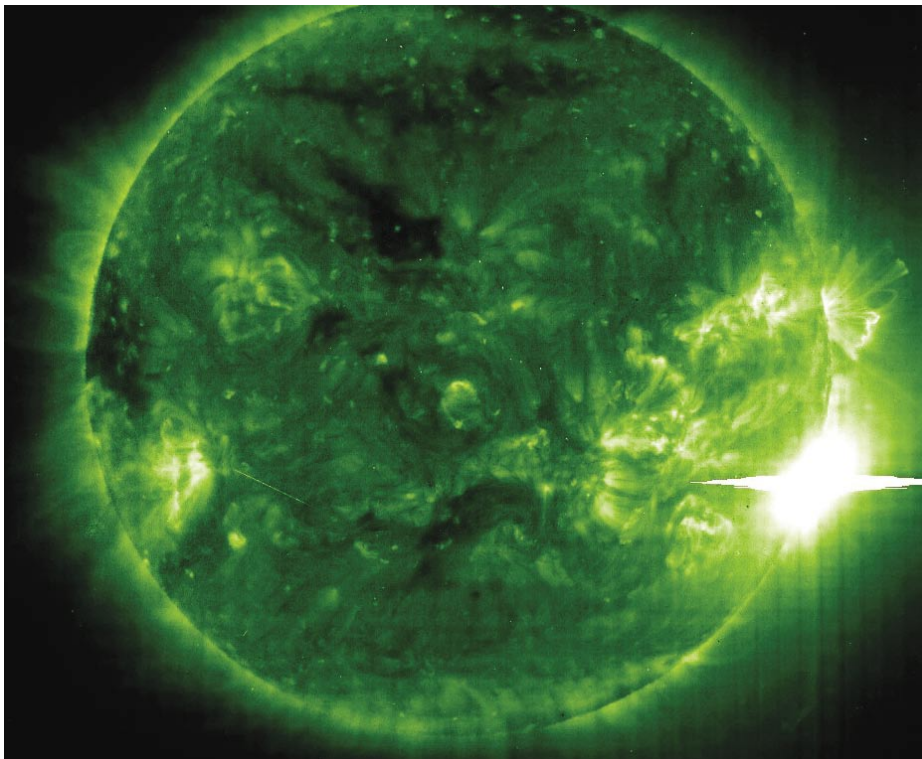


# Environmental Measures

A National Measurement Newsletter

Spring 2006 | Issue 1



## Inside:

Concrete models.....	2
Driving fuel cell research.....	2
Lightening the load of lead-free.....	3
The 'TRUTHS' about climate change.....	4, 5
Something in the air.....	6
Stack emissions monitoring.....	7
Underwater noise measurement.....	7

'Solar flare captured by the SOHO satellite on November 4th, 2003.  
Courtesy of SOHO/EIT consortium (ESA and NASA).'

## Cosmic radiation and air travel: Quantifying the risks

**A transatlantic air flight exposes everyone on board to the same radiation levels usually received every 8-9 days on the ground. However, aircrew members and frequent flyers are more at risk from radiation as they fly more often, typically one transatlantic flight a week. In an average working week they can be exposed to a radiation dose equivalent to 3 medical x-rays of the skull.**

The European Union has introduced legislation to ensure that all EU-based airlines assess the radiation exposure of aircrew, similar to the requirements for the nuclear industry. NPL is working with world-leading airlines to assess the cosmic radiation risk to passengers on commercial flights, and help the

airlines meet the requirements of the new EU legislation.

NPL is enabling airlines to meet the requirements of the new legislation by sharing its expertise in the use of tissue equivalent proportional counters (TEPCs) to measure radiation. Measurements have been

carried out on more than 800 flights with different airlines and the results demonstrate that existing software used to calculate radiation works adequately.

