospect of using a readily available device has spawned widespread interest amongst acoustic specialists and keen members of the general public alike, to attempt to make noise measurements with their smartphone with various (and sometimes unknown) levels of success[1,2]. However, the simple list of hardware components is far from a complete set of pre-requisites. On further consideration, we would add, a microphone with particular and known performance characteristics such as frequency response, dynamic range and environmental dependence, signal processing with verified calculation accuracy in both the time and frequency domains, and then a suitably informed person to use the equipment appropriately and make some profession interpretation of the quantified parameters deemed relevant to the particular application. Without special considerations being made, the smartphone fails to deliver in these re-considered areas. For instance:

- It has no means of calibration
- It does not conform with any standards for measurement microphones and sound level meters[3,4]
- The microphone was not designed for measurement applications
- The smartphone comes with no user guidance for using it as a sound level meter
- The ready access to 'apps' that purport to provide sound level meter functionality fosters mis-use and mis-interpretation of results by lay users.

2.2 Practical implementation

Having essentially ruled out the use of smartphones for reliable noise measurement, but not the significant potential benefits offered by the new vision for noise measurement, outlined at the start, a different approach is needed for achieving densely distributed noise measurement in urban environments. Ironically, the emergence of the smartphone has led to a particular solution.

The substantial incentive to produce reliable and low-cost consumer product microphones, for mobile phones in particular, has seen the emergence of the MEMS (Micro-Electro-Mechanical-Systems) microphone as commercially produced component[5]. In 2009 the demand for such microphones had reached 600 million units per annum, and with the trend for devices to now use multiple microphones, this number is growing rapidly.

This large production volume has made available high quality transducers at a small fraction of the cost of conventional measurement microphones. Although MEMS microphones were not developed and produced with measurement applications in mind, the National Physical Laboratory in the UK identified their potential early in the development cycle. It was considered that if MEMS microphones could be used in place of conventional measurement microphones, the reduction in cost alone would release enormous potential for new noise measurement capability, with their small size and robustness offering further significant advantages. Consequently the first MEMS microphone based measurement instrumentation was developed and has since been the subject of a number of research projects[6-9]. Case studies on aircraft noise, mixed source noise mapping, road traffic noise and noise in hospitals have all helped establish and demonstrate proof-of-concept for this new distributed approach to noise measurement with a network of sensors. For example, Figure 1 provides evidence contributing to the viability of MEMS microphone based noise measurement systems.

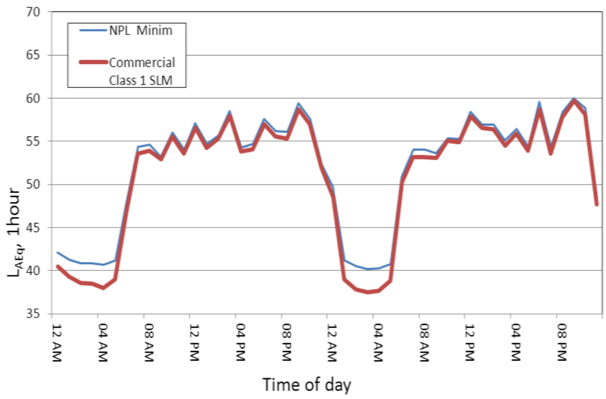

Figure 1. Comparison of MEMS microphone based measurement system (NPL Minim) against a commercially available system for aircraft noise monitoring, conforming to IEC 61672-1 Class 1, showing 1-hour L_{Aeq} over a 48-hour period. The limited performance of the MEMS microphone system at measuring very low sound pressure levels is evident during the night time periods.

3 ENVIRONMENTAL NOISE IN THE CONTEXT OF SMART CITIES

In past times the affluence of a city was measured in terms of its commerce and built infrastructure. Now, with more than half of the global population living in cities, knowledge of how the city functions, communications, its social infrastructures and environmental management become increasingly important factors in the prosperity of the city. The concept of a Smart City as the next stage of urban evolution has recently become popular and features strongly in strategic planning and policy. The smartness of a city is typically assessed by six broad categories indicating urban growth and development:

- regional competitiveness
- information and communication technologies (ICT) and transport infrastructures
- natural resources
- human and social capital
- quality of life
- citizen participation in the governance of the city.

The European Union has been particularly active in prioritising smart urban growth. EU science strategies are focusing on the development of future cities with the vision that every city has the products, services and expertise it needs to integrate its systems and future-proof itself for the benefit of its citizens, economy and environment.

Noise is already recognised as a widespread and significant social issue and management of noise in future cities is a priority. Noise and its impact on the population also has a bearing on the six axioms listed above. Connection with Quality of Life is obvious, but noise data also becomes one of the multitude of parameters that informs the integrated management of the smart city, including for example, transport infrastructures, urban planning, green energy production, environmental management and a host of other concerns that lead to the efficient, joined-up operation of future cities. New technologies therefore offer enormous potential for greater utilisation of noise measurement data in Smart Cities of the future.

4 SUMMARY

Autonomous distributed noise measurement systems provide solutions for managing the impact of noise in the context of Smart Cities. When such systems become cost effective, both in terms of equipment costs and system maintenance, there are opportunities for increasingly widespread deployment with proportionally increased benefits to Quality of Life, health and economy. The challenges in delivering true cost effectiveness lies not only in the equipment costs and making systems accessible to stakeholders, but also in the costs of operating and maintaining the system and making use of the data it yields. The development of expert systems that can be accessible to non-specialist users and the general public, have the capacity for significant impact and public appreciation of complex noise issues.

5 REFERENCES

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