Theme	Communications/ICT	**Price to DIUS**	
Proposal #	C01	**Co-Funding Target**	
Proposal Title	Resilient Communications for Dynamic Wireless Sensor Networks in Extreme Environments	**Start Date**	
		End Date	
Lead Scientist	Michael Collett	**Group Leader**	Andrew Smith

Vision: The fire brigade arrive at an industrial plant to find a blazing inferno and reports of workers trapped. As they pull into the car park, the laptop in their truck automatically brings up a schematic of the building with current temperature readings and locations of people in every room. The fire chief assesses the situation and sends his men in at the point of least risk. But can he rely on the resilience of the communication systems to continue to provide accurate information?

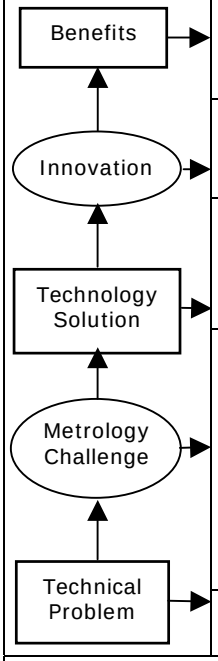
This example is just one potential application of a Wireless Sensor Network (WSN) – a combination of sensor devices, which can measure multiple variables such as temperature, sound, light and vibration. The lack of wiring allows ad-hoc deployment, multiple redundant communication links, dynamic routing and mobility.

This project will set up a network of several hundred transceivers to investigate their communications performance in a range of extreme environments. Drawing on NPL's unique facilities and expertise in EMC and antennas, NPL will become world leader in resilient WSN communications.

Impact: WSNs which can communicate reliably and robustly in extreme environments will be utilised to provide impact across many areas:

- Public safety (e.g. security, fire services, structural health of tunnels & bridges, assisted living)
- Economic benefit (e.g. improved efficiency via asset monitoring, smart metering)

Knowledge Transfer: The project will deliver optimisation of communications techniques (e.g. routing protocols, layout) to enable users to apply best practice when deploying WSNs in extreme environments. The facilities and techniques to replicate the harsh environments will be available to users to test their own systems and applications.



Benefits	Critical applications of WSNs will be enabled in areas of security, asset monitoring and healthcare, for example emergency services will have reliable access to real-time information on the conditions within a burning building. This will let them make decisions on entering and dealing with the emergency, ultimately saving lives.
Innovation	UK industry gains confidence in the application and resilience of WSNs, overcoming a key barrier to adoption. Development of network communications that will function reliably in extreme environments will enable safety-critical applications.
Technology Solution	Users will be able to predict the best network configuration and understand the trade-offs for their chosen application, prior to installation, and optimise any existing systems. A facility for replicating real and extreme environments at NPL will allow users to characterise the resilience of their own WSN systems.
Metrology Challenge	WSNs are low power, dynamic, multi-agent systems with low resilience. By deploying a network of several hundred transceivers at NPL, the performance of WSNs to communicate robustly in environments ranging from stable to harsh will be assessed and optimised. Packet loss rate, data bandwidth and signal strength will be measured in the presence of controlled levels of: ▪ Interference (other systems, malicious signals or emissions from e.g. plant, fire) ▪ Fading (reflections and scattering from potentially moving structures/vehicles) ▪ Harsh propagation media – dust, smoke and steam
Technical Problem	Reliability of WSN communications in real environments is poorly characterised, and not trusted, posing a barrier to adoption, especially for safety-critical applications.

Strategies Supported: UK government strategies expressed in roadmaps for "Growth of the Information Society", "Intelligent Connected World", "Environmentally Friendly Transport", "A More Secure Environment" & "Renewable & Sustainable Energy." It also supports TSB Platform roadmaps for "Assisted Living", "Intelligent Transport" and EU iMERA roadmaps.

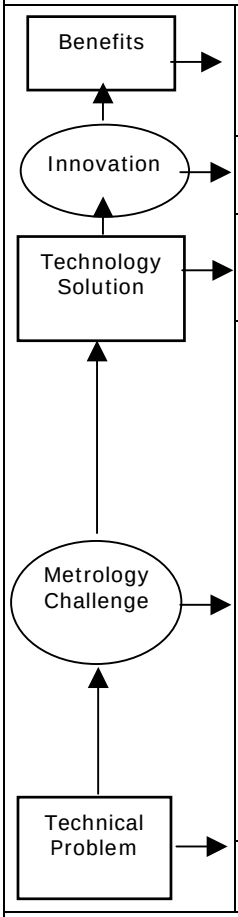
Synergy with other projects: Redirects *MET5.1* to tackle new requirements in large-scale WSN applications. Parallel to *Wireless Propagation & Interference (*I R&D: *W4)* and *Traceable Waveforms for Wireless Comms (NMS: W2)* and *Small and Smart Antennas (NMS: W3)*. Will use outputs of Resilience *in MIMO systems* (NPL Strategic Research). This multi-disciplinary umbrella project supports existing *Structural Health* (AM14) and *MEMS sensor networks* (A2.2) projects and proposed Innovation R&D projects on *Integrated Environmental Monitoring (E4) and Structural Health Monitoring (E6), Process monitoring (NEL)*. Links to IST-RUNES and Critical National Infrastructure.

Theme	Communications/ICT		**Price to DTI**	
Proposal #	C02		**Co-Funding Target**	
Proposal Title	Plastic Electronics (Nanostructured Multi-layer Characterisation)		**Start Date**	
			End Date	
Lead Scientist	Ian Gilmore (NPL)	**Group Leader**	Neil Harrison	

Vision: You are most likely reading this from a printed page – all of this will change with, for example, newspaper content wirelessly downloaded to a flexible display device. The UK is an innovation hotbed in the rapidly growing emerging technology of Plastic Electronics resulting from the UK's world leading academic research base. The worldwide market for plastic electronics is estimated to grow to £15b by 2015 [DTI Technology programme]. This project will lead to accelerated development of higher performance, more stable organic semiconductor devices and systems.

Impact: Plastic Electronics use nanostructured organic layers for flexible/wearable displays, lighting, sensors, point-of-care diagnostics, smart packaging and printable devices and circuits. Excitonic photovoltaics (PVs), which include organic semiconductor solar cells, are of major importance in the technology drive to secure future energy supply and increase renewable energy. This project focuses on manufacturing (including printing) and next generation technologies for PLEDS, OLEDs, OFETs and PV cells. These share the same fundamental technology barriers: correlating and understanding morphological and optoelectronic properties at the nm scale for polymer, small molecule and inorganic interfaces and processed materials. This major project will bring together a large multidisciplinary integrated metrology approach including nanoscale materials characterisation, electrical and optoelectronic metrology and nanoscale surface and interface analysis.

Knowledge Transfer: The project will build on the current excellent collaboration with the industry leaders such as CDT and, for example, our recent metrology and standardisation workshop at a major international organic electronics conference. Inward and outward secondments to industry and academia will be developed as well as high-profile scientific publications and technical reviews.



Benefits	High-efficiency, long lifetime, low cost flexible displays with accurate registration from controlled printing. Strong organic PV uptake helping meet the UK energy challenge, both in terms of energy security and supply of clean and sustainable energy.
Innovation	Improved stability and performance for OLEDs, transistors and PV. Designed surface chemistry and topography for controlled printing.
Technology Solution	Enhanced carrier mobility and novel high-speed in line electrical measurements. Innovative structures (e.g. barrier layers) for step-change in performance. Improved processing methods requiring less accuracy in printing registration.
Metrology Challenge	• The challenge is to develop the metrology of material, chemical and electrical properties at the nanoscale, especially at interfaces, and to correlate those measurements with device characteristics, for example mean exciton diffusion length, exciton formation zone, hopping distance, charge transport and trapping. NPL has unique multidisciplinary skills and capability to bring new insight (including staff with 10yrs+ commercial R&D OLED experience). • Development of new capability for Scanning Capacitance Microscopy and Scanning Kelvin Probe Microscopy for nanoscale electrical measurements (charge trapping), and optoelectronic measurements (time of flight, transient EL). • Explore new approaches for high-speed electrical measurements. • Crucially, measurement needs to be combined with a multiphysics modelling approach to understand processes from molecular to device length scales. • Innovative surface analytical techniques (C_{60} and Ar_{2000} 3D-SIMS and imaging XPS) will be developed for 2D and 3D characterisation of ink-jet printing and engineered surface chemistry for controlled patterning, morphology and structure of next generation devices.
Technical Problem	Low lifetime, low mobilities for printed transistors, and too low efficiency (£/kW too high) for PVs. Large area rapid production of high-performance devices needed

Strategies Supported: TSB Key Technology Areas "Information Communications and Technology" (Plastic Electronics) and "Advanced Materials". 2007 Energy white paper, MSET roadmaps.

Synergy with other projects: 3 Technology Programme projects, SCOPE, DECAF & Flex-Display.

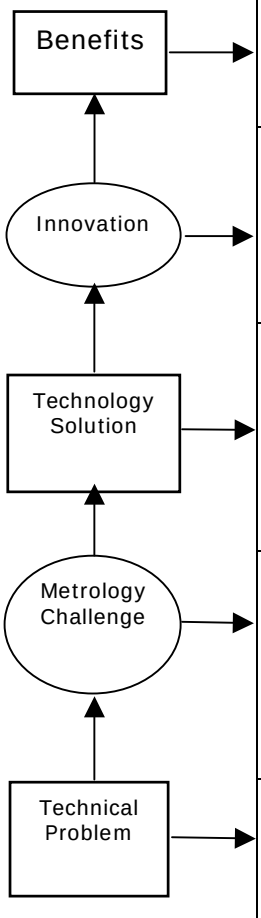
Theme	Health/Biotechnology		**Price to DIUS**	
Proposal #	H01		**Co-Funding Target**	
Proposal Title	Enhanced biopharmaceutical processing		**Start Date**	
			End Date	
Lead Scientist	Neil Harris (LGC) Anna Hills (NPL)	**Group Leader**	Julian Braybrook (LGC) Marc Bailey (NPL)	

Vision, Impact and Knowledge Transfer:

Vision: Improve biopharma production methods, reduce costs and improve speed to clinic with associated benefits for all bioprocessing sectors. The UK has a leading position in biopharma with over 480 emerging biotechnology companies, employing over 26,000 people, with over 200 products in clinical development, reflecting the importance of maintaining a leading edge position in terms of new technology and product design, in a global market estimated to be worth in excess of $40 billion dollars annually. Current methods for selecting suitable cell lines for production are data limited and a metrology challenge. Direct translation from small scale to larger scale production is not necessarily a direct comparison often leading to inappropriate cell line selection, stifling product development, increasing costs and loss of potential therapies.

Impact: Building on MET 3.5, LGC and NPL will apply the capability, measurement and modelling techniques developed to identify factors key to selecting and maintaining healthy, robust cell lines to enable efficient production, yield, purity and quality of the desired product. This holistic approach enabling more targeted, sensitive, and reliable early stage measurements.

KT: This project will inform the emerging 'white' (industrial), 'blue' (marine) and 'green' (plant) bioprocessing sectors. These are seen as key in driving the future development of novel bioproducts, to produce cleaner, safer products in a sustainable manner and aid UK competitiveness. To encompass this, key linkages with each of the KTNs in the relevant sectors will be exploited to ensure the effective KT objectives of promoting innovation in bioprocess measurement.



Benefits	Better selection and maintenance of key cell sources will result in more controlled scale up or scale out enabling faster, more efficient manufacturing processes, resulting in safe and efficacious drugs for patients and healthcare providers at a decreased cost.
Innovation	A validated set of measurements will provide information about cellular processes beyond that which is currently available, to provide a predictive structure to the full scale manufacturing process. The availability of data rich information will enable corresponding efficiencies in bioprocess production, allowing tighter control of the process at the early development stage with associated downstream efficiencies resulting from more robust selection of lead cell lines.
Technology Solution	The solution is to take a model bioprocess and use traditional bioreactor production as a comparator. The test system will be at the microwell scale to mimic an early stage selection system, or, in the case of 'scale out' systems, the final production system. The current MET 3.5 project has established both measurement and novel data modeling techniques. This capability will now be exploited to develop a measurement regime that enables effective cell line selection and scale up/out to ultimately improve product development.
Metrology Challenge	Current measurements tend to focus on simple measurements of growth, stability and host selection and industry has expressed the need to have 'more information, earlier in the process'. The metrology challenge is to take current analysis a step further and be able to offer more targeted, sensitive, reliable measurements that use key indicators such as metabolites, gene expression and protein biomarkers linked to the culture parameters and pulled together with the appropriate data modelling system to provide more comprehensive data sets.
Technical Problem	Current bioprocess production systems do not possess the required sensitivity and measurement infrastructure to ensure that: All potential lead cell lines are selected appropriately; Measurements taken on small scale culture are applicable or translated to more intensive scale up or scale out systems to ensure production of the desired product to required yield and quality.

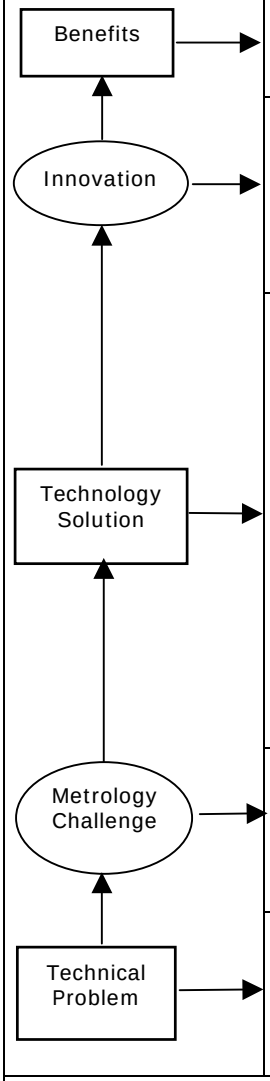
Strategies Supported: Key Technology Strategy Area of Bioscience and Healthcare- "Exploitation of Bioscience by industry". Bioscience Innovation and Growth Team (BIGT) 'Bioscience 2015' report. BioProcess UK KTN. MSET fora. Bioprocessing Research Industry Club (BRIC).

Synergy with other projects: Other current Innovation R&D projects (MET 1.1, MET 3.5)
Other NMS work areas (ChemBio Metrology), bioprocessing projects under the Technology Programme.

Theme	Health/Biotechnology		**Price to DTI**	
Proposal #	H02		**Co-Funding Target**	
Proposal Title	Reliable and low cost protein-based point of care (POC) tests for early diagnosis of human disease		**Start Date**	
			End Date	
Lead Scientist	Robert Porter (NPL)	**Group Leader**	Marc Bailey	

Vision, Impact and Knowledge Transfer:

- To develop the metrology capability to support the introduction of rapid, simple, quantitative, multiplexed, low volume point of care biosensors for rapid and effective diagnosis and treatment of cardiac disease. Cardiac disease is responsible for 1/3 of deaths and 1 in 10 people that appear in hospital with chest pains have Cardiac disease. Present ECG systems are not accurate enough; blood test is the only accurate determination of a heart attack. It must be noted that this platform system can be implemented in any proteomic or genomic test
- The impact is to improve rapid accurate diagnosis in a low pain manner at the patents bedside to enable correct and rapid treatment of the patent, to be declared healthy and return home quicker thus reducing hospital cost. Though effective metrology and traceable measurement we hope to ensure confidence in POC test and better future uptake in the hospitals. UK science and industry has historically lead the way of POC test this technology will enable the UK to continue that tradition
- Knowledge transfer will be in the form of a diagnostic product prototype, which will be disseminated through the Sensor, Healthcare KTN, publications, patents, presentations and NPL web-site



Benefits

- Creates internationally leading biosensor technology, utilising 3 science areas
- Create a simple POC device that will reduce mortality in the general population due to early detection and effective treatment of disease. This will reduce costs to the UK healthcare through reducing the need for lab-based assays.

