Institution: Liverpool John Moores University

Unit of Assessment: 16 Built Environment and Architecture

a. Context

The research activities of UoA16 are based at the Built Environment and Sustainable Technologies (BEST) Research Institute within the School of Built Environment at the Faculty of Technology and Environment. The Institute encompasses an international, multidisciplinary team of established academics in their respective fields. The main research aim for this assessment period is to consolidate and advance our research base to cover the main types of impact, including:

i) Contribution to new and innovative methodologies, new marketable products, practices, process development and systems, *for example*, by establishing novel multidisciplinary non-invasive sensors approach or by introducing a new process and industrial prototype systems;
ii) Improvement of existing products, *for example*, by extending functionality, reliability and lifetime, or by introducing appropriate novel monitoring and automation algorithms or structures;
iii) Improving of current practices and policies, *for example*, by providing international studies on new the value of cities, their contribution to national economic competitiveness and their national economic contribution in future;
iv) Improvement of efficiency and cost, *for example*, by reducing process time and energy usage through new microwave techniques, or by improving the design/monitoring of a system.

BEST has three committees; (1) Executive Board Committee represented by the Dean of Faculty of Technology and Environment, School and BEST Directors and Chair of the Industrial Steering Committee. (2) Industrial Steering Committee represented by the industrial partners, School and BEST directors. (3) Management Committee represented by the Heads of the Research groups.

The industrial steering committee (consists of 17 members of whom 11 are from our key industrial stakeholders e.g. United Utilities, Balfour Beatty, Mechan Controls, Biofuel Wales, BAM Construct UK, Carillion PLC), meets annually where the unit's academics and the industrial partners engage with exchange of ideas and the feedback from industry helped in consolidating our collaboration with flexible approach with industry in terms of establishing a joint research and development program, provide bespoke solutions, knowledge transfer partnership (KTP), consultancy and product license agreement. This has led to fruitful and strong collaboration with industry to be continued during the REF period and beyond.

The main non-academic users of the unit's research includes companies working on: energy from waste (e.g. United Utilities, Stopford, Biofuel Wales, Longma Clean Energy), supply chain procurement (e.g. Fusion 21, Alder Hey Hospital, Wirral Homes), water/wastewater and environmental solutions (e.g. United Utilities, Hydro International-USA, Acondaqua-Spain, Ashleigh Farms-Ireland), construction and property enterprises (Redrow, TechnoBees-Turkey), sustainability and facility management (Ministry of Defence, Liverpool One, Amey Group), health and safety (House of Parliament, Council of Gas Register, Public Health UK, Fire and Rescue Services), asphalt and aggregate (Tarmac, Cemex-Mexico, Lafarge-France, Balfour Beatty), manufacturers (Sairem-France, Finnings, Mechan Controls) and software companies incorporated non-invasive sensor for real time monitoring (MedePad, Xpertrule, Animalia-Norway, Faccsa-Spain). BEST consists of five research groups working closely with industry;

1. The Liverpool Centre for Environmental Technologies. The group offers companies' bespoke and focused research on water/wastewater/environment.as well as consultancy services.
2. The Liverpool Centre for Material Technology. The group provides a wide range of services with focus on research and development into heavy building and road surface materials.
3. Facilities Management, Property and Planning. The group provide contemporary, relevant and meaningful research to the practice of facilities management, property and planning in the international business environment.
4. Construction Management and Economics. The group comprises research across a range of topics, including: Lean and Agile construction, stakeholder management, project performance, quality management, risk management, sustainability attitudes and behaviours, financial aspects in construction and multi-cultural project environments.
5. RF and Microwave. The group focuses on multidisciplinary activities related to environmental, sustainability and renewable energies by providing the industry with complete system solution using novel microwave technologies and non-invasive real time sensor solutions.

