Institution: Cardiff University

Unit of Assessment: 15 – General Engineering

a. Context

Impact is embedded in the Unit's culture through our long-standing engagements with end users, underpinned by our curiosity-driven research. Impact is delivered through our three Research and Innovation Themes, which address major societal, economic and environmental challenges. These are: (i) Energy, (ii) Mechanics, Materials and Advanced Manufacturing, and (iii) Health, Security and the Digital World. We focus on engagement with industry, both with large multi-national companies and SMEs. Other key beneficiaries include governments (Welsh, UK, EU), NHS patients and clinicians, and charities such as Arthritis Research UK. We deliver wide-ranging impacts, including: (a) economic, environmental and health, (b) policy advice and international standards, and (c) public understanding. Our impact strategy is part of our five year strategic plan, developed by our Senior Management Group (comprising the School's Director and Deputy Directors) and the Research and Innovation Committee. It is reviewed by Cardiff University's Executive Board and informed by our long-standing, 49-strong Industrial Advisory Board.

b. Approach to Impact

We value highly, and are differentiated by, the industrial experience of our academics, with 60% having spent at least two years in industry. Impact generated from our research has always been a major part of our strategic planning. In 2008 we established an Innovation and Engagement (I&E) Committee and Office (under a Professorial Director), developed our first I&E strategic plan and appointed an experienced Business Engagement manager. These decisive actions led to:

- Creation of six new strategic partnerships (now eight in total), funding three new academics;
- Launch of two major offsite Research and Innovation Centres: the Gas Turbine Research Centre (with QinetiQ) and the Morgan-Botti Lightning Laboratory (with EADS);
- 14 new Knowledge Transfer Partnerships (KTPs), raising Cardiff University to 4th in Russell Group for KTPs (15th in RAE2008); Engineering hosts 50% of Cardiff's total number of KTPs;
- Establishment of our Knowledge Transfer Centre (KTC) in 2009, restructured and enhanced in 2012 as our ***Business Gateway***, giving a single point of contact for all business engagement;
- Doubling of confidential disclosures (to 74 in total), leading to 12 patent filings;
- Refreshed membership of our Industrial Advisory Board (IAB), to align with our key Themes.

Our engagement with key users has been promoted through the following routes:

(1) Strategic partnerships: These are with Ford, EADS, Tata Steel, Renishaw, Ricardo, National Grid, Cogent and National Instruments. We became a Tata Steel "UK Centre of Excellence" (one of nine in the UK) and host a National Grid Centre (one of four). One project with Tata Steel has delivered energy cost savings of £5M/year and CO_2 reduction of 56 ktonnes/year. We also developed CPD Courses for Tata, training over 400 staff over 4 years. Our microwave device models have been built into National Instruments' simulation tools (*Case Study 3*) and our engine design work with Ricardo has led to major economic and environmental impacts (*Case Study 4*).

(2) Industry-Academia Funding Schemes: The Morgan-Botti Lightning Laboratory and our KTC were both funded from our £4M portfolio from Welsh Government's Academia for Business (A4B) programme. We believe KTPs to be a very effective mechanism to accelerate impact via industrial engagement, examples including KTPs with European Thermodynamics, SKF (UK), Modern Water Ltd. and Power Planning Associates (PPA). Our KTPs with PPA and Ford (in waste management) were rated "Outstanding" by the TSB. The portable lifting product developed within our KTP with REID Lifting accounts for 55% of its sales, for which it won the prestigious Queen's Award for Enterprise in Innovation 2013. We have received £2.9M of TSB funding since 2008. We use EU structural funds to engage with SMEs; for example, via the Low Carbon Research Institute and "ASTUTE", a major KT project for high value manufacturing, which has assisted 60 companies.

