Institution: The University of Leeds

Unit of Assessment: B14 Civil and Construction Engineering

a. Context

The University of Leeds's submission to this Unit of Assessment (UoA) encompasses two academic schools, the School of Civil Engineering (SCE) in the Faculty of Engineering and the Institute for Transport Studies (ITS) in the Faculty of Environment. Across the UoA we generate a wide range of impacts on government, business and society both nationally and internationally. Research in the UoA addresses societal needs in the face of rapid changes, whether environmental, economic or demographic and so has wide impact. We see civil engineering and transport studies as the use of scientific methodology and theory to solve real problems and therefore impact is integral to our operations.

Research in the UoA is organised into three institutes. The **Pathogen Control Engineering Institute** (PaCE) takes a global outlook, investigating the interactions between infrastructure, the environment and human health, with research on resource recovery from wastes, bioremediation, airborne disease transmission, water and sanitation. Key impacts cover: improved process efficiency for water and environmental treatment companies and health services; policy and implementation for national and international bodies (*Case Study 5*); commercialisation of technology and expertise. The **Institute for Resilient Infrastructure** (iRI) is concerned with ensuring that the physical infrastructure systems underpinning our way of life can adapt to changes, both in the way we use them and in the social and physical environment in which they are created, designed, built and operated. Impact is integral to this and key impacts are: enhanced business opportunities through innovation with engineering consultancies; improved investment decisions by government departments; new materials for construction; improved design through incorporating new knowledge in design codes; improved design efficiency for manufacturers and users (e.g. *Case Study 4*). The **Institute for Transport Studies** (ITS) undertakes richly multi-disciplinary, transport-related research. The primary impacts of this research are felt in public policy and services, where research developments inform changes to: (a) official practitioner guidance which must be followed by promoters of transport investment schemes (e.g. *Case Study 1*); (b) benchmarks imposed on the performance of regulated transport infrastructure providers (e.g. *Case Study 3*); and/or (c) 'quasi-regulation' imposing specific requirements on the design of transport products and services sold by the private sector (e.g. *Case Study 2*).

The outstanding highlight of the REF period is ITS's award of a 2009 **Queen's Anniversary Prize** in recognition of *'sustained excellence: 40 years impact in transport research and teaching'*.

b. Approach to impact

We use specific mechanisms to generate impact as an integral part of our internationally-leading research. We also engender a culture that encourages agility in response to emerging opportunities and is flexible in supporting these. Below we focus on **collaboration**, **knowledge transfer** and **wider engagement** and give an overview of our approach followed by evidence.

Our **collaboration with users** delivers impact through engaging with them at the start of the research process, in order to tailor the research to proven need and to embed impact as part of the research programme. These interfaces ensure close alignment between research outcomes and exploitation, and frequently lead to follow-on research. More broadly, we engage our Industrial Advisory Boards, made up of leaders from our target organisations (e.g. Halcrow, Vodafone, Yorkshire Water, DfT, Highways Agency) to advise on the development of our research strategy and operations. A common feature of our research projects is the establishment of industry steering groups who are involved in setting targets and monitoring key milestones. We regularly organise research days (recent topics have included 'Mobilities, Infrastructures and Resilience: Developing Interdisciplinary Understanding' and 'From Individual to Governmental Approaches: Developing Interdisciplinary Understanding on Decision-Making Processes') and conferences to engage users by outlining latest research and identifying future research needs. We have pursued a policy of actively recruiting (and retaining) staff from senior posts in industry and governmental organisations: Evans (World Bank); Wright (UNESCO); Daly (RAND Europe); de Jong (Significance); Tillotson (Yorkshire Water) and similarly visiting professors and fellows: van Vuren

(Mott MacDonald); Worsley (retired from DfT); Quinn (retired from Gateshead Council), Mitchell (Crossrail). These appointments facilitate knowledge transfer and provide an important catalyst to new partnerships.

Both schools are active in the development of strategic partnerships with key players in selected fields. Strategic partnerships with Arup and Indah Water Konsortium have been initiated or maintained during the REF period. Two of the principal themes of the Arup partnership, water (Arup: Mark Fletcher) and transport (Arup: Alistair Gordon), are especially pertinent to this UoA.

Our **collaboration with users** is evidenced through impacts on their policy, practice, expertise and design processes. Project-based partnerships with various transport consultancies (e.g. AECOM Ltd., Arup, Atkins, Jacobs Consultancy, Mott MacDonald, MVA, URS, and Steer Davies Gleave) have given rise to 99 commissions totalling almost £3.5M during the assessment period. These partnerships cover both the delivery of a single project, as well as longer-term arrangements as part of framework agreements covering the procurement of research by government and regulators. With regards to the latter, ITS has an unrivalled profile on key frameworks both in the UK and Europe, and this has played an important role in the impact pathway (notably for *Case Studies 1* and *3*). During the REF period ITS has been appointed to four EU frameworks (involving partnerships with Panteia/NEA (TREN/R1/350-2008), Tetraplan (MOVE/A3/523-2011), pwc (MOVE/A3/350-2010) and Transport & Mobility Leuven (IPTS/2009/J02/24/OC), respectively); two DfT frameworks (led by Arup and URS (PPRO 04/45/12) and AECOM (DfTRG/0008/2006), respectively); a Highways Agency framework (HA114/2/1308); and two PTE frameworks, for GMPTE with Arup (2011-081067) and the TfL Academic Research Partnership.

