Institution: Newcastle University

Unit of Assessment: 14 Civil and Construction Engineering

a. Context

Beneficiaries of our research span civic and regional organisations through to national and international industry and government. Beneficiaries, organised by research groups, include:

Environmental Engineering (EE) collaborate with the ***water and process industries*** and the ***international public health community***. Key relationships include Northumbrian Water Ltd. (NWL), L'Oreal (see Impact Case Study, ICS 2), AstraZeneca-UK (AZ) and Engineers without Borders. As an example, Newcastle University and NWL have an institutional MoU where EE and Water Resources Engineering (WRE) staff meet regularly with NWL experts to produce agile responses to NWL operational needs. Further, EE has 15 industrial co-sponsored PhDs with NWL, AZ, and three other companies, as well as six EPSRC-funded STREAM EngD students. Beyond industrial impact, *Curtis* provided voluntary leadership in the international response to the cholera epidemic after the 2010 disasters in Haiti. A major EE impact area is reduced energy use in water and waste management, especially coupled with improving public health and reducing antibiotic resistance in emerging and developing countries (partnered with AZ and others).

Geomatics (Geodesy and Geospatial Engineering, GGE) contribute to the ***international climate change community*** with 12 papers cited in the IPCC Fifth Assessment Report (AR5) (*Clarke, King, Moore, Penna*) and membership of ESA's Sentinel-3 Mission Advisory Group (*Berry*). GGE research significantly impacts on ***global land and offshore engineering surveying***, with CASE PhD collaborators including SubSea 7/Veripos, Fugro-Intersite Ltd., Ordnance Survey (OS), British Antarctic Survey and British Geological Survey. Geodetic methodologies using global navigation satellite systems (GNSS) have been used for monitoring oil platform subsidence for Shell, BP, Fugro and Maersk Qatar with income since 2008 exceeding £450k. Contracts from The Survey Association (TSA) assessed Network RTK GNSS system performance in Britain, developed best practice positioning guidelines for the survey profession (now downloaded over 2900 times from TSA's website), and led to delivery of bespoke GNSS CPD courses for all OS land surveyors in 2012. A similar approach has been taken in laser scanning by *Mills* with English Heritage (EH), where partnership that started with CPD provision led to fundamental RCUK-funded collaborative research and developed to include dissemination of best practice (also translated into Japanese) and co-authored publication of EH's *Metric survey specifications for cultural heritage*.

Geotechnical and Structural Engineering (GSE) benefit the ***construction and consultancy industries*** with impacts from micro-scale, where *Rouainia's* research on soil plasticity has been incorporated in the industry standard finite element program PLAXIS^{TM}, through to site scale, where the spin-out company Electrokinetic Ltd. (see ICS 3) won the Energy and Environment Award and awards from both the Institution of Civil Engineers (ICE) and Institute of Highway Engineers in 2013 for innovation and environmental benefits of its novel slope remediation technology. *Elia's* research on dynamic slope stability has been used in the seismic safety re-qualification of the Marana Capacciotti dam (Italy) and *Davie's* hydrothermal mechanical model for concrete has been used to support a nuclear safety case for Magnox. *Gosling* and *Bridgens'* architectural textiles research is currently being incorporated into Eurocodes (*e.g.* CEN/TC 248/WG 4 and CEN/TC 250/WG 5) and their testing, material characterisation and analysis of textiles has been used in a wide range of commercial applications around the world, including the roof and wrap for the London 2012 Olympic Stadium.

Transport Engineering (TE) interact with ***local and national government***, including a strong presence in DfT and regional/national advisory boards for transport policy. *Blythe* works with national government as External Research Advisor, member of Future Road Strategy Expert Group and on Road User Charging for DfT, and has given oral and written evidence to Transport Select Committee. Impacts arise from research into traffic and pollution, smart cards, electric vehicle driver behaviour and road pricing. TE enjoys close relationships with local authorities and transport operators, many through its industry focussed MSc and CPD programmes, leading to funded collaborative projects *e.g.* with regional transport companies formalised through *TransportNewcastle* and achieving impact *via* Intelligent Transport Systems UK.

