

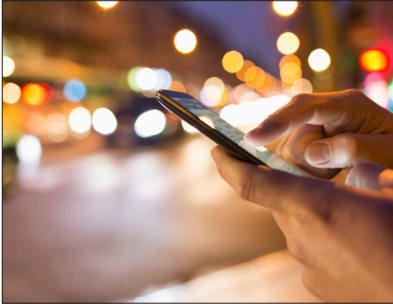
NMS INTERNATIONAL SCIENCE REVIEW 2016

Public summary



Public Summary

Measurement matters. Every time you use satellite navigation, put petrol in your car or receive a medical diagnosis, you are putting your trust in measurement.



The UK's National Measurement System (NMS) is the technical and organisational infrastructure which ensures a consistent and internationally recognised basis for measurement. The UK, along with all other developed countries, invests in our measurement infrastructure to allow measurements to be made with integrity and consistency by developing and maintaining internationally recognised measurement standards and practices.

The UK's NMS consists of a core infrastructure of measurement laboratories connected to a wider measurement community of service providers. This allows us to deliver the benefits of measurement to UK end-users by providing confidence in the measurements you make.

A recent independent International Science Review assessed the quality and relevance of the science output of the larger NMS laboratories. This review focuses on:

NPL
(National Physical Laboratory)

LGC
(formerly Laboratory of the Government Chemist)

NEL
(National Engineering Laboratory)



The UK's National Measurement Institute

The UK National Measurement Laboratory and Designated Institute for chemical and biometrology

The UK National Measurement Laboratory and Designated Institute for fluid flow metrology

Background

The International Science Review Board was charged with the following four tasks:

- *Benchmark NMS Science output against appropriate peer groups to identify areas of particular relative strength or weakness*
- *Make assessments of the wider economic and social impact of NMS-supported science, measurement services and consultancy*
- *Assess the appropriateness of balance in the portfolio between core metrology functions, stakeholder and 'responsive-mode' activities and long-range research*
- *Assess individual NMS laboratories and collate contribution to the UK NMS as a whole*

Based primarily on written evidence prepared by senior scientists from the six Science Divisions at NPL and the teams at LGC and NEL, assessments were completed by a group of 32 Expert Reviewers. The Expert Reviewers were drawn from appropriate scientific peers in NMIs, industry, academia and other research and technology organisations. Half of the Expert Reviewers were from outside the UK, ensuring that this exercise represented truly international conclusions.

The Review Board drew a collective conclusion about the overall performance and international standing of all areas of scientific activity within the NMS (including measurement services, knowledge transfer, training and consultancy) by considering the assessments from the Expert Reviewers, other documentary evidence, interviews with senior scientists and managers, personal knowledge, laboratory visits and technical expertise.

The Review Board also reported several observations and recommendations.

This International Science Review of the NMS concluded that:

All the National Measurement System Science areas perform at an internationally-competitive level

More than half of the National Measurement System Science areas are considered to be internationally-leading

Review Board Members

Paul Stein	Chair of the Review Board; Director Research and Technology, Rolls-Royce, UK
Alex Halliday	Professor of Geochemistry, University of Oxford, UK; Vice President (Physical Sciences Secretary), Royal Society, UK
Alan Johnson	Global Strategic Account Director, Emerson Process Management, UK
Robert Kaarls	Past-Secretary of the International Committee for Weights and Measures (CIPM), BIPM, NL
Paul Mason	Deputy Director Research and Chief Scientific Advisor, Innovate UK, UK
Yukinobu Miki	Director General, National Metrology Institute of Japan (NMIJ), JP
James K Olthoff	Director of the Physical Measurement Laboratory, National Institute of Standards and Technology (NIST), USA
Maria Luisa Rastello	Director of Science, Istituto Nazionale di Ricerca Metrologica (INRIM), IT
Rodney Townsend	Managing Partner, GnosTek, UK

Results

The following areas were considered internationally leading within the NMS:

Science and Global Position

Acoustics and
Ionising Radiation
Analytical Sciences
Chemical and
Bio Metrology
Flow
Time, Quantum and
Electromagnetics

Engagement and Impact

Analytical Sciences
Chemical and
Bio Metrology
Environment
Flow

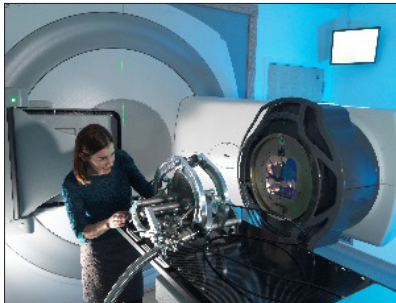
**All areas of the NMS are
internationally competitive**

