Institution: Loughborough University

Unit of Assessment: B13 Electrical and Electronic Engineering, Metallurgy and Materials

a. Context

The Unit's research is structured in three broad Groups: Communications, Energy and Systems.

Main non-academic users of the Unit's research

The Unit's research has a high level of significance for a wide range of industrial and professional users. We are engaged with over 50 different organisations of different scale including Alstom, Dstl, Eon, BAESystems, ESA, RSSB, Jaguar Land Rover, Linde-BOC, MBDA, QinetiQ, Unipart Rail, Rolls-Royce & Thales.

Other users of our research and expertise include major non-University research organisations internationally such as Los Alamos and Oak Ridge National Laboratories, USA, and Government Departments (High Court of Justice, London and the Russian Embassy).

Main types of Impact generated and their relationship to the unit's research

The impact generated by the Unit's research takes the following forms:

- Provision of Technical Expertise via Consultancy agreements – This type of impact is generated by all research groups and involves many staff in the Unit due to the reach and relevance of our research results and expertise.
- Professional Services (eg Expert Witness) – Energy (**Eames**) and Systems Group (**Kalawsky**).
- Provision of IP via licensing agreements – Communications (**Vardaxoglou**, **Parish**) and Systems Groups (**Chouliaras**, **Mulvaney**).
- Influence and Development of Standards and Policy – This activity has focused mainly on our research in Photovoltaic Characterisation (**Gottschalg**) and Energy storage (**Eames**) in the Energy Group but also applies to Systems Engineering policy (**Henshaw**).
- Training Provision – All three groups provide this. Systems Engineering training is in great demand; as is our expertise in Renewable Energy and electrical discharges (**Smith**, **Novac**).
- Start-up Companies - During the assessment period, the Unit has been involved with Antrum Ltd, Axilica Ltd, Dialog Devices Ltd and Purbeck Solutions Ltd.

During the assessment period, the total value of the unit's consultancy and knowledge exchange activity, (excluding license royalty payments and short course revenue) was **£894k**. This was generated from **75** activities involving **24** staff from the Unit.

b. Approach to impact

In 2009, a strategy for Research, Teaching and Enterprise was developed for the Unit and pursued by appropriate tiger teams. The third objective, concerned with industrial collaboration, set in place actions that have provided the Unit's approach to impact and which set the context for the case studies and other examples of impact as described below. The actions, published in 2009, were:

1. To establish a strong, broad-based, research-focused advisory board representing the users of the Unit's research and teaching.

This instigated set-up of a Future Advisory Board (FAB) that comprises representatives from the Defence, Energy, Space and Transport sectors. The FAB is chaired by **Prof. Michael Withers**, the Unit's Royal Academy of Engineering Visiting Professor in the Principles of Design; it meets bi-annually to advise senior managers within the Unit of research, teaching and impact issues. At each meeting the group reviews, in-depth, a particular area of activity. An example of such a review is our rapid chip design research (**Chouliaras**, **Mulvaney**) that is exploited through a spin-out company from the Unit - Axilica.

2. To formulate a strategy to use our Visiting Professors to develop ideas and broker partnerships.

About 50% of the Unit's 19 Visiting Professors are based in industry; they are appointed for a fixed term on the basis of contributions to teaching, research and enterprise. The industry-based Visiting Professors advise on the needs of industry and are active in reviewing research proposals to advise on quality and relevance to industry, ensuring the maximum potential for exploitation of our work. E.g., Loughborough University is the leading academic institution in the area of pulsed power for defence (**Smith**, **Novac**) and the impact of this research is directly managed by a Visiting Professor from Dstl.

3. To develop process and roles for establishing and maintaining relationships with industry.

In 2009, the Unit appointed an External Relations Manager to expand the Unit's links to industry and to manage the more significant relationships. One key element is provision of Continuous Professional Development (CPD) for our industrial partners. Our Systems Engineering research achieves significant impact through CPD. The Masters level modules in Systems Engineering, Communications and Renewable Energy are based on research conducted during this assessment period. These have been delivered to up to 30 staff per year from companies including: Alstom, BAESystems, DSTL, Network Rail, Rolls Royce, Saab and Jaguar Land Rover.

4. To identify benefits for industry, e.g. gearing/leverage of industry research funds through university collaboration.

We have achieved this via our Engineering Doctorate Centre in Systems Engineering (**Goodall**, **Dixon**) which was deliberately broad based in order to provide significant systems expertise to impact a wide range of industrial sectors. A further example is our Wireless Communications activities through our spinout company Antrum (**Vardaxoglou**). Our website has been extended to include a specific area dedicated to "working with business" that has a comprehensive and detailed list of expertise, so that industry can find precisely the skills or knowledge it requires for consultancy or research. This has resulted in unsolicited approaches that have exploited the Unit's research directly through consultancy services; examples include for Singapore MoD (**Henshaw**) and the High Court of Justice (**Kalawsky**).

