

Institution: Lancaster University (LU)	
Unit of Assessment: UoA 15 (General Engineering, Main Panel B, Sub-panel 15)	
<p>a. Context: Impact in Engineering at LU is integral to the UoA and Dept's mission and strategy. As described in the Dept's 2008 5-year plan "the overarching raison d'être is to make an impact on global issues confronting humanity by leading-edge research", a vision restated in LU's new <i>Strategy for 2020</i>: "to produce world-class research that changes practice and thinking". This strategic focus on significant, high quality and far-reaching impact is implemented <i>via</i> strong partnerships with end-users, reflected by Engineering's research group structure mapping onto its primary beneficiaries <i>viz</i>:</p>	
Primary Beneficiaries	Research group(s) addressing Primary Beneficiary
Energy Sector	Energy Group, inc. the LU Renewable Energy Group and the Lloyds' Register Foundation Centre for Nuclear Engineering
Security Sector	Engineering of Microwaves, Terahertz & Light (E-MIT), Nuclear
Microelectronics/Microsystems	Micro-Nano Systems Group, E-MIT Group
Manufacturing & Construction	Structures & Manufacturing Group
<p>Key beneficiaries include business & industry, policy makers, NGOs (inc. charities), professionals/practitioners and the public. Types of impact delivered by working in partnership with these include:</p> <ul style="list-style-type: none"> • Economic impacts across all sectors by provision of knowledge, IP & training to (inter)national business, development and growth of spin-outs and support to innovation-focussed SMEs; • Policy impacts in the areas of energy and security via commissioned reports to UK Gov't and its agencies, evidence to select committees and representation on international delegations; • Security impacts by uptake of novel portal scanner and nuclear materials monitoring technology by national / international security companies and security & safeguards agencies; • Impacts on professionals/practitioners in construction, microsystems and energy by provision of CPD; design standards & codes; and reports to Gov't on e.g. best practice in nuclear new build; • Environmental Impacts via: new decontamination/decommissioning methods and understanding of wastes for the nuclear industry; forecasting tools for demand management in the water industry • Health Impacts in diagnosis and prevention via new medical imaging technologies, point-of-care diagnostic tools and data modelling tools for epidemic prediction. 	
<p>b. Approach to impact: Since its creation in 1969, LU's Engineering Dep't has been <i>culturally</i> and <i>strategically</i> committed to high-quality research conducted with end-users in the context of application. Culturally, the road to impact starts with compulsory MEng industrial projects for u/g students (e.g. recently creating tidal turbine prototypes for WASP Ltd, Cumbria) through to new spin-outs (Hybrid Instruments, enablingMNT) and fully-funded chairs (Lloyds Register Foundation (LRF) Chair in Nuclear Engineering). Strategically, impact is <i>delivered via research partnerships with end-users</i> – a key objective of our 2008-14 research strategy (see RAE2008 submission). Examples include:</p> <p>(i) Collaborative research We work with a wide range of national/international partners on research funded/co-funded by the end-user, both in individual relationships (Gilkes Ltd in the area of renewables; Sellafield, National Nuclear Lab (NNL), React Engineering Ltd. in nuclear; e2v & Rapiscan, provider of portal scanning systems to most of the world's ports/airports, in security; Thales, Oclaro & Pilkingtons <i>via</i> RAEng Fellowships in semiconductor device manufacture) and consortia (e.g. the £9.1M EPSRC Innovative Electronics Manufacturing Research Centre, 15 industrial partners). Economic impacts are realised by knowledge/IP transfer, e.g. new test engineering tools for the international microelectronics industry (STMicrosystems, QinetiQ, Philips, see REF3b); KT of new product & process designs for hydro/marine energy conversion, advanced fuel cells & components, wind turbines & condition monitoring tools, and economic analysis of renewables to the Energy Sector (BP, Centrica, AFC Energy). Industry income has more than tripled since 2008, 60% of our £9.8M post-2008 research income coming from end-user collaboration. Notable pathways of engagement include policy work, SME focussed activities, use of students & work with charities. Details follow.</p> <p>(ii) Assisting the work of Government by giving evidence to select committees, representing the UK on DECC, BIS & FCO delegations to Japan, US & EU, and by working with UK Gov't Ministries (DfT, DECC) and Engineering Institutions (e.g. RAEng, IET) on reports underpinning policy making in energy, transport and sustainability (see REF5 §b). As a member of the IET Energy Policy Panel, Kemp's reports on Transport Energy have been used widely in forming Gov't transport policy, e.g. contributing to policy on high-speed maglev trains and on electric vehicle charging infrastructure.</p>	

