Institution: University of Exeter

Unit of Assessment: 15 General Engineering

a. Context

Exeter Engineering works particularly closely with end users as reflected by generation of 50% more industrial research income (e.g. business, TSB, regional development agency) compared with RCUK during the REF period. We are structured into six industry-facing research groups:

1. **Functional Materials Group (FMG)** (lead: Wright), includes **Centre for Graphene Science (CGS). FMG** designs and fabricates novel materials and devices for use in the data storage and communications industries. Users and beneficiaries include IBM, Toyota, Hewlett Packard, ST Microelectronics, Alliance Storage Technologies. Types of impact include a spinout (Theta Technologies), commercialisation of new materials (GraphExeter) and automotive applications of permanent magnet technology (e.g. Toyota Prius).

2. **Materials and Manufacturing (MMG)** (lead: Zhang), includes **Centre for Additive Layer Manufacturing (CALM)**, **Exeter Advanced Technologies (X-AT)** and **Centre for Alternative Materials and Remanufacturing Technologies (CALMARE)**. **MMG** develops new materials, manufacturing processes and systems e.g. for aerospace and defence. This group works very closely with industry at the highest technology readiness levels (TRLs). Users/beneficiaries include EADS, Rolls-Royce, CIFUNSA (Mexico), Dow Corning, and ICI. Impact is mainly in new materials, devices and manufacturing process improvement. **CALM/X-AT** specialises in additive layer manufacturing (ALM) i.e. rapid prototyping, and commercialisation of the processes. The range of beneficiaries and type of impact is gauged by the 220 business assists since 2011; also 3D (chocolate) printing spinout ChocEdge was created in 2012, benefiting manufacturers (e.g. Thorntons) and consumers. **X-AT** works closely with companies on problems such as processing materials and composites recycling (e.g. ColorMatrix). **CALMARE** is a new *Business Technology Centre (*BTC) providing businesses access to Exeter's expertise in production efficiency, recycling, remanufacture, sustainable materials and lean manufacturing.

3. **Water and Environment_(WEG)** (lead: Kapelan), includes Centres for: **Water Systems** (**CWS**), **Energy and Environment** (**CEE**), **Business and Climate Solutions (CBCS). WEG** focuses on water infrastructure and sustainable building design. User groups include UK and overseas water utilities, the construction industry, and cross-sector businesses coping with climate change. **CWS** uses informatics to tackle problems of sustainable water management, and has enduring links with end users e.g. Arup, Halcrow, Yorkshire Water, Hong Kong Water Dept., HR Wallingford and the Environment Agency. Research impact includes decision support tools for emergency management, flood detection and real time network optimisation. **CEE** works with government, local authorities and businesses on improving energy and environmental performance. Users of its detailed future weather files include Jacobs (e.g. Blackfriars Station redevelopment). **CBCS** is a BTC supporting regional businesses (over 100 SMEs to date) to consider, mitigate and gain competitive advantage from climate change. It is steered by practitioners from the Met office, Regen SW and IBM.

4. **Structures and Dynamics Group (SDG)** (lead: Pavic). **SDG** includes spinout limited companies Simpleware and Full Scale Dynamics (originally spun out from Sheffield). It deals with modelling, observation and management of performance of civil infrastructure at full-scale, with emphasis on vibration serviceability, structural health monitoring and human biomedical/mechanical applications. Users include consultants (e.g. Buro Happold), Contractors (Jacobs), facilities operators (Atomic Weapons Establishment, Premier League football clubs), aerospace companies (Airbus) and national research agencies (NASA). **SDG** impact is via development of software, industry design guidance and consulting.

5. **Renewable Energy (REG)** (lead: Johanning). **REG** undertakes research leading to better understanding of the spatio-temporal variation of waves, coupled dynamic behaviour of ocean energy devices, the control and failure of highly dynamic components, integrated

photovoltaics, and new materials for power concentration. It has partnerships with most of the major companies in this sector, e.g. Ocean Power Technologies (OPT), Scottish & Southern Energy, Jacobs Engineering, J+S, Fred Olsen Renewables, Bauer Renewables. Impact has been through substantial changes to OPT work programme and site identification, design of the next generation wave electricity converters and contribution to international standards.

6. **Camborne School of Mines (CSM)** (lead: Wall). **CSM** engages with mineral extraction industries within a context of sustainability by applying research in safety, monitoring for environment assessment and optimisation of mine design and operation. Users and industrial partners include Rio Tinto and Anglo American. Impact is through improvements in safety, economy and reduced environmental impact.

b. Approach to Impact

For Engineering, research problems are developed primarily through interaction with end users and by our industry-focused centres. This in turn helps to stimulate blue skies research.

