Institution: Queen's University, Belfast

Unit of Assessment:12

a. Context

Drivers for Society

Society today faces a number of global challenges with changes in our climate and environment, our increasing and aging population, and our ever increasing demand for energy. A sustainable future requires efficiency in resources and materials, and the capability to manufacture complex products to support health, mobility and a cleaner environment. Fundamentally these need new materials, efficient manufacturing processes that minimise energy and waste, design processes that maximise the utilisation and value of scarce resources, and technology for producing cleaner energy and reducing harmful emissions. Our research addresses some of the key issues in this broad suite of challenges, in an effort to affect change for the better.

Impact Domains

The impact arising from the research in this submission is evident in the domains of:

- The Environment - Through reductions in waste, efficient processing, emissions, clean energy production.
- Health and Welfare- Through bio-engineering, emissions reductions and mobility
- Economic and Commercial - Through savings in industrial processes, innovative new products, spin-out companies and value added engineering.
- Public Policy & Services - Through understanding of global systems and processes which guide decisions in value of technology.

Types of Impact

There are five types of Impact:

- Generation of knowledge & IP for industry.
- Improvements in efficiency and reliability for industry, reducing costs and increasing profits.
- Increased market share resulting in jobs and inward investment, and spin out companies.
- Increased health & vitality in patients
- Reductions in waste and emissions.

Range of Activities, the problems they address and the insights they bring.

The activities of the 50 staff in this unit are tackling fundamental problems in the general technology areas of Materials, Energy and Design & Manufacture (as per REF5). The solutions developed are directly impacting the domains as above. Most projects are based around an industrial challenge, for example where a lack of understanding of a process, or system, prevents implementation of new technology, and so naturally generates new knowledge from investigations and studies. Examples include:

- Pilot scale polymer processing facilities in **PPRC** which have been used for development of new products and processes within the Northern Ireland Polymer industry (**Harkin-Jones, Menary)**.
- Research on polymer materials and extrusions led to a KTP with Cherry Pipes which won a national award, making significant savings for the company, improving their product quality (**Ngyuen**).
- **CenTACat** covers a number of areas in clean energy and emissions reduction, for example the work on biogas production (**Rooney**).
- Energy generation for transport has supported the development of very efficient hybrid drives (**Douglas, McCullough, Kee**) for public transport busses.
- Insights into biogas systems have contributed to EU decision making processes in policy (**Smyth**).

The range of activities with this sizable group is therefore extensive. Fundamental materials developments bring insights to their behaviour leading to new applications. They also provide opportunities to replace resource-intensive materials, with new lightweight sustainable variants. For example biopolymers developed for the rotational moulding process and now used in the Total Petrochemicals concept car. (**Harkin-Jones, Kearns**).

Beneficiaries and the benefits they received

The types of impact generated by the work affect individuals, companies and the wider population. Individuals have benefited with improved health, for example via the improved hip joint technology. Over 50 companies, both locally and internationally, have benefited significantly from research undertaken by the team. As per the case studies, and other exemplars, this has ranged from local improvement to design or production process, increased profits or reduced costs. The case studies highlight some very exceptional company impact with substantial profits and major international market opportunities and successes (e.g. **Menary**). The wider population has benefited from the reductions in emissions and waste from a number of projects (**Cherry Pipes, Wrightbus**).

Local society has benefited from the medical device related research via educational workshops and training events for hospital staff. Clinicians have benefited from collaborative opportunities to trial and evolution new surgical protocols and tools. Patient comfort and recovery has improved as a direct consequence of the work on hip joints, by reducing post operative complications such as dislocations (**Dunne, Orr**).

