Institution: University of Bradford

Unit of Assessment: B14 Civil and Construction Engineering

a. Context

The main types of impact relevant to this Unit appear in the provision of built environment and resources management leading to the improvement of quality of life and the environment. Examples include the development of a novel noise barrier for the reduction of environmental noise, water/energy resource management, and climate-change adaptation and mitigation in urban environments. The Unit advocates both the importance of sustainability for social and physical infrastructure systems and the requirement to provide appropriate technologies and knowledge exchange to address the needs of such systems to adapt to climate change and reduce their adverse impact upon the environment and society.

The primary non-academic user groups and beneficiaries for the environmental research delivery are water companies, Local Authorities, international agencies (such as UNEP-DTIE, UNESCO, and EC DG Research and Innovation) and the Highways Agency. The primary non-academic user groups and beneficiaries for the infrastructure research delivery come from the building industries and steelwork manufacturers. We also have a strong representation on the councils and branches of the learned societies in the UK, US, Latin America and Europe (e.g. ICE, IStructE, ECCS, and ASCE) that have a major influence and impact upon public policy and services. The Unit has representatives on the Standards Committees in the UK, Europe, and the US for the development and revision of the Codes of Practice that have major impacts upon practitioners and professional services.

b. Approach to impact

The University of Bradford has the mission statement *Making Knowledge Work* and this ethos is central to the Bradford Centre for Sustainable Environments (BCSE). The Centre comprises a team of specialists developing the knowledge and capabilities to enable the transition toward sustainable environments. The Centre is based within the School of Engineering and Informatics and includes researchers from the Schools of Social and International Studies, and Life Sciences. We take an interdisciplinary approach that integrates technological, organizational, and societal solutions to meet contemporary environmental challenges. Recent research by BCSE on visual and auditory stimuli in open spaces, how they interact in the perception of tranquillity, and the validation of a tranquillity rating prediction tool has been extensively cited in a Civil Aviation Authority report (2012) in support of the Department for Transport's objective that the Directorate of Airspace Policy should pursue policies that will help to preserve the tranquillity of the countryside. Our innovative multi-disciplinary approach to urban design has been most recently applied to the post-earthquake regeneration of Canterbury, New Zealand.

The Centre is supported by the Research Support and the Business Partnerships teams within the university's Research and Knowledge Transfer Support (RKTS) function. These teams encourage and support business activity and collaborate closely with external businesses and intermediaries. The RKTS function is responsible for administering Knowledge Transfer Partnerships (KTPs). The RKTS commercialization team works with academics across the University on novel research with commercial potential and helps academics to protect and gain revenue from their innovations. The University's intellectual capital originates from the research, teaching, and knowledge transfer activities of University staff and post-graduate research students and through collaborations with partner organizations, e.g. companies, universities, public sector organizations. The University uses a formal project approval process that requires academics to consider 'pathways to impact' (local impact including relationships with local industry, health services, commercial organisations, and the third-mission sector).

Our approach to impact is captured by the School's vision in which we aim to "strengthen our role as an integrated multidisciplinary School through increased global impact and flexibility to inform

and meet evolving regional, national, and international challenges." All staff members are provided with a range of opportunities and incentives to engage with organisations and to increase the impact of their research. The School promotes close links with industry, professional bodies, and policy makers. The development of impact, knowledge transfer, and business engagement is incorporated into individual staff annual performance reviews.

The environmental engineering theme in BCSE focuses on studying the science behind the processes, feedbacks and interactions of current and emerging environmental impacts, and the ways in which negative impacts can be mitigated. Currently the influence of environmental noise, flooding, sediment transport, water transported pollutants, and extreme waves are being investigated. This includes their effect upon both the natural and the built environment, and much of this work revolves around the use of sophisticated laboratory techniques, coupled with the development of new modeling and sensor technologies to allow the development of new mitigation technologies.

