Institution: Queen's University Belfast (QUB)

Unit of Assessment: UoA13

a. Context

QUB has a strong track record of technology transfer and research commercialisation recognised, in 2009, by THE's "Entrepreneurial University of the Year" award. This includes its creation of fifty nine spin-out companies which by 2012 had 1164 employees and a combined turnover of £146M p.a. A number of these were created from the UoA's research including Amphion Ltd. (acquired by Conexant) and APT Ltd. (acquired by Cambridge Silicon Radio).The UoA has, over many years, been very active in supporting UKTI and InvestNI in attracting Foreign Direct Investment (FDI) into the UK. Examples include Seagate, Analog Devices - now ICEMOS (*HFE*), Tyco, Xilinx and Q1Labs - now IBM, (*SDS*), SAP (*DC)* and Caterpillar (*EPIC*). The UoA has long standing collaborations with companies in the EU, US and Asia that have led to important industrial application. These include the European Space Agency and EADS Astrium on Satellite applications, Adidas on body worn networks, McAfee and IBM on malware research for mobile and network devices and Cisco Systems on Software Defined Networks. The architecture of Altera's latest Stratix-V Advanced Systems Development Kit (DK-AS-5SGXEA7N) has also been strongly influenced by UoA work on hardware accelerated IP traffic analysis. We have extensive experience of EU research consortia including five current FP7 programmes. Within Northern Ireland we are also helping to drive a rapidly growing Capital Markets sector (5000 new jobs in 5 years) through a Doctoral Training Centre funded by Citi Group, NYSE Euronext, First Derivatives, Fidessa and Singularity. The UoA is one of the main participants in QUB's Knowledge Transfer Partnership (KTP) Programmes, one of the most successful in the UK. Other mechanisms for delivering competitive edge to industry include joint research and consultancy projects to facilitate the growth of companies such as Randox and Andor (RAEng McRobert winner/finalist respectively). With this background the UoA also played a central role in creating the vision that led, in 2004, to the building of the Northern Ireland Science Park (NISP) and the UoA's research flagship, The Institute of Electronics Communications and Information Technology (ECIT), where a major portion of its research is now undertaken. 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.

b. Approach to impact

Central to our approach has been to recognise that whilst research and research impact, such as technology transfer and innovation, are related, these typically require different types of people with different expertise i.e. research is the creation of new ideas and new knowledge, whilst 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 whilst 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' of 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. Six of its members are FREng, including three who are also FRS. This board

includes Professors Andy Hopper, Mike Kelly (both Cambridge), Steve Furber (Manchester), Tobias Noll (Aachen), Virgil Gilgor (Carnegie Mellon) and Jan Rabaey (Berkeley). Impact acceleration is further enhanced through secondment schemes, including Marie Curie Industry-Academia Partnerships, Engineering Doctorates and RAEng industrial secondments. Secondments from industry are encouraged through honorary/visiting professorships/fellowships.

This environment was significantly enhanced in 2009 by the creation, within ECIT, of the Centre for Secure Information Technologies (CSIT). 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, with 80 people, the UK's largest academic research centre in Cyber Security has since been designated an EPSRC/GCHQ "Academic Centre of Excellence". CSIT involves a number of UoA's research clusters and 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, (text removed for publication), BAE Systems, QinetiQ, Altera, Infosys and Roke Research. The board also has representation from (text removed for publication) CSIT also operates an associate membership model, whereby other companies (typically SMEs) participate – currently Qosmos, RepKnight, Netronome, Tyco, Seven Technologies and Titan IC Systems. 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.

