Institution: University of Leicester

Unit of Assessment: 15 General Engineering

a. Context: Our main non-academic users are: large companies including Westland Helicopters, Alstom Power, Alstom Grid, National Grid, Rolls Royce, MBDA, TWI, Bridon and Jaguar; industrial bodies such as MIRA; SMEs such as European Thermodynamics Ltd, St Jude Medical and Synchropulse; the NHS, the Police, Ofcom and Natural Resources Canada.

Impact is both economic and societal. Our engagement with companies relates to improving their products, and facilitating future product and service developments. Work with industrial bodies and government organisations enables them to make critical decisions about their expenditure on and investment in R&D projects, expenditure of public budgets, and the development and operation of regulatory frameworks. Our work also leads to impact with societal benefit, e.g. health through improved heart operations, understanding of the brain, forensics and the justice system.

b. Approach to impact: The UoA extensively engages with industry and other external bodies. Evidence of our value comes from a series of high-value cash contracts - exemplars are given below. More formalised impact strategies at departmental and college level are considered in (c).

Consultancy and direct contracts with industry: The University's Enterprise and Business Development Office (EBDO) facilitates industrial consultancies and contracts. Over the REF period, consultancy has totalled £200k, including a major consultancy of £110k with a company with UK manufacturing in the power supply industry.

- **Dodd** undertook consultancy for Alstom Grid, Stafford, UK on surface potential measurements for HVDC that led directly to a two-year KTP (rated *outstanding* in its final assessment) and the development of a £1M HVDC cable test facility (see Impact Case Study). This facility enables Alstom to compete in the world market for turnkey HVDC electrical power transmission solutions for supergrids, HVDC interconnections for existing AC transmission grids and offshore wind farms. The facility has enabled the establishment of partnerships between Alstom and HVDC cable manufacturers worldwide. Dr Fabrice Perrot, MD, Alstom Grid Research and Technology Centre said "The expertise that Dr Dodd is able to provide our company with is very unique within the industry".
- **Hainsworth** is now applying forensic expertise (see Impact Case Study) that developed as the result of two enquiries passed to her via colleagues for consultancy on criminal cases, one of which was on knife sharpness and the other a pathology case involving dismemberment. This is an example of a situation where the initial consultancy led to research with PhD students and a burgeoning range of topics (breaking of glass, stabbing, sharp edges, etc) resulting in a body of scientific evidence to support the justice system, and exemplifies an agile response.
- Fully funded direct contracts with industry total £1.8M, including: £388k Augusta Westland (**Turner**); £200k Jaguar Cars (**Hainsworth**); £186k MBDA (**Prempain**, **Turner**).

Innovation Partnership and Innovation Fellowships: Innovation Partnerships supported SMEs in the East Midlands in design, engineering and manufacturing processes and were funded by the ERDF (European Regional Development Fund) and ECIF (Economic Challenge Investment Fund). Innovation Fellowships, funded by HEFCE, are competitive awards to develop the commercial potential of academic research by offering funding of £10,000.

- **Weston**, for example, has solved a corrosion problem in cast iron for Aluminium Roofline Products Ltd, which will enable them to dominate the market for their product. With Canard Design he investigated failure modes in hip braces, and with Croft Filters helped them to design better filters with improved market penetration.
- **Lefley** had Innovation Partnerships with Synchropulse Ltd on electric motor development and with Farsan Ltd on improving the efficiency of a refrigeration system, and an Innovation Fellowship to develop smart electric motors, and also having integrated Bluetooth communications for remote data and condition monitoring. The latter has led to a licence agreement with Synchropulse Ltd (see below) to evaluate the technology with potential customers and manufacturing partners, with a view to exploring new markets.

Research Councils and FP7: Projects funded by Research Councils and the EC FP7 scheme provide strong internationally based industry links.

