Institution: General Engineering

Unit of Assessment: Panel B (15): General Engineering

a. Context

The School of Engineering and Technology's Centre for Engineering Research has a long history of industry-focused research and development evolving from the research base. Over the past 15 years, our research portfolio has strengthened and the centre currently enjoys over 30 collaborations with industrial partners and public sector organisations. We have well-equipped research laboratories and staff accommodation, and multinational staff. Many have experience of working in industry, so business collaboration, impact and end-user benefit are at the heart of their work. Since RAE 2008, the centre has undertaken 26 Knowledge Transfer projects with a total value of £2.6 million, which represents a 123% increase in income and a 70% increase in collaborative partnerships. The centre also has a strong track record of successfully using KTPs, sKTPs and iCASE projects as vehicles for gaining impact from our research. Our research groups are conducting multidisciplinary research, which often results in widening the reach of our impact. For example, research in materials science has been carried out with pharmacology, life sciences, the business school and physics, and work in microengineering has extended to include research with biochemists, microbiologists and biotechnologists.

Many of our partnerships are long-term relationships with large and small organisations. Our strategy and approach to managing research impact is underpinned by the industrial relevance of our activities, and seeks to provide a sustainable platform from which to grow future exploitation of our research outputs. Our research beneficiaries are diverse and numerous, including large multinational engineering corporations; the UK defence sector; UK government, NGOs and public policy makers; local and national SMEs; and international research teams. Outreach includes annual seminars, events and showcase activities that highlight research achievements and allow schools, professional engineers, the public and others to experience our work. Such opportunities also offer research students the chance to develop networking and communication skills. A university incentivisation scheme, operating for over 15 years, encourages staff to participate in commercial consultancy, R&D and spin-out activity. Incentives include IP sharing as well as access to institution-wide promotion opportunities through to professorships, with specific routes for enterprise and innovation. The centre, and the university's Business and Enterprise Team, supports staff in commercial engagement by providing training in, for example, networking, commercial contract writing, IPR, project management and budget management.

b. Approach to impact

Impact from our engineering research occurs predominantly through the contribution of new knowledge or new or improved processes and technologies that bring rapid benefits to end users. This can result from the development of new ideas or products, such as our microfluidics and microengineering work for the Defence Science and Technology Laboratory (Dstl), or new understanding of fundamental principles of engineering science, as in the case of our materials processing with antibacterial and anti-viral materials. Equally, our work on automatic number-plate recognition (ANPR) systems for the Home Office and police provides knowledge in the form of improved algorithms, new hardware in FPGA applications, new products and data for our collaborators, and improved policy and legislation. Impact is therefore achieved at several levels, including products and processes for industry as well as benefiting policy makers. Increasingly, wider society also benefits through showcase events involving schools and the wider public. Although our heritage has been based on industry-relevant research and development, we have strengthened our portfolio of underpinning science and basic research across the Research Centre. This continues to provide academic integrity and credibility whilst strengthening the platform for future research grant and funding applications. Other mechanisms, such as KTPs, sKTPs, iCASE, patenting, IP-partnering and consultancies, are used to exploit our basic research outcomes to the benefit of end-users. The centre has run 11 showcase events since 2008 to raise business awareness of our capability as well as bringing groups such as schoolteachers and professional institutions into our research laboratories to demonstrate technological advances.

Our **Microfluidics and Microengineering Research Group's** approach to impact is to maintain contract-based relationships with key partners, such as our long relationship with Dstl, for whom we are a significant delivery partner. The group bridges the gap between traditional academic research and advanced prototype development, thereby facilitating rapid technology transfer. Projects have included invention and manufacture of novel micropumps and the collaborative development of a Portable Integrated Battlefield Biodetector through participation in the MoD's Technology Development Programme with a consortium of SMEs. The group has provided underpinning technology to Dstl and MoD for microfluidics, multiplex antibody patterning of biodetectors, optical particle counting, and design of cyclonic air collectors, many subsequently productionised by commercial partners. Other projects have produced specialist air samplers and novel biosensor antibody patterning systems for in-house Dstl deployment. Current projects include the research and development of electro-wetting on dielectric devices for precision micro-droplet manipulation. The group's policy is to widen and strengthen our collaborator base and the breadth of technology expertise. Examples include: collaboration with UCL's Department of Biochemical Engineering in a Joint Synthetic Biology Initiative project optimising a micro-bioreactor design to culture GM cells for CBW agent sensing; a joint FP7 consortium project led by TTZ Bremerhaven on algal sensing in aquaculture; and research with the Food and Environment Research Agency, which is providing a field-deployable detection system for Ash dieback spores.