Direct economic impact has been via efficiencies in time to market; accelerating the implementation of new technology. Increasing profits by reducing risk, rework and improved performance relates to developments in design methods and new simulation tools (**Armstrong, Robinson, Early, Murphy, Thornhill**). Change in working practice by introduction of new tools and methods has helped companies become leaner, removing lower value processes from their normal practice (**Butterfield**).

b. Approach to impact

How staff engage with users

Staff engage with users in a number of ways, all of which crucially inform research direction. Over 90% of all research projects are sponsored by industrial partners who help to drive and participate in the research programmes. The UoA has a longstanding record of direct industrial funding, and the balance of funding is strongly weighted to industry direct funding.
Engagement with industry and society occurs through education, research programmes, knowledge transfer and direct consultancy. Some 18% of the education portfolio is delivered by industrial practitioners, which allows for undergraduate team projects to be based in industry. The unit is also active in outreach programmes such as the W5 regional public science centre programme on energy and the environment run for dissemination to school children and the general public.

More substantive projects are supported through research programmes. Industrial partners typically either define the problem (**Creative Composites work on thermoplastics**), or are co-creators of more adventurous programmes such as the national EPSRC and TSB programmes (**EPSRC TMAPP, EPSRC Nectise, TSB Hybrid Bus**). These programmes have longer lead times with engagement between academic staff company practitioners and senior management leading to the conception of new project ideas. Many individual programmes have research staff and students based in the company (e.g. **Bombardier, Creative Composites, Rolls-Royce**) and others have led to University spin-out companies (e.g. **ADFertech** via TSB funding, **Walker**)

The industrial research centres play a pivotal role in this: Polymer Processing Research Centre **(PPRC), QUESTOR** Environmental Research Centre**,** Ionic Liquid Laboratories **(QUILL)** and Northern Ireland Advanced Composites and Engineering Centre **(NIACE)**. These centres have strong engagement with industry. In particular most of this research work is led by industrial partners who present problems and academics bring their skills to bear to find solutions and

generate new collaborative ideas from this.

The UoA has organised a number of **major international meetings (ESAFORM, ATIO)** and conferences (see REF5) over the REF2014 period which have been aimed at industry-academia interaction audiences and maximised opportunities for impact. Within the main research centres there is a flexible policy to priorities industrial access to equipment and facilities as well as in-house expertise.

Nature of relationships

Relationships come in different forms, and the unit aims to have a broad portfolio. For example, some projects have research students placed in the company for 2 of the 3 years of their **PhD**, others have shorter periods such as in the **EngD** programmes. The **KTS scheme** has seen partnerships with both **Rolls-Royce** and **Transcendata** to site staff in the company and embed research knowledge. The EPSRC Systems Engineering doctoral (led by Loughborough) centre which includes **Rolls-Royce, Bombardier, Airbus and FG Wilson** as partners. A number of relationships are strategic, such as that established with **FG Wilson (Caterpiller)** and **Bombardier**, who have sponsored the **Royal Academy of Engineering – Bombardier Chair** in Aerospace Composites. Long term relationships have developed with multinationals such as **Eastman Chemicals, Petronas** and **Johnson Matthey**

Follow-through to Impact

Uptake of results by collaborative partners and their success in embedding new practices has helped support generation of new funding and the creation of a virtuous circle. Results and impacts from one project often form the foundation for follow on work. For example, improvements in capability combined with increased sales and reduced costs for several companies was a foundational element in the formation of **NIACE**. As per the case studies, spin outs have also resulted to drive new technology to market.

The Unit embeds exploitation awareness, and all long term concept programmes are built with this ethos. Patent applications are encouraged and growing, and near market potential ideas are driven via '**Proof of Concept'** funding, for which there have been 8 programmes. Direct transfer of knowledge and technology is through the Northern Ireland Technology Centre and the KTP scheme for which over **£1.3M** of funding has been secured.

Staff also take advantage of funding initiatives such as **Innovation vouchers**, provided by **InvestNI**, the regional development agency which provide SME with a first taste of research and development.