Innovation

- Novel strategies for biomarker detection and quantification through traceable novel SERS active nano-particles tags (SANT) (Oxonica) as probes for analytes and eliminate non-specific activity in a patentable diagnostic format.
- The SANTs are based on a central gold core with a SERS reporter molecule covering encased in glass. By changing the SERS reporter molecule we can have different labels allowing for mutiplexing within the assay

Technology Solution

Taking an integrated approach of 3 key Scientific skills and competences we can

- Determine the optimal conditions for measuring SANT in whole blood
- Determine measurement de-convolution of different SANT representing different target analytes in real samples
- Quantifying the amount of reactive functional groups and efficiency of biomolecule binding on the nano-particle with state-of-the-art surface analysis in order to improve SANT conjugate and assay sensitivity.
- Develop efficient samplings, handling, mixing and separation systems through laminar flow microfluidic devices.
- Integrating specific biology into the fluidic system to ensure measure specificity and repeatability through well controlled bio-measurements.

At the end of this process we will have achieved a prototype multiplexing POC device with traceable accurate results on low volumes to reduce patient discomfort

Metrology Challenge

Present state of the art for POC are simple qualitative test that require large biological samples (120μl). This system will enable a multiplexing function on a substantially smaller sample volume (5-15μl) providing an accurate calibratable format to enable ease of use and reduce possible misinterpretation. This would provide a dramatic improvement in measurement in the hands of the end user

Technical Problem

There presently is little traceability, accuracy and precision between POC systems and traceability with clinically based systems. The confidence of these systems are low. Present systems are at best Pseudo calibratable and require large finger prick blood sample. Our system will be developed traceabable to clinical measurements and produce the low volume calibratable measurement test format that is needed.

Strategies Supported:

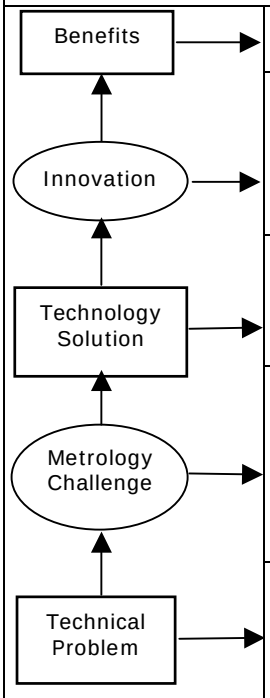
TSB Bioscience and Healthcare key technology area – medical devices. EEC IVD directive 98/79/EEC.

Theme	Health/Biotechnology		**Price to DIUS**	
Proposal #	H03		**Co-Funding Target**	
Proposal Title	Metrology to control biocompatibility of implantable devices		**Start Date**	
			End Date	
Lead Scientist	Paul Tomlins (NPL)	**Group Leader**	Jeremy Wormington	

- **Vision:** To provide measurement capability and develop an instrument that enables the engineering of surfaces on implantable materials so that the lifetime of the implant is increased and to enable different parts of the same implant to respond selectively enabling the development of innovative solutions to implantation problems.

- **Impact:** Being able to reliably control the body's response to an implanted material has enormous potential for UK industry by providing a competitive edge for a range of implant markets including orthopaedic joints and stents. The annual global markets for these implants are $17b and $2.5-3b respectively and growing due to the ageing populations of the western world. There will also be significant cost benefits for healthcare providers as a result of improvements in the durability of implants e.g. current hip implants last around 10 years depending on the surgeon's skill and the lifestyle of the patient. More importantly the ability to tailor cell responses will improve the quality of life for the recipients of these new materials and coatings.

- **KT**: A key output will be a prototype optical instrument that product designers will use to quantify cell-surface interactions through measurement of the time dependent peripheral contact angle between the cell as viewed from above, and the underlying substrate. The device will be used to generate quantitative data for cell interactions with existing implant surfaces as well as screening those under development, reducing the need for animal testing.



Benefits	Increased implant life reduces the frequency of replacement operations, reduces the cost to the NHS and the impact on the patient.
Innovation	By understanding the complex relationship between the surface texture, chemistry of materials and cell behaviour implant manufacturers will be able to engineer surfaces that will control cell behaviour. The ability to tailor cell responses will improve the durability of existing implant designs and reduce undesirable side effects such as clot formation
Technology Solution	Produce an affordable, easy-to-use instrument/software package capable of quantifying the biocompatibility of a material with a cell as indicated by changes in the contact angles between it and the surface when viewed from above. Low contact angles are synonymous with enhanced biocompatibility.
Metrology Challenge	To develop a method for quantifying biocompatibility based on cell shape and wetting angle that will be validated by measurements of key biomarkers that are indicative of cell stress. To identify the link between material surface chemistry and surface texture at the nanoscale level with time dependent changes in the composition and conformation of the adsorbed protein layer using mass detection and advanced imaging techniques.
Technical Problem	The life expectancy and performance of implants such as orthopaedic joints is limited by the lack of choice of surface engineered solutions. Current test methods for biocompatibility are limited to assessments of the potential toxicity of materials and wear debris and these do not support the development of innovative surfaces.

Strategies Supported:
TSB- Advanced materials, Bioscience and Healthcare, Foresight Report on Biomaterials technology (UK 2003), Advanced Tissue Engineering and Science (US 2007)

Synergy with other projects:
This project is aligned with a EU proposal (Metrology on a cellular scale for regenerative medicine) that provides additional resources through collaboration with other European NMI's (LGC, PTB and INRIM). It is an extension of MET1.4. The project will also benefit from MET 1.3 which will develop methods for analysing the changing chemistry of single cells.

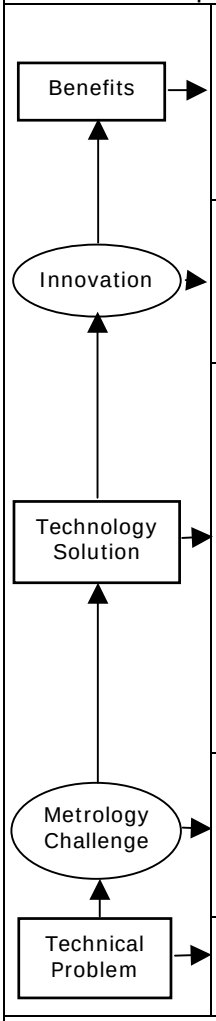
Theme	Health/Biotechnology		**Price to DIUS**	
Proposal #	H04		**Co-Funding Target**	
Proposal Title	Improved detection of in-vivo magnetically tagged nanoparticles for non-invasive physiological imaging		**Start Date**	
			End Date	
Lead Scientist	Witold Chalupczak (NPL)	**Group Leader**	Dr. Hilary Elliott	

Vision, Impact and Knowledge Transfer:

Vision: Accurate detection of magnetically tagged cells facilitating early stage detection of cancerous growths.

Impact: This project aims to develop a sensitive, non-invasive detection system based on Atomic Magnetometry (AM). The sensitivity of the system for detecting magnetically tagged nanoparticles in a phantom torso will be demonstrated. Common current methods for the detection/imaging of cancerous tumors include techniques such as X-ray Computed Tomography (CT), magnetic resonance imaging (MRI) and Positron Emission Tomography (PET). The most precise of these imaging techniques tends to be slow, expensive to operate and require dedicated large facilities, thus limiting the ease and speed with which they may be used in this type of application. Where contrast agents are used in these techniques, the additional potential for adverse side effects in the patient is considerable.

Knowledge Transfer: Knowledge dissemination through consortium partners will ensure the maximum impact identified above is achieved.



Benefits

The simplicity, cost-effectiveness, potential for portability and overall sensitivity (fT) of the technique in the very early detection of cancerous cells, means a significant step change improvement in overall patient treatment and quality of life.

- Non-invasive technique, which uses non-toxic magnetic particles as an alternative to radioactive tracers and potentially toxic contrast agents.
- Potential in future for hand-held devices e.g. for GP use

Innovation

- AM detects directly the magnetic field of magnetically tagged cancerous cells while MRI currently measures the nuclear magnetic resonance.
- Using superparamagnetic nanoparticles allows cheaper detection scheme with potential for higher sensitivity (>one order of magnitude better then MRI coil)
- Array of AM sensors for application in the spatial imaging of cancerous growths.

Technology Solution

Single and/or Array of AM sensors with fT sensitivity and mm spatial resolution:

Atomic and SQUID Magnetometry use superparamegnetic nanoparticles (e.g. based on iron-oxide ferrites) that have the capacity to bind to various biological molecules and pharmacological agents that target specific cell types including cancerous cells. The combination of Magnetometry and these magnetically tagged nanoparticles offers (in the medium term) the potential for increased sensitivities (of the order of fT) over and above that offered by MRI. Whilst both offer improved sensitivity in detection of these magnetic fields, the simplicity of the instrumentation (in particular the lack of an expensive cryogenic component), the potential for portability, the close proximity enabled to the scanned surface and the better fundamental sensitivity of AM compared to SQUID, makes the former technique the most attractive option for this application.

Metrology Challenge

- Standard fluxgate sensitivities are currently of the order nT (10^{-9}). 1 cm^2 tumour sample (depending on "Tag") 15 cm from its surface generates the field on the order 10^{-12}-10^{-9} T, hence the need for greater sensitivity.
- The creation of a sufficiently sensitive detector (~fT) for detecting magnetic fields generated by low concentration of iron (~1μg of iron/10^6 tumor cells).

Technical Problem

- Low sensitivity of current imaging techniques
- Current dependency of techniques on existence of clusters of cancerous cells
- Side effects of existing contrast agents used in current imaging techniques

Strategies Supported:

- TSB have prioritised Healthcare and Bio Imaging as a key area for investment
- Wellcome Trust identified AM technology as a potential area for future imaging applications.

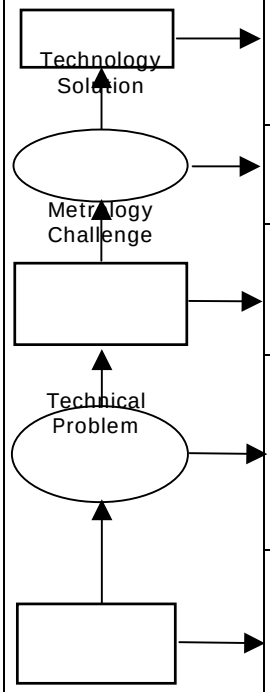
Theme	Health/Biotechnology		**Price to DTI**	
Proposal #	H05		**Co-Funding Target**	
Proposal Title	Micro-scale characterisation of the mechanical properties of polymeric materials		**Start Date**	
			End Date	
Lead Scientist	Tony Maxwell (NPL)	**Group Leader**	Jeremy Wormington	

Vision, Impact and Knowledge Transfer:

Vision: Provide measurement capability to accelerate the development of new generations of medical and polymer electronic devices based on thin layer technologies. Develop measurement facilities to obtain high quality, relevant mechanical properties data that are currently unavailable for design calculations for micro-mouldings, micro-thin films and coatings with dimensions typically less than 100 μm.

Impact: The impact of this project will be to enable design engineers to determine the mechanical behaviour of micro-scale products that cannot be obtained from conventional bulk test methods. This will enable engineers to design for performance, resulting in reliable and innovative micro-scale products.

Knowledge Transfer: This will be through Good Practice Guides and scientific publications, which specify the test methods and procedures for data analysis. New measurement standards will be developed in appropriate ISO/TC61 Plastics standards committees.



Technology Solution	Developers will be able to design reliable products by virtual simulation cutting development times and reducing qualification-testing costs. Regulators will be able to assess safety/effectiveness and approve products more swiftly with benefits to patients.
Metrology Challenge	These techniques will enable engineers to efficiently design innovative and safety-critical micro-scale components with superior performance through novel metrology methods and lifetime prediction.
Innovation	Manufacturers will have methods for obtaining quantitative mechanical data for the design of miniature polymeric components. These techniques will provide the long-term data identified by design procedures developed at NPL within a much-reduced timescale.
Technical Problem	Novel test techniques will be developed that will determine relevant property data on micro-scale components. Miniaturised test methods, including those based on nano- and micro-indentation, will be developed for this purpose. New accelerated test procedures will be developed to provide long-term data within a reduced timescale. Analysis procedures will be validated through comparisons with standard tests on specimens of relevant polymer structures.
Benefits	The polymer structures in micro-mouldings are very different from that in bulk specimens. Property data obtained on bulk specimens are therefore not suitable for confident design calculations. The mechanical properties of polymers are time-dependent, and long-term property data are needed for lifetime predictions. However, the measurement of these is very time-consuming and expensive.

Strategies Supported:

Design Engineering and Advanced Manufacturing – providing capability to determine lifetime performance material properties and a seal of approval to data at appropriate length scales.
Bioscience and Healthcare – assisting the development and approval of innovative devices.
Advanced Materials – Organic (plastics) electronics - inexpensive, flexible devices.
Multi-scale predictive modelling, including lifetime predictions and data for design.

Synergy with other projects: This project will be underpinned by KB projects SM06 and SE02. **SM06** has developed models for lifetime prediction of plastics and will be implementing these in finite element systems. **SE02** is developing procedures for nano-indentation testing. This project is complementary to and has significant synergy with **H06**, which addresses materials metrology issues related to the processing of polymers on the micro-scale.

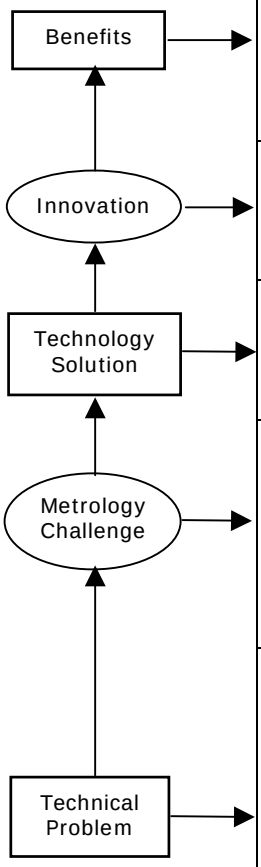
Theme	Health/Biotechnology		**Price to DIUS**	
Proposal #	H06		**Co-Funding Target**	
Proposal Title	Characterisation of polymeric materials for micro-scale processing		**Start Date**	
			End Date	
Lead Scientist	Martin Rides (NPL)	**Group Leader**	Jeremy Wormington	

Vision, Impact and Knowledge Transfer:

Vision*:* To develop metrology capability to characterise the properties of polymeric materials on the short length and time-scales necessary to enable the manufacture of micro-scale products and components for medical and electronic devices.

Impact: The impact of this project will be to accelerate the design of materials and processes resulting in improved performance and reliability of micro-scale products e.g. micro-fluidic devices and medical implants. This will enhance their usage and will enable new and innovative product designs, particularly in demanding applications and for products requiring regulatory approval.

Knowledge transfer: Key technology transfer of test protocols will be achieved through good practice guides, leading to documentary Standards.



