NPL
National Physical Laboratory

Science with impact

Annual Review 05/06

Our vision for NPL is to be the national measurement institute that delivers the highest economic and social impact, through excellent and responsive science.

We will deliver this through:

- Excellence in science
- Increased exploitation of that science to boost UK competitiveness and quality of life
- Integrity and independence as a national asset
- Enhanced international standing

The National Physical Laboratory is operated on behalf of the DTI by NPL Management Limited, a wholly owned subsidiary of Serco Group plc

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Sounding out the whales

NPL is helping to understand the impact of noise generated by human activity on marine life. Whales and dolphins use sound to hunt and communicate, so even subtle acoustic signals may disrupt them. Powerful underwater sound waves can be generated by offshore oil and gas activities, naval sonar and surface vessels. There is growing concern about the impact of this noise, but there is often confusion about the best way to measure and express its levels. NPL has brought together leading researchers, environmentalists, biologists, naval staff and the offshore industry to share acoustic measurement expertise and best practice.

NPL's strategy is to deliver science with impact and 2005 was a year of outstanding results. We are building on our strong scientific legacy to provide tangible benefits to industry and society.

We are proud to report here on some of the past year's breakthroughs and to show how we are taking science out of the laboratory and into homes, hospitals, the workplace and government departments. This printed version of the review is shorter than usual so we can save paper and meet our environmental commitments. There is a lot more detail online at www.npl.co.uk/review. While maintaining our leadership in traditional areas such as time metrology and rejuvenated disciplines like acoustics, we are also working at the cutting edge of metrology for biotechnology and nanotechnology. We are pleased to be forging new relationships and collaborations with regional development agencies and industry bodies. This enables us to actively spread our measurement message to a wide and receptive audience.

The best team

Only the best team can get consistently good results, so we are working hard to recruit top scientists, as well as managers with business acumen and a desire to make an impact. The people we attract from abroad bring new skills and links into other national measurement institutes. Boundaries between physics and other sciences are blurring, which has encouraged the integration of chemists, biotechnologists and engineers to support our activities in areas such as drug discovery and diagnostic medicine. It was encouraging this year to receive more than a thousand applications for 14 graduate positions, evidence of the NPL brand recognition which will help us to build the next generation of scientific leadership.

Emerging technologies

NPL is helping to nurture new disciplines such as nanotechnology and biometrics with the development of new standards and measurement techniques. This enables industry and other researchers to find the potential of these sciences while reassuring regulators and the public of their safety and reliability.

Standard evangelists

The development and maintenance of standards and measurement technologies remains one of NPL's primary roles. The value of this activity was highlighted by a recent survey showing the National Measurement System (NMS) had a £700m+ benefit to the UK economy. NPL is a key government advisor and we have been working to build relationships with the chief scientists of government departments outside DTI.

A novel approach to intellectual property

NPL generates value from knowledge. Ideas and inventions are traditionally patented for commercial gain by a single organisation, but our strategy is to share our knowledge with the widest audience possible. We protect our high-quality science and then make it available to anybody in the economy or society who can use it to deliver value and have an impact. NPL is a national resource, and by developing this approach to intellectual property we are giving our science and technology its widest possible reach.

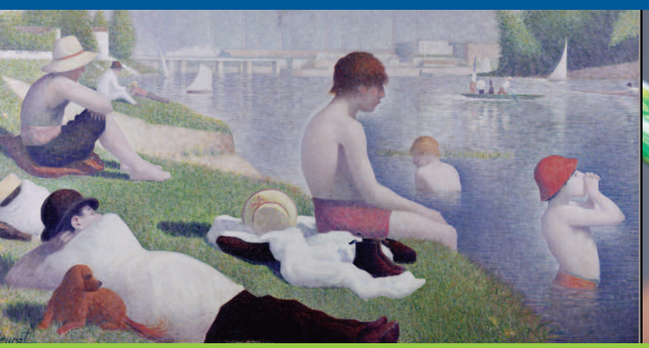
Looking forward with confidence

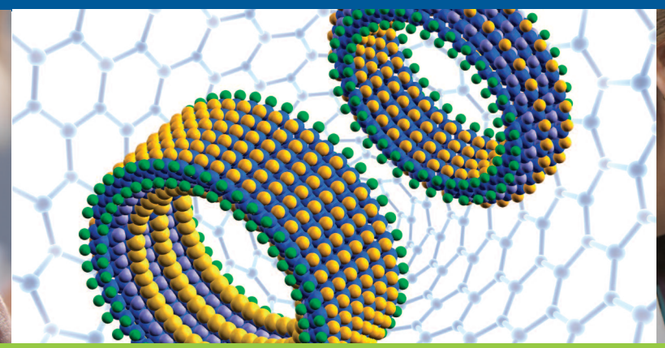
By investing in the best talent and focusing on world-class science and innovation, NPL will continue to help the public and private sectors to benefit from measurement and standards. Please enjoy the following summaries of our activity. We look forward to the next year with tremendous enthusiasm.