Business engagement

Direct engagement with users. An example of this was the NEPTUNE project in which **CWS** responded to a critical business problem, i.e. live detection of pipe bursts, and developed a new decision support system. This was trialled with Yorkshire Water and a burst detection system is now being rolled out by United Utilities. Patent applications have been made for both detection systems.

X-AT's engagement with EADS began with a TSB-sponsored project on laser sintering of nylon powders. The resulting new materials and processes were trialled in Airbus aircraft components. A dedicated centre (**CALM**) was established in 2011 with funding of **£2.6m** from EADS, European Regional Development Fund (ERDF), and the SW Regional Development Authority. CALM-enabled processes are now used in safety critical applications e.g. Formula 1. ERDF estimates **CALM**'s a GVA to the UK economy exceeding **£6m**. ChocEdge applied ALM research to the problem of 'printing' in chocolate, a non-Newtonian fluid possessing 6 stable crystalline phases of which only one is pleasing. The company manufactures 3D chocolate printers and expects to sell up to 1000 machines in the next three years with Thorntons having already bought several. In 2012, BIS secretary Vince Cable said, "*British researchers are once again leading the way turning science into a fun and marketable product with great export potential*".

SDG researchers have worked closely with dozens of organisations (e.g. Arup, Jacobs, Seagate) first via consulting, then via spinout Full Scale Dynamics applying research findings to solve problems with vibration serviceability. They have directly fed these experiences into design guidance used worldwide and applied it e.g. to enable an Olympic Velodrome design saving 400 tonnes of unnecessary steelwork.

Consulting and spinouts. Consulting is used as a mechanism for short-timescale interactions with end-users, particularly within **CSM**, **CWS** and **FMG**. Consulting income over the REF period is in excess of **£1m**. In **SDG** the high-end consulting process has progressed to spinout. Spinouts also facilitate direct engagement for impact enhancement, while providing business agility and flexibility. Engineering spinouts SEAMS, ChocEdge, Simpleware, Full Scale Dynamics and Theta Technologies provide efficient channels for creating research impact, and all grew their economic and other impact considerably during the REF period.

Staff and researcher engagement

Doctoral Training, internships and secondments. Engineering hosts eight research engineers (EngD students) in **STREAM,** an industrial doctoral training centre working on water industry problems such as climate change, urbanisation and network monitoring. It also hosts 13 students as a partner in the **I**ndustrial **D**octoral training **C**entre for **O**ffshore **R**enewable **E**nergy (**IDCORE**) which tackles industry-led design, construction, installation, operation, and maintenance of energy generating devices in the marine environment. Newly announced Centres for Doctoral Training (Exeter-led) in metamaterials and water informatics will provide many more opportunities for industrially sponsored doctoral study.

Since 2008, Simpleware has hosted 30 student internships and **MMG** regularly seconds research students to clients e.g. Rolls-Royce.

Knowledge Transfer Partnerships. 31 KTPs have been awarded in Engineering since 2008. KTP impact generation is exemplified by an associate placed with J+S Ltd who now applies the research as a senior corporate expert.

Industry-focused conferences, road shows and publications. **WEG**, **CSM**, **FMG** and **SDG** staff target events with industry focus including hosting them at Exeter (e.g. **CWS** Industry Awareness Events 2008 & 2013). Best practice guidance and articles in industry-focused journals are written specifically for impact while road shows and public engagement are key features of fellowships (Reynolds, Butler).

Industry-funded appointments. At **CSM**, the British Geological Survey supports a Lectureship in Critical and Green Technology Metals (Moore). First Quantum sponsors a chair in Mining (Jeffrey). Rio Tinto (RT) also supports a chair in Mining and Mineral Engineering (Glass). Glass has worked closely with RT to develop his Cave Planner software that has added almost **£500m** value to its operations.

Institutional support and funding for impact

Support to academics. The University provides full support for impact generating activities through the central Research and Knowledge Transfer (RKT) service. RKT has a team of business development and key account managers who support academic engagement with industry users. For example, RKT closely assisted ChocEdge founder Liang Hao to develop the social and economic impact of his research. Hao was also awarded Study Leave by Engineering for research *and* impact development, leading to a successful spinout.