Benefits	This project will underpin improved product design and performance, reduced time to market, increased manufacturing flexibility, and reduced waste. Though focusing on micro-moulding, the metrology will be applicable to other manufacturing technologies, e.g. ink-jet. It will have multi-sectoral benefits e.g. biomedical (micro-mouldings, printed diagnostics devices) and electronics (micro-mouldings, printed electronics).
Innovation	This project will facilitate the uptake of improved and novel manufacturing processes, e.g. micro-moulding and ink-jet printing, enabling new and improved products with better performance functionality to be designed and manufactured more efficiently.
Technology Solution	The developed metrology tools will enable industry to obtain data under relevant conditions for reliable design of materials, processes and products via simulations, thereby facilitating the development and uptake of micro-fabrication techniques.
Metrology Challenge	Development of measurement techniques and protocols for the rheological, thermal and surface/interfacial tension properties of polymeric materials at the short time and length scales and that are characteristic of micro-processing. This will include the development of methods for very high rate (up to 10^6 s^{-1}) shear viscosity by extending significantly the range achievable using existing methods and addressing inherent errors such as viscous dissipation, high rate transient extensional viscosity, and in-situ micro-rheology.
Technical Problem	Manufacturing of small-scale products and products with micro-scale features by micro-moulding or dispensing of functional fluids, e.g. ink-jet, is becoming increasingly important. At these scales accurate manufacture is governed by the rheological and thermal properties of the fluid and the significant effect these have on the microstructure (e.g. crystallinity) and product performance. Process modelling is an increasingly important design tool, particularly for micro-moulding. Reliable data obtained under relevant conditions are essential for this purpose, but are severely lacking. Techniques for the reliable characterisation of properties at the short lengths (e.g. 100 μm) and time scales of micro-processing (shear-rates up to 10^6 s^{-1}) are non-existent or very limited.

Strategies Supported:

Technology Strategy: Design Eng. & Advanced Mfg.: Advanced mfg. technologies and processes priorities: Advanced mfg. technologies for micro- & nano-systems. Strategy application areas: Bioscience & Healthcare (e.g. diagnostics devices), Electronics (e.g. printing organic electronics). ***MSET Road Map***: Design Eng. & Advanced Mfg. ***IGT***: Support for Biomaterials – novel mfg.

Synergy with other projects:

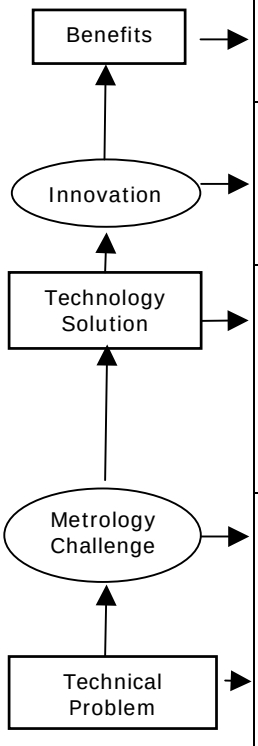
This project is complementary to and will have significant synergy with M4 that addresses materials metrology issues on the mechanical properties of micro-scale polymeric materials. It also builds on AM10 and will complement and input to projects on microfluidics and biomaterials.

Theme	Health/Biotechnology		**Price to DTI**	
Proposal #	H07		**Co-Funding Target**	
Proposal Title	Novel Metallomic Approaches for Improved Anti-Cancer Treatment		**Start Date**	
			End Date	
Lead Scientist	Heidi Goenaga-Infante (LGC)	**Group Leader**	Julian Braybrook (LGC)	

Vision, Impact & Knowledge Transfer: >250,000 people p.a. are newly diagnosed with cancer, a disease that results in 25% of UK deaths. 10% of the world's population is >60 years of age; this is expected to double in 50 years. As most cancers are linked to old age, their incidence will increase without further therapeutic advances. The UK has a robust cancer research community from basic research (e.g. Cancer Research UK) to applied development programmes, & is well placed to translate this into cancer patient benefit to address the global cancer market, valued at £22bn in 2003.

Chemotherapy drugs have been shown *in vitro* to be more effective in the presence of increased levels of elemental species, such as selenium (Se) &/or sulfur (S). This project uses an integrated metrology approach with leading groups in the field to translate, into the clinic, novel intracellular speciation studies in lymphoma cells. This requires administration of relevant elemental species to lymphoma patients before & during chemotherapy at doses that will achieve plasma concentrations at least 10-fold lower than those used *in vitro*. Enabling speciation analysis at very low ppb/ppt levels requires a step-change in measurement capability. Such sensitivity is also required for analysis of intracellular speciation in circulating blood cells at low microlitre volumes; the identification of specific changes in species-containing proteins and low mass metabolites in limited amounts of bioclinical samples. Such studies are required to identify the elemental species mediating the effects involved and potentially which patients will benefit from such intervention early in treatment.

The proposed translation of accurate quantitative measurement capability of elemental species for cancer studies is timely, highly relevant to society and assists the development of other combination therapies. The partners established track record in KT will continue through high impact peer reviewed journal publications & success will have a major impact in improving the treatment of cancer.



Accurate quantitation & identification of Se &/or S species for cancer studies will help determine the optimum combination treatment or the more efficacious source of Se or S to prevent cancer. Success will have a major impact on the treatment of cancers and help improve the quality of life of those affected.
A novel method for accurate, quantitative ultra-trace Se &/or S speciation measurement in complex bioclinical samples is vital for understanding the precise mechanism(s) whereby Se may improve cancer outcomes, either by reducing incidence in chemoprevention trials or by improving the efficacy of chemotherapy in patients with established cancers.
Novel micro-sample extraction, purification/pre-concentration and micro-/nano-flow LC methods, combined with methodologies to enhance the sensitivity of detection of Se/S species using element and molecule specific MS techniques will be developed. The production of new elemental species enriched with stable isotopes will enable, for the first time, study of the metabolic fate of administered Se in animals & humans with cancer using isotope ratio techniques. The final step will demonstrate the approach on samples generated in a human cancer trial.
The simultaneous & accurate quantitative determination of relevant species of Se &/or S at low ppb or ppt levels in complex samples (e.g. plasma, cells & tissues) is challenging due to the limited amount & complexity of the sample, low concentration of the target species & instability of the target compounds.
The mechanism(s) underlying the modulation of the activity of cytotoxic drugs by certain elements, like Se &/or S, remains unclear. Current studies measure total element concentrations due to a lack of reliable methods for determining the distribution of relevant species in complex biosamples. Identifying intracellular speciation is essential to determine the optimum combination treatment &, therefore, to maximize any interaction observed.

Strategies Supported: TSB Key Technology Area of Bioscience & Healthcare; MSET Roadmaps; LGC's measurement R&D strategy for MS centre of expertise & science initiative 'towards the transparent cell'.

Synergy with other projects: DIUS Chemical & Biological Metrology Knowledge Base Programme-Speciation methods & RMs; Leukaemia Research Fund; Cancer Research UK.

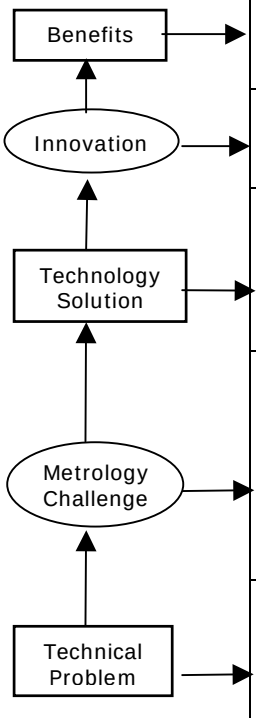
Theme	Health/Biotechnology	**Price to DTI**	
Proposal #	H08	**Co-Funding Target**	
Proposal Title	Rapid community based near-patient DNA diagnostics	**Start Date**	
		End Date	
Lead Scientist	Carole Foy (LGC)	**Group Leader**	Julian Braybrook (LGC)

Vision, Impact & Knowledge Transfer:

Novel sensitive & rapid molecular assays for early detection of disease is a major healthcare objective (Carter report, 2006) & will have a truly significant impact, reducing financial healthcare burden, improving quality of life for patients & increasing market share for the technology developers & users. The UK diagnostics market is projected to grow most strongly of any within EU during the next 5yrs with molecular diagnostics being a high growth product segment, e.g. with the UK prevalence of sexually transmitted infections (STIs) among young people (790,000 diagnoses in 2005), serious long-term harm is expected at a cost of >£1bn. Access to diagnosis & treatment is currently hindered by the need for centralised laboratory testing. Provision of near-patient point of care (POC) tests based on recent advances in polymicrobial testing, including multiplex PCR, microarray & sequencing, make it possible to envisage testing for large numbers of pathogens concomitantly.

The UK has a strong science base with start-ups developing novel technologies which could be made use of for rapid DNA-based diagnostics. Significant opportunities exist for the 4,800 UK based healthcare companies & service providers to become world leaders with a significant share of the $16.3 billion global IVD market. However, a UKCRC strategy review of microbial & infectious disease research identified difficulties in translating basic research advances into practice.

Building on MET 1.5, DNA-based POC developments will extend current work on electrochemical detection methods & incorporate emerging multiplex platforms & technologies. Collaboration with key SMEs & clinical end users will develop, assess & demonstrate the applicability of these products by bringing metrological rigour to the process. This novel network & the partners established record in KT will ensure high impact.



Benefits	Increased coverage of STI 'at risk' population & reduced infection duration through earlier disease detection & diagnosis will lead to more effective, tailored treatment with associated improved quality of life for patients & greater opportunities for diagnostic developers.
Innovation	Development of easily obtainable, accurate, sensitive, robust test devices for use in de-centralised settings by non-experts will enable rapid/personalised medicine to become available at point of care within the community.
Technology Solution	Methodologies for detecting trace amounts of DNA in complex backgrounds through sample enrichment & the use of novel analyte detection methods sensitive down to the single DNA molecule level (digital PCR); improved signal/noise ratio for DNA labels linked to the use of label free systems; integration of above process steps into single disposable 'cartridges' or similar.
Metrology Challenge	Early diagnosis of disease is often dependent upon detection of ultratrace amounts of molecular marker in a complex non-target background. This challenging analytical scenario is compounded when testing is done in a rapid manner using miniaturised & portable instruments. Initial work will address two extreme measurement hurdles: assay sensitivity & robustness in a decentralised setting. Subsequent measurement issues include scalability; platform flexibility capability to accommodate emerging infections concomitantly; cheap, QC & user-friendly device availability.
Technical Problem	The centralised laboratory setting means long waiting times & slow turnaround times for testing. The accuracy of today's near-patient diagnostic assays are typically <90% & vulnerable to high false-positive rates. Tomorrow's molecular diagnostic assays require improved sensitivity to enable robust, early disease detection in a community based testing.

Strategies Supported:

TSB Key Technology Area of Bioscience & Healthcare; MSET Roadmaps; LGC's measurement R&D strategy for molecular biology centre of expertise & science initiative in diagnostics.

Synergy with other projects: DIUS Chemical & Biology Metrology Knowledge Base Programme - trace & rapid diagnostics; DIUS MET Programme – novel NAAT technologies for STI diagnostics; MRC – CASHI study (diagnostic algorithms); UKCRC Translational Infection Research Initiative.

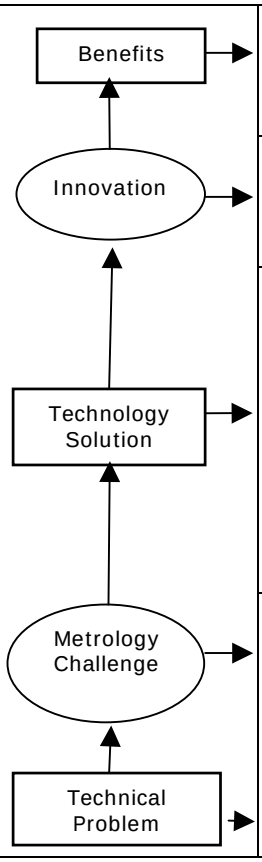
Theme	Health/Biotechnology		**Price to DTI**	
Proposal #	H09		**Co-Funding Target**	
Proposal Title	Novel Spatial Metal Mapping of Amyloid Plaques in the Brain		**Start Date**	
			End Date	
Lead Scientists	Gavin O'Connor & Rebeca Santamaria-Fernandez (LGC)	**Group Leader**	Julian Braybrook (LGC)	

Vision, Impact & Knowledge Transfer: Worldwide there is a new dementia case every 7s; 24.3m persons currently, 4.6m new cases pa. 60% sufferers live in developed countries, but whilst cases are to double here by 2040, India & China expect 300% increases. Alzheimer's disease (AD) accounts for ~2/3 dementia with a UK annual care cost of £11bn. Reducing severe cognitive impairment in elderly by 1% pa would cancel all estimated increases in long-term care costs due to our ageing population.

Despite nearly 100yrs investigation, there is no reliable, non-invasive biomarker for AD; conclusive diagnosis is from post-mortem brain histology. Abnormal accumulation of metals underlies several neurodegenerative diseases; in AD, iron is associated with amyloid plaque burden, an indicator of biochemical changes that result in AD. This project brings together an integrated metrology approach with leading groups to initiate a step-change in measurement capability & translate, into the clinic, novel high resolution spatial metal mapping studies capable of following disease progression.

Quantitative surface measurements of endogenous & exogenous metals in organisms have wide benefits for industrial, health and forensic applications. Interest in the application of mass spectrometry imaging (MSI) techniques for mapping quantitative metal distribution is rapidly growing. Some paramagnetic metals, e.g. iron, heavily influence one of the principal contrast mechanisms for magnetic resonance imaging (MRI), i.e. transverse relaxation time (T_2), giving hypo-intensive areas in the images obtained. However, novel relaxometry sequences suitable for human clinical application are required. Correlation of clinical MR images with accurate quantification of associated metals offers the opportunity to reveal structures directly within the human AD brain for the first time.

The proposed translation of accurate quantitative measurement capability of metal species & clinical MRI for AD studies is timely & highly relevant to society. The partners established track record in KT will continue through high impact peer reviewed journal publications & direct transfer of methods to other stakeholders & imaging centres with dementia interests for further follow-up studies.



Benefits	Novel metal mapping technology will have far reaching benefits in quantitative surface measurements for industrial, health and forensic applications. Specifically here it will help facilitate direct diagnosis of AD at as early a stage as possible, when preventative therapy would be most useful, with associated care savings.
Innovation	Incorporation of matrix stabilizers and isotopic diluents for assessment of the quantitative mapping approach. Correlation of the obtained measurements with novel, clinically relevant MRI relaxometry sequence information for the pre-mortem in vivo diagnosis of AD for the first time.
Technology Solution	Development of element-specific imaging technologies capable of trace level quantification of specific elements (such as iron) in biological tissues. Accurate quantitative metal mapping studies at trace levels in biological tissues by LA-ICPMS involving novel laser quantitative desorption strategies, at the micro-meter scale, of biological tissue and accurate quantitation of its associated metals by ICPMS. Correlation with novel rapid mapping MRI techniques based on Driven Equilibrium Single Pulse Observation of T_2 (DESPOT2) to assess the quantity & extent of plaque burden using phantoms & spiked tissues. Project extension work to healthy human volunteers, pathology specimens & metal speciation studies & clinical management, including monitoring efficacy of disease modifying agents.
Metrology Challenge	Development of imaging technology with the required chemical specificity and spatial resolution that is able to distinguish quantitatively between detailed tissue structures is challenging due to the low concentration of target species & requirement for higher spatial resolution & large volume coverage imaging in acceptable scan durations for human clinical application.
Technical Problem	The inability to follow progression of dementia, such as AD. Current imaging studies are not applicable to the clinic due to the lack of reliability as to the distribution & correlation of relevant metal species with tissue structures.

Strategies Supported: TSB Key Technology Area of Bioscience & Healthcare; MSET Roadmaps; LGC's measurement R&D strategy for MS centre of expertise & science initiative of MS imaging.

Synergy with other projects: DIUS Chemical & Biological Metrology Knowledge Base Programme - MSI; Alzheimer's Research Trust – novel MRI.

