Institution: Loughborough University

Unit of Assessment: B8 Chemistry

a. Context

Loughborough University's (LU) Unit of Assessment B8 (Unit) is wholly based within the Department of Chemistry. It exemplifies LU's Institutional strategy of delivering *'Research that Matters'* by engaging in work involving a wide range of external public and private stakeholders, in partnerships that are strategically aligned to our themed research imperatives (see section b). Typically, during the REF period, some 40% of our research activity has been industrially funded, ensuring the growth and translation of our analytical and radiochemistry specialisms, and fostering new collaborations with partners in areas as diverse as the health and medicine sector, environmental agencies, the energy industry and national security agencies. Our impact manifests itself in spinout companies, new/improved products/services, environmental risk control and policy debate.

b. Approach to impact

In 2009 the Unit focussed on the following themes: Energy, Environment, Health and Security. The driving force behind this approach was a self-critical analysis of the results of RAE2008, augmented by an evaluation of the established research strengths within the Unit. The choice of these themes resulted from feedback obtained both internally and externally to the Unit, and was principally driven by the intention to impact areas of acknowledged national and international significance. In order to maximise the reach and impact of each theme, "theme leaders" now oversee activity in each of the four areas and work closely with Associate Deans for Research (AD(R)) and Enterprise (AD(E)) at School of Science level, as well as the Enterprise Office and the five virtual interdisciplinary Research Schools at University level. This has not only facilitated increased collaboration across campus, but also with other centres of excellence regionally, nationally and internationally.

We have many examples of staff successfully engaging in collaborative projects with industry to provide IP and prototypes, therefore directly affecting the performance and practice of the partners. These examples also demonstrate an agile approach to funding on our part. We employ internal, industrial, European, RCUK and Government funding as appropriate in order to maximize the interactions, all of which will have made full use of the University's Enterprise Office to initiate the links, establish the support or secure the contracts. To illustrate the range and scope of such collaborations and ventures, the following three paragraphs highlight three different approaches to impact.

Collaboration with partners whose requirements naturally overlap with the acknowledged expertise of Loughborough researchers: examples include the joint activities of Prof. Sharp and Dr Reid, work which has directly benefited from the Unit's thematic approach to encouraging collaboration (in this case involving external partners as diverse as *The Institute of Ophthalmology*, *Physikalisch-Technische Bundesanstalt* and LGC Ltd) and from the financial support of the University's *Enterprise Projects Group* (EPG). Their activity has focused on elemental bio-imaging and cellular metallomics, and has received funding from a range of partners. Thus far it has resulted in two patents, one of which has been licensed to the US company *Electro Scientific Industries*, a globally leading provider of laser microtechnology. Their on-going work has recently received KTP funding to enable technology transfer to LGC Ltd and EPG funding to further develop its IP in the area of nano-flow mass spectrometry interfaces, exemplifying our approach to both fostering and then maximising the impact of our work. In another study, collaboration in the development and application of field-asymmetric waveform ion mobility spectrometry combined with mass spectrometry (FAIMS-MS) was initiated in 2008 between *Owlstone Limited* (UK based manufacturer of miniature FAIMS devices), *Agilent Technologies* (a global leader in analytical instrumentation), *AstraZeneca R&D* and Loughborough University (Prof.Creaser and Dr.Reynolds). Not only has the construction of prototype interfaces for combined FAIMS-MS been achieved, such has been the success of the collaboration that the launch of the first commercial product is imminent.

