Institution: University of Liverpool

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

a. Context

Transfer of knowledge gained through research has been a feature of our approach since the Department was founded. This has led to technology transfer and commercial exploitation through both our industrial collaborators and spin-outs.

Our research is undertaken in three overarching ***theme areas***:

(i) Information and communications;

(ii) Energy technology.

(iii) Sensors, diagnostics and biomedical devices;

Within each theme the Department has achieved impact that is ***economic, societal*** and ***environmental***. ***Economic*** impact has been realised mainly through relationships with industry. These include high-level interaction with industrial users (e.g. National Grid). ***Societal*** impact has been achieved mainly in the biomedical and defence areas. There is significant interaction with end-users in healthcare via contacts within the NHS and internationally (e.g. the Thengana Medical Mission Hospital, India). The Department has worked closely with the UK MoD and also defence and defence related companies (e.g. QinetiQ, Raytheon). Significant ***environmental*** impact has been made through the realisation of novel sensor technologies now used for environmental monitoring in the UK and abroad (e.g. for water quality monitoring).

b. Approach to impact

The Department maximises impact by interacting with a wide range of organisations across the industrial, healthcare and security sectors. Within the Department, there is close involvement with more than **50 major companies and research organisations**.

Departmental interactions resulting in economic impact include: Zetica, Guidance (Huang, case study), TeraView (Shen), Advanced Sensors, Q-Technologies (Taylor, case study), ARM, Plessey (Hall, Marsland), Gencoa, Hiden Analytical (Bradley), VATECH, Areva, National Grid (Wu), Fairbanks, MHA, MAST, Electricity North West Ltd (Spencer, case study), Western Power Ltd (Wu, Spencer, Yan), BP, BG, Chevron, Conoco Philips, ENI, SAFC Hitech (Hall, Mitrovic, Taylor), Culham Labs (Bradley, Walsh), Merck (Raja), Philips (van Zalinge), STMicroelectronics (Hall, Mitrovic). As an example of impact, using pattern recognition techniques developed by Wu, in 2012 National Grid achieved an average ***saving of £130-260k per day*** which was passed on to UK domestic and industrial consumers. Impact was achieved, based on silicon nano-electronic research by Hall and Mitrovic, and subsequent industrialisation of a 32nm CMOS process at ST Microelectronics.

Our ***Industrial Advisory Board*** (IAB) plays the important role of facilitating relationships and collaborations between academics in the Department and end users in industry. This board contains external members from AC Delco Electronics, the Health and Safety Executive HSE), the Welding Institute (TWI), BAE Systems, Rhode & Schwartz, Chronos Technology, ARM and QinetiQ (formerly Defence Research Agency). IAB companies fund industrially linked projects e.g. ARM enable technology transfer through funded postgraduate scholarships. Similarly our ***Visiting Professors*** play an active role in helping to raise our profile with industry. Prof K. Edwards OBE (QinetiQ) has worked closely with Ralph in securing impact in the defence area. Examples are the use of real-time guidance algorithms developed by Ralph (2008), demonstrated in hardware for the MoD on the RAF Tornado Integrated Targeting System. In 2010 a suite of real time guided weapon models for a QinetiQ/RAF multi-platform flight simulator system (MTDS) were delivered.

Knowledge Transfer Partnerships (***KTPs) and CASE awards:*** Departmental academics have been successful in developing strong working relationships with local and national industry. Collaborative PhD awards with industry (CASE) have also been an important part of our approach and have been awarded in the REF period by companies such as the AWE (Aldermaston), EADS,

KSS, MKS-Spectra, Merck and UKAEA Culham (two awards). The work with MKS led to a patent application for an ion source. The PhD graduate is now employed at multinational instrumentation company Waters. Since 2008 KTP projects have been awarded with Advanced Sensors, Gencoa, Guidance and Zetica. Monte Carlo modelling research by Bradley led to new designs of magnetron currently marketed by Gencoa. Other outcomes are provided in the case studies.

Sabbatical leave: The Department strongly encourages commercialisation of its research and facilitates the interaction of academics with non-academic users by providing flexible support. For example, the department hosts conferences e.g. the International Conference on Organic Electronics (ICOE 2009) with significant participation by industry (Denso Corporation, Merck, PETEC UK, SILVACO, VTT). The Department provides funding for individuals to travel to meetings and symposia facilitating their impact activities and has a sabbatical system allowing staff to pursue knowledge transfer activities. Huang and Taylor benefitted from sabbaticals since RAE2008, which contributed to their corresponding impact cases.

Direct commercialisation: The Department provides space and facilities for spin-outs (e.g. Q-Technologies). Benefits include access to Departmental workshops and test facilities for advanced measurements not normally available elsewhere. Our future strategy is to enhance our incubation facilities and to encourage further spin-out activity following the successful model already demonstrated.