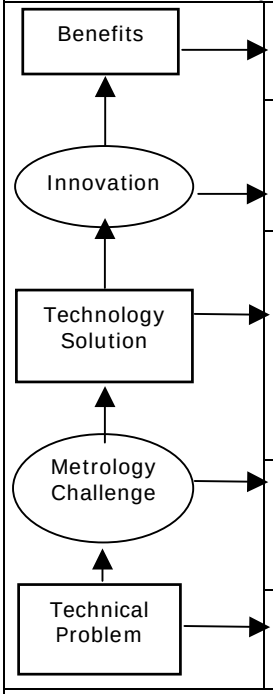
Theme	Health and Biotechnology		**Price to DIUS**	
Proposal #	H10		**Co-Funding Target**	
Proposal Title	Cell monitoring during scale-up processes		**Start Date**	
			End Date	
Lead Scientist	Damian Marshall (LGC)	**Group Leader**	Julian Braybrook (LGC)	

Vision, Impact & Knowledge Transfer:

Regenerative medicine represents a radical evolution in medical treatment where damaged organs are regenerated or replaced using cell based therapies. The worldwide market potential for these therapies is expanding rapidly and is estimated to become worth in excess of $100 billion by 2020, but one major obstacle to realising this, highlighted in the UK Stem Cell Initiative (Pattison) report, is the inability to produce efficiently the large quantities of cells from stem cell lines required to treat patients. Bioreactor systems are needed that enable sufficient quantities of cells to be grown & monitored in a controlled manner.

Growing & controlling mammalian cells (particularly stem cells) in any current bioreactor presents major measurement challenges because of the change to a 3D culture environment. This project brings together an integrated metrology approach with leading groups to build on the successful outputs of the MET 1.1 scale-out bioreactor project which demonstrated the feasibility of, & further challenges associated with, establishing a suitable bioreactor system for expanding stem cell equivalents. Appropriate cell-based techniques are now required to ensure that growth/differentiation conditions developed for standard culture can be translated to a bioreactor environment in a controllable manner.

UK companies involved in the sector are predominantly SMEs, lacking both the financial ability & expertise to develop measurement solutions in isolation. This project will therefore impact significantly, enabling reduction in development & manufacturing costs as well as laying the foundation for future production of clinical products based on stem cells. The partners established track record in KT will continue through high impact peer reviewed journal publications & involvement in key UK & international networks.



Benefits	Enable stem cell therapy companies to increase control over the manufacturing process, reducing manufacture costs & speed to clinic, improve/accelerate product development & increase quality & safety standards.
Innovation	Currently there are no robust technologies for reproducibly measuring cells in bioreactors. The project will investigate the application of various novel measurement technologies to aid efficient & economic scale up of regenerative medicine products & processes.
Technology Solution	Novel strategies will involve the application of advanced imaging technologies, mini-sensors, protein/gene biomarker expression & inferential technologies (dielectrophoresis) to create more targeted, reliable & sensitive minimally invasive approaches for measuring local cell environment, e.g. physical & chemical parameters, & cell behaviour, e.g. metabolite production, viability & differentiation state, in bioreactor systems. Statistical modeling will refine & determine the key measurements required.
Metrology Challenge	Translation of robust measurement controls derived in a standard 2D differentiating culture to 3D culture in a bioreactor environment. Application of integrated advanced imaging & emergent biosensing technologies into a complex bioreactor system.
Technical Problem	The lack of intelligent scaled production processes capable of mimicking 2D standard culture in a 3D system.

Strategies Supported: TSB Key Technology Area of Bioscience & Healthcare; MSET Roadmaps; LGC's measurement R&D strategy for cell biology centre of expertise & science initiative of improved bioprocessing

Synergy with other projects: DIUS Chemical & Biological Metrology Knowledge Base Programme-tissue engineered product quality, EPSRC REMEDI, EU STEPS.

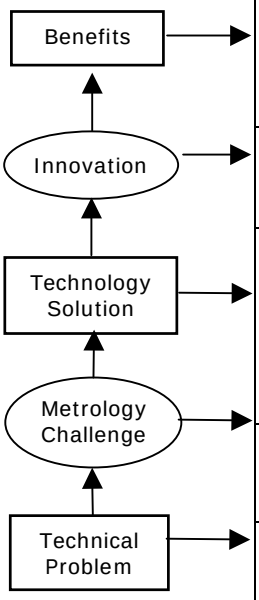
Theme	Health/Biotechnology		**Price to DTI**	
Proposal #	H11		**Co-Funding Target**	
Proposal Title	Single cell analysis		**Start Date**	
			End Date	
Lead Scientist	Damian Marshall (LGC)	**Group Leader**	Julian Braybrook (LGC)	

Vision, Impact & Knowledge Transfer: The challenge for the 21st century is understanding biological complexity and the emerging concept that biology can be viewed as an informational science leading to the 'digitalisation' of medicine, i.e. through the extraction of information from single cells, with more profound implications for society than those seen with digitalisation of ICT.

The development of advanced cell-based therapies as a tool to combat tissue damage and disease is revolutionising the healthcare industry. Such therapies offer new benefits to an NHS that spends 7.2% of UK national income on healthcare provision and is increasingly burdened by the needs of an ageing population. The UK currently enjoys a strong position in the development of advanced cell based therapies via a favourable regulatory framework and a strong academic knowledge base. This revolution is set to continue with the development of stem cell therapies which are adding to tissue engineering products that are either in the late stages of clinical trials or already competing in a marketplace estimated to be worth $10 billion by 2013.

Measurement accuracy in cell-based systems is however limited currently by the intrinsic variability in, and 'background noise' associated with, whole cell populations. Overcoming these by measuring cell processes at the single cell level is an emerging concept made possible by recent advances in the fields of molecular, cellular, systems and computational biology. This project brings together leading groups in the field to provide an integrated measurement platform able to extract highly resolved information from isolated single cells by challenging the extreme ranges of measurement detection for cell-based systems. Improvements in the analysis of single cells will benefit not only cell based therapy development but will ultimately impact upon the wider pharmaceutical, diagnostic and environmental sectors.

This is timely and highly relevant to society. The partners established track record in KT will continue through high impact peer reviewed publications. Industrial collaboration will benefit exploitation in an embryonic market where resources to effect translation alone are lacking.



Benefits	Translation of novel quantitative measurements to understand processes at and within the single cell will lead to reduced intrinsic cell variability & better/safer cell-based therapies for the clinic (healthcare sector) & improved drug discovery platforms exploiting stem cell technology.
Innovation	Realisation of a range of 'omic' methods at the scale of the single cell; enhanced understanding of the cell's functional and dynamic compartmentalisation under different physiological conditions.
Technology Solution	Single cell isolation, localisation and arrays employing preferential 'binding' and dielectrophoresis. Cell characterisation using novel optical and sensor tools; single cell scale gene expression measurement (digital PCR linked to flow cytometry); single cell mass spectrometry (MALDI) imaging; metabonomic profiling and proteomic marker analysis (CE/LIF). All of these will be intrinsically linked to bioinformatics modeling of key data.
Metrology Challenge	To provide robust methodologies for handling, separating, isolating and characterizing single cells. Particularly single cell gene, protein and metabolite analysis linked with data analysis to integrate and model the key outputs.
Technical Problem	A lack of multiplatform analysis for the characterization of single cells currently hinders the commercial application of cell technologies and slows their widespread uptake by UK industry.

Strategies Supported: TSB Key Technology Area of Bioscience and Healthcare; MSET Roadmaps; LGC's measurement R&D strategy for cell biology centre of expertise & science initiative 'towards the transparent cell'.

Synergy with other projects: DIUS Chemical & Biological Metrology Knowledge Base Programme – MS-based cell imaging and cell-based toxicity; TSB MNT - stem cells for drug discovery.

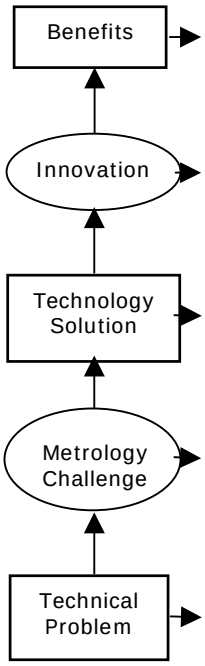
Theme	Security		**Price to DTI**	
Proposal #	S01		**Co-Funding Target**	
Proposal Title	Ensuring the Reliability of Multi Measurand Biometrics Systems		**Start Date**	
			End Date	
Lead Scientist	Tony Mansfield (NPL) Paul Debenham (LGC)	**Group Leader**	Bernard Chorley (NPL) Julian Braybrook (LGC)	

Vision, Impact and Knowledge Transfer:

Vision: To maximise the speed and reliability of non-invasive person authentication systems to support UK Government initiatives for border security and commercial identity theft by providing the capability to assess the performance of multi-measurand systems. The partnership combines the strengths of LGC as a major supplier of forensic services to UK police forces, LGC particularly in fingerprint analysis and NPL in iris and facial recognition.

Impact: Address the current difficulty in assuring sufficient performance and interoperability in national-scale biometric systems using face, fingerprint, and iris recognition. Such systems necessitate inter-working between components supplied by different biometric companies, but this is hindered by the lack of adequate specification standards for the interface components and the fact that several critical issues affecting performance have not been scientifically characterised. Recent completion of a first generation of biometric standards will allow NPL to address assurance of performance and interoperability of biometric systems to be developed from 2009 onwards.

KT: The primary routes to take-up will be though development of appropriate standards for specification and evaluation of biometrics in standards committee ISO/IEC JTC1/SC37 Biometrics, and through direct advice to, or collaboration with, government agencies and the biometrics industry developing large-scale biometric systems.



Benefits	Improved effectiveness of biometric technology in large-scale applications: e.g. improved security (better detection of known terrorists, reduction in illegal immigration) while maintaining usability (i.e. avoid queues at passport control), and minimizing intrusiveness (i.e. no need to collect more biometric data than absolutely necessary for authentication).
Innovation	Clients for biometric systems become able to specify the environmental controls & image quality required of biometric sensors, discrimination abilities of biometric algorithms, sufficient to assure end-to-end performance. Standards for biometrics, focus suppliers towards achieving client needs.
Technology Solution	Measures of component properties enable optimisations and a better understanding of what constitutes an ideal environment, user interface, biometric scanner etc. Calibration of measures enables equivalent performance of components from multiple suppliers, and standards to achieve performance and interoperability goals become feasible.
Metrology Challenge	Development of methods and reference data for measuring how biometric sensor properties, environmental factors, human factors, and algorithmic performance affect the performance of biometric systems, particularly those using face, fingerprint and iris recognition. Most such aspects are not being measured yet. In particular, human factors are acknowledged to have a critical affect on performance; nevertheless to date very few performance tests have investigated this. LGC, capability in DNA methods will be used for validation and comparibility.
Technical Problem	Inability to assure performance of a biometric system given the requirements of individual components and process. Performance is dependent on environment, human factors, properties of the biometric data capture system as well as algorithms, but currently no standards or knowledge on how factors combine to determine operational performance are available. The problems are most acute for face, fingerprint and iris recognition as these are the technologies proposed for most large-scale biometric systems.

Strategies Supported:

The project supports the UK's government strategy for identity management [2007 UK National Information Assurance Strategy through enabling the more effective use of biometrics in identity management.

Synergy with other projects: Existing MET project on biometric data quality (case study on iris recognition). EC collaborative PASR BioTesting project.

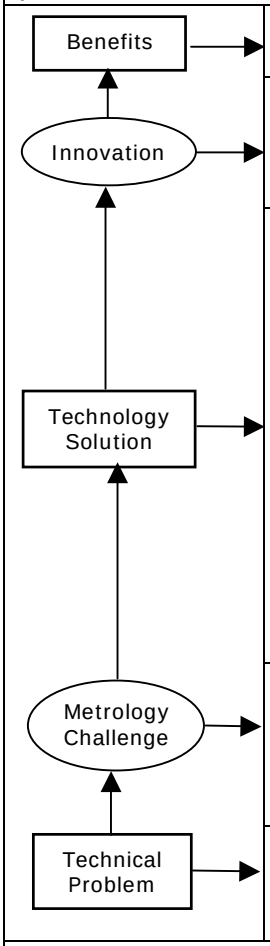
Theme	Security		**Price to DTI**	
Proposal #	S02		**Co-Funding Target**	
Proposal Title	Feasibility study - Anti-counterfeiting techniques for documents, smart cards and data security		**Start Date**	
			End Date	
Lead Scientist	Trevor Esward (NPL)	**Group Leader**	Andrew Smith	

Vision, Impact and Knowledge Transfer:

Vision: There is a need for a "biometric" or "fingerprint" for objects, that is, techniques and instruments that can be used to both to code and to measure the unique properties and histories of documents, smarts cards etc, so as to allow the reliable detection of fraud and of illegal attempts to access or alter data embedded in such objects. Anti-counterfeiting instruments that are secure, reliable, quick and cost-effective for end-users can reduce substantially forgery and cloning of documents, and limit crimes such as identity theft and terrorism. Although a number of technologies have the potential to be developed into successful anti-counterfeiting techniques, preliminary experimental work is needed to determine the most likely candidate methods that can deliver concrete benefits within the next 3 to 5 years.

Impact: This practical study will define the scope of a future Innovation R&D project that will turn promising candidate technologies into new instruments. In the retail sector alone, credit card fraud costs businesses and customers hundred of millions of pounds each year. Reliable fraud detection at the point of sale based on the proposed methodology could eliminate almost all such crimes. UK businesses lose more than £40bn a year, about £100m a day, as a result of economic crime.

Knowledge Transfer: A successful feasibility study will identify suitable industrial and academic partners for the next stage of the work.



Fraud will be reduced; detection of crime will be made easier; identification systems will become more reliable.
New instruments will be available that will allow end-users (banks, traders, police, forensic scientists) to identify forgeries and objects such as bank cards and passports that have been tampered with or from which data has been read illegally.
Systematic experimental study is needed of potential techniques for anti-counterfeiting measurements that would identify promising existing techniques to be developed into new instruments. This must combine practical lab-based feasibility studies with market and end-user research to identify the most urgent requirements for such techniques and to prioritize and direct the practical research. The study will identify two preferred methods from different branches of physics on which to concentrate. These will be determined by a competitive process, in which NMS-funded scientists will be invited to propose techniques that could be turned into practical production instruments. The most promising proposals will then be investigated during this feasibility study. It has been suggested that sequences of random bits can be extracted from small areas of paper by probing paper's 3D structure for example via X-ray micro-tomography. The same sequence can be obtained with a high probability even after repositioning the sample (i.e. the paper is self-encrypting).
To develop instruments and methods that are secure, reliable, quick and cost-effective that can identify materials and objects and their history uniquely. Some potential measurement technologies exist in nanomaterials, THz applications and optics that may be suitable for development but it is no yet clear whether these can be developed into effective anti-counterfeiting tools.
All objects have unique properties in their material construction and in their history of use. These properties have the potential to become a "biometric" or "fingerprint" for objects, that could be used in anti-counterfeiting systems.

Strategies Supported: Network security innovation platform; Home Office Strategic Plan 2004-2008 (Confident Communities in a Secure Britain); MSET More Secure Environment road map (extends ID authentication to objects, allows forgery-resistant documents).

