Institution: Newcastle University

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

a. Context

Newcastle University has broad societal challenge themes; sustainability, healthy ageing and social inclusion. This UoA unit comprises a single school and engages primarily in the former two with applications in communications, electrical drives, smart grids, medical devices/systems and future electronics. Consequently impact is generated through licensed IP/know how, patents, spin-out companies, company spin-in, design consultancy and confirmed industry take up of published advances. Over the course of this REF period, the school has had collaborations (technology transfer, funding, and consultancy) with 128 industrial partners e.g. Siemens, Dyson. This has resulted in the funding of 21 CASE studentships and 30 research grants totalling £2M. Key exemplars of how research from our four research groups has been translated into impact over this REF period include:

- Modelling CAD software for state-of-the-art nanoscale transistor analysis has been translated to Synopsis and the school hosts the AIMPRO molecular modelling tool for materials science;
- Advances in biomedical electronics have resulted in the OptoNeuro spin-out company, a low cost ultrasound design to advance obstetric care in the developing world and the transfer of advanced biomedical control algorithms to the Touch Bionics company;
- Innovations in motor design have been incorporated in Dyson products selling 5M units/year, and Hoganas electric bicycles designated for the Chinese market;
- The CANopen communication protocol, invented in Newcastle, is now a worldwide standard.

b. Approach to impact

The School targets the highest impact journals and conferences for disseminating research to the academic community. In tandem, this is followed up with translational research and technology transfer, utilising the school's broad connections with industry. The school has a Director of Engagement whose remit includes the expansion of impact creation activities and promoting the School's achievements to industry and the wider community. For longer term impact, the Newcastle Institute for Research on Sustainability (NIRES, http://www.ncl.ac.uk/sustainability/) is coordinated at the school, and there are strong biomedical collaborations with the Newcastle Institute of Ageing and Health and the Institute of Neuroscience (one of the few primate facilities in the UK). During the REF period, the school has achieved successful technology transfer through the following routes:

- *Translational funding* – The school obtains translation funding from TSB Knowledge Transfer partnerships (KTP), EPSRC Follow on funding and Knowledge Transfer Accounts (KTA), and now EPSRC Impact Acceleration Accounts (IAA). The school has received several awards from each of these sources, averaging two active KTPs at any one time, for example. Specific exemplars include:

  KTA: Supported translational biomedical electronics leading the establishment of the OptoNeuro spin-out company in 2012 and the development of low cost ultrasound technology which is now being commercialised by Delft Imaging of the Netherlands.

  EPSRC follow on /IAA: Supported MESSAGE project establishing markets for the Envirowatch E-mote product, and with Maxeler technologies for financial analysis accelerator chips.

  KTP: Supported collaborations include CMR, Martel, ADL Smartcare, Northern Powergrid, E-Therapeutics. One of the most successful led to a range of underwater communication and positioning products generating £1M pa sales with Tritech International **(Case study 1).**

  TSB: Supported collaborations include Leyland trucks and Prodrive motor systems.
- *Direct industry funded development* – Many of our research activities attract direct funding from companies for product development. Examples of this include the design of innovative machines using iron powder components funded by Hoganas of Sweden, ultra high speed motors for Dyson, electric vehicle traction motors for Zytek and Jaguar-Landrover, aerospace

generators for Goodrich, turbogenerator end-region design for Siemens and the development of acoustic sensors for jet engine fuel control for Rolls Royce. Many millions of end users of transport and energy benefit from these developments with global companies.

- *Company spin-in* – During this REF period the school has successfully integrated engineering teams from Dyson, CPI and Hoganas into the building as a very effective way to transfer our research into novel products. Dyson is the best example of this: it has dedicated offices and laboratories, with six Dyson researchers embedded in the school. Close interaction and technology transfer with the Power Electronics, Drives and Machines research group has had a major influence on the "digital motor" designs in their mass market products such as hand–held cleaners and hand driers, used daily by millions of people worldwide (**Case study 2**).
- *Company spin-out* – three spin-out companies currently exist to exploit research from the school. Northern Digital is developing graphics accelerator technology based on logarithmic scale processors. Envirowatch Ltd is manufacturing and marketing wireless environmental sensor network nodes (E-motes), with systems supplied to many cities in the UK and worldwide. OptoNeuro Ltd was established to commercialise ongoing neuroprosthetic optoelectronics research (e.g for retinal prosthesis, brain pacemakers).
- *Industrial secondments* – In this period, 2 of our academics performed secondments. Horsfal received a RAEng award for a one year secondment with BAE systems, Atkinson was seconded to Hoganas (Sweden) for ten weeks, leading to a patent and further funding.
- *Collaborative Research* – Many of our EPSRC grants include a very substantial in-kind contribution of staff time, access to facilities etc from industry. Some grants are jointly funded by industrial consortia, such as in the EPSRC Autonomous and Intelligent Systems (AIS) programme. Additionally, Intel, ARM, Dyson, BAE and others have funded PhD studentships during the REF period.
- *Patents* – The school pursues two IP strategies: in-house filing and company filing depending on the funding source and negotiations with industrial partners. Several important patents have been filed during the REF period such as "Sensorless control of a brushless permanent-magnet motor" filed in collaboration with Dyson. In addition, specialised school lab books have been implemented which are compatible with the US 'first to invent' system, and the Faculty enterprise services actively support the whole process from filing to granting to licensing.

