Institution: Loughborough University

Unit of Assessment: B14 Civil and Construction Engineering

a. Context

Our Civil and Construction Engineering Unit is wholly-contained within the multi-disciplinary School of Civil and Building Engineering (CBE). Staff in this Unit design, implement and deliver novel transdisciplinary research that has worldwide **reach** and **significance**. In the period 2008-13 we have addressed some of global society's most complex and pressing knowledge needs in the areas of civil infrastructure engineering, transport and water and waste management (see REF5). Our embedded approach to impact strategically aligns with the University's ethos of delivering *'Research that Matters'*. All of our knowledge production and dissemination activities are underpinned by a strong commitment to innovation and enterprise. This ensures that our research delivers real value to industry, governments, regulatory bodies and civil societies worldwide by improving performance, influencing policy and enhancing global health and wellbeing. Key **beneficiaries** include *industry* (clients, developers, consultants, contractors, product manufacturers and infrastructure operators), *institutions and regulatory bodies* (governments, professional institutions, improvement and regulatory bodies) and groups that enhance *civil society* (including international agencies and non-governmental, charitable and non-profit organisations).

b. Approach to impact

The hallmark of the Unit's approach to realising impact is its targeted and coordinated strategy of constant collaboration, dialogue and knowledge exchange with beneficiaries in industry, institutions, regulatory bodies and civil society. This approach ensures the continuous co-production of research, secures collaborative commercial partnerships and in-kind support and ultimately informs and enriches everyday life by improving inter/national economic efficiency, competitiveness, industrial performance and societal wellbeing. At LU, the delivery of research impact is a key element of enterprise. All of our major externally-funded projects involve formal collaboration with stakeholders and we exploit routes to market via commercial providers where this offers an effective impact pathway (for example, research funded by Severn Trent Water on leak location and detection in water supply pipes led to international patent applications and the technology being licenced to a leading North American water company for exploitation).

The Unit's **strategy for maximising impact** comprises a mix of institutional mechanisms and School-based initiatives that collectively support impact-related activities. At the University level, enterprise forms the third pillar of core activity (alongside teaching and research) and is central to the University's 2016 Strategy. This requires the Pro-vice Chancellor for Enterprise to work in partnership with the University's Enterprise Committee, the Enterprise Office (EO) and each School's Associate Dean for Enterprise (ADE) to maximise the impact and utility of LU research. In CBE, the ADE closely collaborates with the Associate Dean for Research and works with a committee of 11 enterprise champions and an enterprise manager who collectively identify and promote opportunities for research impact and knowledge exchange by fostering a culture and environment that promotes and rewards agility, flexibility, collaboration and innovation in research. Professional enterprise and media training are valued core components of staff Continuing Professional Development (CPD), and with public impact and engagement are embedded within our academic culture (through annual personal research plans, performance development reviews and promotion criteria). **Pathways to impact, knowledge exchange** and **impact acceleration** initiatives are supported by LU Enterprise Project Group (EPG) grants (£302k awarded to Unit since 2010) while staff **consultancy** is conducted by LU Enterprises Ltd (£371k Unit income in the REF period). These mechanisms, allied to targeted support from dedicated EO staff, facilitate agile responses to opportunities and drive new research agendas. These top-down and bottom-up activities ensure our research continues to deliver maximum impact on global policy and practice.

The diverse professional and academic backgrounds of Unit staff (55% have worked in industry) enables research impacts to be exploited across a broad spectrum of beneficiary groups, including the institutions that govern and regulate the construction and transportation sectors. Strong relationships with industry (REF5) ensure the Unit's research has both immediate and longer-term downstream impacts on practice, policy and performance (REF3b). Our research has directly shaped political, legal and regulatory domains through our representation on British Standards committees and inputs into technical and policy reference groups (e.g. PRI/57 – *Fleming*;

International Geosynthetics Society Technical Committees – *Dixon*; Technical Advisory Panel of the Office of Nuclear Regulation – *Pitfield*; and the All Party Parliamentary Light Rail Group - *Frost*). We influence international R&D agendas via membership of the Global Core Advisory Group on Water and Sanitation (convened by the World Bank, UNICEF and the WHO) – *Cotton,* and OECD and UN investment through our evaluations of water and sanitation projects in low-income countries – *Cotton, Sohail*. Key beneficiaries directly engage with individual research projects through participation in steering groups and advisory committees and public visibility and dissemination is facilitated by LU's open access Institutional Repository (www.dspace.lboro.ac.uk).