*For further information please contact Dr Graeme Taylor  
020 8943 7087  
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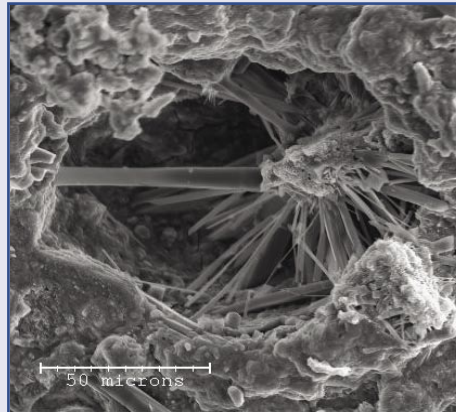


# Concrete models

The contamination of industrial land by pollutants such as accumulated heavy metals is a major problem worldwide. In the UK and Europe there are approximately 100,000 and 1.4 million contaminated sites, respectively. At present the 'dig and dump' approach to remediation is often employed but this merely displaces a problem that will cost between £7-16 billion to clean up in the UK alone.

Special Grade Cements (SGC's) designed to mop-up and trap pollutants are being put forward as a long-term solution to land remediation. These cements can be ploughed into land or used to construct active linings and caps, stopping the spread of contaminants. The application of these cements in the areas of nuclear waste management and environmental protection could prove invaluable. But before such use can be sanctioned regulators will require proof of their ability to lock in contaminants in the long-term, for example through phase equilibrium calculations using reliable thermodynamic models.

An NPL collaborative project aims to provide a reliable model for Calcium Aluminium Silicate Hydrate gels (CASH gels), one of the key components of the



Needles of smithsonite ( $ZnCO_3$ ) growing within the void, in a cement-encapsulated zinc slag

cements. This will enable the thermodynamic behaviour of CASH gels in different aqueous environments and temperatures, from room temperature to 85 °C, to be predicted. Such information is important for regulatory approval. Regulators can look confidently to

the results of calculations using these models developed at NPL to gauge the long-term viability of these materials.

For further information on this project please contact  
John Gisby  
020 8943 7098  
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NPL collaborative projects enable companies to research solutions to specific measurement problems by accessing NPL's expertise and equipment in a cost-effective manner. If you would like to receive further information or have a suitable project you would like to arrange, please contact the Materials Enquiry Point by telephone 020 8943 6701 fax 020 8943 7160 materials@npl.co.uk

# Driving fuel cell research

NPL is helping to commercialise fuel cells and optimise their design. Measurement and modelling tools developed by NPL will make fuel cells cheaper and more durable.

Fuel cells are important to reduce greenhouse emissions and combat global warming which is now widely accepted as a serious threat to our way of life. Government policy is driving research into cleaner and more efficient sources

of energy, with the aim of reducing greenhouse gas emissions. Renewable energy sources will be increasingly used to generate energy, but hydrogen and fuel

cells will be required to store, distribute and produce energy at the point of use. Three major barriers to commercialisation of fuel cells are cost, durability and the establishment of a refuelling infrastructure.

NPL's fuel cell program is addressing the cost and durability issues by developing measurement and modelling tools to optimise fuel cell design and mitigate degradation. The research is supported by the DTI and leading UK fuel cell and component developers.

For further information contact  
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020 8943 7147  
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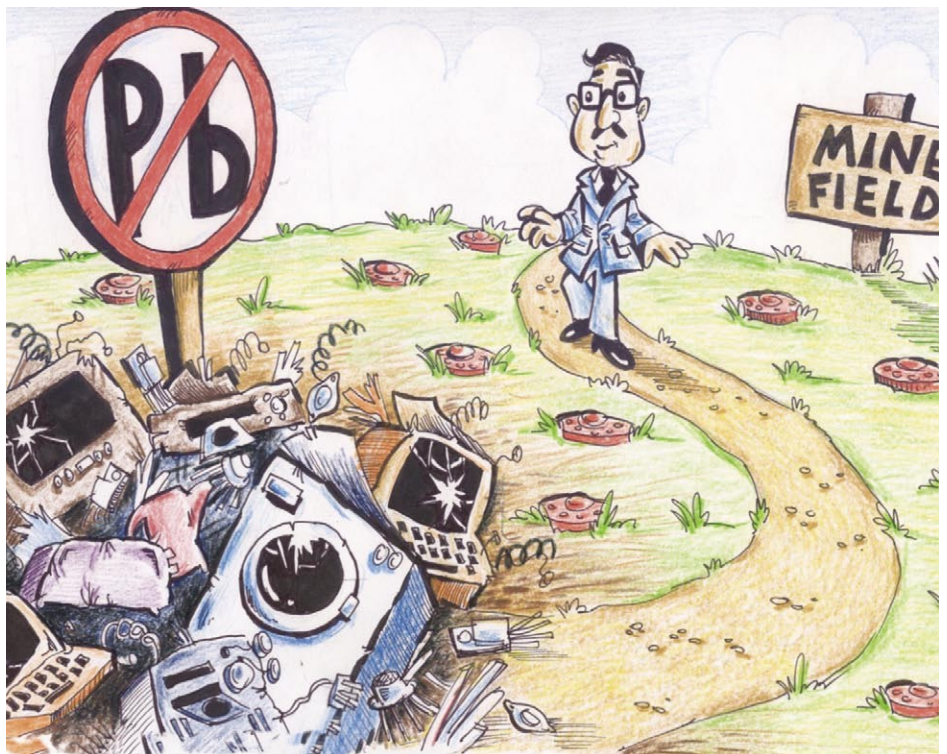