In tandem with our REF4 spend, the school has attracted >£21M in centres and facilities of particular relevance to our impact mission. This funding was awarded by the EU, EPSRC and others over this REF period. This comprises: the >£3M Centre for Advanced Electric Drives (CAED) with secure office space for industrial staff; upgraded semiconductor clean rooms to facilitate the embedding of the Centre for Process Innovation (www.uk-cpi.com/); >£6M investment to create the national XPS facility; £3M Capital grant to allow nanoscale characterisation; a new £7M Neptune National Centre for Subsea and Offshore Engineering; the £1M Sensors, Electromagnetics and Acoustics Lab (SEAlab) to facilitate collaborations with the subsea industry; a £1M Extreme Environment Lab to explore high temperature/radiation electronics. The school is also involved with the new £50M Science Central academic-industrial collaboration environment (www.newcastlesciencecentral.com/) being built around the theme of sustainability (NIRES).

Our school has a dedicated Business Development Manager from the Faculty's enterprise team (www.ncl.ac.uk/res/). In addition to IP formation and exploitation, commercial activities, and company spin-outs, they support KTP and TSB translational projects. The enterprise team also provides funding through KTA/IAA schemes, business voucher funding for collaborative projects and the N8 group of universities' joint Higher Education Innovation Fund (HEIF) funded 'METRC Innovation Award' (www.metrc.co.uk/home.aspx), which can be used to support small research and innovation projects to explore the feasibility of innovative new products and processes.

c. Strategy and plans

In addition to maintaining the successful mechanisms described above, our strategy is to encourage and support all academic staff to play an active role in technology transfer and product development activity. In particular, around half our academics are new entrants since the last RAE due to replacement of retirees and growth; the school has therefore been working with the enterprise team to ensure there are training schemes and support available for their long term

commercial and societal impact. Specific strategies to expand our impact include:

- A core of 7-8 academics (e.g. Mecrow, Taylor, O'Neil) with strong track records in impact creation have been identified to mentor less experienced academics in technology transfer when opportunities arise, and spread best practice on impact creation activities.
- Use feedback from our bi-annual Industrial Advisory Board meetings to guide our approach to impact creation, drawing upon experience of what technology transfer routes work best.
- Utilise our student base to maximize our connectivity with Industry. The school has ~40 undergraduate industrial placements per annum on our MEng programmes, which will be used to support further expansion of CASE PhD studentships and direct industry funding.
- Make maximum use of Newcastle's recent £1.4m Impact Acceleration Account award from EPSRC to support technology transfer projects and use other internal/external funding to ensure that all staff have resources to pursue impact creation activities. Additionally, academics are encouraged to obtain support and funding from research (e.g. the Wellcome Trust) to build impact from biomedical research and facilitate take up in medical applications.
- Identify opportunities to expand the successful spin-in model (e.g. with CPI) to build close relationships with more companies and create efficient exploitation routes for our research.
- Maximise use of our industry facing development and testing facilities (e.g. CAED, SEAlab) to support industrial partners and help develop research outputs to higher TRLs.
- Encourage staff to participate in influential industry bodies such as the National Microelectronics Institute (E.g. O'Neil), national facilities (e.g. Taylor) and provide consultancy to industry (building on the 39 companies supported in this REF period).
- Encourage participation in more interdisciplinary projects, benefitting from the University's mechanisms such as Newcastle Institute for Research on Sustainability (NiRES), to maximise the impact that our research has beyond the boundaries of engineering. Make strategic academic appointments to strengthen areas of cross disciplinary collaboration, e.g. biomedical (Degenaar, Nazarpour) engineering, to expand the reach of our research impact.

In the coming period leading up to the next REF exercise, a number of high impact activities planned. These include a £18M underpinning power electronics grant in collaboration with UK power industries, and a £13.9M biomedical grant to put pacemaker devices into human brains by 2020. Additionally it is hoped that recent spin-outs will mature to exit, and early stage ideas will continue to be pump primed with EPSRC IAA funding. Future promising case studies include:

- *Epilepsy pacemakers:* By 2020 the aim is to perform the (world) first human trial of a new type of optoelectronic/optogenetic pacemaker which could transform the lives of epilepsy patients.
- *Touch Bionics*: An advanced control algorithm has been translated to Touch Bionics Ltd to create a new generation of active prosthetic hands and is presently undergoing patient trials.
- *Compact electric bikes*: Staff from Hoganas are now developing novel motors for electric bikes, with our electrical machines team, which are being transferred to production for worldwide markets.
- *Rare Earth Magnet Free Traction Motors:* developed as part of three ongoing TSB projects, our low cost motor technology will feature in Jaguar LandRover Evoque-E prototypes.

d. Relationship to case studies

Case Study 1 "Underwater acoustic communication" received a KTP grant for knowledge transfer and significant support from the enterprise team for the licensing process.

Case Study 2 "Dyson motors" – direct funded R&D and spin-in leading to close, long term collaboration. This has utilised support from the enterprise team and Dyson-funded studentships.

Case Study 3 "Worldwide Industrial Adoption of Asynchronous System Design" – has utilised support from the enterprise team for consultancy.

Case study 4 "CanOpen" – was the result of an industrially funded project between one of our past Academic's and Bosch. The school supported the PI in the formation of the international standard.