Steve McQuillan
Managing Director

Innovation and impact

NPL's innovative measurement science is making an impact on industry, security, healthcare, sport and the environment.





A new security dimension

Our materials team has patented a 3D barcode with so many potential permutations a computer performing a million calculations a second would take ten times the life of the universe to decode it. The cube-shaped device is small enough to be concealed behind a human hair and can contain data equivalent to the information in four bibles. The NPL nanobarcode may be used to protect high-value items such as jewellery or works of art, or as the next generation of security on banknotes, share certificates and passports.

How does it feel?

NPL is helping designers and manufacturers to measure and understand consumers' response to new plastic materials used in everything from toothbrushes to steering wheels. Our scientists have been working with City University to discover the link between psychological perception of plastics and their physical characteristics. This will help industry to add value by creating products with a luxury feel.

Targeting cancer with tomotherapy

London's Cromwell Hospital is working with NPL to improve dose measurement for an innovative radiation treatment called tomotherapy, which avoids healthy tissue and organs while destroying cancerous tumours. Success depends on delivering the right dose – too little may result in a recurrence of the cancer and too much can cause serious side effects. NPL's dose measurement technique may become the international tomotherapy standard.

Acoustic MEMS technology

New EU directives require the production of noise maps for cities, transport systems and industrial sites. Noise prediction software currently provides the only economical solution, so NPL is working on a new generation of instruments that will make it possible to make direct real-time noise measurements. Prototype instruments the size of matchboxes, based on MEMs and wireless sensor technologies developed with industry, are being tested under laboratory and field conditions.

Excellence in MNT measurement

NPL has helped to establish the Centre of Excellence for Metrology in Micro and Nanotechnology (CEMMNT), a vital contributor to the exploitation of micro and nanotechnologies (MNT) in the UK. The centre will develop measurement and characterisation techniques to support the commercialisation and manufacture of MNT.

Bionanotechnology pioneer

In the summer of 2005 NPL founded the Bio Nano Centre with the London Centre for Nanotechnology and the Institute of Biomedical Engineering at Imperial College.

Time for Galileo

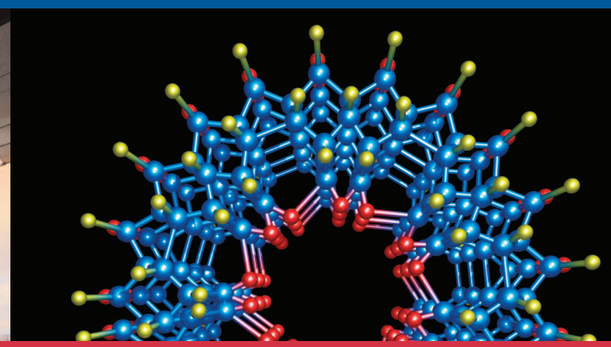
NPL and other leaders in Europe's timing community will synchronise the precision signals underpinning the ambitious Galileo constellation of navigation satellites. NPL's advanced techniques for handling time data from clocks all over Europe will help Galileo to deliver commercial and civilian benefits.

Our impact in the future

Our science is not only having an impact now – we are already laying the groundwork for the impact we will have in the future. Our Measurement for Emerging Technologies (MET) programme is building the measurement capability that will put future innovation and ideas into the economy and people's lives. We are working with some of the UK's leading companies and academics on new multidisciplinary research in areas such as nanotechnology, wireless communication, point of care diagnostics and efficient fuel cells. This enables industry and other researchers to find the potential of these sciences while reassuring regulators and the public of their safety and reliability. Some of our work travels a long way and takes a long time to have an impact. In 1996, for example, we calibrated the antenna standards which were deployed on the Cassini-Huygens probe, a deep space mission which landed almost ten years later on Titan, Saturn's largest moon.