Synergy with other projects: possible link to new Innovation R&D proposal in biometrics

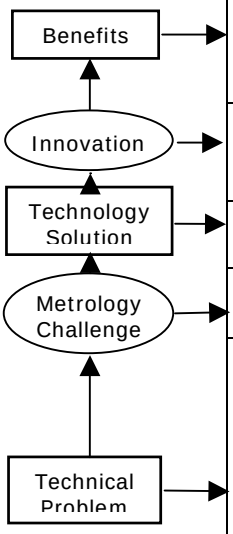
Co-Funding Support: none sought at feasibility study stage. Will identify co-funding sources during the feasibility study to support the full-scale proposal**.**

Theme	Security		**Price to DTI**	
Proposal #	S03		**Co-Funding Target**	
Proposal Title	Chip Scale Atomic Clocks for Security and Defence Applications		**Start Date**	
			End Date	
Lead Scientist	Patrick Gill (NPL)	**Group Leader**	Dr. Hilary Elliott	

Vision, Impact and Knowledge Transfer: Vision: The vision for this project is to develop in the medium term (~7 years), a key capability in the area of Atomic Clocks enabling faster acquisition of high accuracy satellite navigation signals for accurate positioning and delivery of secure assets and longer periods of self-autonomy (particularly significant for self-sufficiency in the event of reduced access to base clock and satellite location signals). Other applications within the communications market include integration into mobile phone base stations and other F&T infrastructure.

Impact: Specifically in the 0-3 year timescale, this project will define the optimal physical mechanism from CPT (Coherent population trapping – Trapping of atomic population in a non-coupled ground-state of a three level system), four-wave mixing mechanism and N-resonances (three-wave mixing type mechanism) for clock operation with component prototypes designed. Until recently, the only devices that could supply atomic clock frequency accuracy in no way matched mobility/volume/power requirements of the UK Defence and Security area, weighing of order a few kilograms, with volumes ~ a litre and consuming tens of Watts of power. More recently progress at NIST (and which is now pursued within a DARPA programme) has shown that such Atomic Clock capability has the potential to be delivered "on chip" in a fraction of that weight and size (~ 1 cm^3), and consuming tens of mW of power. The impact of such technology is considerable, with the MoD "Defence Technology Strategy for the 21st century" stating that the "criticality of an accurate frequency sources to military equipment is significant, not least in terms of applications in Navigational accuracy, resistance to jamming, security level of encrypted communications and signal acquisition speed".

Knowledge Transfer: Knowledge dissemination through consortium partners will ensure the maximum impact in the most relevant sectors is achieved.



The benefit of enhanced atomic clock capability within this project focuses on the potential to achieve faster acquisition of high-accuracy satellite timing and navigation signals in the field, and to enable better self-sufficiency for longer periods in the event of reduced access to base clock and satellite location signals.
The potential application of new cell types and other component designs (compared with that developed by NIST) along with an optimised mechanism for improved clock operation
Investigation / optimisation of clock physics mechanisms, verification of performance under same experimental conditions. Implementation into clock.
Determination of clock signal resolution, signal-to-noise, stability and accuracy for the different atomic physics mechanisms within constraints on size/power/mass.
Standard commercial devices unit cost depends on precise accuracy where with typical accuracies in the region of 10^{-12}-10^{-13} at 1 day the cost is ~£10k. These devices are high value/cost products with volume footprint requiring ~2–4 Eurorack heights, dependent on device. Lower accuracy quartz clocks (at best ~1 part in 10^8) are manufactured in high volume but do not provide the "accuracy" required to meet key critical security applications (as above) and cost ~several pounds. There is thus potential for a low-cost (relative to standard atomic clock packages) high-volume product, provided the physics package can be reduced in size/mass and power consumption to enable ease of integration. Additionally, the operation of a CPT Clock with target chipscale constraints on size/power/mass

Strategies Supported: (i) *TSB QTAP* work has identified Atomic Clocks as critical to UK going forward (ii) *Defence Technology Strategy* specifically identifies Atomic Clock technology as "critical" to many military applications currently and in the future (iii) *European Space Agency* strategy in the use of these systems as high accuracy frequency references for ground stations clocks

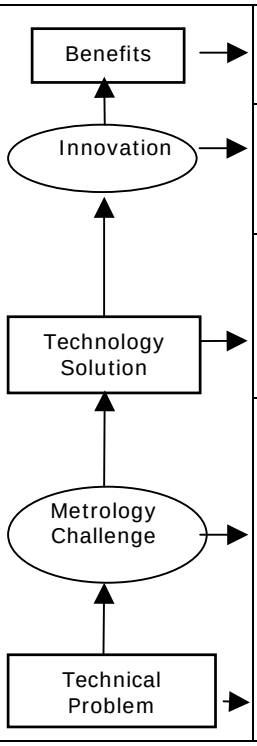
Synergy with other projects: Pathfinder Metrology to develop proof of concept test bed for small Strontium ion optical Frequency Standard.

Theme	Security		**Price to DTI**	
Proposal #	S04		**Co-Funding Target**	
Proposal Title	Rapid Screening of Recent Geographic Movement of Terrorist Suspects		**Start Date**	
			End Date	
Lead Scientist	Rebeca Santamaria-Fernandez (LGC)	**Group Leader**	Julian Braybrook (LGC)	

Vision, Impact & Knowledge Transfer: With 15 attempted terrorist plots on British soil since 2001 & 30 known current plots & 200 groups or networks (~2000 individuals) being monitored, enhanced counterterrorist screening capabilities are an essential component of an effective national security strategy. Information on geographic origin & movement is invaluable for suspect identification in acts of terrorism & provides forensic intelligence for establishing victim identity in murder enquiries & natural disasters. Current technologies & techniques place constraints on the information obtainable about an individual's movement & life-style.

This project brings together an integrated metrology approach with leading groups to translate into the field a powerful newly developed tool able to extract highly resolved information on recent geographic movement of terrorists in custody & suspects under surveillance, non-invasively & from ultra-low sample sizes in realistic time-frames. This requires the combination of stable isotope ratio mass spectrometry (IRMS) data with technologies such as trace element analysis &/or DNA fingerprinting to provide evaluation of a novel human provenance tool. Proof of concept will be shown initially using the ^{34}S & ^{13}C isotope abundance variation on individual hair samples, with the potential to extend the technology to wider population profiles & to finger-nail samples. Multivariate data analysis techniques will be used to analyse data obtained.

The proposed translation of accurate quantitative measurement capability for ascertaining geographic movement of suspects is timely & highly relevant to society. The partners established track record in KT will continue through high impact peer reviewed journal publications & FIRMS members dissemination, success having a major impact in protecting national security & economic well-being, & supporting law enforcement agencies in preventing & detecting serious crime.



Accurate measurement of isotope ratios of individual human samples as a means for identifying geographic origin & movement will be of immeasurable value to the security, police & forensic services.
Rapid screening tool with sufficient resolution to obtain information on individual hair samples pertinent to determining geographic movements &/or human provenance. This will directly assist focussed investigation & threat responses as part of a strategy for enhanced security measures.
Initially, proof of concept through stable isotope 'finger-printing' methodology using LA-ICPMS for $\delta^{34}S$ measurements & an elemental analyser coupled to an IRMS for $\delta^{13}C$ measurements. Translation to real samples. Extension of technology to wider population profiles & fingernail samples. Multivariate data analysis techniques will be used to analyse the data obtained.
Current technologies do not provide realistic sample turnaround times & sufficient resolution for small sample sizes. Correlation of isotopic signatures with country of origin &/or movement between different geographic locations required. The challenge is the development of novel & robust approaches for accurate determination of high precision isotope ratio measurements in individual human hair (& nail) samples.
Currently only limited information about a person's recent geographic movements & life-style (in terms of diet etc) can be gathered. The provision of new technologies with sufficient accuracy & resolution, & speed of analysis is essential to provide necessary further information for security purposes.

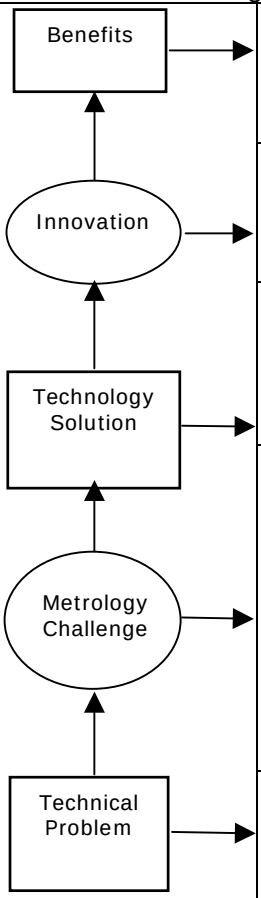
Strategies Supported: Home Office Science & Innovation Strategy 05-08; UK/US Agreement for Co-operation in S&T for Critical Infrastructure Security Matters 04; EPSRC 'fighting crime, increasing public safety & security & countering terrorism in public places' initiative; TSB Key Technology Area of Bioscience & Healthcare; MSET Roadmaps; LGC's measurement R&D strategy for MS centre of expertise & science initiative of mass spectrometry imaging.

Synergy with other projects: DIUS Chemical & Biological Metrology Knowledge Base Programme - IRMS for detecting counterfeit pharmaceuticals; EPSRC/P&G (Queens Univ. Belfast - ^{2}H, ^{13}C & ^{15}N isotope fingerprinting of drugs & counterfeit consumer products); Cabinet Office 'on call' programme.

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T01		**Co-Funding Target**	
Proposal Title	In-situ Dynamic Pressure Measurement In Extreme Environments		**Start Date**	
			End Date	
Lead Scientist	Andy Knott (NPL)	**Group Leader**	Simon Reilly	

Vision, Impact, and Knowledge Transfer:

- **Vision:** Reduced harmful engine emissions and more efficient use of fossil fuels
- **Impact:** Enable developers to improve engine design by giving a more accurate real-time understanding of their performance, allowing the fuel injection and combustion timing process to be optimised
- **KT:** Collaborate with engine developers, sensor manufacturers, universities, and SMEs to develop and publish a dynamic pressure calibration methodology. Present technical results at World Congress of Society of Automotive Engineers (SAE International).



Benefits	The innovations that will be made possible will result in improvements in engine efficiency and reductions in NOx emissions. These will help engine developers to meet more stringent future emissions regulations and reduce the use of fossil fuels.
Innovation	The traceable pressure sensors will enable optimisation of the complete fuel and air injection and combustion process, tailored to individual cylinders. The availability, for the first time, of this high quality data will lead to further engine system management improvements.
Technology Solution	The engine developers will gain the capability to make high quality traceable dynamic pressure measurements as a result of the equipment developed. They will have, for the first time, the ability to carry out in-house calibrations of their sensors against a reference transducer, which has primary traceability to a known dynamic input.
Metrology Challenge	**i)** to develop a new method for generating known dynamic pressures over wide ranges of frequency and amplitude 50 times faster than existing techniques – complementary approaches will be investigated, including **shock tubes** and **combustion bombs** - mathematical modelling of wave propagation in solids and fluid flow in elastic systems will also be performed **ii)** to develop a novel periodic pressure generator that can be used to compare the performance of engine developers' in-house sensors with that of "gold standard" transducers verified using the equipment developed in i) – as well as the mechanical design, signal processing and data analysis will form an important part of this activity
Technical Problem	Automotive engine developers wish to optimise the efficiency and emissions performance of their new products – to do this, high quality in-cylinder and injection pressure measurements are needed, but traceable equipment and methodologies for doing this are not currently available. Developers require traceable absolute pressure uncertainties of better than 1 %, and relative pressure measurement capability of better than 0.1 % - at present, uncertainties are at a level of "a few percent".

Strategies Supported:

- UK Technology Strategy – Sustainable Production and Consumption (Key Technology Area) – Energy efficiency and pollution control
- UK Technology Strategy – Electronics and Photonics (Key Technology Area) - Improvement in car emissions and fuel economy due to the incorporation of electronic systems – Sensor systems / Electronic design and systems
- UK Technology Strategy – Design Engineering and Advanced Manufacturing (Key Technology Area) – Design for . . . health management and prognostics / Advanced instrumentation

Synergy with other projects:

SSfM (signal processing, mathematical modelling) and Engineering Measurement standards (to give initial traceability).

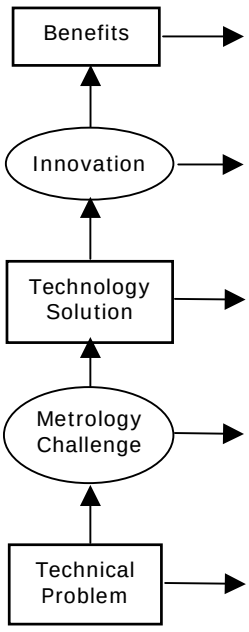
Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T02		**Co-Funding Target**	
Proposal Title	Dimensional measurement using state of the art vision sensor systems		**Start Date**	
			End Date	
Lead Scientist	Michael McCarthy (NPL)	**Group Leader**	Simon Reilly	

Vision, Impact and Knowledge Transfer:

Vision: Although the 'in-process' control offered by vision-sensor technology is partly embryonic, industrialists realise its implementation offers enormous potential over traditional off-line measurements that are dominated by inspector skill. Integration of dimensionally measuring vision sensors into production lines will results in savings estimated to be >20% of current costs, combined with the benefits of increased quality, reduced manufacturing times and falling scrap rates (currently estimated to be £100sM per annum alone).

Impact: This project will support the cost saving goals of production engineers by characterising the performance capabilities of vision sensors (CCD/Diode array systems, providing of rapid 'in-process' non-contact measurement), establishing traceability routes and identifying and solving generic dimensional measurement issues.

KT: This project will engage with production engineers and trade associations, establishing a centre capable of characterising the dimensional and dynamic performances of a wide range of emerging novel vision sensors, both in the laboratory and in industrially based hostile environments. The results will be used to assess ways of optimising their performances, providing traceable routes (to ensure production line quality and cross-compatibility) and advancing their measurement capabilities, thus enabling them to be used to solve demanding metrology-based problems on production lines.



Benefits	The project will drive the application and exploitation of optical sensor technologies (vision sensors) in industrial applications providing: more effective process control methods; increased quality; reduced manufacturing times and lowering scrap rates.
Innovation	True performances of recently developed vision sensors are worryingly unknown. Key innovation, is a combination of firstly, the provision of an NMS-traceable characterisation facility for dimensionally measuring optical sensor technologies and secondly, truly non-vendor impartiality that only NPL can provide.
Technology Solution	Development of measurement strategy permitting sensors to be tested generically on the bench and in a hostile environment. Characterisation of their performance, followed by integration of optimised sensors on to collaborator production lines.
Metrology Challenge	To assess state-of-the-art vision sensors systems, optimising capabilities and providing reference standards. To then apply the developed metrology capability to real industrially situations, where surface condition (dust, oil, reflectivity), for example, cannot be as rigorously controlled as within a laboratory environment.
Technical Problem	The key problem stems from reliance on sensors whose performances are un-characterised. For examples: ~A pharmaceutical production industry using the wrong sensor could clearly be disastrous; ~Or, The nuclear industry, which needs to measure displacement (µm to m) of magnox/warheads in storage for up to 40 years, but doesn't know which dimensional sensor to trust. Issues about accuracy (µm to mm), size, life-span, environment, power consumption (sparks) and vibration are common technical problems.

Strategies Supported:

iMERA roadmaps – *Dimensional metrology for advance manufacturing technologies*

Synergy with other projects:

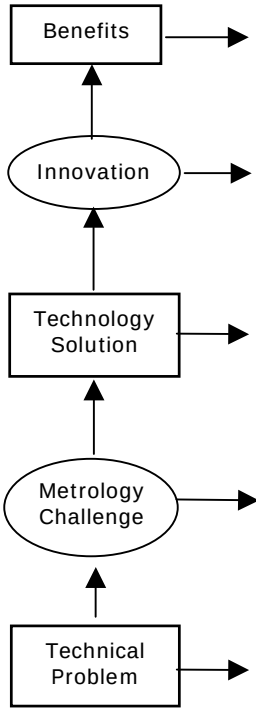
Sensor projects: for example, thermal, pressure etc..

