Institution: Queen's University Belfast

Unit of Assessment: 11

a. Context

Queen's University Belfast (QUB) has a strong track record in technology exchange and research commercialisation, recognised in 2009 by THE's "Entrepreneurial University of the Year" award. QUB was also ranked 1st in the UK for the annual revenues (£112M in 2010) and its spin-off companies (DTI/HEFCE Higher Education-Business and Community Interaction survey, HEFCE 2009/23) and 2nd for numbers employed (982 in 2010 - the most recent available data) and the best UK KTP in 2011. To date, over 50 companies have been created, including several linked to QUB Computer Science: Andor (AIM listed), Meridio (acquired by Autonomy and then Hewlett Packard), Audio Processing Technology (acquired by Cambridge Silicon Radio), and EventMAP. The process technology exchange and research commercialisation is facilitated by mechanisms including joint research with industry, Knowledge Transfer Partnerships (the largest number of any UK university 2011), software licensing and the creation of spin-out companies. The latter is done through QUBIS Ltd, the University's holding company, which was one of the first of such companies to be established (1984) and the first to invest capital as well as IP in such companies.

However, in addition to these more conventional university mechanisms, a more radical approach to research impact has been pioneered by QUB School of Electronics, Electrical Engineering and Computer Science. QUB Computer Science (the UoA) played a key role in creating the vision that led in 2004 to the building of the Northern Ireland Science Park (NISP, www.nisp.co.uk) and its research flagship, the Institute of Electronics Communications and Information Technology (ECIT, www.ecit.qub.ac.uk). ECIT comprises relevant research clusters from Computer Science and Electronic & Electrical Engineering. The objective was to create a new and stimulating environment where research is actively used to help foster economic development, including the attraction, creation and growth of high technology industry. NISP now accommodates 118 companies, from small, growing start-ups to multi-nationals, such as IBM, SAP, Citi, Cambridge Silicon Radio, Microsoft and Polaris. In total, these companies now employ 2100 people generating, in salaries alone, over £100M p.a. for the economy.

QUB Computer Science has also been very active in supporting InvestNI in attracting and then supporting inward investment companies, via collaboration with all our research clusters. Successes include: SAP and Citi Group (in High Performance and Distributed Computing); Andor and CSR (in Speech, Image and Vision Systems); and New York Stock Exchange Technologies and Bombardier (in Knowledge and Data Engineering). The UoA has also been active in the Fusion all-Ireland University-Industry collaboration scheme (e.g. with Vitalograph Ireland).

b. Approach to impact

Central to our new approach has been to recognise that, while research and research impact such as technology transfer and innovation are related, these typically require different types of people with different expertise: research is the creation of new ideas and new knowledge, while innovation and technology transfer is the translation of these ideas into new products, services and businesses. In establishing ECIT (initial 5-year funding £37M, now 175 people), we set out to create a dynamic environment that undertakes research at the highest international standard while also seeking to bridge the "valley-of-death" that often impedes its wider economic impact. Our approach has been to overlay our academic research environment with an infrastructure that is more common in a high-technology company, but in a manner that does not compromise the quality or speculative blue-skies thinking that creates disruptive breakthroughs. This has been achieved by co-locating 22 engineering staff, with many years' industrial experience, alongside academic research teams. Their roles involve cultivating and supporting industry/business engagement, including the creation of proof-of-concept prototypes, work on technology transfer programmes, including KTPs, and facilitating new spin-out companies. They have a well-defined career promotion path that emphasises innovation and technology transfer rather than research publication and funding. They are not tied to specific research clusters, but are flexibly assigned to major projects, as required. This "Open Innovation" environment allows problems to be addressed across the spectrum, from curiosity-driven to market led research, blurring traditional distinctions between pure and applied research. The inflow and outflow of knowledge between academia and

industry, promotes much greater understanding of each other's expertise and challenges at an early stage to strongly enhance the potential of research impact. ECIT's activities are overseen by an International Advisory Board comprising senior industrials and academics with considerable industrial experience. This board currently includes Professors Andy Hopper, Mike Kelly (both Cambridge), Steve Furber (Manchester), Tobias Noll (Aachen), Virgil Gilgor (Carnegie Mellon) and Jan Rabaey (Berkeley).