(iii) SME-centric innovation consultancy. Engineering hosts the **Lancaster Product Development Unit (LPDU)**. Comprised of 5 FTE the LPDU provides a range of KT/KE mechanisms for applying Engineering's research to the innovation needs of industry, particularly SMEs. Formed in 2002 with £1M ERDF co-funding, with a further £8M ERDF co-funding since, LPDU has, post-2008, benefited 325 businesses, resulting in: 230 jobs & £13.5M new sales generated/ safeguarded; 265 businesses introducing new/improving existing products, processes or services. This follows similar success in 2002-2006 for which LPDU was recognised for the quality of its research-led KT/KE activities by Government Office NW and the EC, and awarded 'Exemplar' status for the quality and delivery on ERDF. Complementing ERDF, we also use consultancy, small grant schemes and dedicated grants to support and develop key links with SMEs. Here we have used RDA-funded innovation vouchers and LU's Impact Acceleration Account (*vide infra*) to assist >20 SMEs – leading SMEs to (co-)sponsor PhD/research projects in the UoA (Nanoflex, Veraz Ltd) – and EPSRC/FPVI dissemination funds to transfer research into SME CPD platforms (Epigem UK). According to 2013's *Witty Review*, LU is ranked 9th out of England's HEIs in for its number of engagements with SMEs.

(iv) Studentships with Industry We use iCASE/iCASE-modelled PhD studentships to create end-user benefit. As part of two EPSRC Centres for Doctoral Training in Nuclear, we offer co-funded 4-yr PhD places (with e.g. NNL, Createc). With LU's Environment Centre, we are part of the £9.8M ERDF-funded Centre for Global Eco-Innovation, supporting 7 Engineering PhDs working with SMEs. In 2012, we hosted the single largest number of Nuclear Decommissioning Authority-funded PhDs in the UK (8 FTE). In total, >30 industry (part-)funded studentships have been won/supported since 2008. At MSc level, we use business-facing ERDF/charity-funded MSc research students (>25 post-2008) to deliver impact to industry (Sellafield, James Fisher Nuclear Ltd, see (iii) above, (vii) below)

(v) Addressing charitable missions via: charity-funded posts, such as the LRF Chair in Nuclear Engineering, to address LRF's mission of "enhancing the safety of life and property" on land, sea & air; supervising 4 Sir John Fisher Foundation-funded MSc students p.a. with a mission to "benefit the people living in and around Barrow-in-Furness"; and supporting the Sir Bobby Charlton-founded charity, Find A Better Way, to develop technologies for landmine clearance in former war zones.

(vi) Contributing services to professionals/practitioners e.g. by assisting professional bodies to define design standards for composite structures in construction (see REF3b); by offering our facilities for external use (e.g. our wave tank for the testing of a 2013 Dyson award-winning wave energy convertor); and the making available of freeware modelling tools for forecasting and control. The latter, the CAPTAIN toolbox developed by Taylor, has been downloaded >2500 times since 2008, with in addition 135 licenses purchased and has been used for e.g. demand management in the water industry (Yorkshire Water), prediction of epidemics (hantavirus in Europe) and control of mobile robots for construction (Bachy Soletanche) and nuclear decommissioning (Sellafield, NNL).

(vii) Direct commercialisation of Engineering Research. Exploitation of our knowledge base (15 patents granted/applied for post-2008) occurs through IP licenses (most recently to e2v and Hybrid Instruments) and spins-outs e.g. Hybrid (see REF3b) and enablingMNT (part of the international enablingMNT group, transferring novel methods & knowhow in Design for Test Engineering).

(viii) Professional training using CPD training (incl. FP6 supported provision in Romania) and the research projects of Taught MSc courses (especially in Microfluidics, Smart Systems, Safety Engineering & Nuclear Decommissioning with >200 industry-based students graduated since 2003) to transfer knowledge, access industry problem bases & owners, and so develop research proposals.

In all of the above, we recognise that impact originates from the individual / collective endeavour of staff and students. Thus, we **incentivise & support** them in this as follows.

Incentives & Rewards: LU and Dep't staffing strategies promote as well as reward impact, by e.g.