The recently-launched iBuild project (EPSRC/ESRC: EP/K012398/1) includes nearly 30 organisations drawn from consultancies, local authorities, third sector and government agencies. This has already led to requests for our input from Treasury, Infrastructure UK and the Crossrail Project, and has also led to a CASE Award on Infrastructure with Halcrow. In delivering the Rail Safety & Standards Board (RSSB) T954 project on the value of station security, we reported to a 20-strong steering group involving all key stakeholders in the railway industry, and presented key findings to the Parliamentary Undersecretary for Transport, the Rt. Hon. Norman Baker MP.

We **transfer knowledge to users** through our extensive work with policy-makers, knowledge transfer partnerships, professional development and consultancy. We support and encourage our staff to engage with local and national government, statutory agencies and international organisations, both governmental and non-governmental. Our commitment to this has led to us being recognised as a key national and international centre for policy development in transport, infrastructure resilience and water/sanitation. We have a track record of successful Knowledge Transfer Partnership and the Directors of Research & Innovation and school Research and Innovation Committees actively seek out potential areas for commercialisation (KTPs, patents, spin-outs). Across the UoA we deliver a demand-led programme of professional development to government and industry. We transfer knowledge to the wider public through public dissemination activities and print, broadcast and social media.

Our **transfer of knowledge** is widespread and we select a few examples as evidence. The UoA has provided advice on policy and strategy, for example to the World Bank: design of the first investment program ($200M rural water and sanitation project and *Case Study 5*) using the new “program for results” lending instrument; to DFID: development of the new investment programme for the water sector; to the ORR: benchmarking performance and informing efficiency targets for Network Rail (*Case Study 2*); and to the United Nations: development of the new post-2015 international development targets. Members of staff act as advisors to public and professional bodies (e.g. Infrastructure UK, Treasury, Institution of Civil Engineers, Network Rail, Crossrail, HS2, UK Water Industry Research, World Bank, UN, DFID, UNESCO, Dutch Ministry for International Development, Airports Commission, ORR and Ofgem). Work on validation of a new isolation room design in collaboration with BSRIA (Contact: W. Booth) led to Department of Health (Contact: P. Ashcroft) guidance on isolation room design and construction (14336:1.0:England, Department of Health, 2012). Research on concrete shrinkage (*Forth 1, 2*) has provided new insight into in-service performance and was used in the review of Eurocode 2. Our consultancy activities have involved 46 companies as clients and we use this to develop further impact.

Collaboration with the Central Leather Institute in India using solid waste generated from tanneries, part-funded by Yorkshire Forward, led to construction of a plant in India and subsequent development of this option by a consortium of Water Companies (*Horan 2*). Another water company consortium was involved in research on the recycling of waste screenings which has now lead to full-scale trials by the consortium managed by Atkins (*Horan 4*).

Aqua Enviro Ltd. was spun out in 1998 and provides specialist services, professional development and research in the area of water, wastewater, biosolids and organic waste treatment with clients such as UK water utilities, manufacturing industry, and the waste management companies. It maintains close links to the University and a member of SCE staff (*Horan*) is seconded as Chair. This collaboration entails working closely on PhD and Masters projects providing samples, industry contacts, access to specialist site apparatus and help with technical problems and developing joint EU bids. A further spin-out, ENCOS, was formed in 2008 with IP Group to commercialise research (*Forth 3*) on the use of waste in manufacturing construction materials in order to reduce carbon emissions. The company has now successfully obtained patents, scaled up production and gained regulatory approval. The product has been adopted by several contractors and clients in the UK and international agreements are under negotiation. KTPs include "De-watering in pipe jacking systems" with the Geotechnical Consulting Group Limited which investigated mechanisms to improve the use of slurry based on research in the UoA: eleven contractors forming the Pipe Jacking Association collaborated and used the findings to improve their processes. Through the Water Innovation Hub hosted by SCE (see below) a further KTP, "Connectivity and Resilience of a Large Water Distribution Network" with Yorkshire Water, developed a new visualisation and analysis tool, VASTNet, for assessing the resilience of large scale water distribution networks. This has informed planned investment and was followed up by direct funding from Yorkshire Water.