Water Resources Engineering (WRE) advise and carry out commissioned research for ***flood and pollution risk managers*** at Defra, Environment Agency (EA) and local authorities (see

ICS 1), as well as providing climate scenarios and services to ***UK government*** (ICS 5). WRE impact strongly on the ***insurance industry*** where research into flood risk by *Dawson* was awarded the Lloyds Science of Risk Prize 2012. Research into extreme rainfall led to Newcastle joining the Willis Research Network in 2011 when *Kilsby* was appointed Senior Academic developing large scale models for flood risk over multi-national basins (*e.g.* Danube) for Willis to exploit. Tsunami models developed by *Liang* have been used by ***warning services*** at the EU Joint Research Centre and DPRI, Japan. In addition, the recent appointment of *Galasso* to the GSE group from AIR Worldwide working on seismic risk is now benefiting the ***catastrophe modelling industry***. Work on rainfall extremes and climate change also contributes to the ***international climate change community*** with five papers cited in the IPCC AR5 report (*Burton, Fowler*).

Types of impact range across funded collaborative research from industry and government, knowledge transfer and public engagement, through to a spin-out company delivering award-winning innovative solutions to industry. The majority of our impact arises from collaborative research with industry, either as partners/end-users or through direct funding as development or consultancy activities. Examples of our inter-disciplinary research impacts include:

Infrastructure reliability: Major impacts arise from the EPSRC Infrastructure Transitions Research Consortium where EE and WRE models of national water and waste water infrastructure are used to test strategies for network replacement and improvement for advising utilities and government. Spatial models developed in collaboration between GGE and OS are used to analyse the vulnerability of infrastructure assets (energy, transport, water, ICT) to flood and wind hazards, with specialist analyses requested in 2013 by *Infrastructure UK* (part of HM Treasury) to inform future national provision planning. Our burgeoning leadership here is evidenced by the EPSRC RESNET project's strong impact with National Grid, and *Dawson* and *Kilsby's* membership of the British Energy Climate Change Working Group which advises the nuclear industry on future hazards.

Environmental traffic pollution: The outputs from the EPSRC MESSAGE project impacted directly on Medway Council, which implemented the Newcastle University Integrated Database and Assessment Platform (NUIDAP). Moreover, a Defra contract to Stockport Council analysed the traffic and roadside pervasive monitoring of air pollutants and noise from Envirowatch sensors developed in MESSAGE. Another Defra contract to Newcastle City Council evaluated the impact of Low Emissions Zones and recommended future policy options to reduce the health impact of traffic pollution using the Platform for Integrated Transport, Health and Environmental Modelling (PITHEM) tool that was developed during successive EPSRC SUE projects.

Knowledge transfer into professional practice: The UoA's host School, CEG, acts as the regional hub of the ICE, hosting both the regional office and the ICE North East's evening lecture series. An example of such collaboration enabling uptake of our research into professional practice was a training school for city climate and sustainability officers run in Bilbao under an EU Cost Action. Similar relationships are in place with RICS, Chartered ICES, CIWEM and IHT, all of which accredit various taught degree programmes in our portfolio.

Knowledge transfer to the public: Engagement with the public is achieved through the full range of media, including newspapers, television, radio, internet and public lectures. The Faculty Media Relations Office has made over 100 separate press releases related to CEG research since 2008, with take-up including BBC national TV News, Newsnight, national and regional newspapers and publications as diverse as New Civil Engineer, National Geographic and the Wall Street Journal. The Joseph Lister Award Lecture at the 2013 British Science Festival "What is happening to our weather?" was given by *Fowler*. *Dawson's* activity on cities' climate change preparedness was widely publicised. The Earthquake Engineering Field Investigation Team (EEFIT) lectures disseminate knowledge at both the international and public level, for example Japanese Embassy delegates were VIPs at the Tohoku Earthquake EEFIT lecture (*Wilkinson*).

b. Approach to impact

Our engineering research is problem driven, leading to impact from innovative solutions. Our strategy is based on assessment of societal needs and challenges carried out in concert with a network of industry and government partners. Our approach is to engage stakeholders from the outset so challenges can be established jointly and research outputs co-produced and exploited.