- **Recruiting staff** from industry e.g. Kemp (ALSTOM); Dawson (AFC Energy); Aggidis (Gilkes).
 - **Retention of staff** with mature or developing impact in PT/honorary positions to allow LU to support the optimisation of that impact e.g. Turvey (see REF3b), Kemp (see (ii) above)
 - **Addressing impact metrics** in: workload allocations; probation agreements; and awarding of sabbaticals focussed on achieving impact. Academic promotions criteria require *involvement in activities designed to ensure that appropriate impact of research (outside academia) is achieved.*
 - **Rewarding staff** by promotions and sharing in income from the commercialisation of their work
- Support** is offered from all levels: **university, faculty & department.** At **university level**, LU's

Impact template (REF3a)

Research & Enterprise Service provides support and resource for IP protection / commercialisation, proof of concept projects, KTP development, contract negotiation and KT/KE publicity. Via LU's Impact Acceleration Account, funds are available for industry placement; innovative LU/end-user co-created early stage projects; and for turning research outputs into commercial propositions

The **Faculty of Science & Technology** supports 7 cross-faculty Enterprise & Business Partnership themes. Each is led by an LU/HEIF-funded Business Partnership Manager (BPM) who support staff in maximising their impact, KE and user engagement. We have a strategic framework in which we operate and are managed with reference to KPIs benchmarked against national data. Engineering staff are supported by BPMs for Security, Quantum Technology, Advanced Manufacturing and Energy. The last two sit within the **Dep't**, complementing support from the LPDU (see (iii) above).

c. Strategy and plans: We will maximise use of both new opportunities afforded from our own resource and continuation of existing successful approaches. New opportunities include:

- **New Building:** As part of the strategic investment described above, a new £12M Engineering Building is under construction (completion Nov 2014). New specialist facilities will be available to external users such as a new upgraded wavetank (e.g. Gilkes), fuel cell test lab (AFC Energy), radiometrics/radiochemical labs (Sellafield, National Nuclear Laboratory) and strong floor facilities for load and materials testing of civil infrastructure components to British Standards
- **New Staff:** Our strategy will focus on supporting the 22 staff appointed since 2008 (see REF5), especially ECRs, in performing excellent research and realising its impact. Industry placements will be explored in this context funded by e.g. RAEng and LU's Impact Acceleration Account.
- **The Science Park:** Complementary to facilities within the new building, the new 34,000 m² park to the north of the campus will offer incubator & growth space for spin-out/co-locating businesses.

These opportunities will be pursued in the context of our research strategy objectives (REF5 §b1):

- We will maximize the impact of our research; and
- We will exploit the benefits that accrue from that impact via e.g. return business from benefiting partners and using income from spin-outs, IP licensing etc to fund future research and its impact

Strategy will be implemented by maintaining the methods of §b in the context of a holistic approach to business & impact development. Research Groups, supported by the LPDU and BPMs, will establish portfolios of skills, services & IP across their training, research and outreach activities to maximize value to end-users and increase interaction/collaboration with private sector beneficiaries.

Additional to the externally benchmarked KPIs for business engagement mentioned in §b, an extra KPI here will be the preparation of 8 impact case studies for 2020 (two from each research group), double those prepared for REF2014. Future prospects include: nuclear (LU's nuclear activity being mentioned in the *Witty Review*) and fuel cells work (with AFC Energy) in the Energy Group; energy harvesting in aircraft research (with BAE Systems) in the Structures & Manufacturing Group; use of E-MIT and Cockcroft Institute research in security (with Rapiscan and e2v), communications and at CERN (Lancaster is leading on the Large Hadron Collider upgrade); and roll out of the Micro-Nano Systems Group's Design for Test research into Malaysia & Canada (*via* CPD with enablingMNT).

Informed and exemplified by the latter two examples and those of our impact case studies (see §d below), internationality in all types of impact will be pursued vigorously. Particular emphasis will be on international collaborations/consortia to access global impact pathways (e.g. our leadership of the new LRF UK-US-China Research Centre in Nuclear Safety) and discipline leadership to foster global policy/economic impacts e.g. authoring IAEA reports (see §d CASE A, 2013) and mapping future markets in Health & Usage Monitoring Microsystems for the European Commission (2011).

d. Relationship to case studies: These exemplify the following aspects of our approach to impact

- CASE A, *Enhanced nuclear safeguards monitoring*, shows how we use collaboration between international agencies and spin-out business to deliver policy, services & economic impacts.
- CASE B, *Uptake of Intelligent Microsystems*, exemplifies how we use collaborative research in partnership with international business and SMEs to deliver economic impacts.
- CASE C, *Pultruded glass fibre reinforced polymer composites*, shows how we use engagement with international professional bodies to change professional behaviour by defining best practice.

All cases reflect our strategy of re-investing benefits from our impact in future research and impact, *via* e.g. spin-outs (case A), IP/product licensing (A, B), return business from beneficiaries (all cases).