Observations and Recommendations

The Review Board found that:

1. International leadership in targeted areas is a significant accomplishment, demonstrating considerable value for money; particularly as the NMS annual government budget is notably smaller than those of other leading economies.
2. The NMS operates over a wide range of technology readiness levels, delivering long-range and challenge-led research, as well as core metrology functions and customer-led capabilities. A clearly defined set of key performance indicators could aid internal decision-making and external (national and international) benchmarking.
3. The NMS laboratories are able to clearly elucidate good benefits of their work to the UK and global economy, and to claim leadership in many technical areas. The Board suggested developing a set of quantitative metrics of leadership and economic benefit to the UK and global economy, and reporting on these.
4. With challenging science and customer needs, the NMS needs to do more forward-thinking beyond five to ten years to address future needs. They recommended regular horizon-scanning exercises, to identify essential capabilities to address future needs and develop appropriate roadmaps and delivery strategies to complement any identified future needs.
5. The NMS laboratories operate largely as research, technology and knowledge-based organisations and, as such, use a wide range of strategies: including patenting, licencing, consultancy and services to protect their intellectual property and to exploit their work. Where appropriate, there is a need to further raise the awareness of IP protection.
6. The NMS laboratories show great enthusiasm for their work, as well as a good understanding of the importance, impact and position of metrology in the greater UK and global innovation landscape. It was recommended that succession plans to ensure sustainable future operation of the NMS laboratories are in place and the careers of scientists at all levels are supported and planned appropriately.
7. The NMS laboratories have good connections with, and are delivering, good services to the UK user community and relevant stakeholders. The Board recommends that they should continue to develop strong links with members of the UK innovation and science landscape. A clear stakeholder engagement policy could support internal decision-making to ensure focus on relevant UK priorities and flexibility to adapt to changing requirements.

NMS Science

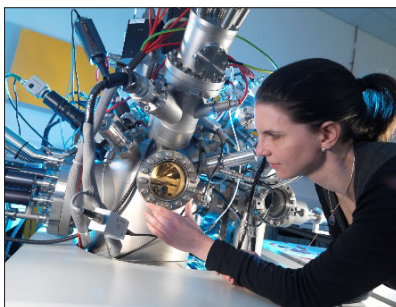


Acoustics and Ionising Radiation

This area comprises the Acoustics, Neutron, Radiation Dosimetry and Radioactivity Groups at NPL. These diverse groups focus on common application areas across the science areas and benefit from a significant number of major facilities, several of which are unique in the UK. It plays a key role in underpinning UK requirements, particularly in Defence, Healthcare and Environmental Monitoring.

Quality of science and global position
Internationally Leading

Engagement and impact
Internationally Competitive



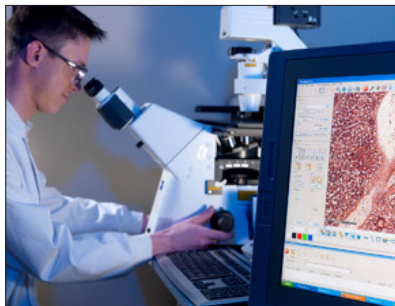
Analytical Science

This area consists of the Biotechnology Group, the Quantitative Surface Chemical Spectroscopy Group and the National Centre of Excellence in Mass Spectrometry Imaging (NiCE-MSI) at NPL. The Analytical Science area is dedicated to advancing chemical and biological metrology at the interface

between physics, chemistry and the life-sciences with a focus on innovation and healthcare. The metrology is anchored to the SI system through the Consultative Committee for Amount of Substance (CCQM) of BIPM and translated to industry through VAMAS interlaboratory studies and ISO International Standards.