Support for Staff and Reward

Discoveries, knowledge and expertise generated by QUB inventors are vital elements in the creation of new products and processes. Staff are directly supported by the **R&E Directorate** on matters relating to potential Intellectual Property (IP) in research results and commercialisation strategy. The **Impact Development Fund** (£3-5k) is designed to support Queen's researchers in developing their collaboration with non-academic partners and the **Business Alliance Fund** (up to £50k) provides specific support for the development of a strategic relationship with potential collaborators for long term engagement. Unit staff have recently been successful in both these categories of funding (**Dunne, Menary, Price, Murphy**)

Staff are encouraged to establish spin-out companies, and several have done so, such as with **Catagen, Vyksen and Blow Moulding Technologies**. Staff typically receive shares from the company and investment from the university. Success is reflected in Queen's becoming the **Entrepreneurial University of the Year** in 2009.

Institutional Support

KTP provides two-way brokerage for companies matching problems to skill sets, new capability and expertise that could be applied to the company. KTP has an excellent system to support proposal submissions and has an almost 100% success rate. It is the **largest KTP centre in the UK** and the unit is one of the largest academic partners, having completed some 20 programmes during the period.

c. Strategy and plans

There are two main aspects to this; Research Activity and Organisation.

In terms of activity, the unit is already moving to address the key challenges outlined by **EPSRC, TSB and central government**, as well as increasing engagement with industry, widening the reach across sectors and application areas. For example, new staff with skills in biomaterials and bio engineering have been recruited to build capability in these areas, and similarly for the energy systems sector. This realignment will allow for future impact in these key challenges. Activity will also refocus through large scale industrial centres and national networks such as **NIACE**, **NCC** and the **EPSRC** centres. This has already begun with some projects for example with the **EPSRC centre in Through Life Engineering Services and in Composites**. Such engagement will be essential in spreading new capability nationally.

Organisationally significant changes have begun with the inception of an **Impact Team** within the UoA which will have responsibility for both identifying opportunities for application of new knowledge and for identifying key gaps and research needs. This is being staffed with experienced research engineers who will work closely with the directors of the research clusters and all our industrial partners. The team will grow the industrial partner base. A new **industrial advisory board** will be established to build on the solid foundation now existing. This board will link with external bodies such as Aerospace Defence and Security (**ADS**) and government bodies. The board will advise on research directions and opportunities.

For long term impact, development of **leadership capability** will be essential and all PhD and Post doctoral researchers will have advanced training in this area. Staff will be encouraged to seek opportunities for **secondments**, such as those supported by the **Royal Academy of engineering in their industrial secondment scheme**. We will continue to make use of their visiting fellowships to keep fresh relevant industrial practices.

The strong track record on **organising and hosting conferences** will be continued; already several international conferences are coming in the 2014-15 timeframe, a prime hosting example being the Royal Aeronautical Society 4th Aircraft Structural Design Conference, 2014 (**Murphy**).

Internally the organisation and operation of PhD and EngD programmes will be brought together using the **Doctoral Training Centre model** whereby PhDs will be focused on needs supported by industry but moreover where a cohort of impact aware students will emerge in the coming generations of graduates.

d. Relationship to case studies

The **Vehicle Modelling of City Buses** is an exemplar of the development of relationships and use of the support infrastructure. Initial engagement of staff via consultancy resulted in small scale projects developing an already successful stream of advanced modelling research, through collaboration on PhD projects and undergraduate projects. Subsequent successes led to a **KTP project to start implementing the technology in Wrightbus**. As noted in the case study, the relationship is building now for future developments through the **TSB project on Hybrid Busses**. The use of the **PPRC as an industrial conduit** is exemplified in the upscaling of activity to apply research knowledge to industrial problems. The technology arising generated a spin out company for the **Rotolog product**, and further direct engagement through provision of training services has spread the technology worldwide. The QUB spin out unit, **QUBIS**, supported the early growth of the company through investment, and advice from the Research and Enterprise directorate helped with **patent applications** and **IP issues**.

Similarly, the other case studies highlight various aspects of the strategy and support structure. The use of **KTP and POC** programmes is shown in the **blowmoulding and hip joint** studies, and all have involved significant support from the KEU for IP issues and collaborative agreements.