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NPL DELIVERING METROLOGY

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Abstract – The principal, and generally exclusive role of a national measurement institute (NMI) is the delivery of metrology. In addition to the maintenance of measurement standards, the delivery of metrology involves providing access to those standards for all with an interest in measurement, as well as responding to demands for improvements in the standards and their dissemination. It also calls for the transfer of knowledge and information in a variety of ways to ensure the use of appropriate technology and the adoption of best measurement practice.

As the UK's national measurement institute, the National Physical Laboratory (NPL) is at the heart of the United Kingdom's national measurement system, delivering metrology in a wide range of fields. Through its extensive research programme it supports the International System (SI) and provides calibration and advisory services to its customers in industry, government and academia.

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1. DELIVERING METROLOGY

Investment in metrology is widely recognised as a public good, which benefits trade, industry, and the public. It is interesting and instructive to see how the world's NMIs differ from each other in the extent of their scientific activities and the range of their metrology services. These variations reflect historical differences as well as the current demand for measurement in each country. This demand is determined by the state of industrial development of a country and is reinforced by the level of government funding the NMI receives. In most cases, delivering metrology involves NMIs in activities ranging from basic scientific research into the realisation of measurement units to the provision of calibration services and advice and training in the field of metrology.

1.1 Delivering standards

By maintaining national standards (which may be direct realisations of SI units or traceable to basic standards in another NMI) an NMI provides traceability for manufacturers, regulators, and accredited laboratories. The equivalence of national standards has been affirmed in the CIPM mutual recognition arrangement (MRA), which has been signed by 52 national measurement institutes, including the National Physical Laboratory. In addition to

establishing the equivalence of national standards, the MRA also provides for the mutual recognition of calibration certificates issued by the participating NMIs.

This MRA is firmly based on an ongoing programme of key comparisons of standards organised by the Consultative Committees of the CIPM and the various regional metrology organisations. It also requires NMIs to assure the quality of their calibration and measurement systems by implementing a quality system that complies with ISO/IEC17025 or by some other means, and many NMIs now use external accreditation to monitor and guarantee the quality of their operations.

1.2 Delivering services

NMIs deliver services to a wide range of customers. The main output from a NMI is the stream of calibration certificates which provide traceability to users who thereby establish the values of their own standards, for internal use or as the basis for further calibration services provided to others. The scope of the services available from NMIs may vary widely, as do their measurement capabilities. What they provide in common is the confidence that comes from their national position, their independence, and their proven competence.

1.3 Delivering science

NMIs deliver advances in science by sustaining research into the improvement of measurement standards and the development of better, more accurate measurement techniques and instrumentation. As well as major research programmes aimed at improvements in the definitions of the SI units and smaller projects which develop and enhance measurement instrumentation, research in NMIs is also addressing measurement issues in fields where the concepts of reliable metrology are not yet well understood.

In chemistry and food science, there is now a growing understanding of the importance of traceability and the significance of uncertainty of measurement, but in other fields, including biology and medicine, there is still a long way to go. NMIs, with their research capability and independent status, have an important role to play in ensuring that metrology is properly understood in all scientific and technological disciplines. They can contribute to this understanding by extending their research activities into these important fields, many of which impact directly on the welfare and quality of life of citizens.

1.4 Delivering solutions

NMIs address the measurement requirements of industry by transferring best practice and NMI capability into commercial environments. This is only imperfectly achieved by providing calibration services, and many NMIs also transfer their technology through publications, training courses and consultancy services. Best measurement practice may also be transferred through demonstrator projects and direct industrial collaboration, while many NMI staff participate in the preparation of specification standards and legislation. Newsletters, websites and best practice guides all contribute to the delivery of solutions directly from NMIs into industry and society.

2. THE NATIONAL PHYSICAL LABORATORY DELIVERING METROLOGY IN THE UK

The National Physical Laboratory (NPL) is the UK's national measurement institute. Founded in 1900, it now employs more than 650 scientists, engineers and support staff. It maintains measurement standards for the SI units and provides access to these by providing calibration services. NPL also conducts research at the frontiers of measurement and materials science for Government, and carries out applied research for industry. Transferring knowledge and technology to industry is an important activity for NPL, achieved through consultancy, publications and good practice guidance, and the operation of a number of clubs and networks. The Laboratory also licenses its inventions and discoveries to instrument manufacturers to ensure the widest possible availability to the industrial user community.

NPL is owned by the UK's Department of Trade and Industry (DTI). It is operated on their behalf by NPL Management Ltd, a wholly owned subsidiary of Serco Group plc, a company specialising in the management of facilities for government in the UK and worldwide. Under this arrangement, the government owner retains policy control, maintaining independent support for industry and protecting international collaboration, while the Laboratory benefits from the contractor's commercial experience. After seven years, contractorisation is seen to have been a success, maintaining the delivery of metrology at an appropriate level for all users in the United Kingdom and continuing to be financially attractive to both owner and contractor. This arrangement positions NPL closer to its user community, and increases the leverage of its work. NPL has grown significantly since the change of status, and its success is reflected in the decision to let a new contract, following a competition, from April 2004.