Collaborative research is the source of most of our impact, whether funded directly from industry/government partners or through RCUK projects which operate with expert advisory boards

including industry/government partners to ensure utility and impact. Our portfolio of 49 EPSRC grants active in the REF period has 250 (unique) partners (by definition of providing a financial contribution) and the EPSRC STREAM IDC currently involves six EngD students in industry.

Establishing dialogue is a crucial first step and is achieved through various means, including targeted CPD courses managed and promoted by a dedicated Professional Development Unit (PDU) with four staff; specialist MSc programmes including part-time and distance-learning provision; alumni programmes maintaining contact with graduates in the UK and overseas; engagement with regional and national professional bodies and policy makers; invitations to join strategic and advisory boards for teaching and research programmes.

Secondment is appropriate in some cases to ensure partners are able to fully exploit the latest advances. UoA 14 staff have recently worked for periods of up to six months with Arup, the Greater London Authority, Network Rail, Newcastle City Council, Tees Valley Unlimited, as well as a KTS to an automotive telematics company and a RAEng Industrial Secondment to Fugro.

Formalisation of relationships occurs through MoUs with some long standing partners (*e.g.* Arup, NWL, Willis, OS, Fugro), leading to regular meetings, co-production of collaborative research, long-term placement of staff (*e.g.* OS Research Fellow *Smith-Voysey*, 2006-12), funding of PhDs, support of RCUK programmes and consultancy where appropriate.

Institutional support is critical in involving wider target partners and we work with the Faculty Enterprise Team to pursue a mutually beneficial 'Knowledge Exchange' strategy, encompassing both a 'market pull' approach of business engagement, alongside the 'technology push' approach. The Enterprise Team is also responsible for managing and exploiting the Faculty's Intellectual Property assets. An example of the team's assistance in speedy take up is the establishment of a KTP in CEG with a local SME (Environmental Measurements Ltd.) where the contract was signed in May 2013 following a first approach in January 2013. In this case the associate is a CEG MSc postgraduate and the initial relationship with the SME was formed *via* a dissertation project.

Dissemination of research outputs is by the conventional means of publication in journals and *via* the internet (blogs, twitter, project and Centre web sites), however we also work with our very active Faculty Media Relations Office, resulting in more than 65 independent television and radio campaigns since 2008. A recent venture with an RCUK Living With Environmental Change film award in 2013, undertaken jointly with NWL, demonstrated the utility of our research on climate change and flood risk to business in planning for change and reduction of vulnerability (see http://www.lwec.org.uk/video/flood-force).

Tracking of impact in order to more effectively target users has until now been the responsibility of project staff, for example logging downloads of data or software (*e.g.* free download of our SHETRAN catchment modelling software or UKCP09 Weather Generator) or adoption of industry standard software (*e.g.* PLAXIS™). Formal consolidation of this activity is a priority for the future.

c. Strategy and plans

Our strategy of impact through collaborative research is working increasingly well and so we plan to enhance and strengthen rather than carry out any radical change of direction.

Science Central is a new urban quarter crucial to Newcastle upon Tyne's economic future and a hub for the scientific growth of the City. The University is investing £50M into an ambitious SAgE Faculty building which will house our new Sustainable Urban Research and Engagement (SURE) research centre on an integrated city-centre site. Research, including a new £5M Long Term Urban Research Facility with Decision Theatre, will sit alongside business, enterprise and the community.

National and international approach: We have recognised that Newcastle's location in one of the poorest regions of Western Europe restricts our easy access to major support from local industry and government. Despite this we have had notable successes in our civic and regional mission, and our investment in Science Central is aimed at bringing further companies to our door. We are further developing our links with targeted worldwide major corporations, international consultancies and agencies, such as the insurance industry (AIR, Guy Carpenter), spatial informatics (ESA, Google), energy sector (BP, EDF, Shell) as well as major civil engineering organisations (Arup, CH2M Hill, Cheung Kong Infrastructure).