In addition, the unit also has a dedicated team (the European Institute of Urban Affairs) whose

impact activities are primarily dedicated at shaping the UK/EU urban policies.

b. Approach to impact

The industrial collaboration has set as part of our research mission, as a result we have organised and structured our activities to strengthen such collaborations and to be embedded in every project undertaken and published outputs.

Staff are supported (e.g. by facilities, equipment, PhD scholarships) and rewarded for achieving impact through LJMU's promotional routes. Industrial engagement is a recognised component of academic activity within the conferment criteria for Professors and Readers in the University. When appointing a new staff member, priority is given to a candidate's potential and experience in making industrial impact through research. In addition, the university's policy ensures that all staff involved in commercialisation will receive a proportion of the licence revenue. The main areas of external impact of BEST is achieved through industrial collaboration and a substantial external funding. The main established mechanisms to develop impact, are:

i) Direct collaboration with industrial partners, e.g. Fusion 21, United Utilities, Biofuel Wales, Inventure, Animalia/Sintef-Norway via KTP, consultancy and license agreement.
ii) Collaboration with industrial partners on research projects funded by third parties (e.g., EU, EPSRC, TSB, Carbon Trust, Gas Safety Trust, Norwegian RC, UK/US Ministry of Defence) through research and development, networking programs and staff secondments.
iii) Dissemination jointly of the main research findings in high quality research journals, thus enabling worldwide access to the results and maximising the impact.
iv) Development of innovative technologies, processes and protecting the findings via patents, reports and policies.
v) Prioritisation of the allocation of internally available resources,
vi) Presentation of the unit's capabilities and current research ideas to industrial partners at various user-oriented meetings (KTNs, TSB workshops, industrial networks) and invited talks.

The types of impact that this unit of assessment utilise can be illustrated by the following examples,

- Contribution to the development of new and innovative methodologies and process for the generation of energy from waste with high efficiency. E.g., EU research for the benefit of SMEs, *"Release of Sugars from Cellulosic Biomass by Microwave Plasma Technology for the Production of Bio-ethanol",* EU Contract-232080, €1.05M, 2009-2011. Collaborators include (Biofuel Wales, PERA, Technosam-Romania, Fraunhofer-Germany, Dará-Spain and Dipolar-Sweden. EU research for the benefit of SMEs, *"Advanced Microwave Plasma Gasification of pig and cow manure for cost-effective of biogas generation"*, EU-Contract-315604, €1.35M, 2011-2014. Collaborators include (Ashleigh Farms-Ireland, Acondaqua-Spain, Sairem-France). TSB projects, e.g., *"Development, Design and Deployment of a Demonstration Scale Microwave Plasma Gasification Plant for the Generation of Low Carbon Energy from Waste",* Project No: 101169, £1.75M, 2012-2015. Collaborators include (Stopford, Finnings, and United Utilities). Project No: TP AE211B, *"Second Generation of Bio-Oils Pilot Plant Using Atmospheric Microwave Reactor of Free Fatty Acids",* £575k, 2010-2012. Collaborators include (Longma Clean Energy, Waste Catering and Xpertrule), TSB-KTP, with Alderhey hospital, £124k, 2009-2011, United Utilities, £140k (2008-2010) and Cokebuster, £176k (2013-2016),
- Contribution to the development, Improvement of existing products and extending functionality and analysis in water and wastewater. For example, direct fund from United Utilities on *"Biological Nutrient Removal of Phosphorous from wastewater"*, 2010-12012, £75k. EPSRC Industrial CASE studentship in collaboration with Hydro International, EP/H50138X/1, 2009-2012, £100k. TSB-KTP001705, *"Develop necessary knowledge to design and operate a sustainable biological phosphorus removal process for wastewater treatment using regenerated carbon source from sewage sludge*", 2006-2009, £180k.
- Contribution to the improvement of current practices and policies, e.g., "*Secondary Growth Poles in Territorial Development*", EU-ESPON 2013-15, £500k, 2010–13. "*Investigation into regeneration sector's response to the credit crunch and recession"*, supported by the Northern Way's Regeneration Momentum Programme, £40k, 2009–10 and "*A study into the impact of the Credit Crunch Department of Communities and Local Government"*, £60k, 2008–2009. European Industrial Academia Partnership Pathway (IAPP), €750k with partners from Manros-France to enhance the productivity of green product for healthcare, 2011-15.