As part of our **wider engagement**, we have contributed to public debate, for example evidence to the House of Commons Transport Committee on 'Transport and the Economy' from Mackie and Marsden was referenced four times by the Committee Report (HC473); paragraphs 18, 61, 82 & 104. Another example is DfT's 2008/9 'NATA Refresh', which included a peer review component chaired by Mackie that was commended within Government for open consultation (contact: Gavin Gaunt, DfT). ITS research has also been cited by senior policy makers. For example, the Rt. Hon. Norman Baker MP, Parliamentary Undersecretary for Transport, commented on "the latest valuable work done by the University of Leeds" in relation to buses and economic growth (https://www.gov.uk/government/speeches/better-bus-areas-and-bsog-reform-conference).
Engagement is also achieved through the media with the assistance of the University's media team and a few examples are given here. Research on flood vulnerability in several coastal cities internationally resulted in an article on the BBC News website (21/8/12) and the Financial Times (22/8/12). In turn this led to interviews and articles in newspapers and websites in Asia and the specialist business press in North America. Materials research led to a BBC programme "How It Works: Ceramics" on 16/4/2012. On the same day in 2013 (28/1/13), *Mackie* was interviewed on the case for HS2 by Channel 4 News, *Marsden* was similarly quoted on the HS2 case by The Independent newspaper and *Tate's* work on urban traffic emissions was covered by BBC Radio 'File on 4', and BBC TV 'Look North' and 'Inside Out'.

Impact is supported by a number of campus-wide resources. These include faculty-based innovation managers, a specialist team of advisors for Knowledge Transfer Partnerships (KTPs) and "innovation hubs" funded by HEIF. HEIF funding of over £6M has been augmented by university funding to develop impact, initiate innovation pathways and build partnerships and knowledge exchange. UoA 14 is strongly committed to, and indeed hosts, sector hubs in 'water' and 'transport systems'. Whilst impact activities are embedded within the SCE's and ITS's research strategies and cultures, further reinforcement comes from staff promotion and reward systems, which include full recognition of an individual's contribution to Enterprise and Innovation.

Impact through commercialisation is achieved by actively identifying and supporting opportunities within the Schools and pro-active engagement with the University's Commercialisation Services team and the relevant sector hub. These offer a wide range of advice, support and funding including: tailored training; advice on enterprise, innovation and achieving impact; funding to support proof of concept and proof of market; IP generation, protection and management; licensing and partnership with existing companies; company creation; and spin-out. Spin-out can be done

independently or in partnership with the University's preferred partner, IP Group PLC. Across the UoA we have used funding from the EPSRC Follow-on Fund, the University's EPSRC Knowledge Transfer Account and funds such as the Regional Development Agency's "Yorkshire Forward" scheme to support commercialisation.

c. Strategy and plans

Our impact strategy is closely aligned with our research strategy (REF5) and comprises:

- Pro-active engagement with users to develop research that will lead to impact and to identify commercial opportunities. This will involve the University innovation services at faculty and university level and in particular the Water and Transport Systems Innovation Hubs.
- Active monitoring of research outcomes to identify opportunities for commercialisation through spin-outs and supporting such developments through the impact pathway.
- Dissemination of research via high quality academic publications, the professional press and wider media.
- Continuous reflection on strategy and approaches leading to evaluation and development.

Over the next 5 years, areas of particular focus will be:

- Sustainable and Resilient Infrastructure: non-academic partnerships developed through EPSRC projects will be used to influence policy and develop business opportunities in the UK and internationally. This is an important area of joint working for SCE and ITS.
- Water, Sanitation and Health: we will build on our work with UK water companies, consultants, government bodies and international organisations to generate impact on operational efficiency, energy recovery and international policy.
- Future of Simulation: with the stimulus of the 5-year £1.28M Programme for Simulation Innovation (PSI) award from EPSRC and Jaguar Land-Rover (RG.TRAN.484861), we will continue to develop the impact pathway from our world leading motion-based driving simulator.
- Vehicle Emissions: the finding that NO_X emissions from modern diesel vehicles in urban driving conditions are significantly higher than previously thought (*Tate 1, 4*) is transforming the case for low emission zones. ITS will enhance capability and expand capacity in this area.

d. Relationship to case studies

Case Study 1: *"Providing the evidence base for UK and international transport demand forecasting and appraisal".* This body of work has largely arisen from research contracts secured through government and industry procurement frameworks. Over many years, ITS has developed profile and reputation as a key supplier of high-level economic analysis, and achieved impacts through dissemination in government policy reports and industry best-practice guidance.

Case Study 2: *"Research showing the capability of in-vehicle intelligent speed adaptation (ISA) to reduce injuries and save lives influences the Euro NCAP safety rating of new cars"*. This case study arises from the Intelligent Speed Adaptation (ISA) project, which was funded by DfT and MIRA, and illustrates ITS's ability to develop long-term industrial collaborations with a research focus. Similar partnerships, in this case with Jaguar Land Rover, underpin the University of Leeds Advanced Driving Simulator.

Case Study 3: *"International benchmarking and econometric analysis used to set efficiency targets for Network Rail"*. In common with Case Study 1, the origins of this body of work are contracts secured under competitive tendering. In this instance, longer-term partnerships have evolved through secondments to ORR (*Smith, Wheat*), and an academic adviser role at Ofwat (*Smith*).

Case Study 4: *"Novel optimisation significantly reduces costs, increases turnover and reduces emissions"*. This case study shows how cutting edge research, funded from various EU projects and by the users, has been transferred into the users' practices, and has led to significant improvement in product design.

Case Study 5: "*Cost-effective safe wastewater re-use for improved food security".* This case study shows the route to impact through international organisations using our research to formulate their policy and project implementation. The adoption of research outcomes by WHO, the World Bank's consultants and individual countries has led to impact on the ground.