- **Warrington**, **Stocker** and **Siddle's** project *Space weather effects on airline communications in the high latitude regions* is joint with Lancaster University. It has collaboration and significant support from Natural Resources Canada (a Canadian Government organisation) and SolarMetrics Ltd (a UK-based SME). Our research into HF communications was directed

towards this particular industry need through a direct approach from Natural Resources Canada due to our previous research for the Canadian Government.

- **Dong** has led an FP7 project (MINTWELD - assessed as *excellent*), with **Atkinson**, to deliver welding models that will find widespread application in European industry (via the UK based TWI) for markets of high economic and strategic importance. An exploitation plan is in place.

These projects have a clear route to exploitation. **Dong's** work has enabled him to lead an EPSRC CDT in Innovative Metal Processing together with the Universities of Birmingham and Nottingham, Rolls Royce, Alstom, TWI, Tata Steel, and Doncasters (£2.3M industry commitment).

Secondments to industry: Secondments are a two way process with the secondee obtaining industrial experience of benefit to their future research, and act as a channel for industrial take-up of their research. Study leave is available for this purpose.

- **Dong** obtained a highly prestigious 2-year Royal Society / EPSRC Industry Fellowship secondment to Rolls Royce. Two international patents resulted and Rolls Royce are now funding industrial trials with a view to applying the work in their products.
- Study leave enabled **Schlindwein** to undertake a 6-month Royal Academy of Engineering Industry Secondment with St. Jude Medical UK, the second most important world manufacturer of equipment for the diagnosis and treatment of heart arrhythmias. The research involving identification of dominant frequencies on the 3D map together with the analysis of phase of atrial electrograms is now being used to guide ablation for patients at Glenfield Hospital. There is also a route to impact through NICE guidelines for assessing sudden cardiac death risk.

Spin-out companies: TTE Systems Ltd (**Pont**) was spun-out of Embedded Systems research in 2007 with significant investment from the University and others. Intellectual property was exploited via the TTE32 processor family, RapidiTTy toolsets and related training courses. TTE is the subject of one of the impact case studies.

Synchropulse Ltd. (**Lefley**) was established in 2000 and continues to be supported (e.g. by teaching relief) by the Department in developing technology for electric motors, and also received a £250k cash injection from Marubeni Europe plc and Life IC of Rotherham. Several patents from the University were transferred to Synchropulse. New regulations in 2015 will drive demand in terms of energy efficiency for <£1k motors, e.g. small motors for refrigeration and ventilation units, increasing market potential.

Other mechanisms employed by the unit: The Advanced Structural Dynamics Evaluation Collaborative (ASDEC) Research Centre (**Hainsworth** and **Rona**) is the UK's first commercial 3D laser (non-contact) vibration scanning measurement and modal-analysis centre, servicing the automotive, aerospace and space sectors. It will be the only facility in the UK providing 3D scanning measurement services and the only one in Europe to provide modal analysis, modelling and certification services. This unique capability will be provided by the range and spatial resolution of the laser Doppler systems enabling the performance of automatic 3D scans of structures at the Centre as well as the field scans at end-user sites. This high tech non-contact technology enables the diagnostics to be performed in hours compared with the longer turn-around times – in terms of days of traditional multi-channel accelerometry. ASDEC is a joint project between the University and Polytec UK, initially funded by a £1.07 million grant from the **UK Government's Regional Growth Fund** and £1.1M University investment. ASDEC is expected to create over 200 engineering jobs in the UK. An ERDF project of £382k has already been secured.

The University operates an **Infrastructure Fund** to support the acquisition of research equipment. It is open to proposers to bid for equipment that will lead to impact e.g. potential impact was part of **Schlindwein's** case for £40k for atrial fibrillation equipment, and in **Atkinson's** bid for a high temperature furnace for tensile testing machines in support of the development of a strategic partnership with Alstom (both bids were successful).