Science with impact

NPL does world-class science and is recruiting the best scientists from the UK and countries including Russia, China, France and Switzerland.



Terahertz sensitivity

Among our breakthroughs in 2005 was the successful testing of a single photon detector displaying extremely high sensitivity at terahertz frequencies. It may find applications in sub-millimetre wave astronomy to help understand the formation of stars and planetary systems.

Burning ambition

NPL has developed a Standard Flame with a known gas composition and steady temperature in the 1500°C-2000°C range. Accurate flame temperature measurements can improve efficiency and reduce pollutants in combustion processes.

Distributed computing

We have used some of our spare desktop computing capacity to create a formidable virtual supercomputer that vastly improves the speed of scientific and technical calculations. Using 85% of the capacity of more than 200 desktops, we helped to model a new piezoelectric sensor and design a sonar loudspeaker. Distributed computing lets us do in weeks what would take years with conventional resources.

Breakthrough nanotube research

NPL has published details of quantum thermal measurements in individual carbon nanotubes - results that may herald nano-electric industrial applications. Nanotubes could be used in computers and other nano-circuits as capacitors or transistors. We have shown that electric and thermal conductivity in high-quality nanotubes is ballistic, caused by scatter-free transport of electrons and photons. This means nanotubes may act as low-resistance interconnectors or super-efficient heat pipes, conducting heat away from nano-scale circuits. NPL was first to make these observations, and is now investigating applications in nanoscale metrology.

Acoustic sensing

We have patented a novel acoustic sensor that can characterise the distribution of cavitation. Acoustic cavitation, the formation, growth and collapse of tiny bubbles under the influence of ultrasound, can be used to clean jet engines, manufacture drugs or help sterilise surgical instruments.

Find out more at www.npl.co.uk/review

International impact

As one of the world's leading national measurement institutes, NPL's scientific expertise has an impact well beyond UK borders.

EU security

Our quantum detection group has joined a European research team to develop security monitoring technology in the terahertz frequency range. The Teraeye team is building a prototype passive terahertz imager sensitive enough to catch and scan single photons. Applications include airport security scanning, crowd surveillance and detection of chemical and biological hazards. Terahertz imaging may also have benefits for biomedical screening, radio-astronomy and processing quantum information.

Redefining the kelvin

NPL's head of temperature standards has joined an international task force working on a new definition of the kelvin.

A convergence of sciences

We helped organise a prestigious 2005 conference on Surface Enhanced Raman Spectroscopy (SERS). A convergence between physics, chemistry and biology, SERS has applications including forensics, drug discovery and medical diagnostics.

Out of the darkness

Our scientists are working to make it safer to drive at twilight and at night when light conditions are most dangerous for motorists and pedestrians. We are part of an international consortium which has conducted research into how the eye performs in low-light conditions. This may lead to new street lighting standards which help drivers to recognise obstacles and react better to dangerous situations.

European metrology collaboration

NPL is leading a 14-country EU collaboration to address common measurement challenges and lay the groundwork for a new European Research Area in metrology. A recent Oxford University study reported that Europe invests up to @83bn in measurement annually – nearly 1% of EU GDP. In addition to the estimated @230bn economic return, there are intangible benefits to quality of life through improvements in the environment, health and security.

Find out more at www.npl.co.uk/review

Impact on health

NPL has a vital impact on human health. We calibrate the instruments used in cancer treatment, develop new devices to improve the quality of life, and provide the standards which underpin modern medicine.

Brain temperature measurements

Our scientists are collaborating with hospital trusts to develop magnetic resonance imaging (MRI) to measure the core temperature of the human brain. This may prevent brain damage in thousands of babies deprived of oxygen at birth. The risk of damage is reduced if the brain is cooled during the first 48 hours of the infant's life.

Air crew safety

We are working with the airline industry to measure the radiation to which aircrews are exposed from solar flares.

Helping the hearing-impaired

NPL is developing a novel cochlear implant in collaboration with the Institute of Nanotechnology. Piezoelectric ceramic sensors acting independently of each other can be tuned to resonate at different frequencies by adjusting their length and width. This may allow hundreds of sensors to be contained in a single implanted hearing device, which will increase the capacity for deaf people to hear a range of sounds, possibly including music.