(3) Major research facilities offering access: We host two prestigious EU Research Infrastructure Network facilities offering access to EU industry: in "Biofuels" (the "BRISK" network, one of only two UK members) and in Micro/Nano Manufacturing ("EUMinaFab" network, the only UK member). Within EUMinaFab we manufactured a critical component of an insulin micropump for Cellnovo Ltd. that enabled the company to win £30M of investment in 2012. The new Morgan-Botti Lightning Laboratory (2011) is a unique UK facility for characterising aerospace components under lightning strikes. The Gas Turbine Research Centre has engaged with over 100 companies,

including Rolls-Royce on new international diagnostic protocols for aviation emissions.
(4) Collaborative research: Since 2008 we have undertaken 92 research projects worth £6.2M with industrial partners, and 3489 contracts for business (total £7.6M); this reflects Cardiff's strong engagement with SMEs, as highlighted by the 2013 Witty Review. We are one of four centres supporting UK healthcare through the NICE Medical Technologies Evaluation Programme. Our research is used by professional sports teams (such as Cardiff City FC) to quantify movement in pre-season screening to significantly reduce incidence of soft tissue injuries.
(5) Industrial studentships: In addition to EPSRC iCASE awards, we make innovative use of our EPSRC Doctoral Training Grant (DTG) and the flagship University's Presidents Scholarships by match funding industrially-supported projects; this effectively doubles our number of DTG studentships. Since 2008, 57 studentships have been supported this way; for example, involving multi-national companies such as Toshiba, Rolls-Royce, EADS, NASA Glenn, Merck and Olympus.
(6) Policy advice and international standards: Our staff advise on Government policy and standards, such as OFGEM Low Carbon Networks Fund Panel (*Jenkins*); BSI and IEC committees on high voltage systems (*Haddad*); Steering Committee of EU "Biofuels" Technology Platform and IEC committee on explosion hazards (*Bowen*). *Nokes* is one of three FIFA consultants advising on international standards for artificial football pitches.
(7) Public engagement: Highlights include hosting the 2012 RAEng Soiree "Engineering a Better Society", attended by the Princess Royal. Our "Engineering for Life" project (EPSRC, £260k) showcased our research on health to over 10,000 school-children. Our research features regularly on TV news and current affairs programmes; for example, the Morgan-Botti Laboratory on BBC's "One Show" and CNN's "Business Traveller"; biomechanics of judicial hanging on BBC's "Horizon".

We identify and optimise routes to impact via our Theme leaders, who report to our bimonthly Research and Innovation Committee, after which we work closely with technology transfer officers in Cardiff University's Research, Innovation and Enterprise Services. Staff impact training and mentorship have resulted in a doubling of our technology disclosures (to 74) since 2008. Cardiff and Sheffield Universities were the first to establish an agreement with the IP commercialisation experts Fusion IP, who mine for innovation, evaluate disclosures, and have since invested heavily in our spin-out companies. We identify, review and publish impact KPIs in our annual IAB review.

Our agile approach to impact opportunities is now enabled through our ***Business Gateway***, which provides a single, first point of contact for business and is resourced to support our academic staff in responding to opportunities with end-users. This "front-door" to business is distinctive since it employs four specialist Technology Translators, who enable business collaboration around our key research facilities, supported by a Business Manager and three technical/administrative staff. It accelerates access and minimises barriers to our expertise and facilities**.** We aim to link the end-user to the relevant academics within one working day, and minimise any bureaucracy (e.g. during contract negotiations). The Business Gateway (and before that the KTC) have supported around 170 companies/year. Recent projects include a radio frequency switch with Thales and United Monolithic Semiconductors, and anti fuel theft devices for the US market with Fuel Defend Global, contributing to 12 new and nine improved products.

We enable staff to achieve (and receive recognition for) impact by incorporating impact in our workload model and by supporting academics through training and impact generating schemes (such as EPSRC's Impact Acceleration Account). Our Business Gateway team support and facilitate all academic staff in their interactions with end-users. Impact is rewarded through the promotion system (for example, *Jones* to Senior Lecturer in 2011, for forensic biomechanics), or financially (such as the share of royalty income from patent licensing). Impact is celebrated through Cardiff University's annual Innovation and Impact Awards, presented by David Willetts in 2012. We have won these awards in every year since their inception in 2008.

We make extensive use of institutional facilities, expertise and resources. We benefit greatly from the business advice and investment of Fusion IP. For example, Mesuro Ltd. (*Case Study 3*) was established in 2009 with £1M investment from Fusion IP. Fault Current Ltd. was established in 2012 with £650k investment from Fusion IP, to provide a unique magnetic limiter that protects utility electrical distribution networks from power surges. We have also exploited the University's £4M venture fund; for example, for the development of novel blood glucose sensors (for patent and development costs, three awards totalling £110k), leading to a major Translation Award from the Wellcome Trust (£890k, 2012). Business development is also supported by Cardiff's Business

Technology Incubator, which was used to assist the development of Q Chip Ltd. (*Case Study 1*).