A number of further specific examples of impact have arisen from the ***Centre for Intelligent Monitoring*** (CIMS) established in 1997 at the Department with multi-million pound funding from the European Regional Development Fund and through support from industry. A key part of the CIMS mission has been ***technology transfer*** of novel optical devices developed using chromatic sensing technology to industry in the North West. Four specific outcomes are given in the case study. Additionally CIMS has also achieved environmental impact in the REF period via two large-scale projects: (i) oil quality monitoring for ENW to reduce waste i.e. only change when needed (ii) air quality monitoring with MBC Sefton which investigated general air pollution of traffic and the docks.

c. Strategy and plans

The University has developed a strategy for promoting impact, and a number of elements of this are significant to the School of Electrical Engineering, Electronics and Computer Science:

1. The University has established the senior post of ***Provost for Innovation***, providing oversight and coordination for a broad range of knowledge exchange activities;
2. The Local Enterprise Partnership has produced the ***Merseyside innovation plan***. The regional priority growth sectors are biomedical technologies (including sensors) and the blue/green economy amongst others. The University and the School are reflecting all of these areas in its research development plans (point 8 below);
3. Establishment of an investment fund (£7M over five years) to ***underpin IP*** protection, which includes support for patenting and licencing agreements. This fund will be instrumental in developing the IP portfolio of Departmental spin out companies (point 10 below)
4. Mentorship and ***incentivising staff***, to promote the realisation of impact. This is being achieved through the exploitation of industrial secondment schemes and through structured events on particular impact topics for early career researchers. The sharing of income has been introduced to incentivise consultancy, with business processes introduced to support contractual and payment issues.
5. A system of ***key account management for selected large companies*** has been piloted with Unilever, and will be expanded to cover five other companies by the end of 2014.
6. The profile of impact is being raised by requiring the recording of examples in the annual ***Staff Professional Development*** Review.

The Department plans to promote impact via the following steps:

7. Given the increasing importance of impact as a metric in research excellence the department has set up an ***impact committee*** in order to oversee and develop impact arising from its

research, at an early stage. The committee consists of current impact case study authors (Huang, Spencer and Taylor), to be joined by recently appointed Marshall. Marshall is founder of an award winning spin-out in the ICT sector TOM Ltd. Industrial members of the impact committee include members of the IAB. The committee remit includes the early identification, recording, support, promotion, dissemination and reward of impact activities of our ***staff and students***.

8. Development of ***new research strengths*** is in areas with high potential for impact, building on the CIMS example, namely: Sensors, ICT and Technological plasma. A significant development here is the launch of the new ***Centre for Autonomous Systems Technology*** (CAST). The Centre brings together Computer Science, Engineering, Electronics, with the Virtual Engineering Centre at Daresbury to provide a mechanism for the exploitation and technology transfer of key University research. The Centre has attracted funding from the Regional Growth Fund and BAE Systems, and is expanding with new staff: two professorial appointments were made in July 2012. In addition, CAST provides opportunities for strategic industrial partnerships, particularly in the aerospace and robotics sectors which have major potential for future impact.
9. In 2013 the Department made some key ***appointments*** with potential for impact a factor in the appointment Marshall, Khursheed, Bowden, Lopez-Benitez and Zhou. This policy will continue in the future.
10. Encouragement of ***start-up and spin out*** companies will be an enhanced feature of our impact strategy. The Department is planning to enhance its facilities for its own start-up and spin out companies. Small early stage companies will be able to benefit from shared resources and proximity to Departmental research laboratories.

The achievement of a broadly based, trusting relationship with a company provides the ideal conditions for impact to be realised. Support mechanisms for developing business-level partnerships are highly prioritised, including: (i) alignment of business development support; (ii) investment in new academic staff where opportunities arise; (iii) allocation of support through local investments such as ***Knowledge Exchange*** vouchers to stimulate projects to realise impact out of research and (iv) development of further KTPs.

d. Relationship to case studies

Our case studies have both benefitted from, and informed, our approach to impact as described in this document. For example, our strategy for specific collaborations with end users and industries includes development of KTPs (point 11). The ***KTP with Guidance Ltd*** demonstrated strong economic impact.

Q-Technologies Ltd is an example of a spin out that benefited from location nearby research facilities (point 10). Underpinning research in the energy sector led to the formation of the Centre of Intelligent Monitoring in 1997. CIMS interacts with a very wide range of collaborators in the energy ***industry,*** in ***healthcare*** and in the ***environmental*** area. The close coupling of research and impact is an example for current staff and facilities development (point 8)