Co-Funding Support: It is anticipated that NPL will be loaned a number of high specification sensors during the period of the project. This will represent large capital savings.

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T03		**Co-Funding Target**	
Proposal Title	Feasibility Study - Traceable Metrology for Climate Change		**Start Date**	
			End Date	
Lead Scientist	Dr Garry Hayman (NPL)	**Group Leader**	Dr Melanie Williams	

Vision, Impact and Knowledge Transfer:

Climate change is the greatest long-term challenge currently facing the human race. It encompasses an extremely wide range of activities, many of which have a measurement and metrological requirement. The aim of this project is to identify key activities and measurands, which would derive the greatest benefit from a programme of metrology R&D. This will improve the quality of the evidence base and support the use of mitigation/adaptation options required to respond to climate change. The output of this initial feasibility study will be a report key stakeholders (a) identifying a prioritised set of these measurands and options and (b) outlining the metrology that could be developed in NMS programmes.



Benefits	The Stern Report made a compelling economic case for taking action now to address climate change. This study will generate tools and methods to improve knowledge (hence reducing risk and costs) and to retain the UK lead in areas such as emissions trading, carbon sequestration/storage and carbon offsetting.
Innovation	Enhanced accuracy/traceability of data and associated models by either building upon existing NMS infrastructure or establishing new concepts to (a) improve the robustness of the measurements and the evidence base and (b) enable the development of enforceable and quantifiable mitigation/ strategies.
Technology Solution	Construction (in partnership) of novel instrumentation and/or calibration strategies, capable of step changes in uncertainties and improved SI traceability of parameters monitoring both impact, 'drivers' and supporting mitigation strategies associated with climate change.
Metrology Challenge	Many innovative technologies are being developed to meet the climate change challenge (e.g., see NPL's review of NERC's technology strategy). A study is required to identify their metrological needs, prioritised against potential impact and likelihood of success.
Technical Problem	➢ Improving the Evidence Base – Long-term comparability, traceability and accuracy of key climate change parameters (such as energy balance, temperature, water vapour) from ground-based or remote platforms ➢ Mitigation and Adaptation - Lack of measurement infrastructure to allow quantification of efficiency/reliability of information for options such as emission trading, carbon sequestration/storage, carbon offsetting schemes

Strategies Supported:

Climate change is a top priority for the UK government, at home and internationally (e.g., UK Climate Change Programme and Bill). The proposed project fits within the thematic area of Metrology for Transport, Energy and Environment and contributes towards NMS and NPL's strategic goal to improve their capability to make measurements for the environment. The activities and objectives are clearly identified as a priority need for both European metrology (within iMERA roadmaps) and those responsible for climate change monitoring (e.g. UN, WMO).

Synergy with other projects: There are strong links with the Met Physical Project on Environment and Climate Change (TS001401-QSO0141), which is relatively limited in scope, and the sector-specific Flow Programme project on Measurement of Flow and Gaseous Emissions for the offshore oil and gas industry. It will also complement the proposed Innovation R&D project on Remote Sensing.

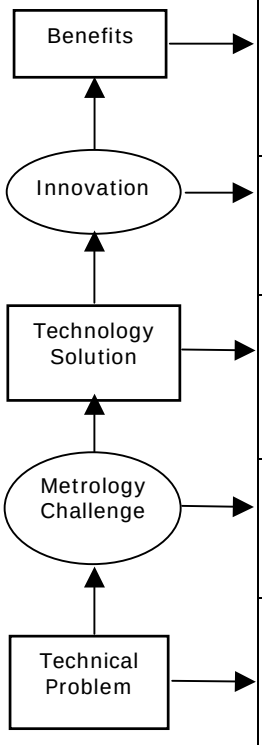
Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T04		**Co-Funding Target**	
Proposal Title	Feasibility Study - Next generation remote sensing techniques		**Start Date**	
			End Date	
Lead Scientist	Martin Milton (NPL)	**Group Leader**	Leon Rogers	

Vision, Impact and Knowledge Transfer:

The vision for this project is to determine the scope for activity within the Metrology R&D Programme for research into the next generation of remote sensing techniques used for remote environmental sensing. It will focus specifically on the measurement of the chemical composition of the atmosphere Remote sensing of the atmosphere, oceans and land offers the potential to revolutionise the assessment of land use, the prediction of natural disasters, the accuracy with which the weather is forecast and our understanding of global climate change.

The impact of this project will be to improve the reliability and confidence in the prediction of these undesirable events by putting a robust system of traceability to national and international standards in place. The increasing demand for earth observation techniques that deliver chemical concentration data for commercial and Government applications will be the driver for improvements in the quality and integrity of the data, as well as for research into new techniques. The volume of data concerned makes it of paramount importance that issues of traceability are addressed during the design and construction of such instrumentation.

This project will determine the metrological requirements for new chemical remote sensing techniques that should be developed in NMS programmes. The focus will be on techniques operating in the visible and infrared spectral regions deployable from satellite or airborne platforms.



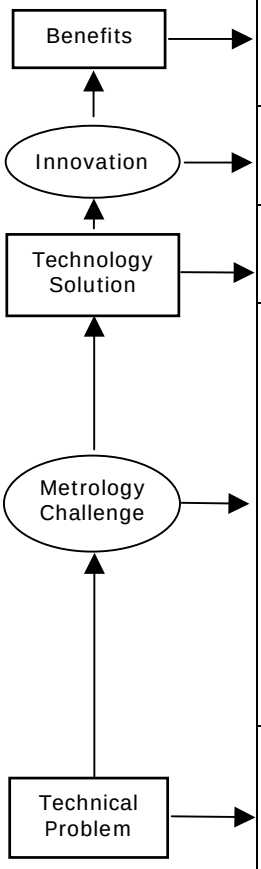
Benefits	The availability of reliable data relating to the chemical composition of the atmosphere will be greatly improved. Government and commercial users of earth observation data products will have increased confidence in their data and be able to make better-informed decisions. These will underpin the validation of models of global atmospheric chemistry a well as being used for the validation of carbon trading data.
Innovation	Exploitation of the latest innovations in photonic technologies will open the possibility for visualizing the chemical components of remote volumes within the atmosphere. This will generate new challenges for the calibration and validation of data.
Technology Solution	New photonic technologies such as fast-pulse and femto-comb lasers and digital light mirrors have become available. These have the potential for vastly increased data rates over established single-wavelength, single-line of sight systems, however, they have not yet been applied to remote sensing techniques.
Metrology Challenge	To identify the scope for new active chemical remote sensing techniques that can take advantage of the latest developments in photonic technology. Then to identify the key steps in the data acquisition process where traceable calibration is required.
Technical Problem	Remote chemical sensing techniques are not available that are capable of wide area sensing of the chemical composition of the atmosphere. In addition there is a lack of traceability for earth observation data products that makes it difficult to compare data from different sources. The project will involve: a feasibility study combined with first stage exploration of the most promising optical technologies for further NMS support.

Strategies Supported: The proposed investigation will identify the scope for Metrology R&D that contributes towards NPL's strategic goal to improve its capability to make measurements for the environment. It will also be consistent with the "photonics" theme of the DIUS Technology Strategy. Established manufacturers of complex electro-optic systems are potential collaborators.

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T05		**Co-Funding Target**	
Proposal Title	In-situ measurement and modelling of fuel cells		**Start Date**	
			End Date	
Lead Scientist	Gareth Hinds (NPL)	**Group Leader**	Lesley Henderson	

Vision, Impact and Knowledge Transfer:

- **Vision:** To facilitate production of more efficient, durable and cost effective fuel cells, which will accelerate the UK's transition to a low carbon economy with the attendant economic, social and environmental benefits, through the industry adoption of an NPL fuel cell model, supported by in-situ techniques for measurement of critical parameters of temperature, humidity, gas concentration and material durability. The focus will be on polymer electrolyte membrane and solid oxide fuel cells, in which the UK has a strong research base and an expanding industrial presence, with both multinationals and innovative SMEs pursuing product development.
- **Impact:** This project (Phase II) will further develop in situ measurement capability of key parameters critical to lifetime assessment and management. In Phase I an improved physical framework for fuel cell modelling was established and the use of in-situ probes was explored. It is envisaged that Phase III will extend the modelling capability to include fuel cell degradation, supported by experimental measurement.
- **Knowledge Transfer** will occur through adoption of the NPL fuel cell model and in-situ measurement techniques by UK industry.



Benefits	Accelerated commercialisation of fuel cells, leading to a significant contribution to the UK's greenhouse gas emission targets; employment opportunities in an entirely new sector; improved urban air quality and reduced noise pollution; reduced UK dependence on imported oil and gas.
Innovation	The NPL fuel cell model and in-situ measurement techniques will be used by the industrial partners as design tools to optimise their product, making it more competitive and cost effective.
Technology Solution	An accessible fuel cell modeling package and a set of in-situ measurement tools, which will constitute a major improvement from what is currently commercially available.
Metrology Challenge	The primary challenge is to investigate what happens ***inside*** a fuel cell during operation in order to better understand the factors controlling the overall efficiency under steady conditions and the progressive deterioration under unsteady operation. The approach is a combination of novel in-situ measurements and modelling, working in tandem. The in-situ measurements (temperature and humidity) explored in Phase I will be extended to gas composition and parameters relating to material integrity, such as fluoride release from the Nafion membrane. These data will provide direct insight into system performance and degradation rate. The advanced modelling framework developed in Phase I of the MET Programme, will be converted to robust and accessible software as a major improvement on existing commercial models. Supporting the model development will be the data from the in-situ measurements, providing both input and validation parameters.
Technical Problem	Major barriers to fuel cell commercialisation include the relatively high cost of raw materials and manufacturing and poor system durability. Improving catalyst efficiency depends on optimising processing and fuel cell design and operational variables but the large matrix of potential variables has hindered progress. Durability testing has shown that regular stop-start conditions, as would be applicable in motor vehicles, reduces lifetime dramatically. This is a potential "show-stopper" and needs to be overcome for extended application.

Strategies Supported: DIUS and NPL Science Strategy in Renewable and Alternative Energy. This project represents Phase II of the MET Programme and is critical to the NPL fuel cell roadmap.

Synergy with other projects: Materials 2007 projects UP14 on electrochemical metrology at the nanoscale and UP08 on multiphysics modelling. Proposed Materials 2008 projects on thermodynamic data for the hydrogen economy and modelling assisted in-situ measurement (MTDATA). DIUS Fuel Cell Networks (HyTRAN, SuperGen). EU FP6 – FCTEST, PEMTOOL and others. DIUS Technology Programme – Low carbon energy technologies, Emerging energy technologies.

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T06		**Co-Funding Target**	
Proposal Title	Multiphysical probing of the properties of multifunctional materials		**Start Date**	
			End Date	
Lead Scientist	Markys Cain (NPL)	**Group Leader**	Jonathan Gill	

Vision, Impact and Knowledge Transfer:

- **Vision:** NPL will offer the UK a centre of excellence for the characterisation of multifunctional materials measured at the nanoscale NPL's expertise based on multiferroic materials metrology including piezo-AFM, dielectric, magnetic, Spintronic and STM atomic probing, will be combined to realise a *comprehensive multidisciplinary* solution that benefits from shared experience and teamwork.
- **Impact:** This project will impact UK industry by enabling the development of new multifunctional materials for advanced sensors, actuators and electronics, through an understanding of materials behaviour at the nanoscale. Examples suggested by the IAG include ultra sensitive room temperature magnetic field sensors, self-calibrated motors and actuators, memory and electronic devices among others. *The traceable measurement of the multiferroic properties of nanostructured & patterned thin films remains a challenge and this project aims to develop such unique capability. This has not been accomplished anywhere in the world and NPL's approach is both unique (integrated SPM) and powerful (multisensor/multiparameter probing).*
- **Knowledge Transfer:** Interaction with end users (Rolls Royce and Seagate for example) based on materials phenomena and systems integration will be matched by an equal interaction with the wider community through our IAG, MAT UK, the Materials KTN and smart.mat for which NPL is on the organising committee. Standards development via VAMAS.

Benefits	Market lead for UK industries through better technology. Sensor manufacturers and actuator developers will be able to explore new functionality for their devices by the tailoring of materials' functional properties at all scales down to the nanoscale. Examples include self-sensing actuators, and new memory devices.
Innovation	Understanding and ultimately controlling materials properties at the micro/nanoscale offers opportunities for nanopatterning, controlled growth of devices, fabrication for data storage, materials with tailored response for optical communications, & biological sensing.
Technology Solution	Enables end user to make multi-functional measurements in one step reducing time, costs and enabling innovative design.
Metrology Challenge	The challenge is to develop a suite of microscale probing techniques that is able to stimulate and to measure the materials' response; ultimately the goal is to combine these into a single traceable measurement system. The work will concentrate on AFM, STM and scanning magnetometry approaches, specifically the AFM to map the electrically induced magnetic response of multiferroics (spintronics), STM to probe response of ferroelectrics and s. magnetometry to probe quantities related to magnetization behaviour (e.g. switching field distributions). Initially, 2- parameter probing methods will be developed, leading to multiple probing.
Technical Problem	There is a lack of reliable methods for characterising materials functional properties at micro and nanoscales. In order to tailor materials properties it is necessary to understand what is going on in the material at these scales. The resulting property data will enable modelling of innovative devices and systems under development.

Strategies Supported: Main Metrology R & D Themes: Multiple UK industries targeted via MSET, smart.mat, EU Piezo Institute; MAT UK and Materials & Sensors KTN's; DE-AM: e.g micro & nano-technology manufacturing, sensors & control: energy efficiency (top focus); ICW: Sensors/smart materials, data storage SEMI. DIUS Grand Challenges: metrology at all scales & to meet energy challenge, MET R&D Themes: Comms/ICT, Energy, Security. NPL Strategy.

Synergy with other projects: Existing NMS ending spring 2008: MET2.1. E2 - Spintronics project starting 2007 – metrology exploratory project. Dielectric probe and magnetic thin films. A major aim of this new project is to bring all these capabilities together with a critical-mass team working on it. Proposed Thin Film project, parts of which might be amalgamated with this project.

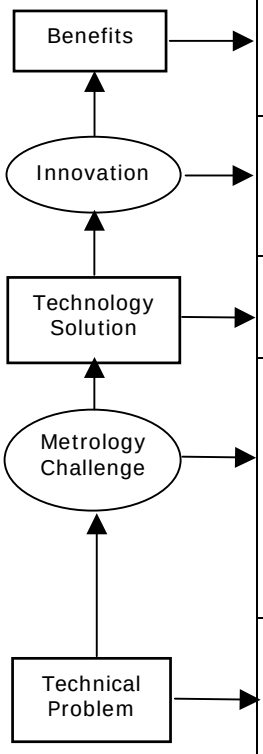
Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T07		**Co-Funding Target**	
Proposal Title	Monitoring the Health of Surfaces to Degradation from Wear		**Start Date**	
			End Date	
Lead Scientist	Mark Gee (NPL)	**Group Leader**	Rob Brooks	

Vision, Impact and Knowledge Transfer:

Vision*:* To develop in-situ measurement techniques that enable the development of understanding at a scientific level of wear and degradation of surfaces by the identification of signatures from key events associated with scientific phenomena.

Impact*:* The techniques developed in this project will allow for the development of sensors for continuous remote assessment of life critical tribological surfaces that will replace current costly regimes for the maintenance of equipment. This work will have a high impact in many engineering areas enabling more efficient use of materials and better assessment of ongoing lifetime of components, particularly in defence, aerospace and nuclear application areas.