5. To arrange annual industry days to showcase research activities to a wide audience.

The Unit has held focused industry days where individual work, or related groups of work, have been showcased. For example, new research results for System on Chip design processes developed with our spin-out company Axilica (**Chouliaras**, **Mulvaney**) were promoted at one such event which was funded by the University's Enterprise Office. Since 2010, the Unit has also held an annual conference, which has included industry participation by invitation.

From the five actions, we have developed a three strand approach to impact: i) **Early engagement** with users to shape research plans toward impact and to raise awareness of opportunities to exploit outputs, ii) **Proactive identification** of commercialisation opportunities, iii) **Support to staff** to work alongside industry in commercialising outputs. These are discussed below:

i). **Early engagement** with users

This is facilitated through Actions 1-5 listed above. Also, academics in the Unit are active on a broad range of professional committees and working groups that bring researchers and users together. These include: Rolls-Royce Electrical, Control, Systems and Electronics Advisory Board (academic advice on technical developments); IMechE Railway Division Board; IET Railway Professional Network Technical Advisory Group (co-ordinates the technical programme); Rail Technical Strategy Leadership Group (Involves representatives of all stakeholders in the GB railway industry and provides technical leadership and strategic development for cross-industry issues). Instrument Industry Liaison Board (Convenor: shares mutual information for industry and provides a forum for liaising with UK Government bodies); Parliamentary and Scientific Committee (InstMC delegate, considers all things related to STEM disciplines); Autonomous Systems National Technical Committee (Chair -Roadmap Committee); Human Factors National Technical Committee (advice to UK aerospace and defence industry); Defence and Systems Institute, Adelaide, Australia (technical advice for future research); Defence Technology and Applications Group (DTAG) of the MoD (expert advice on Pulsed power); National Defence Industries Council (NDIC) Working Group on Systems Engineering and Open Architectures (promotion of open architectures in UK defence supply chain); Systems Engineering National Technical Committee (advice on systems engineering in aerospace); IET Council (main strategy forming and monitoring group); Department of Energy and Climate Change (DECC), (member of the UK PV Strategy Group, key group across the whole PV supply chain, and Chair of Affordability sub-group); Director of the EPSRC Supergen SuperSolar Hub and Chairman of the Management Board; Vice Chair of UK Solar Energy Society.

ii). **Proactive identification** of commercialisation opportunities

In addition to the External Relations Manager see 3 above), the Unit employs a consultant with specific expertise in commercialisation to identify potential impact opportunities. Specifically,

she examines projects to identify how the outputs could be commercialised through patents; via royalty payments from commercial organisations; or via start-up activities.

iii). **Support for Staff** working alongside industry.

Academics now have enterprise terms and conditions within their employment contract and as part of their annual Performance Development Review. They may cite such activity as evidence towards promotion or salary enhancement. [Enterprise is defined as "academic engagement with business, public and voluntary organisations to create social, cultural and economic impact through knowledge exchange"]. Support includes training in Enterprise and provision of time for such activities. For example, all staff attended an Enterprise workshop to help them identify the relevance of their role to enterprise activities. Further, we recently held a competition for the allocation of funds to enhance our impact. Public Speaking training (**Edwards, Dixon**) has been purchased to enhance our ability to promote our research successes.

The Unit positively encourages knowledge exchange activity undertaking 10 projects funded from sources such as EPSRC (Knowledge Transfer Account – KTA) Pathways to Impact and TSB (KTP) during the assessment period. These include: Opto-physiological measurement (**Hu**), KTA (£64.2k), 2013/14; Indoor TV antenna (**Vardaxoglou**), KTA (£46.7k), 2011; Fault Detection and High Redundancy Actuators (**Dixon**) 2*KTA (£72k) 2010; Communication Network Measurement Toolset (**Parish**), KTA £58k 2011; and Interoperability Management for Large Scale Enterprises (**Henshaw**), KTA (£17.2k) exploiting output from the £8.3M EPSRC NECTISE (BAES).

The Unit encourages co-location of industry engineers at the University to better enable exploitation through very favourable conditions. Examples are more than 20 BAE Systems Engineers in a dedicated facility for nine years working alongside systems engineering researchers and 3 JLR engineers co-located in a dedicated facility for three years working alongside systems engineering researchers.