Collaboration in areas where existing expertise has been adapted to partners' requirements: this approach is well illustrated by two cases involving companies specialising in quite different aspects of fuel technology. In the first example, collaboration between Prof Thomas

and *John Hogg Technical Solutions* (JHTS), a leading manufacturer of marker chemicals for the international petroleum industry, was driven by JHTS's sponsorship of two PhDs within the Unit, and the later employment of one through the KTP route. As a consequence, this collaboration has led to development of new fuel protection technology, the filing of a patent on new ion-chemistry systems, and then, in partnership with Kings College Hospital, described the translation of this technology to toxicity screening. The expertise of the Loughborough Enterprise Office ensured the research delivered the capability to JHTS to generate a new market-ready product. In the other example, Dr Christie worked in partnership with *Cynar plc* on their key interest, the production of synthetic fuels from "End of Life" plastics. This work has resulted in the design and commission of lab-scale models of their pyrolysis plant to monitor and evaluate the processes involved. Crucially, it brings together synthetic and analytical expertise, evaluating the basic science whilst working towards the partner company's goal of optimising the future efficiency of the expanding number of *Cynar's* plants in the UK and Europe.

Development of, or interaction with, LU spin out companies: in some cases such companies have formed directly from Unit activity. For example, *Intelligent Energy* is one of the Case Studies while *Charnwood Molecular* is a custom synthesis provider which started within the Unit in 1998, before moving to larger premises in Loughborough and recently (2013) expanding to a site in Nottingham's "BioCity". Both ventures continue to maintain strong links to the Unit. *Enviras* is the latest (2010) company to start within the Unit; housed in the Chemistry building, it is one of very few UKAS-accredited facilities capable of performing Hazardous Waste Acceptance Criteria testing of radioactive samples. It has already secured several prestigious contracts, among them land remediation on the Mid Cornwall Ecotown project (*Imerys Minerals*), radiochemical decommissioning of the *AstraZeneca Charnwood* laboratories and development of the national standard for Cr and Mn analysis in drinking water (*Water Research Council*). Its most recent high profile commission involved characterisation of radioactive beach particles close to Sellafield. The Unit seeks to facilitate and support such endeavour, until the companies grow to the point where a more spacious workplace, either on or off campus is needed. Collaboration between the Unit and spin-out ventures originating in *other* Units is also crucial and actively encouraged. A good example is the on-going interaction of the photochemistry group of Dr Worrall with *Laser Optical Engineering,* who specialise in the development of novel laser-based imaging products. The result, exemplifying our commitment to the Security theme, is *ExDtect*, a field deployable cargo scanning system that requires minimal operator expertise and intervention. After having undergone encouraging trials at UK airports, and boosted by recent TSB SMART funding, together with recognition at the "Counter Terrorism and Specialist Security Awards" in 2012, the full impact of this technology will shortly be felt.

The thematically invigorated approach to impact is ably demonstrated through successful patent application and filings. In addition to the examples noted already, the REF period has seen the Unit file patents in areas as diverse as magnetophoretic separation, catalysis, a mass spectrometry interface and a high temperature supercapacitor. The Unit has employed the institutional IP Office to guide it through the searching and filing of these patents, and has also made use of Enterprise Office-administered HEFCE HEIF funds to fund the initial infrastructure to support developing relationships. The AD(E) advises and guides staff to university support available from the Higher Education Innovation Fund and EPSRC Impact Acceleration Accounts, and currently five staff are engaged with this funding stream. These include projects as diverse as the development of elemental imaging techniques (Sharp, Creaser), building a business case and market analysis for novel flow reactor technology (Christie joint with Manufacturing Engineering) and patenting work on a Skin Pen for non-invasive in-vivo sampling (Thomas).

c. Strategy and plans

The Unit strategy for developing Impact derives from two principles: (i) learn from the success of past endeavours, such as those outlined above and in REF3b and (ii) engage with the University's stated research priorities, as these align with UK and international imperatives relevant to the Unit's expertise. On the latter point, the Unit focus on specific research themes has not only seen strong crossover with the virtual Research Schools *during* the REF period, the themes map strongly with the six *future* research "Challenges" recently identified at University level. This close interplay of Unit and University has facilitated, and will continue to facilitate, the generation of Impact in several ways. Firstly, it focuses effort in defined areas that are targeted by Unit, School and University resources and it encourages collaboration *within* the Unit in order to access said

resources. Secondly, it strongly encourages interdisciplinary research *across* the University to achieve Impact in areas where traditionally there was little or no research overlap. Finally, it provides administrative, technical and infrastructural assistance.