The engagement with key users takes various forms. These include industrial steering groups

within externally funded projects, regular project progress meetings, preparation of reports for industrial partners, and presentations at various industry-oriented events.
Through direct engagement with world-leading organisations, BEST research institute constantly monitors the latest industrial needs and technology trends. New opportunities are regularly evaluated for new research directions and used in project formulation. When undertaking the impact activities, BEST makes use of institutional resources whenever and wherever possible. This includes, for example, LJMU's Research and Innovation Services unit, which has assisted in developing collaboration contracts, IP and Consortium Agreements with industrial partners.

c. Strategy and plans

The primary goal in relation to future research in the unit is to grow research of both high academic quality and high industrial impact. The unit has developed a clear strategy during this REF period and is actively implementing it. Priority will continuously be given to develop research in the areas of national, EU and International importance. The plan is to strengthen the links through the joint projects, to understand the industrial needs in-depth, and then to expand the collaboration by designing more mutually beneficial projects. The long term goal is to form a strong inter-dependence between the unit and industry and to have a continuous input from the Industry.
The unit has recognised that the industrial impact plays a central role in the long term viability and vitality of its research. Both the strategy for achieving impact and the impact plan of the unit are based on the following premises:

- Use industrial impact as an essential criterion when selecting new research projects and directions, allocating funds, staff, and other resources, and promoting staff.
- The BEST industrial committee will have a role in ensuring all projects are (a) relevant to industry, (b) have industrial partners and (c) have a steering group. Strengthen the links with industry through researcher and PhD student secondment, participation in industrial consortia and project progress meetings.
- Align the research with the needs of industry that are of national and international importance.
- Be agile and proactive in looking for new opportunities following the changing needs of industry.
- Publish research findings in journals/open access/conferences of high industrial relevance. Use every available opportunity to disseminate research results at various user-oriented meetings.
- Spreading the impact culture and good practice internally via a variety of measures including training in evaluation techniques; and annual staff professional development programs.
- Continue to foster and implement our research quality at national and international level e.g. Prof. Michael Parkinson's (Director of the European Institute for Urban Affairs) appointment as a Board member of a new organisation set up by the Prime Minister, 2013 to help international investors identify and fund regeneration opportunities in the UK.

d. Relationship to case studies

The first case study, drawn from the European Institute for Urban Affairs which has close link with Group 3 in BEST, demonstrates how the undertaken research evidence, analyses and advocacy have shaped urban policies and decisively influenced policy makers in its city region, the UK and Europe. The research work at international, national and local level has underlined persistent themes: the value of cities, their contribution to national economic competitiveness and the potential of the regeneration of declining cities to increase their national economic contribution in future. The findings has had a major impact upon, and brought a range of benefits to, the wider community by influencing government policy and improving public understanding of urban issues.
The second case study illustrates direct impact and engagement with industry. The demand for biofuels and alternative energies is increasing globally as a sustainable source of energy is sought for the future. Energy from crops is no longer a viable option due to the increase in wheat prices. Scientists at BEST have managed to use novel and efficient microwave systems for converting waste (biomass, food, animal) into energy.
The third case study presents the development of a novel, real-time non-invasive sensor platform for various sectors including water utilities, food, safety and defence. Current approaches include often suffer from low reliability, sensitivity and accuracy, combined with infrequent measurements and high cost, all of which hinders their industrial application. Hence, to meet the current industrial demand we have developed and implemented a new non-invasive sensor platform based on the use of electromagnetic waves meeting the industrial needs.