# Lightening the load of lead-free

**NPL is helping the electronics industry prepare for the huge impact of two EU directives being introduced into UK law by 1st July 2006. These directives, Restriction on Hazardous Substances (RoHS) and Waste in Electronic and Electrical Equipment (WEEE), will ban materials and set recycling targets for electronic and electrical equipment.**

The directives apply to the majority of electronics put on the EU market including mobile phones, toys and tools. There are exemptions for some high reliability or life-critical sectors such as avionics, where control systems can be subjected to severe thermal cycling and mechanical vibration. However, current market pressure suggests these systems may also need to become compliant in the near future.

Industry has already been affected by RoHS. Alternative alloy systems are being introduced due to the imminent banning of lead. The result is a difficult transition period for industry, with no simple 'drop-in' material replacement, a lack of processing knowledge and a relative paucity of reliability data for new materials. These uncertainties will impact and potentially increase market failures of electronic assemblies, an



industry in the UK that is worth £23 billion a year.

Furthermore, following implementation of the directive and the adoption of new materials, there is a higher risk of manufactured goods being less reliable through unacceptable defects or shorter life expectancy.

This period of change means industry has new requirements for measurement tools to control and improve processing, and for characterisation tools to avoid field failures. NPL's projects over the last nine years have helped address this by providing a range of tools for predicting the reliability of new RoHS compliant materials and processes such as alternative solders, conductive adhesives, and plating processes. Using these

tools, manufacturers can be sure their products are safe, reliable and resilient enough for customer use.

NPL's Alan Brewin recently completed a secondment with the Component Obsolescence Group (COG) and developed a guide to the new RoHS lead-free legislation. This guide, 'The Pb-Free Minefield, A Guide to Mitigating Risk during the Transition to RoHS Compliance', addresses the main topics that need to be tackled for successful implementation of the RoHS directive in a company in the electronics manufacturing supply chain.

*For further information or to obtain a copy of 'The Pb-free Minefield', please contact Alan Brewin 020 8943 6805 alan.brewin@npl.co.uk*

## Conductive adhesives

Conductive adhesives are a potential alternative to soldering technology in some electronics applications. However, industry is reluctant to use them due to the lack of relevant performance and reliability data available.

An NPL project on the characterisation of conductive adhesives will provide UK industry with:

- A facility to easily compare performance data in a standard format
- New test methods for characterising the performance and reliability of these materials

A database of materials properties, and a report on the feasibility of new test methods for characterising the performance and reliability of these materials will be available on completion of the project.



# The 'TRUTHS' about climate change

**NPL's optical radiation group want to make measurements of the Sun and Earth with unprecedented accuracy to provide new evidence about the causes and impacts of climate change. An orbiting calibration laboratory on a small satellite has been proposed to the European Space Agency (ESA) by an international team led by NPL's Dr Nigel Fox, and is now gaining support from world climate scientists.**

Assessments of climate change depend on data collected over decades. Scores of Earth observation (EO) satellites are used to provide inputs to, and allow the development of models, that advise policy makers. Satellite surveys are used to quantify the interactions of complex environmental factors involving the atmosphere, the Sun, oceans, pollution, volcanoes, vegetation, and deforestation. The satellites should provide enough information to support national and international legislation. However, in most cases they are not accurate enough to distinguish between the predictions of different environmental models, and scientists cannot agree on their conclusions. "We just don't know if the instruments are really accurate enough once they've been in space for a couple of years," Fox says. "They all seem to produce slightly different results, and that makes it difficult to decide between different models of climate change." For policy makers to accept the data, it must be referenced to a traceable

and internationally accepted standard. Traceable measurements of unprecedented accuracy would be provided by the proposed TRUTHS (Traceable Radiometry Underpinning Terrestrial- and Helio- Studies) calibration satellite.