Under the auspices of the UK MoD Systems of Systems Approach (SoSA) Community, senior systems engineers from Atkins, BAE Systems, Thales (2), General Dynamics, Lockheed Martin UK (2), QinetiQ, SELEX (2), MoD (4) were seconded (40%) for 3 months. The activity was chaired by Loughborough and developed an approach to open architectures in defence procurement. The output has been exploited by the participants, forming the basis for defence directives and assessment frameworks, and by the US and Danish Depts of Defence.

c. Strategy and plans

A restructuring in 2011 gave the School a senior management structure which contains, amongst others, three Associate Deans (ADs), one for each area of Research (R), Teaching (T), and Enterprise (E). Each area of activity is led in the University by a Pro-Vice-Chancellor ensuring that each area is afforded significant visibility at both University and School level. Our strategy is to embed impact strongly in all of our activities such that it becomes second nature for all of our researchers. This will maximise the impact and benefit of our research for all of our stakeholders. There are regular meetings of the AD(R) and AD(E) to ensure that impact is high on the Research agenda. The AD(E) has recently established an Enterprise Task Force to drive this forward via:

- Increasing awareness of impact generation issues amongst staff.
- Proactively identifying potentially exploitable IP from our research portfolio.
- Establishing a Database of Industrial and Alumni contacts for Enterprise involvement.
- An annual industry facing Research/Enterprise Showcase organised jointly by AD(R) & AD(E).
- Identifying potential areas of research expertise for Distance Learning development.
- Generating and distributing Enterprise related promotional material to potential users.

Impact will be further promoted via the establishment of the "Glendenbrook Centre" in the School of Business and Economics, to promote Enterprise activity. The key to this, and the Strategy for the School as presented in the previous section, is to embed the idea of Impact into our research activities at the outset, rather than to view it as a "bolt on" afterthought.

This will continue to be promoted via training sessions, mentoring schemes, discussion workshops (including a recent session at the 2012 School Away Day). These measures, in combination with our existing support for exploitation activities, will ensure that we continue to develop impact from our research.

d. Relationship to case studies

Study 1. Porpoise deterrent pinger for the reduction of accidental by-catch in international fisheries.

Due to having the potential to create impacts of major significance, with international reach, the underpinning research (of **Lepper** and colleagues) was identified for full-funding by the school. This was an investment for the future as the external research funds needed were not present at the time. Once developed, the system was patented by the University with support and expertise from the Enterprise Office. This support extended to licensing activities and is an example of **section b ii)** above - **Proactive identification of commercialisation opportunities.**

Study 2. Raising the Standards for Solar Photovoltaics and Accelerating Deployment.

One of the academic investigators (**Gottschalg**) specifically sought to use the work to drive specific industrial standards. This is an example of **section b i)** above - **Early Engagement.** To this end he joined the relevant standards body and volunteered to be on the writing teams for the appropriate standards. This enabled a direct transfer from research into novel measurement systems to standards and thus ensured that the impact would be of high significance. This approach also feeds back user requirements to the research projects and thus closes the loop between eventual users and the researchers. In accordance with **section b iii)** above, the investigator was encouraged by the School to spend time on this activity with the deliberate aim of ensuring our research would have significant impact through embodiment in the resulting international standards.

Study 3. Significant commercialisation with international impact underpinned by substantial antenna-related research.

This is an example of **Action 4 in section b** above - **To identify benefits for industry**. The background research would not have been possible without significant investment by the University, the Unit and industry to provide a suitable environment including a microwave laboratory involving an anechoic chamber and measurement equipment to support the experimentation. EPSRC KTA funding was used to provide staff secondments to Antrum (**Whittow**); University funding allowed a secondment (**Vardaxoglou**) to ESA. With support from HEIF, expertise within the Enterprise Office was used to generate IP assignment/ collaboration agreements, with further onward license with royalty payments to the University. Training, funded via HEIF, was provided for University employees enabling them to act as Company director/ company secretary. The School also encouraged the company to have members of their staff working jointly with the University researchers in order to ensure effective technology transfer.

Study 4. Transformational Cost-Risk Reductions and Significantly Increased Safety Through Interdisciplinary Model Based Systems Engineering in Extremely Complex Operational Environments.

The impact of this study is broad and far reaching. It arose from **Action 3** above - **To develop process and roles for establishing and maintaining relationships with industry**. The unit provided significant support in terms of the physical environment and Research Students to work alongside the RAs and lead investigators. In doing this, they were able to interact with the users of their tools to ensure they were used to maximum benefit in a broad range of environments.

Study 5. Signal Processing Solutions for the Networked Battlespace.

The main approach to impact generation was by direct transfer of our research results into QinetiQ, the industrial user. This was facilitated via exchange visits between the university researchers and engineers in the company, including short term secondments. A key aspect contributing to the success of this was the willingness of research staff in the Unit to support this transfer via direct assistance to QinetiQ as needed. This Case Study is another example of **Action 3** above - **To develop process and roles for establishing and maintaining relationships with industry** and of the School's willingness to support and empower staff **(iii,** above**.** The success of this approach means that the research had significant impact within the collaborating company and beyond.