Institution: Cardiff University

Unit of Assessment: 14 – Civil and Construction Engineering

a. Context

Civil Engineering Research and Innovation at Cardiff University has achieved wide-ranging impact over many years. Our primary users are large companies, governmental bodies and SMEs, although the benefits derived from our work stretch far beyond this main group of users. Our research delivers a broad-range of impact including: (i) economic, environmental and health, (ii) policy advice and international standards, and (iii) public understanding. The Civil Engineering Unit is organised in two Themes, which were chosen to address societal, economic and environmental challenges, namely: 'Mechanics, Materials and Advanced Manufacturing', and 'Environment and Sustainability'.

b. Approach to impact

Two underlying principles of our research and innovation strategy are that (i) the greatest impact frequently arises from curiosity-driven research, and (ii) that proper Innovation and Engagement (I&E) support is needed to maximise impact. In the light of these, we re-appraised our already successful approach to impact and developed a new I&E strategic plan. This builds on our strengths (e.g. existing strategic partnerships) and broadens our routes to impact. This re-appraisal led to the following decisive actions in the period 2008-13:

- Appointing a Director for Innovation and Engagement (I&E), who chairs our new I&E Committee and is responsible for all I&E matters.
- Creating an I&E support office, led by our Marketing and Public Engagement manager.
- Appointing a Business Engagement Manager with excellent business credentials.
- Establishing a Knowledge Transfer Centre (2009-12) for ease of business access; this was restructured in 2012 as the enhanced ***Cardiff Engineering Business Gateway***, which provides a single point of contact for all aspects of business engagement. This Business Gateway has its own offices and five dedicated members of staff.
- Creating the highly successful 'BRE Centre for Sustainable Construction'.
- Strengthening our strategic partnerships with CH2M-HILL, Laing O'Rourke, Environment Agency, British Geological Survey (BGS), Ford and LUSAS.
- Securing seven new Knowledge Transfer Partnerships (KTPs), helping to raise Cardiff to 4th in the Russell Group in terms of the number of KTPs awarded (15th in RAE2008).
- Refreshing the membership of our Industrial Advisory Board to align with our key Themes; this established board consists of 49 senior industrialists of strategic importance to our activities.

Engagement with key users

One of our major advantages, when engaging with end-users, is that over 50% of our staff have significant (>2 years) industrial experience. The credibility this provides, along with our drive to achieve impact, has helped to develop and sustain several highly successful partnerships. An indication of the strength of these partnerships is that six companies, (CH2M HILL, BRE, Laing O'Rourke, Arup and LUSAS) have sponsored Professorial Chairs in the Civil Engineering Unit at Cardiff during the REF period.

Our ***Strategic partnerships*** and ***collaborations*** have led to very considerable impact, as evidenced by the following examples.

- We have deepened our collaboration with BGS, the major partner in the SEREN project (2010-15) in which, by May 2013, 31 enterprises have been assisted, 13 collaborative R&D projects spawned, 2 enterprises and 10 jobs created (also see Case Study 2).
- Laing O'Rourke has initiated major projects based on a new ultra-high performance, fibre-reinforced, cement-based composite (UHPC) developed at Cardiff University. The projects initiated in the REF period include the construction of high rise office blocks in London and pedestrian bridges at level crossings for Network Rail. The same UHPC material has recently been taken up by the Spanish company Abengoa Solar.
- Our numerical concrete models have been implemented in the commercial finite element software LUSAS, and widely used in the design of major projects by international companies (e.g. URS, Atkins Global). Example projects include large Caisson structures in Pohang

Yeongilman harbour (Korea), a major LNG facility in South Korea (KOGAS-Tech), an extension to Glasgow railway station and a number of M4 bridge assessments.

- Airbus has used the Cardiff-developed program VICONOPT for analysing buckling and vibration of structures for many years. Most recently it has been employed in the design validation process for the A350 and A320 aircraft.
- The BRE Centre has generated impact in knowledge mining and Building Information Modelling (BIM). In particular, Cardiff has been instrumental in BRE hosting BuildingSmart UK.
- The partnership with CH2M HILL (previously Halcrow) has resulted in widespread impact in the hydro-environmental domain (see Case Study 1).

Altogether in this REF period we have worked with 30 companies on research projects worth £880K, two government agencies and 20 companies on consultancy contracts worth >£1.4M.

Industry-Academia Funding Schemes: KTPs are one of our main mechanisms for industrial engagement. We have had 7 KTPs, including projects with BRE, Ford and LUSAS. A further KTP project with 'REID Lifting' won the prestigious 'Queen's Award for Enterprise in Innovation in 2013.

We have benefited from other industry academia schemes, including receiving support from the Royal Academy of Engineers (RAEng) industrial placement scheme for a secondment to LUSAS; a Knowledge Economy Skills Scholarship (KESS) with Tata, which resulted in development of a novel vertical tidal turbine; and a TSB funded development of 'BIM-Based Regulatory Compliance Design Environment' with BRE.

Major research facilities offering access. Two major laboratories, developed with EU structural funds, have been accessed by many of our users during the REF period, as illustrated below.

(i) The Characterisation Laboratories for Environmental Engineering Research (CLEER) laboratory has undertaken 47 projects with 23 outside organisations and engaged with 110 businesses. It has created 8 jobs, 6 products or process improvements and attracted £730K investment, e.g. a 'clean up' project for The Coal Authority.

(ii) The Cardiff University Structural Performance (CUSP) laboratory has been used on a wide range of projects e.g. testing new rebar configurations (CELSA), fibre reinforced panels (Laing O'Rourke), London Underground rail benching (Balfour Beatty), motorway bridge hinge joints (Atkins Global) and properties of manufactured sand (Kayasand).

