Institution: The University of Leeds

Unit of Assessment: 12.

a. Context

As detailed in REF5, this UoA generates economic, environmental and social impact from the research delivered through its three research institutes:

Institute of Medical and Biological Engineering (iMBE) is one of the world's leading biomedical engineering research institutes, recognised for its distinctive ability to generate social and economic impact from its research. It delivers engineering solutions for the ageing population in: (i) preclinical tribological simulation systems, (ii) lower wearing and longer lasting joint replacements and (iii) biological scaffolds for cardiovascular tissue. It hosts an Innovation and Knowledge Centre (IKC) in Medical Technologies (http://medical-technologies.co.uk/) and WELMEC (£11.2M, WT088908/z/09/z), one of the four centres of excellence in medical engineering in the UK. iMBE received the Queen's Anniversary Prize in 2011, for its world-leading research and impact.

Institute of Engineering Thermofluids, Surfaces and Interfaces (iETSI) carries out multi-disciplinary research in engineering application areas where heat transfer, single and multi-phase flows and/or reactions at fluid and solid interfaces are crucial, particularly in the energy and industrial fluid processing sectors. Impacts from its research include: [text removed for publication] reduced risk of vapour cloud explosions due to membership of the Buncefield enquiry panel.

Institute of Design, Robotics and Optimisation (iDRO) carries out multi-disciplinary research that develops frameworks underpinning design processes and applies them to complex engineering products and systems. Its research focusses increasingly in medical robotics and multidisciplinary design optimisation for energy-efficient transport. Impact from its research has led to it hosting a new £2.6M EPSRC/industry-funded *National Facility for Innovative Robotic Systems*.

The main non-academic user groups and beneficiaries of the UoA's research include: its wide range of industrial collaborators (ranging from SMEs to major multinationals), hospitals and healthcare professionals, patients and the general public. Impact is achieved through:

- Collaborative research projects with industry, leading to innovative and safer new products and processes (e.g. longer wearing joint replacements with DePuy);
- Knowledge Transfer (KT) to users through consultancy, staff secondments, short courses and provision of software tools (e.g. delivered through our IKC);
- Influencing public policy through expert contributions to public enquiries and committees (e.g. Buncefield enquiry, http://www.buncefieldinvestigation.gov.uk/reports/index.htm);
- Successful commercialisation of our research (e.g. our Tissue Regenix spin-out, http://www.tissueregenix.com/, Parker Hannifin's award-winning droplet filtration systems, http://www.beeas.co.uk/winners/beeas-2012-winners.pdf).

b. Approach to impact

We achieve impact from our research by deploying our internationally-leading research capabilities on key industrial, societal and legislative challenges in the healthcare, energy and industrial fluids processing sectors. We encourage staff to achieve impact through our promotion and salary criteria and individual staff payments and ensure that our staff have the skills and facilities to achieve impact by (i) providing multi-disciplinary staff development and training in key areas such as impact and innovation, knowledge transfer and company directorships; (ii) by investing ~£400K p.a. in new research equipment. We recognise the important role of excellent fundamental research in achieving long-term impact by funding a strategic mix of complementary fundamental and applied research projects through the School's PhD budget (> £250K p.a.).

Collaborative research with industry: As described in REF5, our excellent funded research links with the industrial and heathcare sectors provide effective pathways to impact from our research. Impact is achieved by pro-actively engaging with users at the start of the research planning phase and throughout the project lifecycle to ensure that we address the key research challenges and that we provide research outputs that create the maximum impact. We seek advice regularly from

our wide network of collaborators, e.g. at user-focussed meetings, such as the Leeds Oncological Engineering conferences, and from our experienced Industrial Advisory Board. Support for our approach is available on a case-by-case basis through e.g. subject-specific expertise from the UoL's Research and Innovation Service (RIS), and its Sector Hubs in Energy, Medical Technologies and High Value Chemical Manufacturing, that are funded by Higher Education Innovation Funding (HEIF) and other UoL investment to support impact and knowledge exchange. This enables us to build strategic links with external partners (e.g. via two-way staff secondments; e.g. Cameron, Ireland). Within iMBE, WELMEC and our IKC provide further support for impact by providing facilities and healthcare professionals to undertake translational clinical research.

Our approach has been very successful. In the healthcare sector, the IKC and our RegeNer8 network (www.regener8.ac.uk) have supported 132 co-funded collaborative projects that have resulted in £50M of private investment which will produce a seven-fold downstream economic growth in services and manufacturing (TSB, Concept to Commercialisation, a strategy for business innovation, 2011-15, p25). We have the world's largest academic facility for tribological studies of hip, knee and spine joint replacements and our research with DePuy has resulted in lower wearing and longer lasting hip and knee joints, which have benefitted hundreds of thousands of patients worldwide; we have also identified problems with ceramic matrix composite bearings and large diameter metal-on-metal hips which led to their withdrawal from use. Our research on dCELL biological scaffolds has been commercialised by Tissue Regenix and by clinical tissue banks in the UK and Brazil. In the energy sector, our fundamental research on corrosion in the oil and gas sector [text removed for publication] and our combustion research has led to significantly better engine and gas turbine efficiencies. Our research in design optimisation led to the commercial development of highly-oriented polymer ropes (Bridon, DuPont) and, in flow modelling [text removed for publication], including a droplet filtration product for Parker Hannifin that won both the Grand Prix and Green Product of the Year prizes at the 2012 British Engineering Excellence Awards.