Enterprise and impact inform new staff appointments and the development of current staff; all staff review annually their enterprise and impact targets as part of their Performance and Development Review and Personal Research Planning. The Unit "Theme Leaders" are viewed as vitally important in the identification and shaping of new projects and our thematic approach is intended to drive continuous process improvement in our approach and capability. Furthermore, the thematic approach *itself* will be scrutinised and constant critical review of the quality and relevance of our themed research will result in evolution and adaptation**. Consequently the Unit is investing in the development of new research leaders to deliver both research and enterprise impact.** For example, Dr. Christie was appointed AD(E) for School of Science in 2012, Dr. Wijayantha has recently been appointed LU's Research Leader in Energy, while Dr Buckley is an EPSRC CO2Chem Network Academic Fuels Cluster lead. In addition, the latter two both won places on the EPSRC funded Loughborough University "Developing Leaders" programme, where the emphasis is on developing impact through collaboration, and have established a model for the further development of our staff. Future academic appointments will strengthen our research themes and in due course the underpinning physical structure will be enhanced by the Chemistry Relocation Project, a significant and ambitious multi-disciplinary and consolidated research centre.

Identifying new partners continues to be at the heart of the on-going refinement of our research themes and is thus a crucial component of our future strategy for impact. Another critical component stems from the need to assess the full impact of work in progress. Many of the projects noted in REF 3b are at stages where their established impact will continue to grow (e.g. via commercialisation) as they fully mature over the coming years. In such cases the Unit will continue to benefit from the dedicated support that is provided, via the Enterprise Office for IP Commercialisation and knowledge exchange, allowing for a full range of interactions with the outside world via consultancy activity, knowledge transfer partnerships, patenting, licensing, strategic business relationships and business development. Our intention is to maintain and enrich our partnerships and seek to maximise the impact of our current activities. We are confident in our ability to do this using both internal mechanisms within the Department and School (through the AD(E) and recently formed School Enterprise Committee) and University level programmes, where funding through Enterprise Projects Group is competitive and mentoring is offered at all stages of research through to impact. We have selected three different Case Studies for REF 3b to demonstrate the success and reach of our approach, **and the experience and expertise gained from these ventures will be applied to our current set of emerging high impact projects over the medium to long term**.

d. Relationship to case studies

The three case studies exemplify the Unit strategy for Impact, and illustrate that enterprise in its broadest sense has been an established element of our operation over the last 20 years. *Intelligent Energy* (spin out, section b) grew from original collaborative research between the Departments of Chemistry and Aeronautical and Automotive Engineering. The concept was developed within the Unit and staff were encouraged to grow the business within the current Chemistry estate. Since the mid 1990's the Unit has trained and developed many of the current staff, and with Loughborough University support, *Intelligent Energy* relocated to the campus's Science and Enterprise Park, where it has grown to be a substantial employer in the local area with a truly international presence. Strong connections/collaborations continue between the Unit and the company. Radiochemistry has been an acknowledged area of research excellence within the Unit for over 40 years; its expertise has been sought by national and international bodies associated with framing policies on nuclear waste management, and it supplies expert opinion and advice and post-graduate trained specialists to numerous companies and bodies. The Forensic Case Study has developed completely within the REF period, and is a role model for the Unit's research, enterprise and impact strategy. Building upon initial research discoveries (pump-primed through the allocation of DTA funding), Dr Kelly has developed a range of research partnerships and a suite of new forensic techniques. Augmented by LU's Enterprise Office with resources (EPSRC Knowledge Transfer Account and HEFCE Higher Education Innovation Fund) and IP funding and consultancy, the Unit has facilitated the rapid growth of this programme, complemented by the campus-wide Crime Science Research Group.