Institution: Queen's University Belfast

Unit of Assessment: UoA12

Title of case study: The Economic Impact of the Centre for Secure Information Technologies (CSIT)

Period when the underpinning research was undertaken: from 2001 to 2014

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Sir John McCanny	Regius Professor	1984 – 2017
Maire O'Neill (née McLoone)	Regius Professor	2003 – present
Vincent Fusco	Professor	1985 – present
Sakir Sezer	Professor	1996 – present

Period when the claimed impact occurred: from 2014 to 2020.

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

The Centre for Secure Information Technologies (CSIT) is a national cybersecurity research institute emphasising research excellence combined with a unique model for, and focus on, commercialisation and innovation. CSIT is the UK's only Innovation and Knowledge Centre (IKC) for cybersecurity. CSIT played a key role in the development of major government reports on cybersecurity strategy and economic policy in the UK and EU. In addition, it has been instrumental in catalysing the development of the Northern Ireland Cybersecurity Ecosystem, DCMS programmes, start-ups, attracting FDI which had led by 2019 to the creation of approximately 1600 jobs in this sector.

2. Underpinning research

CSIT was established in 2009 as the UK's Innovation and Knowledge Centre (IKC) in Cyber Security with initial funding from EPSRC, Innovate UK, Invest Northern Ireland, and Industry totaling GBP[text removed for publication]. Based on its innovation translation and academic successes, a further GBP[text removed for publication] in phase 2 funding (from 2015 to 2021), was obtained.

The IKC call through which CSIT was created, stated that successful applicants would *"be established in an area of emerging technology where **world-class scientific breakthroughs had already been achieved,** with the potential to bring about paradigm shifts in a broad range of market applications"*. Key to the success of CSIT was its ability to produce significant high-quality impactful research; examples include **R[1] Mc Canny, R[2] R[3], Sezer, R[1] R[4] R[5] O'Neill (McLoone), R[6] Fusco**.

Phase 1 and Phase 2 CSIT IKC funding, was predicated on established, and continued, world-class high impact research excellence at QUB, in hardware design for applied cryptography; hardware accelerators for inspecting malicious content; physically secured wireless. A representative sample of this body of work sustained before and during CSIT IKC phases 1 and 2 are detailed below.

Selected research outputs related to the formation of both IKC phases are:

Novel hardware optimizations of the Advanced Encryption Standard (AES) resulting in the fastest reported AES design at the time, **R[1]**. This technology was successfully commercialized by Amphion Ltd and utilized to provide security in 100,000,000 set-top box chip sets for which O'Neill (2014) was awarded an RAEng Silver Medal.

Research on lookup acceleration and pattern matching by Sezer for network processing, **R[2], R[3],** led to novel architectures for parallelization of data-dependent pattern matching operations. The work resulted in the formation of a spin-out company, Titan IC Systems Ltd, 2007, acquired by Mellanox 2020.

Research on a hardware evaluation of candidates for the SHA 3 Hash Algorithm, **R[4],** informed its standardization by the US National Institute of Standards and Technology, post its presentation at the 2010 NIST SHA-3 candidate conference.

A novel Physical Unclonable Function (PUF) Identity Generator, to date the lowest in cost, most robust, and efficient design for FPGA devices, was described in, **R[5],** and demonstrated by Thales for electronic component counterfeit protection.

In **R[6]**, a radio system was awarded the 2011 IET MAP Journal premium, then licensed to Microsense Ltd. for use in an advanced microwave security product, and won the 2010 regional finals of the Intertrade Ireland Seedcorn Business Competition.

Each of the above outputs has made a distinct and material contribution to the development of CSIT's four key research areas:

- Secure connected services
- Networked security systems
- Industrial control systems
- Security intelligence

The quality of CSIT's core body of research was recognized in 2012, through the peer-reviewed award of Academic Centre of Excellence in Cyber Security Research (ACE-CSR) status, NCSC/EPSRC. It was one of the first eight UK universities to be awarded this status, renewed in 2017.

In 2015, CSIT was awarded the Queen's Anniversary Prize for Higher and Further Education for its outstanding work in protecting online activity of internet users globally.

3. References to the research (indicative maximum of six references)

R[1] McLoone, M., **McCanny,** J.V., *High Performance Single-Chip FPGA Rijndael Algorithm Implementations*; Workshop on Cryptographic Hardware and Embedded Systems (CHES'01); Springer-Verlag, pp 65-77, Paris, May 2001 https://doi.org/10.1007/3-540-44709-1_7

CHES is the premier venue for research on design and analysis of cryptographic hardware and software implementations.

R[2] McLaughlin, K., **Sezer**, S, Blume, H, Yang, X, Kupzog, Noll, T, A scalable packet sorting circuit for high-speed WFQ packet scheduling, IEEE Transactions on Very Large Scale Integration (VLSI) Systems, Vol. 16 (7), pp 781-791, 2008. 10.1109/SOCC.2006.283896

R[3] This novel research work was patented filed in 2006 and granted 2011: Sorting Apparatus and Method, US Patent *US 8,032,543 B2*, 2011, Inventors S. **Sezer**, K McLaughlin.

R[4] Baldwin, B, Byrne, A, Lu, L, Hamilton, M, Hanley, N, **O'Neill,** M, Marnane, W.P, FPGA Implementations of the Round Two SHA-3 Candidates, 20th International Conference on Field Programmable Logic and Applications, (FPL 2010), pp.400-407, Italy, August 2010. 10.1109/FPL.2010.84

At the 25th FPL conference, held in London, 2015, this publication was selected as one of the top 27 papers over the 25 year history of the conference 'deemed to have most strongly influenced theory and practice in the field.'