We have a particular strength and tradition of delivering impact from *industrially-focussed* research and we work with clients/developers (e.g. BAA, Eurocontrol), consultants (e.g. Arup, URS, CH2M), contractors (e.g. Costain, Balfour Beatty), product manufacturers (e.g. Aggregate Industries, Hanson Structherm) and infrastructure operators (e.g. Network Rail, Manchester Airports Group, National Grid, Severn Trent Water, United Utilities) to develop new **tools, products and processes** that yield demonstrable benefits for practice, policy and performance worldwide. These include: a water leak detection system (Severn Trent Water) – *Dixon*; tools for analysing school transport subsidies and parking provision (UK local authorities) – *Enoch*; UK guidance on design of landfill containment systems (Golder Associates, Environment Agency) – *Fowmes, Dixon*; UK best practice guides for highways testing (Highways Agency) – *Frost, Fleming*; and Public-private Partnership toolkits and guidance for developing countries - *Sohail*. Evidence of the relevance and value of our research to industry is the £1.9m of contract research that was undertaken by the Unit and reported to the Higher Education Business Community Interaction survey in the REF period.

Industry and policy connectivity is further enhanced by our EPSRC (EngD) Centre for Innovative and Collaborative Construction Engineering (CICE). CICE is in its third funding tranche (£12m in total) and in the current REF period 33 sponsoring organisations have provided £1.7m in cash and £3.9m in in-kind support. Each EngD student devises and implements a research programme that produces tangible impacts for their sponsor. Annual public engagement and impact demonstration activities are an integral component of the programme and a prerequisite of the EngD award.

The Unit's research has exerted significant influence at *institutional and policy levels*. Our research outputs have informed inter/national Government and industry reviews that have directly shaped policy, practice and standards worldwide (e.g. REF3b airfield safety case details how our research was integral to the US Federal Aviation Administration's Airport Cooperative Research Programme into runway accidents). Industrial stakeholders and research beneficiaries actively seek Unit expertise and guidance and staff have been invited to join many advisory groups for professional institutions (e.g. the International Geosynthetics Society, the Water Supply and Sanitation Collaborative Council, and the US Transportation Research Board), improvement bodies (including UK Sustainable Aviation and Sport England) and regulatory agencies (e.g. DEFRA, Environment Agency, Department for Transport, Health and Safety Executive, Office of Nuclear Regulation, British Standards and UK local authorities). It is our ability to transcend traditional disciplinary boundaries and industry/regulatory fragmentation that lies at the core of our influence and success.

The Unit's work in water and waste delivers life changing impacts by guiding and supporting the activities of not-for profit charitable organisations and civil societies in both the developed and the developing world. We have an outstanding record of using our research to inform some of society's most complex and pressing challenges. As a result of our world leading research, staff in the Unit have been invited to serve on global advisory groups and hold influential positions in the UK and overseas (*Cotton* is a member of the UN advisory group on water and sanitation and *Smout* is Chair of the Board of Trustees RedR UK). Our impact is exemplified by our work with collaborating stakeholders including the Bill and Melinda Gates Foundation (who recently bestowed a $60,000 prize on the Unit for our work to 'reinvent the toilet'), Water Aid, Oxfam, SNV, Tearfund, World Vision, DFID, the World Bank, the African Development Bank, UNICEF and the UNDP.