The TRUTHS mission plans the establishment of a set of internationally accepted SI traceable reference targets - Sun, Moon and Earth deserts that could be used to provide calibrations for EO data collected by other satellites. Such reference targets are highly stable, and so could be used to back correct archived data. The TRUTHS mission is unique in establishing high accuracy SI traceable data in-flight - a "calibration laboratory in space". On board the small satellite, a suite of instruments will measure the input solar irradiance and solar reflected radiance (Figure 1).

These instruments will be calibrated directly against an on-board primary standard - a cryogenic radiometer (CR) through a procedure, which mimics that carried out on the ground. The CR is the primary standard of choice for terrestrial applications. Adapted for use in space, it compares the heating effect of optical radiation with that of electrical power - transferring all the difficulties associated with current space based optical measurements (drift, contamination etc) to more stable electrical SI units.

One aim of the TRUTHS satellite is to transfer its high accuracy to other satellite missions measuring optical radiation. It will do this by calibrating optical radiation from reference targets such as the Moon, or large uniform areas like deserts. Other satellites can then calibrate their instruments against

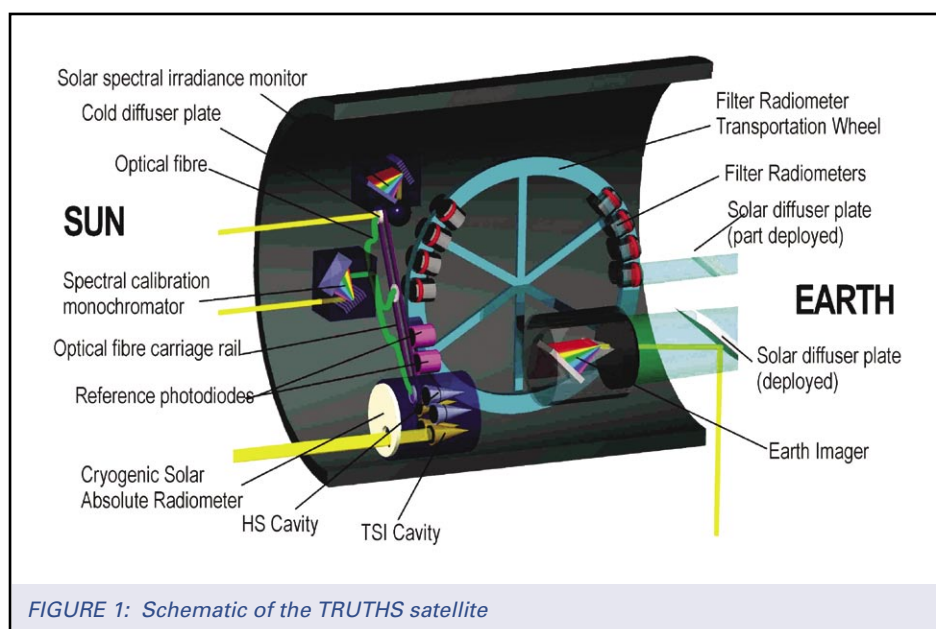


FIGURE 1: Schematic of the TRUTHS satellite

# TRUTHS mission goals:

- Measure the radiation – Sun, Earth and Moon - 10 times more accurately
- First satellite to calibrate itself - directly traceable to SI units via a primary standard - in orbit
- Provide absolute high accuracy calibration for other EO missions
- Diagnosis of reflection from the Earth to give details of the atmospheric chemistry (esp. in UV and near IR)

these reference targets. The Earth imager on TRUTHS would provide high-resolution spectral and spatial measurements of reflected solar radiation at multiple angles on a range of Earth targets. Thus in addition to the calibration of reference targets, the resulting spectral information could be used for specific science studies to help understand the carbon cycle – by identifying and quantifying the type of vegetation on land and in the oceans, as well as sources of pollution and the clarity of the atmosphere.