Recognition and reward: Enterprise is an explicit criterion for promotion and merit awards**.** The potential for impact is now a consideration for appointments. **Hainsworth** and **Dong** had successful professorial promotion cases that were strongly based around their industrial work. Staff undertaking consultancy may also receive financial reward in addition to their salary.

c. Strategy and plans: The Engineering Department has been actively engaged in promoting research impact as we have always had extensive collaboration with industry (and this is based on their respect for our expertise). We value engagement with the industrial community as a source of funding for our research, as the subject for our research activity, as a partner in the co-production of knowledge and as a consumer of research findings and outputs. In explicit recognition of the

importance of the impact agenda, our departmental research strategy document has recently been expanded to include specific goals and plans for supporting impact and our annual research review process now considers activities related to research impact. The Department, together with the College and the University will continue to provide support to help develop relationships with industry; this is seen as an important part of our core business, along with teaching and research. Our 3rd and 4th year undergraduate modules and our postgraduate teaching will continue to be research-led and thus our research is having an important impact on the future generation of engineers. As part of our impact strategy the following main objectives will be pursued:

- Appoint staff with an awareness of and capacity to make a contribution to the impact agenda.
- Shape the Department to respond to the impact agenda, e.g. incentivise in workload modelling.
- Encourage inventiveness, the patenting of inventions, and their exploitation.
- Facilitate staff meeting industrialists through travel funds and organisation of events targeted at industry such as our Showcase Event in February 2013, where we invited a wide range of key industrialists to come and learn more about the research strengths of the Department.
- Continue to negotiate actively strategic industrial partnerships. These involve commitment from the University in people and equipment relevant to the company's interest and concrete financial commitments from the company.
- Stimulate staff to engage further in research based industrial consultancies.
- Continue to encourage participation of staff in Royal Academy of Engineering and Royal Society industrial secondment schemes as a strong mechanism promoting research impact.
- Regularly review the areas of work that are close to having impact to identify actions for driving them forwards, e.g. the "linear matching method" (LMM) is a numerical simulation method wholly developed at the University for accurate life assessment calculations within the UK power generation standard for assessing the lifetime of high temperature plant components. The current methods are inherently conservative and therefore costly. The LMM is less conservative and is already being used by EDF Energy but is now ripe for further development.

We explicitly recognise that these activities require financial support as well as staff time. It is planned to provide travel funds and equipment funding to promote impact. The Department has already had several successful applications for University Innovation Fellowships, which have allowed relief of teaching, and plans to continue with this. Study leave will be granted to allow staff to develop working relations with industrial partners. The Department will continue to work closely with the University's EBDO, which publicises our capability to engage with business and deals with all aspects of contracts, business cases, IP protection and market review. The following strategic developments will be taken further:

- EBDO has launched projects to specifically enable staff to engage with key stakeholders. A number of strategic partnerships are developing in collaboration with the College and the University with the support of the College Business Manager.
- The College is establishing strategic framework agreements with major companies, e.g. with Alstom Power, and with TWI where over £1.5m funding for the partnership in PhD training has been approved by TWI and the University.
- The University is working with ERDF on a new project entitled "Innovation through Research Support Accelerator" (IRSA) which is looking to accelerate the research, development and exploitation of new products, services, technologies, processes and markets for SMEs by collaborating with R&D at the University.
- EBDO have developed resources to identify funding opportunities for industrial collaboration.

d. Relationship to case studies: The insulators case study exemplifies impact through research initially supported though EPSRC, NSF/EPSRC and FP7. Contract research agreements followed, together with consultancy, and led to a KTP with Alstom Grid. Consultancy in stabbing and dismemberment cases identified large gaps in the understanding of how knife sharpness related to the force required for stabbing and of how individual saws related to the marks left on bone. This led to joint projects with the East Midlands Forensic Pathology Unit. Subsequent research was driven by the academic need to solve the research questions whilst being linked to practical cases. The electrostatic precipitators case study originated from a LINK project with National Power and Deakin Davenset Rectifiers (DDR). Subsequently, a Teaching Company Scheme (TCS) was set up with Elequip. Research into the construction and use of time triggered embedded systems was undertaken through a variety of externally funded research projects and a series of PhD projects.