Institution: University of Central Lancashire (UCLan)

Unit of Assessment: 13 Electrical and Electronic Engineering, Metallurgy and Materials

a. Context

UCLan's Centre for Materials Science (CMS) and Centre for Fire and Hazard Science (CFHS) have been undertaking world-leading research with real-world impact, in line with UCLan's medium term strategy. At the heart of UCLan's mission is the drive to work in partnership with businesses and the wider community. Our commitment to research impact is centred around three main themes:
Economic - focussed on our areas of expertise, providing support to industry nationally and internationally. **Public Safety, Wellbeing and Health** – By identifying key priorities, investigating the problem, and developing solutions, we are making major contributions, from understanding fire toxicity (the largest cause of death in fire) to pioneering new methods for diagnosing cancers.
Societal and Environmental - Providing clean water, reducing dependence on environmentally harmful fire retardants, and reducing death and injury from fire by appropriate considerations of risk and hazard significantly improve the lives of individuals. Also, increasing public and industry awareness through a structured programme of outreach activities that stimulates pubic engagement and interest in science. Our main user groups include international and regional SMES (e.g. Feedwater and Q-Bioanalytic) national and international companies (e.g. Borealis and Samsung), governmental departments (e.g. Ministry of Defence and Food and Environment Research Agency) professional services (e.g. Fire service and National Health Services) as well as the public, in particular disease sufferers.

b. Approach to impact

UCLan has a adopted a pro-active strategy to enhance relationships with industry that includes showcasing our research, instrumentation and testing facilities and making them readily accessible to industry. We know that some problems will require more complex solutions, and more input from UCLan. The JB Firth building (completed 2011) shows how we've implemented this strategy. The ground floor contains a state-of-the-art instrumentation suite (a 140 m^2 instrumental laboratory surrounded by eight large instrument rooms); the top floor houses the fire laboratory equipped with both research facilities and most standard flammability tests; providing access to these facilities often leads to further collaboration in our areas of expertise. Also located there are our functional materials research laboratories.

Conferences are regularly organised on campus to bring industry to our doorstep. The Royal Society of Chemistry's Fire Retardant Technologies attracted over 100 delegates, mostly from industry, to UCLan in 2009, and will do so again in April 2014. Once relationships with industry are established, the priority is to sustain them. This requires pro-active intervention, not waiting for industry to maintain the relationship. Such regular contact keeps us up to date with developments, including how yesterday's research is impacting today. The whole process of industrial relations has been recently reviewed, restructured and streamlined into a single Funding, Development & Support (FDS) Unit. In the initial stages of a grant development, the FDS team and the Innovation and Enterprise unit are available to help shape the proposal and identify and negotiate with appropriate partners, subjects and/or end users; identify activities requiring further support, e.g. intellectual property development; identify sources of funding to facilitate the promotion and implementation of research findings.

Specific impacts from the three main themes are described below:
Economic Impact: Staff submitted to this UoA have been very successful in attracting industrial funding. In addition to **Hull**'s case study on HMH fire retardants, **Bond** has developed novel technology for the upgrading of biogas from small scale anaerobic bio-digesters. Previously available technology focused on large scale digesters, such as land fill sites and was not commercially viable for small scale facilities. The development of this new technology has allowed Biotech Services Ltd to secure funding (£100k) to build a pilot plant and to market the technology. This is increasing the commercial attractiveness of small scale bio-digestion units, as now there is an economically viable means of producing gas for sale into the national gas grid - previously all biogas had to be utilised on-site. Work on enzymatic polymerisation of polyester polyurethanes led to new industrial process at Baxenden Chemicals, though this area of the business was subsequently sold. **Kelarakis**' work on C-dots (carbogenic nanoparticles), of potential as nanomarkers for oil field exploitation, has led to Saudi Aramco investing in a multi-million dollar research project in

collaboration with Cornell University. **Hayes**' work on modelling new type 2 diabetes treatments has led to the identification of some of the most potent inhibitors of glycogen phosphorylase discovered to date. Further studies exploiting this knowledge should lead to a set of drug candidates ready to be tested in clinical trials. Other work in the area of carbene chemistry has led to the development of novel ligand systems and their metal complexes, with potential in small molecule activation and catalysis for cheaper and greener industrial processes such as syntheses of fine chemicals and pharmaceuticals, decontamination of industrial wastewaters and oil desulphurisation enabling more efficient and cheaper bulk-scale chemical processes. There are two patents in the area of nuclear materials; (**Bond**) UK Pat. App. No 1312312.0 which is concerned with the production of simulant irradiated graphite which permits large scale experiments to be performed without the hazards associated with using radioactive materials and UK Pat. App No 1317553.4, which outlines the development of a novel process for the reprocessing of radioactive waste which will be essential for GEN IV reactors and for the future of nuclear energy within the UK. Work on the synthesis of Carbocyanine dyes (UK Pat. No WO/2013/114115) as phototherapeutic anti-tumour agents and **Baker**'s spectrometric diagnosis of brain cancer (UK Pat. App. No 1220573.8) will provide for a more dynamic and responsive diagnostic clinical environment