An example of the success of our approach to impact is provided by the development and application of acoustic technology for rapid sewer pipe blockage detection, known as *SewerBatt*^{TM} (http://www.acousticsensing.co.uk/). The technology uses sonic waves as an efficient and cost effective way of pinpointing flaws/blockages in pipes. A spin-out company, *Acoustic Technology Limited*, will manufacture and market *SewerBatt*^{TM} and has recently undertaken trials with ten water companies in Australia.

The infrastructure engineering theme investigates the development of new construction techniques, and low-energy construction materials that have higher levels of sustainability, developing new structural analysis and construction methods in order to gain an improved understanding of the behaviour of buildings and structures, in order to improve their safety and to formulate better rehabilitation strategies

The School supports the award of research funds for facilities aimed at producing impact, and evidence of recent success is influencing Eurocode 4 refinements: a £500k investment in the *Heavy Structures Laboratory* has enabled new industrial-academic links. Together with the Universities of Stuttgart and Luxembourg, the *Steel Construction Institute* and *Arcelor Mittal*, the world's largest steel producer, we are collaborating to develop more economically efficient shear connection rules for modern long-span construction. A key part of the project is to test composite beams with degrees of shear connection that are lower than currently permitted. The longest composite beam test ever carried out was performed in the Heavy Structures laboratory and an open-invite seminar was held at Bradford to coincide with the test.

c. Strategy and plans

The strategy and plans of BCSE reflect fundamental and modern engineering research with a strong emphasis on application that will lead to quality and sustained impact outcomes by:

- Strengthening our collaborations with over 130 leading international public and private organizations in Europe, Asia, Latin America, and Africa;
- Developing our relationship with the Centre for Low Carbon Futures, a collaborative organisation that focuses on sustainability for competitive advantage and brings together engineers, natural scientists, and social scientists from a number of universities (including Birmingham, Hull, Leeds, Sheffield, York) to deliver high-impact research on the current themes of energy systems, green growth, and smart infrastructure. The Centre informs policy formation, encourages technological innovation and builds capacity supporting national governments and industry with evidence-based research and delivery of new technologies;
- Continuing our tradition of knowledge dissemination and training, for example through our industrial seminars (e.g. *Steel Construction Institute* on composite construction, EU InfoDays, and co-organization of knowledge transfer events in Brazil) and 'training the trainers' to cascade knowledge;
- Encouraging research directors to actively seek areas of potential impact and to develop these

for the future, inviting people to come forward with their current research or plans.

We shall create more effective knowledge transfer between the University and private, public, voluntary, and community sectors.

- A new programme of collaboration between BCSE and the University-wide Sustainability Enterprise Centre, funded by the ERDF, will involve active business-University collaboration in a new physical space where businesses can engage with researchers. The Centre will provide support for our sustainability research and is closely linked to the *Ellen MacArthur Foundation* on the circular economy via our working partnership with the School of Management. This will facilitate additional business-focused collaborations with a strong sustainability focus;
- We shall encourage and provide practical support for students and staff to be involved in enterprise and new business development.

d. Relationship to case studies

The two selected impact case studies illustrate Bradford's long-term approach to multi-user engagement and demonstrate the global reach and significance of impact work within BCSE. They show research impact on a variety of users, including businesses, individuals, and policy makers, and they reflect the variety of impact work undertaken within the Unit. The case studies exemplify the virtuous circle of engagement with users in research development, analysis, critique and implementation. They evidence the broad nature of our impact within environmental, societal, and scientific spheres, driving the implementation of sustainable resource management and influencing both policy and standards that impact upon pubic wellbeing.

1. Research into noise barrier technology led to the manufacture of a product named 'ArmaSound', licensed to *Armacell UK Ltd* for acoustic linings. The company is able to reuse up to 95% of its production waste to produce new, high-value acoustic products with increased acoustic performance.
2. Research into traffic sound propagation has resulted in more accurate and efficient predictions enabling more effective design and positioning of noise barriers. This has led to a new European Standard, CEN EN 1793-4, on noise prediction modeling of road traffic noise and the revision of the policy on the Calculation of Road Traffic Noise (CRTN) by the Highways Agency. These have a direct impact upon environmental noise reduction on and around motorways.