Recognition and reward for impact. The University holds an annual Impact Awards competition. **REG** won the Outstanding Regional Impact category in 2012 for their work with the Wave Hub offshore wave energy device test facility. Impact activities now form part of the annual staff performance development review process and these are now explicitly recognised in the workload model. At least two promotion decisions (Hao and Young) have been strongly influenced by impact.

Funding for impact. Seedcorn funding for new ideas and larger funding to underpin longer term relationships have played major roles in generating the impact case studies. A share of HEFCE Higher Education Innovation Funding (total **£2.1m** for the University), is used to run an Open Innovation Fund competition for impact generating activities. These activities include **£0.2m** for the Centre for Graphene Science to commercialise graphene manufacture.

Large scale investment. The University has invested in capital facilities to enable industry collaboration, in **CALM**, imaging (**FMG**), structures and graphene lab, totalling **> £13m**.

c. Strategy and plans

Exeter Engineering is naturally oriented towards end users and hence creating impact. In line with Government targeting of public investments at an innovation-led, private-sector driven recovery, our key strategy is to contribute by:

- concentrating resources on our existing areas of impact strength distributed over all six Engineering groups, and developing a limited number of new ones (e.g. infrastructure) which are aligned with the key priority areas (e.g. defined by the RCUK and Technology Strategy Board) reflecting societal and industrial needs.
- firmly embedding and supporting impact as a 'third mission' activity of equal importance as education and research (as recommend by the recent Witty report).

Based on this strategy, our specific goals and plans are as follows:

1. Staff recruitment and development. The University has identified Engineering as a crucial discipline for delivering impact. Hence, it has already invested heavily in recruiting staff who can deliver strong impact (e.g. Nash came from QinetiQ, whilst Pavic, Brownjohn and Reynolds brought their spinout company Full Scale Dynamics Ltd with a client list of over 80 blue-chip

companies). This is set to continue as follows and we will:

- target for recruitment academic staff with either a proven capability or potential for strong impact generation;
- support and train all engineering academics in how to generate and evidence tangible impact through their research;
- aim to appoint at least *six additional* senior practising engineers as visiting professors, to work with each of our six research groupings;
- aim to have at least *six* of our academics appointed as industrial chairs (e.g. RAEng), working part time for Engineering spinouts or seconded to industrial positions;
- develop metrics for measuring academic impact, and will associate these with targets and rewards to match those in education and research;
- enhance senior academic engagement with policymaking at all levels.

2. Impact facilitation. These are ambitious plans. Strong support infrastructure, including efficient business processes, access to funds and support by professional services, are vital to deliver them. Hence, we will:

- create a single *point of entry* into Engineering and embrace fully the developing University 'open innovator' policy making sure that we are easy to do business with;
- appoint a dedicated College case officer for each research proposal to facilitate all aspects of impact development from facilitating links with end users;
- use institutionally gathered evidence of impact to prioritise bids for HEIF support disbursed via the University's Link and Strategic Funds, including matched funding;
- streamline the process and help incubate at least two viable service- or IP-based spinout companies;
- set up an Impact and Collaboration task & finish (in 2014) group with academic and business members, with recommendations implemented for REF2020.

3. Business engagement. We will stratify this engagement naturally into four levels:

- *Strategic*, with major multi-national companies at CEO level and requiring investment and co-creation by the University (e.g. IBM, MoU signed July 2013);
- *Framework*, with major companies managed by the University RKT. We will set up these agreements with at least two major companies (e.g. Rolls Royce, Atkins).
- *SMEs*, through Knowledge Transfer Partnerships and by extending our existing Business Technology Centres; managed by the College research team.
- *Consulting*, managed by individual academics supported by the professional services team. We aim to increase consulting activity to £10k per FTE per year.

d. Relationship to case studies

Our five case studies illustrate the diversity of mechanisms for delivering impact across a wide spectrum of users with successes informing impact plans:

- The **Water Case** shows how an impact portfolio can be built based on enduring relationships;
- The **Simpleware Case** demonstrates how research implemented into practice can then acts as a catalyst for new research and is a positive indicator of Exeter's third mission activities;
- The **Agility and Optimisation Case** illustrates the business benefits of research and the synergy with postgraduate training opportunities;
- The **Diagnosing Malaria Case** demonstrates the importance of strategic funding where the impact is compelling and the potential immense;
- The **Climate Data for Building Design Case** draws on expert knowledge of the sector and also illustrates the economic benefits of applied research.

Several of the case study successes also validate Engineering's strategy of freeing up of academic time to develop impact through fellowships (Butler, Eames, Young), study leave, secondments and workload reductions.