Knowledge Transfer to users: HEIF and Sector Hub funding provides generous support for KT activities, such as short course development, and staff secondments to and from external partners. We also offer attractive financial payments to staff to encourage consultancy and value their successes in attracting funding centred around KT (e.g. KT Partnerships and the RAEng Industrial Fellowship schemes). Our promotion and salary criteria are designed to reward staff who achieve impact from KT and consultancy (e.g. Kapur's promotion to Chair in Applied Fluid Mechanics).

Our approach has resulted in a wide range of Continuing Professional Development (CPD) courses (e.g. in orthopaedic mechanics and fire safety and hazards), tailored courses for industry (e.g. on spine biomechanics for DePuy) and extensive, long-term consultancy work (e.g. with DePuy on joint replacements and Shell on fuel combustion and engine testing). We have also had numerous successful KT Partnerships (11 awarded during REF period): KTP007212 with DePuy, for example, on metal-on-metal hip joints identified the corrosion mechanism causing ion release in hip joints. The supervisor (AN) co-chaired the subsequent ARUK task force into this issue. Our KT to industry has enabled them to achieve their commercial goals [text removed for publication];

Contributions to public policy: Our staff engage pro-actively with government, local authorities, industry associations, engineering institutions and research councils. We actively encourage them to work on policy and enquiry committees and contribute to their reports at all individual staff reviews and through our criteria for achieving senior academic promotions and the higher salary bands. Our approach has led to e.g. Bradley's work on the Buncefield Incident report (see Case Study 3) and Neville's work as co-chair of the ARUK Enquiry into corrosion in hip replacements.

Commercialisation of our research: We work with the UoL's Commercialisation Services (CS) team and its commercialisation partner, IP Group, who, collectively, provide training, advice and funding for: (i) IP generation, protection and management: the UoL policy ensures that staff and their schools benefit directly from successful IP exploitation; (ii) licensing and partnership with companies; and (iii) company creation and spin-out.

Successful examples include our novel, regenerative biological scaffold, dCELL, commercialised by the university spin-out, *Tissue Regenix*, and our partnership with Simulation Solutions Ltd, which has directly led to its growth [text removed for publication].

c. Strategy and plans

Our strategy for achieving impact is developed through our Research and Innovation (R&I) committee, comprising the Director of R&I (DoRI) as Chair, Head of School, Institute Directors, Director of Postgraduate Studies and elected staff members. This committee provides regular advice and communications on the latest opportunities for research application and exploitation, including updates from the UoL RIS and Sector Hubs. The DoRI sits on the faculty-level R&I Committee providing input to and information from the higher level University strategy for impact.

We will continue to engage pro-actively with users at the start of the research planning process and will increase our impact by a package of measures including: (i) increasing the importance of impact potential as a key criterion for staff recruitment; (ii) providing all our staff and research students with a wider range of tailored training on enterprise, impact and innovation; (iii) increased focus on challenge-driven research in key healthcare, energy and fluids processing sectors (e.g. disease specific models for joints, corrosion in oil and gas networks, cooling of electronics); and (iv) fostering a culture that actively encourages and rewards impact through our promotions and salary criteria and attractive financial payments. We will continue to target funding opportunities for unique experimental facilities for collaborative research and consultancy with industry (e.g. our Hauzer PVD system funded by EP/H050027/1) and will access the financial and management support available from the UoL's RIS and Sector Hubs to achieve greater exploitation of IP by accessing their proof-of-concept/proof-of-market funding (>£900K between 11/12-14/15).

We have an ambitious programme of plans for increasing impact from our research, including:

- Establishing the Medical Technologies IKC as the national innovation centre for medical technology*:* Our new Centre for Innovative Manufacturing in Medical Devices (£5.6M, EP/K029592/1) and University investment will further support impact and innovation.
- A key focus on orthopaedic implants, biomaterials and regenerative therapies and advanced imaging applications: Leeds Musculoskeletal Biomedical Research Unit (www.lmbru.ac.uk) has been renewed for 2012-2017 and will provide support to address translational challenges around joint replacement technology and biological scaffolds.
- Building upon our unique capabilities in corrosion research for the oil and gas sector to address key safety and productivity challenges from erosion-corrosion and two-phase flow.
- Exploiting the unique capabilities of our National Facility for Innovative Robotic Systems to build effective, functioning devices for patients and healthcare professionals.

d. Relationship to case studies

The impact case studies demonstrate the effectiveness of our approach to achieving impact.

Case Study 1: dCELL regenerative biological scaffolds*:* Economic and social impact from the commercialisation of our research on regenerative biological scaffolds by UoL spin-out company, Tissue Regenix. It shows the effectiveness of our mechanisms for encouraging company creation.

Case Study 2: Long lasting joint replacements: Economic and social impact from our research with DePuy to develop lower wearing hip and knee prostheses, improving the quality of life of over 100,000 patients p.a. This demonstrates how our industrial collaborations yield impact.

Case Study 3: Improved fuels, combustion and reduced hazards: Economic and environmental impact from the development of more efficient and sustainable fuels. Social impact from improved safety of fuel installations. An example of how staff contribute to the formulation of public policy.

Case Study 4: Flow modelling research*:* Economic and environmental impact from the application of our flow modelling research and KT to coatings, pharmaceutical and automotive companies. Promotion of Kapur to Chair demonstrates how highly the UoA values impact of this nature.