Within Computer Science, the Speech, Image and Vision Systems (SIVS) cluster is completely located at ECIT. Relevant researchers and projects from the HPDC and KDE clusters are also located within ECIT. For several major multi-cluster projects, ECIT acts as the hub.

This environment was significantly enhanced in 2009 by the creation, within ECIT, of the Centre for Secure Information Technologies (CSIT, www.csit.qub.ac.uk). This £30M UK Innovation and Knowledge Centre (IKC) has been funded by EPSRC, TSB and InvestNI, with industry and university contributions of £7M and £8.8M respectively. CSIT has since been designated an EPSRC/GCHQ Academic Centre of Excellence. CSIT involves the SIVS and KDE research clusters in Computer Science, plus clusters from Electronic and Electrical Engineering. The UoA's research expertise in Intelligent Video Surveillance and in Machine Learning and Knowledge Engineering (for Cyber Security) is at the heart of CSIT's plans. CSIT has extended the original ECIT experience through the creation of a US-style membership model where companies pay an annual fee to join its Industrial Advisory Board. This board provides valuable feedback that informs and helps prioritise research and innovation programmes. Current members include Cisco, IBM, McAfee, Thales, GCHQ, BAE Systems, QinetiQ, Altera, Infosys and Roke Manor Research. The board also has representation from DSTL, CPNI and MoD. CSIT also operates an associate membership model, whereby other companies (typically SMEs) participate. As an EPSRC/TSB IKC, CSIT's role is "to accelerate the commercialisation of world class research into new products, processes or services and to foster collaboration and deliver competitive advantage to the businesses with whom they interact". CSIT is thus developing as a "Global Innovation Hub" with strong links to similar centres internationally, e.g. CyLab at Carnegie Mellon University, Stanford Research Institute, Georgia Tech Research Institute and ETRI in Korea. Membership provides early sight of research and allows partners to use this for internal R&D purposes. This provides a mechanism to "try before you buy" with full licence agreements created where IP is scaled up and used commercially, thus accelerating the uptake of research and helping to short-circuit the tortuous IP negotiations that often characterise university technology transfer.

c. Strategy and plans

The strategic approach adopted has a number of other key characteristics. Firstly, our focus is on our core research strengths. We also work with partners to share research road maps. Thus, we seek to develop an "over the horizon" view informed by future needs, challenges and opportunities. We take strong cognisance of areas of national strength as identified by the BIS "Technology and Innovation Futures" and "Eight Great Technologies" reports as well as emerging EU Horizon 2020 trends. An important part of our strategy also includes training new PhDs to meet future skills needs in relevant growth areas. One example is the Capital Markets programme, which is akin to a Centre for Doctoral Training, involving University of Ulster. We receive support and funding from five key companies including NYSE and Citi, with PhD students in KDE, SIVS and other clusters.

Conventional university research often focuses on specific problems involving a few individuals. The UoA strongly encourages a much more holistic and "mission-led" approach where we engage directly with partners to identify research grand challenges, typically with a team approach requiring a spectrum of expertise. CSIT's research, for example, is focused on three main challenge themes namely: Security in (a) a Hyperconnected World, (b) Financial Services and (c) Transport Corridors, with inter-related work programmes designed to achieve ambitious objectives. QUB Computer Science is closely involved in (b) and (c), and involved in (a). In our experience this grand challenge approach provides a much more effective approach to problem solving and research impact delivery compared with undertaking sets of several smaller, often disjoint, research projects. Critical to our impact strategy has been the creation of a professional support infrastructure comprising a Commercial Director and three Business Development Managers all of whom have extensive experience of high technology industry worldwide and whose activities include developing strategic partnerships with research labs and industry worldwide. Our business development staff work closely with QUB's Research and Enterprise

