Institution: The University of Birmingham

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

a. Context

The School of Electronic, Electrical and Computer Engineering (**EECE**) has 65% of its income from non-research council sources, with a total of £7.8M directly from the MoD, industry, and UK government. Total European contract income is £10.8M forming a strong bridge between research and industry. Working with the civil and defence industries across a range of sectors is embedded within the culture of the School. An expanding worldwide reputation for quality research, strong contact with end users and sustainable expertise are the core of the strategy. The success is based around three major, long standing research groups. The groups, Microwave Devices and Systems (**MDS**), Railway Engineering and Energy (**REE**) and Human Computer Interaction (**HCI**). Active grants for these groups during the REF period show a well-balanced industrial funding portfolio of £3.1M, £5.7M and £5.0M respectively.

b. Approach to impact

The **MDS** group has for many years been the only academic supplier of advanced radar research and development to Jaguar Land Rover. This together with long term agreements with Selex (£1.7M) and the MoD form the bulk of £3.1M of industrial grants to the group.

The **REE** group is the main suppliers of academic research to the UK rail industry (Network Rail, London Underground, Department for Transport) and undertake research for the international rail industry in Germany, France, Japan, China, Singapore, and USA. The grants directly from Network Rail totalled £1.8M. The rapidly expanding work on Energy in the School has developed strategic relationships with National Grid (£0.4M) and E.ON (£0.2M) with additional funding from FP7 (£0.2M), EPSRC (£0.3M) and local government (£0.5M), all funding totaling £1.7M

The **HCI** group forms the primary UK academic source of research, development and exploitation expertise on Human Factors and Virtual Environments for training and visualisation within the MoD, primarily enabled through a Defence Technology Centre (DTC). The total industrial and government grant portfolio is £5.0M, of which £3.1M is thorough the DTC.

There is substantial support and strategy developed at University level: The University's Research and Knowledge Transfer Committee providing strong leadership of all of the institution's activities. Impact is supported by the University's **Research and Innovation Services (RIS)** and **Enterprise development (ED)** offices. In **RIS** commercial development is spearheaded by the company Alta Innovations providing services to academics including market research, facilitating grants, commercialisation, filing patent applications (EECE have 5 granted patents since 2008), finding commercial partners, negotiating license agreements, IP advice, setting up spin-out companies (EECE has 2 since 2008), consultancy agreements (60% of staff currently have consultancy), and helping to raise investment funds. **RIS** also develop Strategic Partnerships (we have strategic partnerships with National Grid, E.ON, Selex, BAE SYSTEMS, QinetiQ and Jaguar Land Rover) and provide support to develop, bid for, and manage complex multi-party projects. They also provide specialist support for EU programme application and management (we had 25 EU programs bringing £3.7M to EECE). Finally **RIS** manage the Birmingham Research Park which offers purpose built accommodation to organisations. **ED** is tasked with raising awareness within the research community of the potential for the commercialisation of research and to help equip researchers with the knowledge and skills. For example they manage innovation and impact funding competitions and funded personal development programs such as Medici.

The 9 Schools in the **College of Engineering and Physical Science** benefit from an 8 person knowledge transfer support team, who provide a strategic overview, liaise with RIS and provide business development mangers (BDM) to schools; one is assigned to EECE. The College provides a strong mechanism for internal interdisciplinary links; for example the REE Group is part of the College wide Birmingham Centre for Railway Research and Education.

EECE level activity is led by a **School Research and Knowledge Transfer Committee** supported by the **Industrial Liaison Committee** and enabled by the culture and enthusiasm of the staff. Both strategic School funds and individual funds are available to staff, the latter distributed formulaically based on their performance. The School has a **sabbatica**l system which includes impact in its objectives, and recently has helped to develop international collaboration in railway systems and

communications.

The **staff profile** is one of the primary mechanisms in achieving quality research, generating knowledge which leads to impact. Strategic staff recruitment has strengthened existing world class areas. The REE group has had one new staff member with expertise in power systems and a 5-year Birmingham Research Fellow (BRF) whose contract leads to a lectureship. Three new staff members have been appointed in the MDS group with expertise in systems and component development. The University Human Computer Interaction Centre established funded collaboration with Computer Science with a professor and two new members of staff in Computer Science and one BRF in EECE. The impact links extend to **postgraduate students** through entrepreneurial skills courses and with MSc students through a course with industrial studies and our employability days. We have an industrially attended **open day**. Incentives for maintaining and growing the culture of industrial cooperation include appropriate rewards through **promotion and consultancy**. Support for staff is provided to grow impact related work and includes a vast range of university organised **training courses**, a **mentoring system**, an annual **Away Day**, annual **Performance Development Review**, internal **peer review** of proposals and **Grant Writing Groups**. The School has two funded **secondees** (Prof P Cannon (FREng) and Dr M Angling) from QinetiQ improving our long established connections. In addition to the substantial strategic partnerships there are many examples of how impact has been achieved using the mechanisms above; a selection is given below:

- The company **ZeroHertz Ltd** is currently being set up and was enabled by research work on a radar based electronic 'fence'. The research started in 2001 with an EPSRC feasibility study (EPSRC, £80 k), subsequently followed by a DTC (2003-2010, £910k) and a further EPSRC grant (2012, £500k) in partnership with SELEX Galileo (Luton). In addition to the spin out company SELEX is moving towards a product of a light buoy chain forming a fence to protect Exclusive Economic Zones and off-shore assets (wind farms, oil rigs, etc).
- An EPSRC feasibility study (£63k 2006-7) on **reconfigurable antennas** provided support for a successful EPSRC grant (£438k, 2008-2011) with Sony Ericsson and Motorola. With RIS support, **4 patents have been granted** and funding from 'EPSRC pathways to impact' has been used to **establish the company Smart Antenna Technology**. The project won both the National Discovering Start-Ups and the Enterprising Birmingham Competitions. Investment has been obtained, with a business plan estimating future royalties of £350M per year.
- EECE has developed a **peripheral nerve interface** which resulted in a patent in national phase prosecuting in Europe and the US held jointly between Birmingham, Kings College and Cambridge University. The work developed from a £1.8M EPSRC grant (EP/C52330X, 2005-9, £213k) followed by a DSTL grant (£65k, 2011).
- A study for the Department for Transport to understand the **energy savings available through the use of novel hybrid and bi-mode trains** showed a 16% energy saving was possible if certain traction systems were employed. This together with our studies on future requirements and optimal operation informed the procurement decisions of vehicle fleets in the UK (~£7 billion) and Singapore (~£1 billion).
- Working with the School of Health and Population Science, EECE has developed **software tools for running electronic trials for Primary Care Trusts**. The first trial is with **107 West Midlands GP surgeries**; the software uses anonymous data mining to find appropriate patients and support for trials. The work is commissioned by the National School for Primary Care (4 grants total £270k) and the CLRN (3 grants £220k). Collaborative work is extending across the UK, with Kings College looking at GP surgeries in London.
- In the late 1990's there was informal **collaboration with the Technical University of Ilmenau, Germany and the Fraunhofer Institute on waste water treatment**. Exchange visits funded by the British Council and the German DAAD (£18k) led to on-site treatment plant analysis. This led to a consortium of 5 water companies/authorities and 6 universities being funded through EU project SMArt (2001-2004, £193k). Implementation is now in 9 treatment plants in 5 countries.
- **Work on speech** is well established in the School and contracts from EPSRC (£261k), EU (PF-STAR, 2002-4, £160k), GCHQ (£623k) and industry (20/20 Speech) enabled the identification of an opening for **a spin out company**, **The Speech Ark,** which collects and sells speech and language corpora. The company has sold corpora to 6 universities and is collaborating with

Sony and Disney.
- An **interactive theatre production** supported by the EPSRC **Partnerships for Public Engagement program** (£115k 2 years) was launched. Post-performance evaluation from teachers of the 1140 children participating show that every performance increased understanding of the impact of science and engineering on society.

Other end-user **funded examples** of impact since 2008 include: the world's first image of the earth's surface using signals from GPS satellites enabling 24/7 imaging, superconducting microwave filters enhancing radio astronomy measurements, new resilient internet protocols, mapping of underground services (e.g. water pipes), acoustic speed sensors for navigation, the first mobile ad-hoc communications network of underwater nodes and vehicles, wideband magneto-dielectric wideband antennas, smart energy control systems, control and protection strategy for wind farms, identification of birds through analysis of their song, visualisation of faults from 3D seismic data, cancer identification from images, using artificial intelligence in education, using genetic algorithms to determine the structures of terrorist cells, and a number of practical examples of wearable computers.

Further impact activities include **6 external training courses** strengthening our links to industry, membership of 2 standards committees and participation on a range of industrial and government committees.

c. Strategy and plans

The strategy is to maintain and enhance the currently successful culture of industrial cooperation and dissemination whilst taking on new appropriate opportunities. Through the mechanisms described in section (b) staff are encouraged to develop a **long term approach** to their impact activities. The School's strategy recognises the importance of strategic staff appointments, the various support and encouragement mechanisms and dissemination of appropriate information.

We will help enable the UK rail industry to realise the next generation low carbon traction and intelligent infrastructure for cost-effectiveness and improving network capacity, as defined in the UK Government TSLG Rail Technical Strategy 2012. Our well established research on terahertz systems, on-body communications, cognitive radio and radar systems are in EPSRC Growth Areas and we will bring this research into the impact arena. Our Speech research has recently been recognised by GCHQ (£623k contract), and this together with our strong multimodal HCI work, augmented by virtual reality and wearable computing puts us in a strong position for a variety of impact mechanisms building on our extensive DTC involvement.

We will significantly **expand** our very successful large commitments, which include our strategic relationships with Jaguar Land Rover, Selex, QinetiQ, BAE SYSTEMS, Network Rail, National Grid, E.ON and the MoD. This is in parallel with the **continued enhancement** of the smaller developing end-user relationships, a few of which are described in the examples above. **New relationships** will develop through new staff appointments and the transfer of the high quality School research. **Small companies** are central to economic development, and we plan to continue not only relationships with external small companies but also build new spin-out companies of our own. Individual staff are encouraged to work on standards and other committees and we intend to build on our EPSRC supported public engagement work.

d. Relationship to case studies

The impact described in all of the case studies has been facilitated by University and School policies. The studies evidence impact arising both from fundamental research and from the identification of significant user needs as discussed in section (b).

The car radar for example is the result of long term collaboration with Jaguar Land Rover bridging the gap between research and development. The mobile phone antenna was achieved through high quality EPSRC funded research and the inventiveness of the EECE staff with a deep knowledge of industrial requirements. The Railways-related case study resulted from many years of valuable collaboration with industry, significant EPSRC funding of the Birmingham Railway Centre and dedicated staff with a desire to succeed. The Games Based Simulation case study is based on long term DTC funding for military training simulators. The impact is not only through the extensive use of the simulators, but also supports the many small companies helping develop the commercial systems.