Match-funded studentships: The Unit makes innovative use of its EPSRC Doctoral Training Grant (DTG) and the University's flagship Presidents Scholarship scheme by supporting match funded projects with industry. Since 2008, 21 students have been supported industrially, e.g. with BRE, Alan Griffiths (Contractors) Ltd, Laing O'Rourke, CH2M HILL – Halcrow, LUSAS, Kayasand Ltd, and Forest Research.

Policy advice and international standards: Staff advise on policy and standards: e.g. *Falconer* is a member of the Global Water Security Panel, which reports to Government Chief Scientist (2009-10); a member of the Government Expert Panel for Severn Tidal Power Studies (2008-10); and an advisor to Corlan Hafren Ltd. *Thomas* is currently Chair of the UN International Atomic Energy Agency Technical Committee 'Building Confidence in Geological Disposal of High Level Nuclear Waste' and the UNIDO Chair in Innovation: *Rezgui is a* Member of a working group on Energy Efficiency of EU Smart Cities Stakeholders Platform.

Public engagement: The Geoenvironmental Research Centre's 2013 Queen's Anniversary Prize has received wide publicity. The School hosted the 2012 Royal Academy Soiree 'Engineering a Better Society', attended by the Princess Royal. *Falconer* and colleagues have given: (i) over 180 public talks on the Severn Barrage, flooding and water security, (ii) evidence to the Energy and Climate Change Select Committee of the House of Commons, and (iii) appeared on several TV and radio programmes, including BBC's Countryfile. *Karihaloo's* recent work on honeybee combs has been reported by the media across the world. *Gardner* won the British Science Festival 'You Heard it Here First' and broadcast on The Naked Scientists website. *Thomas's* address to the Royal Society and RAEng Report on Shale Gas have been widely disseminated.

Identification of resulting impact and agile approach to opportunities: Our agile approach to opportunities is exemplified by our Business Gateway, providing a single point of contact for business and resources to support our academic staff in responding to opportunities with end-

users; for example, an enquiry from Vertech International led to *Lark's* involvement in the UK's first recycled plastic bridge, which crosses the River Tweed.

Enabling staff to achieve impact from their research and recognition for impact: Impact generated by academic staff is recognised in the School's workload model and by the receipt of royalty income from patent licensing. Impact is also rewarded through the promotion system (e.g. Impact was a significant factor in the promotion of *Lark* and *Jefferson* to Chairs).

Use of institutional facilities, expertise and resources: Cardiff was one of the first universities to establish an agreement with IP commercialisation company Fusion IP, which provides an expert business development team and an £8.2M investment fund for spinouts. For example, proof-of-concept funding was secured for new water treatment technologies.

Other mechanisms to support and enable impact: Engagement with our Alumni provides a natural route to impact; e.g. a BIM based project with Alan Griffiths Contractors was initiated in 2013 by a former student, who is now a regional manager with the company. The 49 industrial engineers, managers and company directors, who comprise our **Industrial Advisory Board (IAB)**, provide a valuable resource for identifying, guiding and realising impact from existing work.

c. Strategy and plans

We have set out a strategy for managing impact into the future by restructuring our approach to I&E and impact. The first element of this strategy relates to the ***Business Gateway***. This is so important to our future plans that we have already underwritten £1M of future industrial income to maintain and expand its activities for the period 2013-15. This will be a major contributing factor to our future impact success through its agile and effective response to impact opportunities.

A second element to the strategy is to realise the impact from our wide-ranging ***multi-disciplinary work***. Our projects with chemists and biologists on new engineering materials, geo-energy and marine energy, all have great potential impact, which we aim to maximise during the next REF period. Our work with IT specialists on building information systems and on computational modelling techniques also provides considerable scope for future impact. From 2014 onwards we expect to benefit directly from Cardiff University's £250M 'Innovation Fund' and the resulting new multi-disciplinary University Research Institutes, which are well-aligned to our Themes.

We will ***review our existing strategic partnerships*** in order to ensure their vitality and functionality. We also plan to generate new partnerships to expand the scope of our impact. In the UK, for example, we will seek to strengthen our collaboration with Costain, which is part of the industrial advisory group on our new project on self-healing materials. We also aim to develop new international industrial partnerships; this endeavour will be led by our Deputy Director for I&E, who is responsible for developing global industrial strategic partnerships (for example, with Tata/India).

Our strategy also involves greater engagement with our ***IAB***, which constitutes an impressive network of industrialists from whom we can derive new partnerships and collaborations.

We plan to foster a greater ***spirit of entrepreneurship*** amongst our staff, postgraduate researchers and undergraduate students. Our new partnership with the Alacrity Foundation for technology commercialisation, the University's agreement with Fusion IP and new MSc courses in Entrepreneurship, provide the machinery and training necessary to support students/researchers in the creation of start-up companies.

A final element of the strategy is to derive greater ***impact from our Alumni***. Former students create a natural international network of professionals with a strong connection to Cardiff University; for example former students now occupy senior management positions in UK and overseas consultants, contactors and governmental bodies (e.g. Directors with Arup and Atkins).

d. Relationship to case studies

Case Study 1 on 'Improved Flood Hydrodynamic Models' has resulted, in particular, from collaboration with CH2M HILL which has sponsored *Falconer's* chair, part funded six PhD students and partnered Cardiff University on a number of EU research projects.

Work with the Swedish Nuclear Fuel and Waste Management Company, Atomic Energy of Canada's Laboratory, as well as *Thomas's* role as chair of a UN International Atomic Energy Agency Technical Committee, have all led the impact described in Case Study 2.