While pressed by the DTI to continue its high quality research, NPL is responding to the commercial and government policy climate in which it works, and the nature and scope of its services have developed in response to the needs of its customers in industry, science and government.

2.1 National measurement standards at NPL

NPL maintains the measurement standards for the UK, as the basis for a wide range of traceable calibration services, and works to improve these services where there is

demand for increased scope, new capabilities, or lower uncertainties.

For example, NPL plays a critical role in providing the standards for radiation doses delivered in X-ray procedures. With over 40 million X-rays taken each year in the UK it is imperative that patients are exposed to the lowest radiation doses consistent with obtaining the required diagnostic information. The new diagnostic and mammographic X-ray exposure facility at NPL is furnished with clinical machines which simulate the beam qualities used in clinical practice, thus ensuring that NPL's standards provide an improved calibration service which meets the clinical need and complies with all the relevant legislation.

The cryogenic radiometer is the primary standard for the measurement of optical radiant power. As such it forms the basis for optical radiation measurements at all leading national standards laboratories. Scales for primary spectral responsivity can be established by calibrating transfer standard detectors against the cryogenic radiometer. These scales are then transferred to industry, using standard photodetectors, where they are increasingly used to improve processes and further the development of new products.

NPL's radiometer is among the most accurate optical detectors in the world, measuring with an uncertainty of $\pm 0.005\%$. NPL pioneered the development of this instrument, with a fifty-fold improvement in accuracy, and copies have been supplied to a number of other NMIs. This is one of the many standard instruments NPL can supply to meet specific measurement needs.

2.2 NPL's services

NPL maintains world-class metrology facilities and offers calibration services with the highest available accuracy in all major fields.

Each year the Laboratory carries out several thousand calibrations, mainly for laboratories accredited by UKAS (the United Kingdom's national accreditation body), which in turn complete nearly a million calibrations annually. All the calibrations delivered by NPL are traceable to the national measurement standards. NPL also delivers innovative, specialised measurement services, tailored to new and demanding applications.

2.3 Scientific research at the forefront of metrology

The government-funded long-term research programme at NPL has three main themes: (1) frequency standards and metrology, (2) fundamental constants and related SI units, and (3) particles, molecules and waves. Details of this programme can be found on NPL's website at www.npl.co.uk/quantum/qtm/, but highlights include:

- the development of a new high accuracy optical frequency standard based on a single cold trapped ion;
- the quantum manipulation of atoms with the aim of reducing the cold collisional frequency shift in caesium fountains;
- the continued development of the watt balance to improve its long-term stability;
- the development of a prototype quantum current standard, with an accuracy of 1 part in 10^6 ;
- identification and spectroscopy of single molecules.

These projects will provide the foundation for the fundamental measurement standards at NPL and elsewhere in the next ten years. NPL is also undertaking longer term research with the aim of building capacity in promising new fields, such as nanotechnology and biometrology.

2.4 Metrology solutions from NPL

NPL has an unrivalled track record in solving real, commercial measurement problems. The Laboratory offers a broad range of measurement consultancy services backed by extensive research and testing capabilities. In addition it delivers solutions through its eleven collaborative clubs, which bring together companies, instrument "end users", academics, and user groups. Each club covers a specific area, and most hold regular meetings, with specialist working groups to share and solve technical problems.

To help small engineering manufacturing companies identify the benefits of improved measurement practice and process control, NPL led the 'On-machine Measurement' project. Partner representatives visited the companies to identify process improvement areas and implement a process involving the loan of essential measuring equipment. In each case, substantial savings were identified, leading to a permanent improvement in the company's capability.

3. THE INTERNATIONAL DIMENSION

As a leading NMI, NPL participates actively in metrology cooperation within Europe and in the wider world. A signatory of the CIPM MRA, it has participated in 268 key and supplementary comparisons and has more than a thousand CMC entries in appendix C of the BIPM database with a further four hundred under review.

Within EUROMET, NPL leads the RegMet project, which aims to improve collaboration in Europe between regulators and metrologists. Partially funded under the European Commission's fifth Framework Programme, RegMet has established a two-way dialogue between the

regulatory community and the national measurement institutes. The principal output from the project will be a template, which will be made available to regulators, national governments and the European Commission for embodiment in policy and practice wherever they consider it advantageous to do so. More details are available on the website at www.regmet.dk, where there is also information about MetroTrade, in which NPL is also participating. MetroTrade aims to identify and, where possible, remove measurement-related impediments to international trade.

In addition, and probably more significantly, NPL is leading the MERA project which is planning metrology for the European Research Area. All the EUROMET NMIs are participating in this project, which started on the 1 September 2002 and will run for 12 months. MERA involves an evaluation of the current collaboration in European metrology and an assessment of the potential for increasing cooperation in research. Following a participants' workshop last December, an extensive consultation exercise is now under way to establish the level of support among users of NMIs' services for closer collaboration, ahead of a second workshop in June which will include representatives of government ministries and funding agencies. The final report will include a roadmap for the development of metrology in Europe along collaborative lines.

There is no doubt that these developments will have a profound effect on the activities of NMIs in the coming years. NPL will continue to work with its partner NMIs in other countries to deliver services and solutions based on the most reliable standards and underpinned by outstanding scientific research.

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