Human tissue scaffolds

We are working with cell biologists and the tissue engineering community to develop soft tissue scaffolds which could reduce the demand for transplanted human tissue and organs. The scaffolds are support structures made from biocompatible materials acting as a temporary housing for culturing cells. Over time, the cell-seeded scaffold becomes a fully functional block of tissue which can replace a patient's damaged tissue. Using patients' own cells reduces the need for immunosuppressent drugs.

Counting nanoparticles

NPL is improving measurement of airborne nanoparticles. In 2005 we won a contract to run the UK Particle Counting Network for the Department for Environment, Food and Rural Affairs. We assembled a powerful consortium to improve the quality and volume of data available to air quality and climate change researchers. This will help inform development of air pollution mitigation policy. We also established a Nanoparticle Research Laboratory to assess equipment used to analyse air quality.

Safety and security

By researching the impact of other technologies, NPL is contributing to the safety of the individual, the security of information and to environmental protection.

Detecting contaminants in drugs

We are helping the biopharmaceutical industry to evaluate technologies which detect impurities in drugs. Our biotechnology team is also helping the industry to get drugs approved faster by reducing the time and cost of testing.

Certifying quantum cryptography

NPL is playing a key role in the standards that underpin quantum cryptography. The technology provides absolute security for two-way communication because both sender and receiver can detect if an eavesdropper has intercepted transmission of their encryption key. Single photon techniques are fundamental to quantum information processing and in 2005 NPL organised the second international Single Photon Workshop. It attracted 80 experts covering quantum information, astronomy, nuclear physics, medical physics and biophysics. NPL has a long history in cryptography. While at NPL Alan Turing designed a stored program computer which led to the breaking of German ciphers in World War Two.

Safe and sound

We are helping car manufacturers like Land Rover to predict the effect of accidents on passengers. Violent impacts affect the whole interior and exterior structure of a vehicle and have implications for the materials selected by manufacturers during the design process.

Reliable biometrics

The next generation of biometric technology is being tested at NPL ahead of its introduction into banks, airports and ID cards. Biometrics is the recognition of individuals based on their biological and behavioural traits. It is a rapidly evolving technology and there are not yet any formal schemes for certification or product evaluation. NPL is working with leading technology companies and government departments to evaluate the competence of several new products, including 3D face scanners and systems which recognise veins and irises.

Transferring knowledge

The years of knowledge and experience at NPL has its greatest impact when shared with the commercial world and other researchers.

Measurement services

NPL maintains world-class metrology facilities and offers calibration services with the highest available accuracy. Every year we do thousands of UKAS-accredited tests and calibrations for instrumentation and measurement companies – all of them traceable to national standards. NPL also tailors measurement services for new and demanding applications. As the highest point in the traceability chain, we are a source of accuracy and credibility for UK industry. Among our recent work is the calibration of probes for the mobile phone industry to measure the absorption of radiation in human tissue. This helps to ensure devices meet safety standards. We have contributed to a safety review of new road charging technologies and enabled a British meteorological observatory to monitor performance of the European Space Agency's first Galileo satellite.

Kaye & Laby online

NPL has put the 600 pages of Kaye & Laby's *Tables of Physical and Chemical Constants* onto the web as a free online resource for scientists and engineers. *www.npl.co.uk/reference_data*

Measurement for innovators

NPL offers free technical advice, joint projects, training, secondments and consultancy. We have more than 400 scientists providing contract research with an emphasis on the development and application of innovative measurement and testing technology. For example, NPL is working with a large instrument manufacturer on 3D measurement at the nanoscale, and we are helping the UK's lighthouse authorities to test the brightness of its signals. Our scientists are providing guidance on the use of fibre optic sensors to warn of structural weaknesses in buildings, and the healthcare industry uses NPL services to customise hip implants.

Impact in the regions

We are running regional measurement surgeries for small companies and tailoring our measurement advice to the needs of a particular sector or region. Our science and commercial expertise is becoming accessible to a broader audience through new relationships with technology clusters and the regional development agencies.

Contact NPL

The National Physical Laboratory is operated on behalf of DTI by NPL Management Limited, a wholly-owned subsidiary of Serco Group plc. NPL services range from free technical advice to contract research and UKAS accredited measurement.

The NPL Helpline is the first point of access into NPL. Helpline staff will discuss your enquiry and recommend the most suitable person to help you.

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Searchable online database of NPL staff and services
www.npl.co.uk/expertise/search.php

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