Directorate on issues such as contract negotiation, patent application/filing and IP licensing. The Research and Enterprise Directorate also helps negotiate Knowledge Transfer Partnerships. Spin-off companies are facilitated through QUB's early stage investment company QUBIS Ltd. Exciting new start-up opportunities are currently being nurtured through initiatives such as the TSB's SBRI, EPSRC Follow-on funds and InvestNI "Proof-of-Concept" programmes. These include Liopa (lip-based biometric verification for mobile devices) described in one of the case studies. Also important is the facilitation of young externally created "spin-in" companies. These are typically ICT companies that reduce their risk of early failure by using the support and research infrastructure available in the ECIT building. Twenty five companies have been facilitated during the REF period.

Strategic Marketing is also very important. This uses "horizon scanning" to couple research expertise with new market opportunities. Business Development staff regularly exhibit at high profile trade events and conferences using capability briefs to promote new technologies. UKTI and InvestNI also actively promote the UoA internationally using ECIT/CSIT as a showcase to attract high calibre FDI visits. Activities also include keynote presentations at international business events, e.g. the media presentation at the 2013 G8 Summit Cabinet Office YouTube video.

A further important aspect is the UoA's relationship with the Science Park's NISP CONNECT (http://www.nisp.co.uk/?page_id=34), which fosters entrepreneurship by accelerating the growth of promising technologies and early stage companies. CONNECT also promotes entrepreneurship in academia by the £25k Award, which is modelled on MIT's $50K award where potential academic spin-outs compete for an initial seed-corn prize and a package of support. Submissions based on research in QUB Computer Science have won categories of this competition on two occasions in the REF period, including Liopa's winning of the Digital Media & Software category in 2013.

Acceleration of impact is also facilitated through secondment schemes to and from industry, including EPSRC's Secondment scheme. One example is with Cambridge Silicon Radio, in the area of speech enhancement for in-car audio devices.

d. Relationship to case studies

The outworking of the research and the interaction between the various impact delivery structures in the UoA has led to all three submitted Impact Case Studies. Two of these (from research in the SIVS cluster) have been facilitated through ECIT; and one spin-out company (arising from research in the KDE cluster) has grown through the University's more traditional business support services, including QUBIS.

(i) *Affordable Confocal Microscopes Enabled by Novel Digital Imaging Techniques*. Andor is a world-leading company in confocal microscopy (and a QUB spin-out). Through a £2m collaborative project (£1m to QUB), we enabled Andor to develop a brand new low-cost confocal microscope, by delivering key novel image processing software. This has brought this powerful technology to a wider audience of medical researchers, and opened up a new international market for Andor, strengthening its internationally leading position.

(ii) *Applications of Novel Speech and Audio-Visual Processing Research*. A ground-breaking approach to speech enhancement is outperforming all existing state-of-the-art methods, and has impacted the R&D strategy of a multinational consumer electronics company and a company specialising in health monitoring equipment. A novel branch of our speech research has led to a new commercial biometric identification system for mobile devices, called Liopa. The product and its award-winning commercialisation strategy will be realised through a new spin-out company. Liopa epitomises the success of ECIT's new impact philosophy. The founding members include a Business Manager, and Engineering Manager, and ECIT Engineer and an academic.

(iii) *The commercial impact of scheduling and optimisation on university space planning and utilisation*. A spin-out company has taken the UoA's research in algorithms for scheduling, resource planning and problem description (in collaboration with University of Nottingham), and has developed tools which have led to major construction cost savings through better utilisation and reduced real estate. In one case, the client reports savings of £70m in saved construction costs. This case study illustrates the more traditional pathway to commercial impact; where all the University's business support mechanisms have been involved in laying a sound foundation which, in the current REF period, is now paying off through major international impact.