Solar radiation is the driving force of the Earth's climate and small changes in the total output of the Sun can have significant effects on the Earth's surface. It is believed that a 0.3% change in Total Solar Irradiance (TSI) was responsible

for the mini-ice-age of the 17th century. The TSI record relies upon the data from many different solar radiometers flown over the last 20 years, whose inherent variability (~0.8%) can affect the prediction of models of global temperature change by as much as 0.8 K. The cryogenic solar absolute radiometer (CSAR) of TRUTHS is designed to reduce this uncertainty by more than a factor of ten and establish undisputed, continuous TSI data for the future.

In addition, TRUTHS can make calibrated high-resolution measurements of Solar Spectral Irradiance (SSI) from the UV to the IR. Solar irradiance variation data are essential to understanding and monitoring complex earth climate systems, including global warming models, El Niño events,

ozone depletion, and atmospheric chemistry.

The TRUTHS proposal and its objectives are gathering attention and momentum in the international climate change community, with specific interest coming from the World Meteorological Organization, UN and other international programmes. NASA and National Measurement Institutes in the US and Europe are interested in a collaborative effort to establish an orbiting space measurement laboratory.

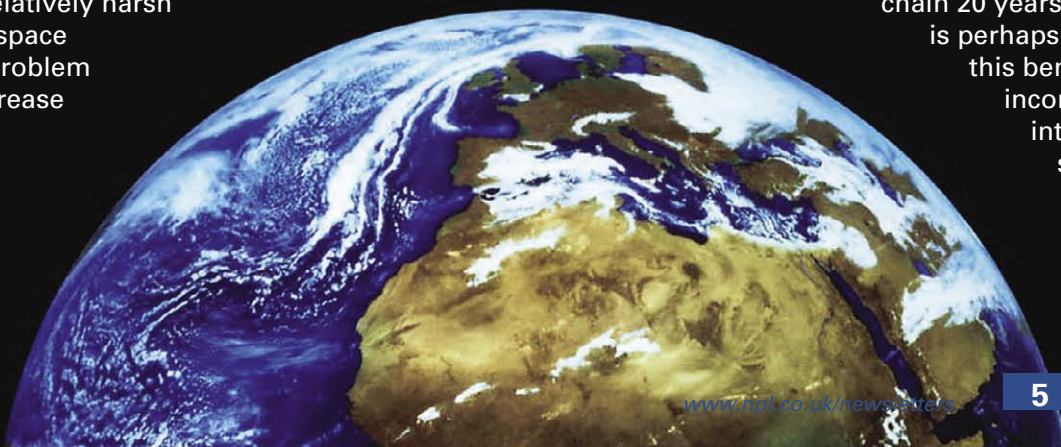
*For further information on TRUTHS and NPL's research on climate change, please contact:  
Nigel Fox  
020 8943 6825  
nigel.fox@npl.co.uk*

## Terrestrial vs TRUTHS

Satellite instrumentation is currently calibrated against primary standards through a traceability chain. The terrestrial calibration methodology carried out by an NMI (National Measurement Institute) can be traced back to a primary standard able to achieve uncertainties of 0.001%. However, the number of steps beyond this primary standard rapidly increases the resultant uncertainty. Subsequent storage and then transfer to the relatively harsh environment of space compound the problem and not only increase the uncertainty but, in effect completely break the traceability chain.

By mimicking the terrestrial calibration chain in-flight, TRUTHS would yield an overall SI traceable uncertainty of < 0.5% in spectral radiance - more than an order of magnitude better than any other EO mission. The main difference in the translating of the methodology into space is that TRUTHS will use the Sun as a source for its calibration sequences rather than a

laser source or high temperature black body as used on the ground. Since the Sun is only used as a convenient source, with its spectral power measured directly every time it is used by the CR (primary standard), any drifts are inconsequential. This step change reduction in uncertainty is similar in magnitude to that obtained when NMIs, led by NPL, started to introduce cryogenic radiometers into their terrestrial calibration chain 20 years ago, and it is perhaps timely that this benefit is now incorporated into the EO sector.