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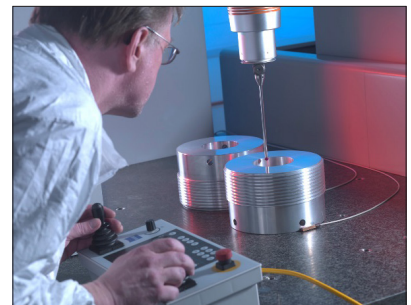
Chemical and Bio Metrology

LGC delivers underpinning chemical and bio-measurement science for the UK. Its research areas span the sectors of advanced therapeutics, diagnostics and safety and security and are delivered through the four core streams of measurement research, calibration facilities, reference materials, and training and consultancy. LGC's measurement capabilities comprise state-of-the-art mass spectrometry, PCR and cell characterisation of products and processes, with many of our testing and calibration services accredited to ISO/IEC 17025. LGC uses its expertise to develop internationally-recognised measurement standards that are used as benchmarks in analytical laboratories with reference material production accredited to ISO Guide 34. LGC plays a leading role internationally to develop laboratory best practice and harmonise measurements across the world through the Consultative Committee for Amount

of Substance (CCQM) of BIPM and ISO International Standards. In addition, LGC is home to the unique function of the Government Chemist, providing expert opinion and advice to Government.

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Engineering Measurement

The four areas included are Mass Metrology, Dimensional Metrology, Temperature and Humidity; as well as a group which delivers Engineering Measurement Services at NPL. The area disseminates three SI units: kelvin, kilogram and metre (with the kelvin and the kilogram realised directly within the Division). It also provides direct support for industrial processes, engineering and manufacturing. The outputs are used throughout many industrial sectors including aerospace, defence, advanced manufacturing, automotive, energy, nanotechnology, oil and gas, food and building management either through measurement services or direct third party contract work for industrial, academic, regulatory and government customers.

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Environment

This area is formed of the Gas and Particle Metrology Group, the Emissions and Atmospheric Metrology Group, the Earth Observation, Climate & Optical Group and the Centre for Carbon Measurement at NPL. The areas activities are focused on the accurate physical and chemical measurement of gases and particulates in the air matrix, both outdoor air and emissions to outdoor air. Work also underpins optical radiation and photonic measurements from the UV to thermal infrared. It also provides traceability for earth observation satellites: both the observations and the derived bio-geophysical products. It is also the focus of all of NPL's climate and low carbon technology work.

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Internationally Competitive

Engagement and impact
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Flow

NEL maintains, develops and operates the UK national standards for flow measurement of gases, liquids and multiphase flows. It also provides the national standard for density measurement of gases and liquids at pressures up to 300 bar. This area has a very strong industry focus, and works closely with industry on challenging flow measurement applications either through use of the national standard facilities, or computational flow modelling. There

is a very active engagement with international standards development across numerous flow measurement technology areas, ranging from differential pressure to multiphase flow which in recent years has become a specialist area for NEL because of the scale of industrial importance and impact of multiphase flows.

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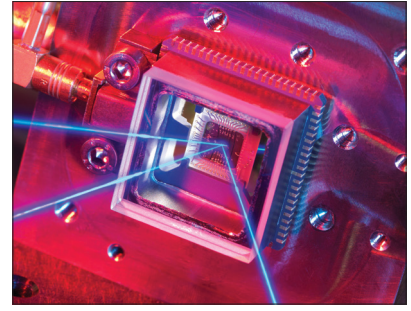


Materials Measurement and Data Science

The Materials Measurement and Data Science Division has four science areas: Advanced Materials Characterisation, Electronic & Magnetic Materials, Electrochemistry and Data Science at NPL. The area provides world-leading materials measurement and modelling capability, focusing on a fundamental understanding of how materials behave at a highly-localised level in response to external stimuli and the application of the insight gained into the development of novel materials and the prediction of macroscopic performance, especially in challenging environments. Theoretical modelling is an essential complement to the measurement technique by providing the fundamental framework that defines materials behaviour, enabling linkage at different length scales, identifying critical parameters, and enabling prediction of performance. It is also developing a new data infrastructure to promote confidence in the effective use of data.

Quality of science and global position
Internationally Competitive

Engagement and impact
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Time, Quantum and Electromagnetics

This area is structured into four groups: Quantum Detection; Time & Frequency; Electromagnetics

Measurement and Electromagnetics Technologies at NPL. This area provides the metrology infrastructure and traceability for time (the SI second) and electrical measurement (the SI ampere) and traceability to the electrical units (the ohm and the volt) and other electrical measurements from dc to THz. Quantum research covers quantum SI, materials and technology. Time & Frequency focuses on precision clocks, transfer methods, underpinning physics and new technologies, whilst the Electromagnetics research includes communications metrology, health and safety, smart grids, remote sensing and traceability.

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