The UoA is also integrally involved with NISP CONNECT, an independent, non-profit organisation modeled on and supported by San Diego CONNECT. CONNECT acts as an honest broker to encourage the development of innovative technologies and early stage companies through a series of educational, mentorship and leadership programmes. UoA staff and PhD students are encouraged to attend the "Halo" programme (UK Business Angel Network of the year 2010), and monthly "brown-bag" lunchtime sessions where entrepreneurs share best practice. It also runs a £25k Award, modeled on MIT's $50K award, where potential academic spin-outs compete for an initial seed package of support. UoA staff have won this four times during this REF period.

c. Strategy and plans

The strategic approach adopted has number of other key characteristics. Firstly, with finite resources, our focus is on our core research strengths. In addition, we 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 are and will continue to build strong relationships with the TSB's Connected Digital Economy and Satellite Applications Catapults. We also 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. Examples include new satellite applications technologies such as Frequency Selective Surfaces and self-steered antennas, new network and data security technologies, advanced technologies for industrial plant control, technologies for Smart Grid and Smart Grid Security and body worn communication devices for medical electronics applications. The UoA is also a member of the BIS Cyber Growth Partnership (chaired by the Minister) to facilitate a strategic Government and industry partnership to grow the UK Cyber Security sector.

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 major research 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. In our experience this approach provides a much more effective approach to problem solving and research impact delivery compared with undertaking sets of smaller several, 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 Mangers all of whom have extensive experience of high technology industry worldwide and whose activities include developing strategic partnerships with research labs and industry worldwide. Examples include EU FP7 engagement and $3M in programmes with ETRI and LG in Korea. The latter has created new Physical Unclonable Function technology now being used to authenticate payment for the charging of electrical vehicles. A strategic partnership in Cyber Security signed with InfoSys (India) will create a joint lab addressing new technologies for cloud based data and mobile security. This will involve joint research projects, sponsored PhD scholarships, internships, and faculty exchange. Other methods that promote impact include joint R&D programmes, sponsored PhDs and contract R&D. 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, including five UK KTPs and two Republic of Ireland/NI Fusion schemes during the REF period. Spin-off companies are facilitated through QUB's early stage investment company QUBIS Ltd. The UoA, through ECIT, NISP and QUBIS, has links with VC firms in the US, UK/Ireland who provide the risk capital needed through different stages of company growth. During the period eight new spin-offs have been created with Microsense, Titan IC Systems, Analytics Engines, ACT Wireless showing strong growth. Exciting new start-up opportunities are currently being nurtured through initiatives such as the TSB's SBRI, EPSRC Follow-on funds, InvestNI "Proof-of-Concept" programmes and a RAEng Enterprise Fellowship. These include Flish (flat antenna technology for satellite applications) and Liopa (biometric and speaker verification authentication for mobile devices). Also important is the facilitation of young externally created "spin-in" companies. These are typically ICT sector companies that reduce their risk of early failure by availing of the support and research infrastructure provided through taking space in the ECIT building. Twenty five companies have been facilitated during the REF period.

Strategic Marketing is also very important and will be expanded. This uses "horizon scanning" to seek 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 regular keynote presentations at international business events, e.g. the media presentation at the 2013 G8 Summit Cabinet Office YouTube video.

d. Relationship to case studies

The Impact environment developed over the past decade, has resulted in many examples of research impact. These include (a) the UoA's role in helping to transform a derelict "brown field" shipyard site into a vibrant technology park (b) many examples of successful technology transfer to large companies and organisations nationally and internationally and (c) the creation of growing start-ups. The case studies selected are ones which are sufficiently mature in terms of the levels of quantifiable evidence sought. The IP cores case study pre-dates the environment described, whilst the other three have benefitted strongly from it. However, it is important to highlight that the IP cores case study and the experiences gained in taking speculative research from seed funding through various stages of VC investment and acquisition has strongly helped shape what is now in place. The other case studies are based on the successful transfer of research to established organisations in the UK, Europe, US and China, with an approach consistent with what has been described i.e. based on close interaction of academic and industry personnel at an early stage. An important aspect has been the two way secondment of people including joint formulation of (a) the research and then (b) the advanced development programmes needed to achieve success with agreed road maps. These three cases have all involved the use within the UoA of its specialised laboratory facilities for "proof-of-concept" demonstration and prototype manufacture and test prior to these technologies being scaled up for industrial manufacture or application.