Indirect impacts have been realised by enhancing our knowledge capacity and capability through inter/national networks, dissemination events, reports, research training and CPD activities. CBE hosts the European Construction Institute (ECI), a self-funded membership-based institute of Europe's leading engineering construction organisations (including AMEC, BP and Foster Wheeler) that exploits the benefits of research and maximises its impact across Europe (e.g. developing new approaches to modular construction of oil/gas platforms – *Palmeri*). We also lead

and/or play a major role in inter/national **networks** including CLIFFS (Climate Impact Forecasting for Slopes) - *Dixon*, SportSURF (sports surfaces) – *Fleming* and SWITCH (water demand management) - *Smout*. These networks, coupled with our **industry short-courses** (highway testing – *Fleming, Frost*), **events** (sustainable aviation - *Budd*), **conferences** (including the annual Water Engineering Development Centre conferences – *Cotton, Sohail, Smout, Kayaga, Smith, Fisher, Reed*) and **CPD** (200+ registered distance learning students in water and sanitation generating £250k+ income per annum) ensures our research reaches a wide range of stakeholders and individuals. Professional media training equips Unit staff to fully exploit the education and public dissemination potential of the mass media, including television, internet, newspapers and radio, where it is appropriate and expedient to do so (e.g. *Sohail, Budd, Goodier).*

c. Strategy and plans

Our 5-year strategy is to maximise the impact of our research by **extending reach** to new stakeholder constituencies and **increasing significance** by encouraging the highest quality. We will continue to deliver impact through enterprise activities embedded at all levels within the School and the University. Specifically, we will: (1) support the development of **more effective impact pathways** by mobilising a high-level 'user strategic forum' to achieve closer industry and government involvement. This forum is convened by our ADE and comprises highly influential industry figures including: Watkins (Aggregate Industries); Raybould (URS); Embley (Costain); Woolliscroft (Constructing Excellence) and key industrial visiting professors e.g. Waterman, Banyard, Oliver and Porritt; (2) establish the new Loughborough Centre For Sustainable Built Environment (see REF 5b) to provide **a vehicle for extending the reach and impact** of our research; (3) benefit from the University **incorporating enterprise activity into academic contracts**, encouraging greater exploitation by all staff; (4) take full advantage of the opportunities afforded by the University's EPG funding including EPSRC Impact Acceleration Account to **fund technology transfer, staff secondments and dissemination**, enabling greater global engagement with our work; and (5) introduce new processes to **review proposals to strengthen the quality and impact of our research** and prioritise support accordingly. In addition, we will exploit specific commercial opportunities with industry momentum including: a basic Slope ALARMS sensor for developing countries - *Dixon*; sensor fusion algorithms for intelligent transport systems - *Quddus*; and sensors for continuous monitoring of trace water contaminants - *Wheatley*.

d. Relationship to case studies

The success of our impact policies are evident in the case studies returned in 3b. The development of *A low-cost practical sensor for early warning of impending landslides in global environments* has led to improved warning of landslides. This case study acts as an exemplar that demonstrates how School and LU support mechanisms can be harnessed to develop and execute a commercialisation plan. Patenting of the technology, business plan development, marketing, proof-of concept trials and commercialisation received EPG and EPSRC KTA funding, and the EO supported funding applications. *Biogas recovery from treating waste* has led to a new wastewater treatment plant at Unilever and resulted in £2m savings over the last 4 years. This case study exemplifies the success of our approach to industry interaction and collaborative working and how outputs from previous research have been used to produce a solution for a pressing and significant operational need to implement more sustainable processes. *Improved access to urban water services in Uganda and other developing countries* has been achieved through the implementation of change management programmes that were designed using our research. The case study demonstrates how we have improved the health and quality of life of some of the world's poorest people and shows the significance and reach of our work. *Improved global airfield safety* has been achieved through a new method for classifying and modelling commercial aircraft accidents. This has led to safer airfields and airfield operations at major North American airports and informed a UK public inquiry into airport expansion. The case study illustrates how our research has directly and demonstrably impacted on public safety.

These studies collectively exemplify how the Unit: ensures impact by supporting staff in commercialisation; adopts successful commercialisation and policy-shaping models for research exploitation; realises enhanced quality of life and public safety; extends across stakeholder groups and international borders; encourages exploitation of synergies with industrial partners through enterprise activities; and is focussed on the strategic interrelationship of impact mechanisms.