A further mechanism to support and enable impact is our IAB, established over 25 years ago, which provides us with impact support and guidance tailored to our activities. It comprises senior industrialists from our key stakeholders and collaborators, which meets five times a year to advise on joint research, innovation and commercialisation activities from an end-user perspective.

c. Impact Strategy and Plans

Our Business Gateway is vital to our future impact strategy, since it enables ***further effective business engagement*** leading to industrial impacts of greater reach and significance. We will focus on ***Innovation*** – where we have enormous potential for impact – and we have already integrated innovation into our research agenda. Our Research ***and Innovation*** Committee has guided the composition of our Research ***and Innovation*** Themes by aligning groups with exciting potential for innovation (for example, high frequency electronics and biomedical engineering) and identifying future cross-thematic opportunities. These include novel medical sensors, cell-culture microplate technology and surgical simulation using state-of-the-art numerical techniques. From 2014 onwards we will benefit directly from Cardiff University's £250M "Innovation Fund", including its ambitious plans for new University Research Institutes, which align well with our three Themes (for example, in "Energy"). Here we will explore opportunities to introduce "Open Innovation" models, where the boundaries between industry and academe become permeable. We will continue to contribute to ***regional economic development*** through knowledge transfer (KTPs), EU structural funds and by working with investors (such as Terry Matthews' Wesley Clover Corporation). To implement our impact strategy we have identified the following focus areas:

(1) Entrepreneurship**:** We will drive and incentivise a culture of entrepreneurship throughout our Unit. Over the next five years, our target will be to create several spin-out companies (from our research base) and student start-up companies. Spin-outs will be enabled by: (a) our Innovation Club for early career researchers, (b) identifying academic "Innovation Champions" in each of our Themes, (c) our "Innovation Lecture" series (for example, Dr. Lyn Evans, LHC project leader at CERN, 2011), and (d) mentorship by selected IAB members and Fusion IP. Student start-ups will be supported by our new partnership with the Alacrity Foundation for technology commercialisation, which also involves two new MSc courses in Entrepreneurship.

(2) Internationalisation: Over the next five years we aim to (i) develop two new international strategic industrial partnerships (e.g. with Tata in India), (ii) contribute to international policy through government engagement, and (iii) contribute to three new international standards.

(3) Responsiveness through our Business Gateway: This is so important to our future plans that in establishing it we have already underwritten over £1M of projected industrial support income over three years. It is a truly distinctive feature of our Unit and will be a major contributing factor to our future impact success through its highly agile, and effective, response to impact opportunities.

(4) Embedding Strategic Partners: We will develop *embedded* strategic industrial partnerships, encompassing research, training and employment, utilising mechanisms such as sponsored posts.

(5) Leadership and Advice: We aim to be one of the leading Russell Group universities for promoting integration of research, innovation and impact. We will build on our current activities on policy advice, such as *Bowen* on the Dods-Westminster Innovation Panel, *Jenkins* on the advisory panel for the TSB Catapult in Energy Systems and *Barrow* on the TSB nano-KTN advisory board.

We will foster and develop an innovative culture via seedcorn funding, seminars, advice and mentoring. We will assess our impact success by the metrics and culture set by international impact leaders, from industry (such as General Dynamics) and academia (such as MIT).

d. Relationship to Case Studies

Our four case studies demonstrate the importance of long-term industrial links, institutional support and diverse mechanisms for generating impact, which have helped inform our future impact plans and strategy. Q Chip Ltd. (*Case Study 1*) was developed with ***institutional facilities, expertise and resources*** from Cardiff University and the Cardiff Business Technology Incubator. Acoustic emission monitoring (*Case Study 2*) resulted from two ***KTP awards*** and a number of ***industrial contracts*** to validate the technique. Mesuro Ltd. (*Case Study 3*) was established with £1M investment, including ***institutional investment*** from Fusion IP. Low-carbon engine design (*Case Study 4*) originates from a ***strategic industrial partnership*** with Ricardo.