Impact professional support: Our large portfolio of RCUK projects and their associated "Pathways to Impact", coupled with a large constituency of stakeholders and partners, requires a

co-ordinated and efficient approach across the UoA. We will therefore better marshal our approach to impact by restructuring our in-house professional support team, including the PDU Team Leader (Bird), Graphics and Web Designer (Jeans), Materials/Publications Development Officer (Thompson) and PDU secretary (Brodrick). This effort will be supplemented by a new full-time Impact Officer (Strano), commencing December 2013, with the goal of substantial improvements in achieving, tracking and reporting impact. The post is subsidised by CEG and part-funded by contributions from RCUK and other projects where appropriate. The broad remit of the post is to:

- Co-ordinate KE and KT programmes, linking academics and industry partners;
- Develop and maintain web facilities for advertising and downloads of outputs;
- Organise regional and national seminars and workshops to showcase our research to industry and promote professional practice;
- Maintain a database of partners and end-users, designed to streamline communications with industry where "stakeholder fatigue" is to be avoided;
- Log uptake of datasets, software and models so that impacts can be tracked and reported back to HEFCE *via* the Research Outcomes System (ROS) and statutory reports.

d. Relationship to case studies

Our research strategy is based on the ESE paradigm which provides a framework for inter-disciplinary research itself and also identifies grand research challenges to be addressed. Engaging with end-users at the outset in identifying these challenges provides immediate impact whenever innovative solutions are discovered. The case studies are drawn from across the UoA, reflecting the broad base of impact driven research:

ICS 1 *Underpinning policy and practice for sustainable catchment management.* The ESE paradigm informs our approach to impact in that we seek scientific understanding before engaging in engineering design and advice on policy. Research in this case study addressing land use and flood risk management was commissioned by Defra and the EA specifically to provide an evidence base and understanding of a long standing issue in identifying the scales at which land use change can affect flood generation. This issue had not been adequately addressed by previous monitoring programmes, resulting in *belief* rather than *evidence* based policy. Together with end-users at the EA we have used this new understanding to help them formulate policy and practice.

ICS 2 *Energy reduction for sustainable wastewater treatment.* This study exemplifies our research philosophy of combining fundamental leading edge research in microbiology and chemistry with developing practical solutions at an industrial scale. Our approach is to embed the needs of industry partners with real problems from the beginning of projects, which is best exemplified by our EU IAPP project with L'Oreal (ENERMIN). Similar close relationships with other industrial partners recently resulted in joint-funding by NWL of a major pilot plant (£500k investment) as a key component of our new £5.6M EPSRC Frontier Engineering award.

ICS 3 *Electrokinetic geosynthetics (EKG): revolutionising industry practice in infrastructure management and environmental impact reduction.* This case is an example of the more autonomous impact achieved through the spin-out approach where existing industrial partners were not immediately available for exploitation and the technology was not sufficiently proven. The spin-out was established in 2000 and recent successful applications demonstrate the effectiveness of this longer term approach to impact.

ICS 4 *Best policy, scientific practice and engineering solutions for mining-polluted river systems.* Exemplifies the collaborative and co-production route where initial research, CPD provision and then long duration relationships with, in this case EA, staff (*Potter*; Visiting Fellow in Mine Water Research in EE) has resulted in direct environmental gains and job creation.

ICS 5 *Robust risk assessments of climate change, flood and drought.* An example of both agility (opportunist use of an established method in a new application) and targeted take up of developed methods by industry (consultancy and water utilities) and government (Defra, which funded the development of a web tool for the national climate change projections, UKCP09). The success of a freely provided web tool to achieve wide impact has encouraged our development of further web services, *e.g.* spatial weather generator from EPSRC ARCADIA; climate services for the Caribbean *via* CARIWIG, funded by the DFID Climate Development and Knowledge Network.