KT: The project will be carried out in collaboration with Southampton University who have carried out some early work in the area. The main output will be guidance in the monitoring the health of surfaces demonstrated by two specific new monitoring techniques.



Benefits	The provision of reliable surface monitoring techniques will result in major cost savings in the effective maintenance of equipment allowing for lifetime extension, the elimination of costly diagnostic routines and equipment disassembly/reassembly, and in some cases increased safety of life critical equipment.
Innovation	The development of new surface health monitoring technology will enable manufacturers and operators of equipment and vehicles to produce a new generation of innovative products which are smarter and diagnostic intelligence is built in.
Technology Solution	The work carried out in this project will enable multi sensor probe technology to be developed that can be incorporated into equipment to give a continuous read-out of the condition of tribological surfaces.
Metrology Challenge	To develop new techniques that can form the basis of sensors that will monitor the condition of surfaces subject to wear for eventual application in the field. These will be able to give an early indication of significant degradation of the surface that could lead to unacceptable or even catastrophic loss of performance. The techniques will be based on the capture and identification of physical signatures such as electrostatic, conductance, inductance, electrochemical and ultrasonic that are generated from micro-scale wear mechanisms. It is likely that a multi-probe approach will be used in final devices.
Technical Problem	Lack of understanding of the degradation of sliding surfaces means that prediction of failure of engineering systems is not easy, leading to inefficient operation, catastrophic failures, and unduly large safety factors. Current condition monitoring based on vibration analysis or analysis of particulate debris in oil does not give the early warning of degradation or failure that is required.

Strategies Supported: The following DTI strategies are supported: The ***Advanced Materials*** Key Technology Area with surface engineering as a key area and surfaces and coatings were identified as a key theme for metrology. The ***MSET roadmap for Environmentally Friendly Transport*** identifies surface engineering as a key application area. Surface engineering has also been identified as key areas in the NPL strategy.

Synergy with other projects:

This project has synergy with other structural health monitoring projects, and with project AM09 on the development of low friction coatings.

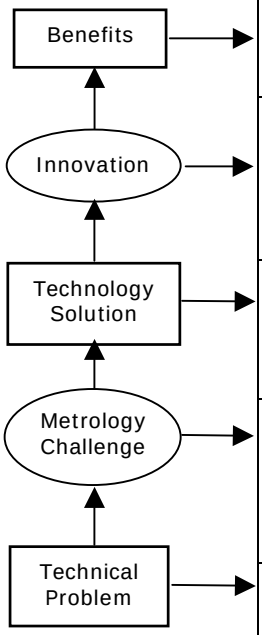
Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T08		**Co-Funding Target**	
Proposal Title	Novel in situ measurement using nanoparticles in polymer composites		**Start Date**	
			End Date	
Lead Scientist	Bill Broughton (NPL)	**Group Leader**	Bill Broughton	

Vision, Impact and Knowledge Transfer:

Vision: To improve structural integrity and safety of joined composite and multi-material structures through better design and in situ measurement of strain.

Impact: Provide designers/engineers with diagnostic tools, embedded structural health monitoring (SHM) sensors and test methodologies for accurately monitoring/assessing material degradation and structural integrity (remnant stiffness/strength/life) of bonded and bolted composite structures (cradle to grave).

Knowledge Transfer: NPL design software (CoDA), web-based interactive Adhesive Design Toolkit, scientific papers, standards, reports, presentations and web pages directed towards suppliers/end users in aerospace, rail, oil/gas, construction and energy (wind turbine) industries.



Improved design, lifetime prediction and management diagnostic tools will reduce operation and maintenance costs, maximise weight savings/reduced safety factors (increased sustainability), increase product reliability and enable early detection of structural critical damage for preventative maintenance. Introduction of new "smart" materials with increased functionality/performance.
New/novel nanoparticle (CNTs) embedded SHM sensors for long-term monitoring and assessment of material degradation and structural integrity (cradle to grave) enabling: (i) performance driven design and optimised lifetime management of structures; (ii) improved material selection and utilisation; and (iii) processing optimisation through rapid low cost quality assurance solutions.
Diagnostic toolkit consisting of new/novel inspection techniques (nanoparticle SHM sensors and smart fasteners), validated test methods, design procedures and predictive models to accurately monitor/assess damage, structural integrity and remnant life under static/dynamic loading – providing best practice for SHM.
Develop permanent/durable embedded nanoparticle SHM sensing techniques for accurate long-term monitoring/assessment based on mapping of electrical resistance/impedance or magnetic permeability. Quantify the changes in these measurements in relation to composite degradation and lifetime of components and structures.
No agreed framework for in-service testing and monitoring of joined composite structures due to limited availability of validated predictive models/design and measurement procedures, and reliable in-situ monitoring/inspection methods for determining structural integrity/remnant life. Existing SHM methods limited by sensor durability over the lifetime of structure.

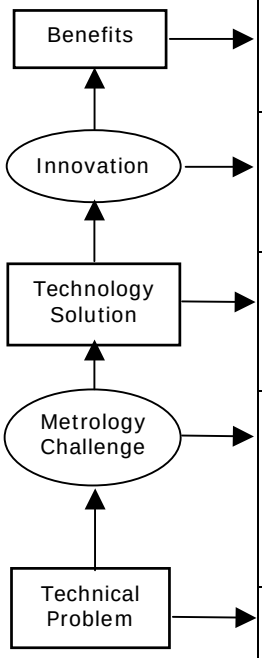
Strategies Supported: **NPL Science Strategy:** Project supports SHM, composites, nanomaterials and multifunctional materials. **Key Technology Areas**: Design Engineering and Advanced Manufacturing: Improved design, safety and reliability, and provision of non-destructive diagnostics for in-situ inspection, Bioscience and Health Care (medical implants) and Advanced Materials: Multifunctional materials including damage tolerant and self diagnostics, Electronics and Photonics: Supports development of NDE techniques, SHM sensors and associated electronic systems, Sustainable Production and Consumption: Improved design procedures and enhanced quality and durability leading to energy saving, increased efficiency and sustainability.

Synergy with other projects: Complements **IMAJINE**, MET Wireless sensors, SM10 Characterising Micro/Nano-scale Interfaces in Composites, AM11 Measuring and Modelling Dispersion in Nanoparticulate Reinforced Polymers, AM14 Structural Health Monitoring and AM17 Fatigue Design Toolkit for PMCs. The project will provide (and receive) relevant information and data relating to material, structural and sensor performance to the above-mentioned projects.

Theme	Transport/Energy/Environment		**Price to DTI**	
Proposal #	T09		**Co-Funding Target**	
Proposal Title	Distributed Sensor Metrology		**Start Date**	
			End Date	
Lead Scientist	Norman Glen (NEL)	**Group Leader**	Jane Sattary	

Vision, Impact and Knowledge Transfer:

This project will enable industries to acquire accurate but cost effective measurement and monitoring of processes through employing arrays of distributed low cost, low-accuracy sensors by exploiting data management techniques to provide accurate measurement values. Distributed sensors enable multi-functionality with the on-line measurement of additional parameters but also providing spatial information over a changing field. The project will access the feasibility of integrating distributed sensors to provide accurate measurements to meet industries needs to monitor processes and also assure energy efficiency and reduced environmental impact. Results from this work will be widely disseminated to industries through conferences, seminars and publications to enable the uptake of this effective measurement approach by industries. This project will propel UK industries to an advanced measurement position; enable effective monitoring and compliance with EU environmental policies. In addition, the UK market and development of MEMS sensing technologies will be accelerated, thus enabling the progression towards integrated intelligent systems and also facilitate effective continuous, high throughput industries.



Large impact on industries requiring cost effective on-line process monitoring, control and optimisation. Feasible environmental, energy and normally inaccessible monitoring. Industries impacted: MEMS, sensor and instrumentation manufacturers; aerospace; oil and gas; nuclear; process plants; refrigeration industries; environmental monitoring; remote sensing technologies
Industries are under increasing pressure to deliver cost effective and competitive products and processes, but also must operate under additional constraints of environmental issues and energy efficiency. Cost effective measurements and instrumentation monitoring will enable these requirements to be meet.
Utilisation of miniaturised MEMS sensors to enable accurate measurements and spatial mapping of environments/energy fields using numerous low cost (possibly disposal) sensors along with data management techniques to provide more accurate measurement to industries.
Feasibility of using an array of distributed low cost sensors as a cost effective alternative to high accuracy single point measurements to provide equivalent accuracy through data management techniques of the less accurate but numerous measurements from the array. The array of sensors will also provide addition spatial information on changing parameters over an area or even entire process plant through the integration of multifunction sensors.
High accuracy meters and sensors are expensive and only provide a single point measurement. Hence they are not a cost effective solution to monitor a complex network, large area or numerous parameters.

Strategies Supported:

2007 Energy white paper.

TSB Key Technology Areas “Electrical, Electronics & Photonics”, “Information and Communication Technologies”, “Sustainable Production and Consumption” and “Design Engineering and Advanced Manufacturing”.

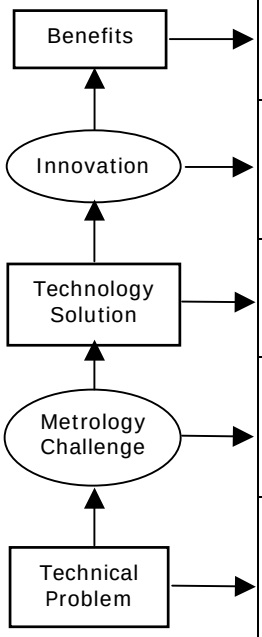
Synergy with other projects:

JIP non-invasive flow measurement, low carbon technologies, utilities metering in the food and drinks industry, MEMS sensors projects, emission monitoring, environmental monitoring, data management for process industries, chemical sensor development with LGC, MEMS measurement programmes at NPL e.g. Metrology for Advanced MEMS Sensors. Four Technology Programme projects.

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T10		**Co-Funding Target**	
Proposal Title	Hydrogen as a Transport Fuel		**Start Date**	
			End Date	
Lead Scientist	John Bingham (NEL)	**Group Leader**	Jane Sattary	

Vision, Impact and Knowledge Transfer:

Hydrogen is seen as a potential energy carrier that can provide largely pollution-free energy for transport applications either in fuel cells or combustion engines. Although the use of hydrogen as a transport fuel is still future, the research and development community is currently active and a range of demands for traceable measurement science and technology must be addressed now to ensure that the UK maintains its position in this important sector. The vision is to address all the measurement challenges in the supply and use of hydrogen in transport by setting up a metrology hub featuring vehicle and fuelling facilities and creating a national network of links to other organisations with niche activities in the sector. Existing national dissemination routes will be used to transfer the knowledge gained in this programme of work.



The proposed programme of work will provide vital underpinning to an emerging sector in UK technology. Beneficiaries will include developers of hydrogen infrastructure and hydrogen storage systems and also companies involved in vehicle technology whether with engine or fuel cell propulsion systems.
A national centre will be established with facilities for storing and metering hydrogen and for operating vehicle drivetrains (engines or fuel cells) on test beds and in vehicles. This innovative approach will provide an interface between core NMS activities and practical measurement environments.
Best practice in the sector will require a review of all current and anticipated measurement systems and the implementation of a series of work packages to address these.
A range of metrology issues arise from the use of hydrogen in transport: monitoring storage, metering hydrogen to vehicles, sensors for safety systems, measurement for R&D and control in fuel cells and engines, control of hydrogen quality (particularly purity).
Current transport technology is based on fuels which are liquid at ambient conditions and have high energy density by volume. Hydrogen is gaseous at ambient conditions, has low energy density and leaks easily. Systems, sensors and control issues all demand new measurement technologies to support safe distribution, storage and use of hydrogen.

Strategies Supported:

Hydrogen as an energy carrier for transport applications is part of the future solution to the problems of fossil fuel depletion and climate change. This is set out in:

- Hydrogen Energy Strategic Framework for the UK – the Government's response
- Government Energy Review, 2006

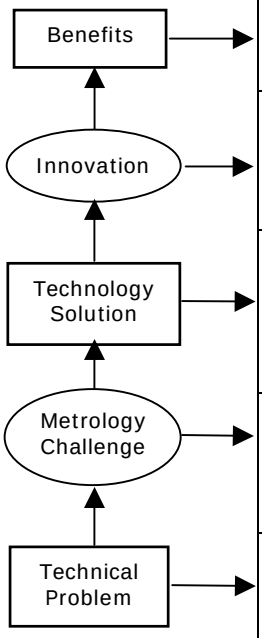
Synergy with other projects:

EPSRC Supergen Fuel Cells
MET project: Fuel Cells
MfI Projects: Gas flow and temperature distribution in fuel cells, Performance of fuel cell hybrid vehicle, Flow in SOFC
Fuel cell hybrid bus demonstrator for Whitelee Wind Farm

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T11		**Co-Funding Target**	
Proposal Title	Metrology Developments for Marine Power Systems		**Start Date**	
			End Date	
Lead Scientist	John Bingham (NEL)	**Group Leader**	Jane Sattary	

Vision, Impact and Knowledge Transfer:

Marine power forms a key element in the Government's energy strategy and it is proposed to address the current measurement challenges in both wave and tidal energy systems in a major UK programme to be undertaken by NEL, the European Marine Energy Centre (EMEC) and the New and Renewable Energy Centre (NaREC). The intention is to consolidate developing measurement technologies and procedures into traceable standards in the NMS portfolio. A range of novel remote sensing techniques will also be developed in the programme in conjunction with appropriate academic and industrial partners. The intention is (1) to increase the exploitation of the UK marine energy resources, (2) to secure the UK's position as a leading developer of marine power systems and (3) to ensure that innovative development of measurement systems in the UK is fully traceable to NMS standards.



Benefits	The western coastline of the British Isles has high reserves of marine energy, and the formal engagement of NMS metrology expertise will benefit developers of marine power systems and energy companies assessing sites for energy extraction.
Innovation	The marine energy sector is characterised by innovative designs but no single device yet dominates the sector. Traceable measurements using robust instruments are therefore required to ensure uniform assessment of these devices.
Technology Solution	A national network of organisations will share facilities and metrology expertise to develop, assess and rank measurement techniques for wave energy and tidal energy determination. A key feature of the solution provided will be implementation of instruments in hostile marine environments accessed through EMEC and New Park Management (Pentland Firth – Crown Estates)
Metrology Challenge	Energy in the marine environment is present as waves and tidal flows. Measurement systems have to operate in hostile environments and have to determine expected energy yields and also gather data in support of environmental impact assessments (noise, vibration, materials issues)
Technical Problem	Procedures for determining energy in the sea currently lie outside the scope of NMS activities. It is proposed to assess seabed and sea surface instrumentation and to implement high resolution GIS (geographic information system) maps on a sample sea area.

Strategies Supported:

Marine power is part of the future solution to the problems of fossil fuel depletion and climate change. This is set out in:

- Meeting the Energy Challenge, Government White Paper, May 2007: Section 5.3 Renewables
- Government Energy Review, 2006

Synergy with other projects:

EPSRC Supergen Marine

NMS MfI projects : Marine hose pump research, marine energy determination, noise from marine power systems, data reconciliation techniques for complex marine systems

NMS Programmes: Flow and Engineering, Acoustical, Physical (electrical)

Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T12		**Co-Funding Target**	
Proposal Title	National Wind Energy Metrology Centre		**Start Date**	
			End Date	
Lead Scientist	John Bingham (NEL)	**Group Leader**	Jane Sattary	

Vision, Impact and Knowledge Transfer:

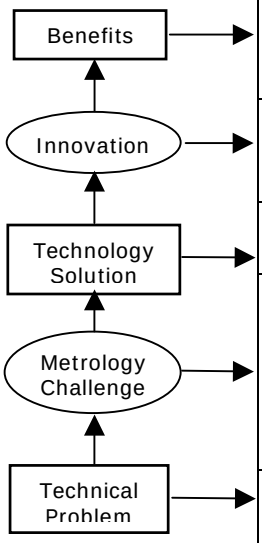
Wind power forms a key element in the Government's energy strategy and it is proposed to establish a national wind energy centre to address the metrology issues arising in this sector. Three technology areas will be addressed: small wind turbines, large wind turbines and energy storage.