The **Materials and Structures Group** has focused on collaborative relationships with key partners in the UK aerospace and defence sector, with particular interest in metal–ceramic and ceramic–ceramic joining for high-temperature applications, composites and functional materials. The expertise involves fundamental knowledge of metal–ceramic interfacial relationships that can be exploited in bonding systems capable of withstanding extreme environments. Our collaboration with Airbus has led to changes in the way fatigue and impact damage are incorporated into aircraft design. With MBDA, a world leader in missiles and missile systems, new ways of processing high temperature ceramics and new aeroelastic analysis and clearance of weapons systems both experimentally and numerically have been developed. An MBDA EngD student used thermochemical characterisation of a new C-C-SiC composite product as the first stage in the selection procedure for a new product. A patent is also held with Heales Enterprises on a new impact-resistant polymeric material. Consortium activity in antiviral/antibacterial nanoparticles (Qinetiq nanomaterials Ltd, Johnson Matthey, Retroscreen Virology Ltd, Sun Chemicals, Pall Aerospace and three UK HEIs) is enabling the partners to optimise the size, shape and composition of nanoparticles for antibacterial/antimicrobial applications. Further impact is achieved through commercial consultancy and testing, and our provision of training workshops for commercial clients. For example: Composites Repair (~40 engineers p.a. attended for each of the past 10 years); Airframe Stressing (MBDA, 2009, 12 attendees); Control Engineering and Fluid Systems and Propulsion (MBDA, Rolls-Royce, Pratt & Whitney, BAE; 13 courses, 2011–13, total 140 attendees). These facilitate knowledge transfer and often develop into ongoing relationships. In partnership with the KMM virtual institute, specialist training has been delivered to 20 European academic staff on experimental techniques for fatigue modelling of metal matrix composites.

The **Sustainable Energy Technologies Research Group's** impact strategy similarly fosters close links with industrial partners. The group has enjoyed R&D contracts and IP agreements with ITM Power for hydrogen vehicle technologies, Power Train Ltd for throttle-less engines, Renewable East for wave power energy conversion, and ChemCol Ltd for fuel additives research. KTPs with Secomak Ltd and Coopers Bearings Ltd have created energy-efficient drying products and developed a numerical simulation and new testing methods for products. The latter KTP led Coopers Bearings towards a £250,000 award for new bearing products on offshore wind farms. The group has also made use of iCASE awards in the areas of PEM fuel cell and SOFC fuel cell technologies in a new collaboration with EU Energy Solutions. A collaborative project with AVL Powertrain UK Ltd on Energy Management Strategy of Plug-In Hybrid Electric Vehicles has led to the research output being used by AVL in the design of new PHEV powertrain control strategies. As a result of this research, separate funding was secured in collaboration with the university's Centre for Sustainable Communities, which led to the formation of a spin-out company, Evalu8 Transport Innovations, which specialises in low carbon transport solutions. With £7.5 million in funding from the Office of Low Emission Vehicles, EEDA, ERDF and participating public and

private partners, Evalu8 has installed over 460 electric vehicle charging points across the East of England. With agreed interoperability with neighbouring regions (TfL's Source London and Plugged-in-Midlands), Evalu8 has raised the regional public profile of EVs, helped organisations address their carbon reduction commitment and is engaged with all aspects of the industry from vehicle to driver. The group's work with Tianjin Yiqi Auto Company (China) has also led to a 3–5% improvement in their engine fuel economy and reduced emissions. With BAE Systems, via an iCASE award, it has also developed a new intelligent hybrid power management system for extended UAV operations.

The **Digital Media Processing and Biometrics Group**'s focus is on strengthening commercial partnerships but also expanding its public outreach and policy engagement to gain wider impact. Research with CitySync has led to next-generation Automatic Number Plate Recognition systems with a full 'standalone' prototype on an ARM-DSP System-on-Chip platform with novel algorithms for high-definition images operating in real time. The group has supported the Home Office and local constabularies through developing new technology for ANPR anti-countermeasures, as well as advising on national policy for improved standards and legislation (using two Home Office-sponsored EngD students). In May 2013, the group ran a workshop for the Home Office and Centre for Applied Science and Technology staff together with 15 ANPR industry representatives to share best practice and discuss the requirements for new national standards for ANPR. Wireless communications systems research, initially developed with strong international collaboration involving 11 universities and subsequently supported through an EPSRC iCASE (with GigaSat), KTPs with TTI and by the Royal Academy of Engineering, enabled a new generation of software-defined handheld spectrum analysers to be produced. Regular showcases permit wider public appreciation of technology and research, e.g. over 100 schoolchildren have undertaken activity days in the SmartLAB, and 8 Institute of Rennes students have been summer interns.

c. Strategy and plans

Our strategy for maximising impact across the research centre includes maintaining a focus on the highest quality research outputs; increasing research group membership to facilitate greater capacity; nurturing emerging talent; enhancing already strong knowledge exchange partnering and consortium activity; further emphasis on IP exploitation through internal awareness and training for staff, and through partnering with specialist IP companies. Our plans to deliver this include:

a) Sustaining an integrated partnering approach with business and industry for direct flow through to end users, while developing our interdisciplinary collaboration and policy engagement.
b) Identifying partners with expertise in exploiting IP in specific disciplines as well as raising awareness of IP amongst staff and students.
c) Invest in enabling infrastructure, travel funding, networking, IPR training for staff, facilities, etc. This attracts businesses and collaborators to the university, leading to lasting partnerships.
d) Exploit our hands-on showcases and evening seminar events to bring industrialists into the Centre for Engineering Research.
e) Maintaining a mix of project scales and partner size, from large EU multipartner projects, to short term, lower cost and smaller projects for micro- and SME organisations.

Each of the research groups is developing plans for impact generation alongside the required research delivery plans for the post-REF period.

d. Relationship to case studies

The two case studies are illustrative of the broad types of impact that the centre's research provides. The biodetection case study demonstrates the benefit of the extensive and trusting relationship established between Dstl and centre researchers, underpinned by our ability to provide such end-user partners with a holistic engineering solution from problem analysis to field-deployable hardware. The materials research case study describes the Materials and Structures Group's resolution of a quality control issue for C4 Carbides, where the solution has saved the company over £100,000 per annum. The case study demonstrates how research conducted some time ago has been exploited for the benefit of end-users through a KTP scheme.