Public Safety, Wellbeing and Health: In addition to **Stec**'s ground-breaking work on fire toxicity described in the case study, Hull's work has had significant impact which includes the development of fire safe formulations for various industries: Scapa Polymerics (now part of AlphaGary Ltd) – new cable sheathing formulations; Lonza wood protection – new fire retardant timber treatment; Pilkington's Pyrostop – transparent fire protection; Trelleborg Anti Vibration Systems (AVS) – low flammability rubber shock absorbers for railway applications; and Elkem – new applications of silica fume as a fire retardant additive in PVC and EVA. He has also unravelled the fire behaviour of Victrex's high performance PEEK polymer to demonstrate its suitability as an aluminium-replacement in aircraft, and identified signature products of early fires for enhanced fire detection for Tyco Fire Protection Products. In addition, CFD modelling allows prediction of pollutant dispersion and fuel build-up, leading to explosions. Our assessment of the fire toxicity of disposable barbeques (believed to have caused 10 UK deaths) may be the most directly quantifiable contributor to saving lives. **Kulkarni'**s work on water-in-oil nanostructured emulsions in food products has increased the possibility of producing surfactant-free formulations as a healthier option. His work on lipid nanostructures may lead to better nanocarriers for drug and gene delivery and to identify new therapeutic targets through structural understanding of membrane proteins. **Baker**'s and **Hayes'** work also contributes to this theme. Baker currently holds a visiting position within Lancashire Hospitals NHS Trust in order to provide an effective pathway to impact. Baker's work on serum spectroscopic diagnosis of disease has received significant funding to drive it towards the clinic and as such is a strategic area of growth for impact

Societal Impact: In addition to the work on fire safety and the resulting societal and environmental benefits described above and in the two case studies, we have a structured programme to communicate our own research insights to the public and industry. **Baker** has delivered public lectures on his research into the rapid diagnosis of cancer, raising public awareness of new research and engaging with cancer patients and their families in a dialogue about the future direction of research. The UoA has developed a You Tube presence with the "Chemistry Magic Show" video receiving almost 5000 viewings (Mar 2013) from an audience of 8 – 16 year olds. Feedback indicates the video has inspired these youngsters to consider a career in chemical research. We are currently planning Chemistry and Research experience days for 800 A2 students in collaboration with the Royal Society of Chemistry's ChemNet and we are also hosts for the *Top of the Bench* analyst's competition. We will host the Regional Finals of the RSC Schools' Analyst Competition in 2013 and 2014 and the Grand Final in 2014.

The UoA is taking a lead in the public discussion of energy futures by holding public debates upon Fracking and Nuclear energy in 2013-14. Both sources of energy are strategically important for the nation, have strong bases in the region and excite fierce controversy. These open public debates will place UCLan at the centre of the North West community by providing a space for informed debate on important topics for the future of the North West.

c. Strategy and plans

Our strategy to increase our impact on a regional, national and international level is focused on the following objectives:

- To focus our research on applied industrial, commercial and societal problems.
- To continue to offer "open door" use of our extensive analytical and fire test facilities, in order to attract appropriate collaborators.
- To establish formal and informal collaborations with key players (universities, industry and, government bodies) and to establish our leadership in niche areas of expertise.
- To maintain and instigate "revolving-door" knowledge exchange networks with regional, national and international partners requiring access to our areas of expertise.

This strategy has been underpinned through the staff appraisal scheme, encouraging academics to include research impact in their performance objectives.

In order to achieve these plans internal funding will be specifically directed towards increasing impact. The internally competitive UCLan Innovation Voucher scheme will be utilised to enable further engagement between academics and industry to build innovation and capability within industrial companies. Current roles within the UoA that focus on impact are Outreach Officer, Business Development Manager (Bond) and Research Co-ordinator (Hull). In the future these roles will be supported across the UoA by providing additional staff (such as PDRAs) solely for business development work, with a remit to work closely with the UCLan Public Engagement Manager (PEM). The UCLan PEM facilitates applications for external funding, supported events and provides training in key communication skills. Through staff roles on RSC committees we have been able to interact with professional bodies and schools, the time required for these roles will be "ring-fenced" in order to enhance this interaction.

In order to enhance the commercial exploitation of our research for the benefit of the UK, the University is developing a Science and Engineering Innovation Centre (SEIC). This will provide the necessary support, facilities and infrastructure to facilitate the commercialisation of research produced within the institution. Given the applied nature of much of our work, this will provide a vital conduit for ensuring that the high quality research produced within this UoA achieves impact. The SEIC will increase external access to our facilities and testing, making more companies aware of our expertise, in testing and analysis, opening the door to fuller collaboration. One of our strategies to enable this is through ERDF funding to target regional SMES and to exploit the Preston City Deal that aims to enhance and develop Lancashire's Enterprise Zones.

We also plan to increase our focus on Continuous Professional Development and Training for industry via in-house short courses and e-training packages. This will lead to new and strengthened collaborations with industrial partners. For example, a highly acclaimed short course *Hazards from Fire* was delivered to industrialists in June, 2011, bringing over £10k income. A request has been made to repeat the course late in 2013. The CFHS will continue to expand its work in the development of international standard test methods within the fire arena, using research findings to influence policy and practice, reducing the hazards to life, harm to the environment and damage to property from fire.

d. Relationship to case studies

Our research has had wide ranging impact across materials science. Both case studies detail how we follow clear aims and objectives, and progressively meet those objectives in order to achieve our goals. In the first case study on fire retardants we recognised that the pathways to impact came through rigorous science and evidence-based understanding of the mechanism of the new HMH fire retardant. In the second, the politics associated with fire toxicity also needed to be addressed. While it is plain from UK or US fire statistics that fire toxicity is the main cause of death and injury in fires, large industry (particularly the foam insulation and PVC cable industries) lobby extensively and support studies attempting to refute this conclusion. It is always argued that if a fire doesn't start, fire toxicity is not a problem – yet it still remains the major cause of death. This has necessitated participation in standards' bodies, particularly ISO, in order to prove the argument and provide the world with a robust means for quantifying fire toxicity.