(1) In collaboration with the British Wind Energy Association a metrology centre will be established at NEL's wind turbine test site for independent performance measurement of all small wind turbines. These measurements will be used for accreditation in the DBERR Low Carbon Building Programme.

(2) Significant new metrology challenges relating to air flow characterisation, rotating machinery assessment, structural condition monitoring and intelligent self checking of data are arising in the large wind sector. These will be addressed by integrating core programme work as appropriate.

(3) Wind power is an intermittent energy source and is therefore most effective when used in conjunction with energy storage. The characterisation of batteries, battery management systems, supercapacitors and the metrology challenges in hydrogen production will be addressed.

The project will provide the NMS with a pivotal metrology role in this strategically important sector in the renewable energy industry. The outputs will assist small wind turbine developers, energy suppliers and electrical network operators. The full support and commitment of the BWEA provides the project with immediate access to powerful national and international KT mechanisms.



Benefits	The proposed centre will be used by all small wind turbine companies to gain accreditation for their products, benefiting all stakeholders and moving the NMS to a key position in the energy sector. Similarly enhanced condition monitoring and energy management technology will benefit the large wind sector.
Innovation	The growth of the microgeneration sector in the UK is driven by innovative companies. Traceable measurements, transient techniques, advanced sensors and data handling techniques will bring ionnovative metrology to this sector.
Technology Solution	Techniques will be developed for standardised measurement of wind turbine output covering transient wind speed, power, noise and vibration and strain.
Metrology Challenge	New standards for small wind turbines are demanding independent traceable measurements for transient wind and power output, noise and structural vibration. Large wind farms are demanding improved measurement technology for condition monitoring and wind speed measurement in conjunction with sophisticated data self-observation capability, proactive control techniques and goal-driven configuration management.
Technical Problem	There is currently no UK centre for addressing the metrology challenges in the wind sector. Small wind turbines are highly transient and new measurement techniques are needed to address this. Large wind turbines demand increasingly sophisticated wind measurement and condition monitoring for wind farm operation and energy storage.

Strategies Supported:

Wind energy and distributed power generation (which includes small wind turbines) are part of the future solution to the problems of fossil fuel depletion and climate change. This is set out in:

- Meeting the Energy Challenge, Government White Paper, May 2007: Section 5.3 Renewables
- Government Energy Review, 2006

Synergy with other projects:

EPSRC PROSEN project: Data handling; *Carbon Trust*/TWI project: Condition monitoring; *NMS MfI* projects : MEMS for small wind turbines, remote wind speed sensing techniques; NMS MfI proposals: Transient wind turbine power measurement, noise and vibration from wind turbines, telemetry system development for blade characterisation; *NEL*: Small Scale Wind Turbine Club Hydrogen as energy storage medium for wind energy

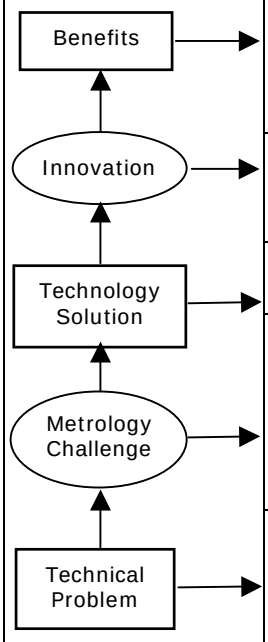
Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T13		**Co-Funding Target**	
Proposal Title	Monitoring for structure lifetime extension: Measurement, prediction and the unexpected		**Start Date**	
			End Date	
Lead Scientist	Nick McCormick (NPL)	**Group Leader**	Alan Brewin	

Vision, Impact and Knowledge Transfer:

Vision: To maximise the capability of existing UK infrastructure such as transport and to ensure maximum future lifetime from new build requires structural heath monitoring (SHM). For successful SHM suitable measurement techniques are required to provide appropriate data that is then used for lifetime prediction, including extraordinary events that play a major part in managing the structure.

Impact: This project will provide measurement capability to manage the lifetime of large structures. These structures require continuous monitoring of stress, strain and the environment to evaluate their condition, monitor the rate of deterioration by mechanisms such as corrosion of steel work and concrete reinforcement, cracking, impact and fatigue. For example, in the case of UK rail bridges, nearly 40% (over 10,000 and worth in excess of £1M each) are metallic and subject to degradation from corrosion, 10% are concrete and suffer from environmental attack, the remainder are masonry and these provide a formidable metrology challenge in measuring appropriate data that can then be used for lifetime prediction. The capability to do this will enable asset holders to maximise the lifetime of structures by coping with long term degradation, new scenarios caused by change of use, and an expected one of events or excursions in the environment. The project requires the development of new innovative compact chemical sensors, new crack detection sensors and innovative applications of digital image correlation to monitor global structure deflections.

KT: The output from this project would be measurement devices and methodologies that will be readily implemented as a low-cost system that would be capable of wide deployment. Although the focus of the project is bridges the system would have application in other areas for plant and pipeline monitoring and composites engineering. To encourage uptake of this capability we will develop full-scale demonstrators with the seconding organisations, that are suitable for disseminating good practice and provide UK knowledge centre for SHM.



Benefits	An SHM system will alert asset owners to ongoing maintenance needs, as well as unexpected extraordinary events like for example, a road vehicle crashing into a railway bridge, measuring incident severity and ensuring infrastructure capability is maintained in times of local or regional crisis.
Innovation	Wide scale deployment of these systems can reduce maintenance, guide repair and extend lifetime whilst ensuring safety and maintaining capacity within an ageing infrastructure and will have a large impact on quality of life.
Technology Solution	The provision of new measurement capability to continually assess the local environment in terms of chemistry, stress and strain.
Metrology Challenge	To develop a miniaturised sensor system based on combining state of the art optical methods such as Raman spectroscopy with microfluidics to sense the environment (chemistry,pH). Coupling these with crack detection methods (acoustic emission), corrosion monitoring (potential) and digital image strain mapping to produce a system for the assessment of environmental assisted failure.
Technical Problem	In large structures a wide variety of sensors are needed to measure parameters required to assess the state of the structure in terms of its lifetime related to environmentally assisted failure. There are a large number of laboratory based sensing systems available but these have not been used in the field due to their expense, complexity or fragility.

Strategies Supported:Technology Strategy Board :*Electronics and Photonics*: SHM sensor devices are often electronic or photonic devices. ***Information and Communication Technology:*** wireless sensing, data mining, visualisation and simulation. ***Emerging Energy Technologies:*** Alternative energy supplies.

Synergy with other projects:. There are links with the Technology Fund projects ACLAIM and IMAJINE. Successful existing academic partnerships will continue with this project with IC and Surrey, including a joint NPL/EPSRC project with City University.

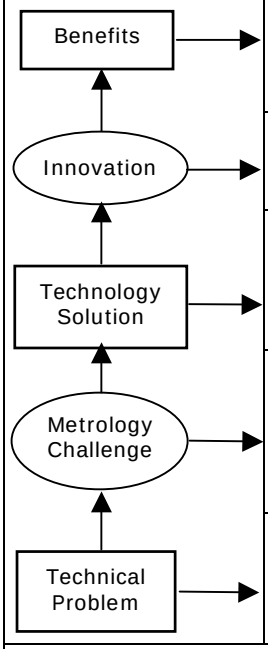
Theme	Transport/Energy/Environment	**Price to DIUS**	
Proposal #	T14	**Co-Funding Target**	
Proposal Title	Feasibility Study - Robust Network Nodes for Real-Time Cross-UK Environmental Sensing	**Start Date**	
		End Date	
Lead Scientist	Rachel Yardley	**Group Leader**	Melanie Williams

Vision, Impact and Knowledge Transfer:

- The ultimate vision is to enable all NMS supported sensor-networks to be operable via a system of robust and reliable nodes

- The vision for this project is to accelerate the implementation of UK government's environmental policies, greatly improving capability for environmental sensing, by the use of large distributed networks for environmental sensing in the UK, for example installation of networks comprising thousands of sensor nodes including on-transport (mobile) nodes. To install such a network in the field will require use of outputs from complementary co-running NMS projects (e.g. the proposed project on Wireless Sensor Networks) looking at issues including data fusion protocols, integration of individual sensors to avoid mutual interference, assessment and improvement of sensor uncertainty, and resilient wireless operation
- The impact of *this project* is the development of a tool-kit of 'universal' sensor nodes with plug-in environmental sensors, providing real-time environmental information for decision makers, focussing on the design and architecture of the sensor nodes themselves and on schemes for sensor calibration.

- KT will be via peer reviewed & conference papers, appropriate trade journals, practical demonstrations at workshops, metrology clubs (including WiSiG), KTNs & IAGs.



Benefits	For the first time instant, comprehensive information on environmental parameters will be available in the UK, giving better, more informed environmental control opportunities, improved public health through continuous monitoring and a capability for rapid response in emergencies.
Innovation	Co-ordination of inputs from other institutions (e.g. many UK universities and standards bodies) to provide a metrologically sound and traceable network of sensors – some of them mobile.
Technology Solution	Development of a large network of multi-parameter nodes for local sensing, some remotely sited, some transport-based & mobile. Each node to be capable of monitoring temperature, moisture, audio & electromagnetic noise, atmospheric pollutants, particulates, radioactivity, biological agents, air-flow.
Metrology Challenge	The challenge is to design, test and evaluate the sensor nodes. (1) Specification: of parameters to be measured, of sensor integration, of node architecture and of effective network design, (2) R&D on sensor calibration schemes including self-calibration of remote nodes, (3) testing and evaluation of prototype nodes (NB. using existing sensor technologies).
Technical Problem	Designing a metrologically sound node that is: • Resilient and reliable under hostile working conditions • Sustains the traceability of the measurements • Allows for expansion and is future proof

Strategies Supported: UK Environmental strategies at the highest level. DEFRA commitment to sustainability. MSET& DfT roadmaps for: *Environmentally Friendly Transport*: reduced impact from transport, noise reduction & Nox, Sox particulates; *The Built Environment*: air quality, water management, extreme weather, micro-energy generation; for *A More Secure Environment*: extreme weather conditions; for *ICW*: RF exposure; *Cross-cutting:* low-cost & wireless sensors, gas detection, noise, sensors for bio & chemical hazards, sensor fusion.

Synergy with other projects: Existing NMS: MET 5.1 on Wireless Sensor Networks, MET3.1 on Sensors. NMS and DIUS Technol. Prog. projects on MEMs Acoustic Sensing, Energy Scavenging and Detection of Particulates; SSfM projects on data fusion; DfT MESSAGE Project (Sensors on Transport). This project will complement other proposed NMS projects that will perform R&D on the sensors themselves, on WSN resilence, on remote atmospheric sensing, on data fusion and on effective data displays. A co-ordinated strategic approach to all of these NMS sensor network projects will be adopted by NPL to ensure maximum effectiveness, cost-effectiveness and impact.

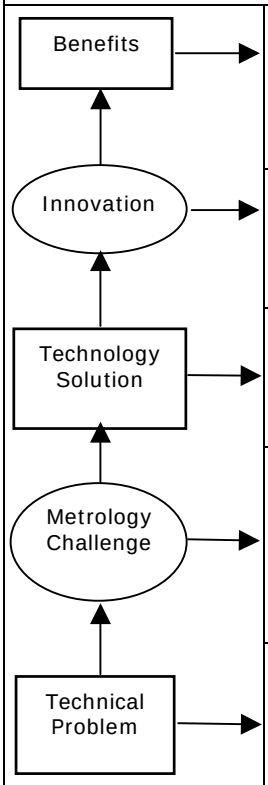
Theme	Transport/Energy/Environment		**Price to DIUS**	
Proposal #	T15		**Co-Funding Target**	
Proposal Title	Improved production of biorenewables		**Start Date**	
			End Date	
Lead Scientist	Neil Harris (LGC)	**Group Leader**	Julian Braybrook (LGC)	

Vision, Impact and Knowledge Transfer:

As the world population increases, sustainable economic development depends upon secure supply of raw materials for manufacturing. The majority of consumer goods are currently made from hydrocarbons from the petrochemical industry. These resources are limited, depleting, environmentally damaging, and need replacement by renewable or bio-based alternatives. The aquatic environment, via its unique range of niches not mirrored in the terrestrial environment, provides an excellent resource for the discovery of new chemical classes for sustainable manufacture. However, harvesting bioresources from such environments is neither economically sustainable nor viable and transfer of cultivation to controlled conditions is needed. For the UK to exploit its growing position and compete in an expanding world market of $1bn, novel reactor systems are required to overcome the current challenges with existing systems.

This project will investigate the range of bioreactors available either as an evolution of current reactor technology or via emerging disposable or bespoke systems. Focus will be on both marine and algal organisms: an industrially relevant marine organism containing novel enzymes and/or the ability to produce chemical precursors that enables specific enzyme expression and/or product monitoring via the biocatalytic pathway: an algal source used for oil production or environmental clean-up, allowing product monitoring and characterisation.

The UK is a leader in the exploitation of biotechnology; the proposed focus is timely and fits with Government commitments to sustainable development. Exploitation of new resources is vital for maintaining industrial competitiveness against a background of declining fossil fuel reserves and ever increasing focus on minimising environmental impact. Success will have a major impact on the increasing drive for sustainable manufacture within the UK and internationally and maximal use will be made of the well established KT mechanisms in this area.



Benefits	Bio-renewables will help to achieve clean, sustainable, safe processes at affordable cost and with benefits for the environment and climate. Significant impact would be in the industrial biotechnology sector in improvements in the use of renewable marine resources. Sectors impacted will include: energy, food, health and manufacturing.
Innovation	The industrial biotechnology sector is increasingly looking to sustainable manufacture driven by the use of new biological resources. Development of better bioprocesses tailored to the specific challenges and needs of this sector will enable this potential to be fulfilled in an industrial/production setting.
Technology Solution	To take appropriate algal/marine models for biocatalysis and biorenewable/ remediation and investigate use of traditional bioreactors versus emerging systems and the application of appropriate novel monitoring systems linked to multivariate data analysis to enable more efficient production methods.
Metrology Challenge	Novel chemical classes will come from aquatic microorganisms living in potentially extreme environments (temperature, pressure, stimulation, high salinity). The challenge is to harness emerging reactor designs capable of mimicking the extreme culture condition requirements and monitoring techniques able to provide improved indicators of key process variables and ensure that appropriate upstream scale up and production will be successful.
Technical Problem	Harvesting and maintaining bioresources from a marine/algal environment is neither economically sustainable nor economically viable. The alternative of using bioreactor cultivation of marine micro-organisms to enable scale up to industrial scale processes is problematic due to the diverse range of culture and processing conditions required when compared with terrestrial resources.

Strategies Supported: TSB - Bioscience and Healthcare: “Exploitation of bioscience by industry”; Foresight Marine Panel - “A study into the prospects for marine biotechnology development in the UK”;‘Securing the Future – the UK Government Sustainable Development Strategy’; MSET Roadmaps; LGC’s measurement R&D science initiative of improved bioprocessing.

Synergy with other projects: Blue Microbe, Bioscience for Business KTN, CPI, Centre for Marine Bioprocessing, CoEBio3.