# Something in the air

**A recent European Union study blames air pollution for shortening our lives by more than six months. NPL is improving our understanding of the main culprit - airborne particles. Why these particles are so detrimental to our health is one of the biggest unanswered questions in relation to air quality.**

Airborne particles are extremely diverse, varying in size, composition and origin. Carbon particles from diesel engines are just a few nanometres in size, while windblown dust particles, typically rich in silicon, are tens of micrometres. Some particles originate from natural processes, such as sea salt particle formation, while others arise from human activities. Many particles are formed by the reaction of gases in the air, for example the gas ammonia (from agricultural sources) reacts with nitrogen dioxide (from vehicle exhausts) to form particles of ammonium nitrate.

Due to their diverse nature, it's not easy to identify what properties of airborne particles are relevant to health. Different particle sources and sizes can generate a more toxic and harmful mix, but current legislation refers only to total mass of particles below 10 micrometres in size (PM10), or below 2.5 micrometres (PM2.5). So, NPL is measuring and characterising airborne particles as an important step towards understanding their detrimental health effects.

NPL is leading the way in three areas: improving the reference methods for PM10 and PM2.5; validating the procedure to determine whether an automatic method is equivalent to the reference method; and exploring other types of measurement such as particle number concentration and composition.



*A comparative trial at NPL - sampling the air for PM10 with size selective inlets*

## Seeing through the legislative haze

Air pollution knows nothing about national boundaries, so international cooperation has always been important. Pollutants that cause the most serious health problems in the UK - particles, ozone, and nitrogen dioxide - are often formed within the atmosphere from emissions in other countries.

Air quality legislation is therefore a high priority for the European Union. Directives covering particles, nitrogen dioxide, sulphur dioxide, lead, carbon monoxide, benzene and ozone are being revised. Among the proposed changes are an emphasis on "fine" (PM2.5) particles rather than "coarse" (PM10), reducing exposure in each country rather than setting a single European limit, and an explicit statement that

"natural" sources of pollution are excluded.

Alongside the directives, which specify relevant concentrations, the task of standardising measurement methods so that monitoring is accurate and comparable across the EU has also been undertaken.

NPL has provided UK input into the European Committee for Standardisation (CEN) standards. NPL also provides highly accurate primary standards and operates UK monitoring networks on behalf of Defra (Department for Environment, Food and Rural Affairs).

*For further information on NPL's air monitoring research and opportunities for collaboration, please contact Paul Quincey 020 8943 6788 paul.quincey@npl.co.uk*

# Joint Industry Project - stack emissions monitoring

**NPL is helping to reduce pollution by improving the use of filters in emission stacks.**

NPL conducted field measurements on emission stacks as part of a particulate sampling project within the DTI's Joint Industry Programme (JIP) and found that many filters were not working correctly. The problem appeared to be the result of material being lost from the filters during testing. As part of their investigation, NPL tested a range of filter holders and filter papers under controlled conditions.

The tests used the stack simulator developed at NPL, which reproduces a range of typical gas conditions in a sampling region of a stack. Equipment suppliers provided sample filter holders for the tests, and a range of filter types were tested.

Initial results indicate that significant losses can be seen from filters over a half hour sampling period, under typical flow conditions. The outputs from

these tests are being used to develop, in collaboration with the Source Testing Association and the Environment Agency, guidance on undertaking particulate testing, including recommendations for conditioning filters prior to testing.

*For more information contact  
Rod Robinson  
020 8943 7146  
rod.robinson@npl.co.uk*



*The initial aim of the project was to carry out an exercise to validate nozzle designs, which are currently used in the UK but which were not included in the original validation work for the European Committee for Standardisation (CEN) low dust standard. To achieve this, a field comparison was undertaken to demonstrate the equivalence of the nozzles against validated ones. The measurements were undertaken at the Lafarge Cement, Cauldon Works, during August 2005. The teams and personnel involved in the Nozzle Validation Scheme include CES, Redwing Environmental, Quantitech and Tecora. The equipment was provided by Clean Air Engineering, Zambelli, Tecora and Sick Maihak.*

# Underwater Noise Measurement: Measuring environmental impact

**NPL is increasing awareness in the offshore industry of the growing need for environmental impact assessments of underwater noise radiated from their machinery and platforms.**

Underwater acoustics plays a key role in the off-shore industry, where remotely operated vehicles (ROVs) are used as sub-sea platforms for acoustic systems such as sonars and positioning transponders, enabling underwater visualisation and navigation.

Most of these acoustic systems involve actively transmitting sound into the ocean. The increasing levels of human-made sounds in the ocean - whether deliberately generated or not - has led to concern over marine noise pollution. In particular, there is an increasing need to research the

effects of underwater human-made noise on marine life and divers.

As with air-borne noise, before an assessment can be made of noise exposure, agreed methods of environmental noise measurement and monitoring must be established. NPL, in collaboration with the Society for Underwater Technology (SUT), held a one-day seminar on the subject of the measurement of underwater noise radiated from machinery and platforms. The aim of the event was to increase awareness of current concerns in this field, its potential for impact on industry



and to examine current best measurement practice for noise assessment.

*The seminar consisted of a series of presentations by invited speakers with expertise in this field. To view the abstracts and presentations please visit [www.npl.co.uk/acoustics/underwater\\_noise/](http://www.npl.co.uk/acoustics/underwater_noise/)*

If you would like further information on any aspect of **Environmental Measures**, please contact:

Tel: 020 8943 6880 | Fax: 020 8943 7160 | E-mail: [environment@npl.co.uk](mailto:environment@npl.co.uk)

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## Have your say on a major NPL research programme!

**The Valid Analytical Measurement - Physical (VAM-P) programme provides accurate and traceable analytical measurements for UK industry and society. The technical content of the next VAM-P programme is currently being formulated at NPL. The input of experts in the environmental sector is needed to ensure the programme meets all of the UK's analytical needs.**

Analytical measurements are vital to the UK economy - they ensure product quality, monitor impact on the environment and satisfy legal requirements. It is estimated that the UK spends approximately £8 billion on analytical measurements every year.

The VAM-P programme underpins the reliability and integrity of these analytical measurements by supporting the development and maintenance of reference methods and standards, and through demonstrating comparability of analytical measurements with those of its trading partners.

The VAM-P programme runs in three-year cycles, with the next programme due to commence in October 2006. Key areas of the programme directly relevant to the

environmental sector are:

- Pollution and emission measurements
- Gas standards (e.g. ozone precursors, natural gas, odorants, SO<sub>2</sub>, NO<sub>x</sub>, etc.)
- Trace gas analysis
- Micro- and nano-particle measurement (composition, mass, size, etc.)
- Remote sensing of chemicals and particulates

Your input into the formulation of the next programme will help to steer the content to support your changing measurement needs and challenges.

The proposed programme is available for comment on the VAM-P formulation website: [www.npl.co.uk/formulation/vam](http://www.npl.co.uk/formulation/vam). Please visit this site to give your feedback, and to find more detailed information on the VAM-P programme.

*For further information, contact the VAM formulation team*  
020 8943 6443  
[vam@npl.co.uk](mailto:vam@npl.co.uk)



## Exclusive event Oxford V Conference 2006 26 - 28 June 2006 at NPL

This international event happens every four years and will be in the UK this summer! NPL's Optical Radiation Measurement Club (ORM) and the Council for Optical Radiation Measurement (CORM) announce a three-day conference focussing on Optical Spectrometry. The conference is intended to bring together people with interests in spectrophotometry, appearance, fluorescence and advances in technology.

*For further details and to register please visit:*  
[www.oxford-v.npl.co.uk](http://www.oxford-v.npl.co.uk)

## Forthcoming events

[www.npl.co.uk/events](http://www.npl.co.uk/events)

### Metrology or Meteorology?

5 April 2006

Royal Society of Meteorology  
NPL, Teddington

### 15th Meeting of the Intelligent Sensing Program (ISP) Sensors Knowledge Transfer Network

26 April 2006

IEE, Savoy Place, London  
[www.sensorsktn.com](http://www.sensorsktn.com)

### Location and Timing Knowledge Transfer Network

European Navigation Conference and Exhibition 2006

8 - 10 May 2006

Manchester International Convention Centre  
[www.enc2006.org.uk/](http://www.enc2006.org.uk/)

### Optical Radiation Measurement Club Meeting

28 - 29 June 2006

NPL, Teddington

### Humidity Measurement and Calibration course

17 - 18 July 2006

NPL, Teddington