R[5] Gu, C., Murphy, J., **O'Neill**, M., A Unique and Robust Single Slice FPGA Identification Generator, IEEE International Symposium on Circuits and Systems (ISCAS), pp. 1223-1226, Melbourne, June 2014. 10.1109/ISCAS.2014.6865362

R[6] Fusco, V , Cantu, H, Self Aligning Wireless Link Utilising Modulated Backscatter, Sept. 2010 IET Microwaves, Antennas and Propagation.4 (9), p. 1347-1353. 10.1049/iet-map.2009.0354

4. Details of the impact

As an IKC, CSIT overlaid its core research excellence with its dedicated business development function and its engineering team to promote industry engagement and facilitate the co-creation of solutions with industry partners. This led to a unique research and innovation environment.

CSIT's Role in Job Creation and SME Support

CSIT has been heavily involved in UK job creation in the Cyber sector. In 2020 CSIT, on behalf of the UK Government, co-authored the most comprehensive analysis of the size and scale of the UK's cyber security industry, **S[1]**, which cites 1600 new Cyber jobs in NI (2019). The Royal Society Policy Report **S[2]** states "(CSIT) has formed the centre of a local cybersecurity ecosystem that includes over forty companies". CSIT has been pivotal to this, through its foreign direct investment engagement with, and provision of talent for, major sector players from the US and beyond, e.g. Black Duck [text removed for publication] jobs in Belfast (2016). In 2019 NI was the No.1 destination for FDI in cyber security for US companies, **S[3]**. **The Director of Technology Invest Northern Ireland said, "it is our assessment that CSIT, through its research, innovation, commercialisation and ecosystem development activities, has been pivotal in growing the NI cyber security sector since its foundation", S[4].**

Six CSIT spin out companies have been created, including Liopa (2016) who use lip biometrics for authentication, ([text removed for publication] staff). This process is facilitated through *CSIT Labs* (2016) an incubator programme helping new businesses to start, scale and engineer cyber security products. This to date has assisted 16 early-stage start-ups with engineering support to minimum viable product stage.

In order to support early-stage ideas and start-ups, the UK Department for Digital, Culture, Media and Sports has funded three major UK national initiatives in which CSIT is a co-founding partner.

HutZero (2016) the leading Cyber entrepreneur bootcamp, which by 2020 had delivered five programmes (116 people), and seven Cyber security startups.

Cyber101 (2017), a five-year programme of business advice and mentoring to help new UK cyber security firms grow. GBP[text removed for publication] has been raised by cyber security start-ups since joining the Cyber 101 programme and 160 start-ups/scale-ups have been supported.

The London Office for Rapid Cybersecurity Advancement (LORCA), Plexal/CSIT/Deloitte, GBP[text removed for publication] an innovation accelerator for UK cybersecurity start-ups. Since June 2018, 35 companies have completed the LORCA programme with a further 20 currently in progress. These include B-Secur (ECG biometric authentication), a Belfast start-up which benefitted from CSIT engineering support, and was selected by Tech Nation in 2018 for their *Upscale Programme* supporting 37 of the UK's fastest growing Tech Companies. Another LORCA company, Angoka, decided to base their development office in Belfast in January 2020 **"all because of CSIT" (Executive Chairman) S[5].**

The economic impact role played by CSIT was summarised by the ex-Head Cyber Security Growth and Innovation, DCMS, "*CSIT have played a critical role in not only developing the world class cyber ecosystem in Northern Ireland, but are an integral part of the wider UK cyber growth and innovation landscape, contributing strongly to the support of DCMS programmes in this area. This is further recognised by their reputation internationally as an exemplar for the role of academia in cyber innovation and ecosystem development"*, S[6].

CSIT also co-founded the international Ecosystem of Ecosystems Partnership in Innovation and Cyber Security (*Global EPIC*), 2017, which now has 30 Members in 17 countries, and

has launched a global soft landing programme enabling trade and investment opportunities for UK cyber security companies.

CSIT influence on Policy

In July 2016, the Royal Society Cyber Security Research Policy Committee (McCanny CSIT PI was appointed co-chair) published a report on Progress and Research in Cybersecurity, **S[7].** The report highlighted that the original GBP850,000,000 UK National Cyber Security Strategy had no explicit cyber security research strategy, and gave little emphasis to research translation, and the role of high technology start-ups. These key themes were subsequently implemented in the updated National Cybersecurity Strategy 2016 (sections 7.2.4., 7.2.5., 7.3.), **S[8]**. His work on **S[8]** led McCanny (2017) to be selected for expert consultation by the EU High Level Group of Scientific Advisors 'Scientific Opinion No.2/2017 on Cybersecurity in the EU', **S[9].** A Joint Communication to the European Parliament and Council was subsequently delivered, **S[10]**, which built on a number of the recommendations listed in **S[7]**. This resulted in the establishment of an EU cybersecurity certification framework, now embodied in the 2019 EU Cybersecurity Act. This act establishes a European cyber security certification framework for information and communications technology products, services and processes.

5. Sources to corroborate the impact (indicative maximum of 10 references)

S[1] 2020 UK Governments Cyber Security Sectoral Analysis
S[2] 2020 Royal Society Policy Doc Research and Innovation Clusters
S[3] NI No.1 destination for foreign direct investment in cyber security for US companies
S[4] Director of Technology Services Invest Northern Ireland
S[5] Angoka Chooses Northern Ireland for Headquarters
S[6] Email from DCMS Head of Cyber Security Growth and Innovation
S[7] Cyber Security Research Policy Committee 2013-2016 report
S[8] National Cybersecurity Strategy Report
S[9] Cybersecurity in the European Digital Single Market No.2/2017
S[10] Resilience, Deterrence and Defence: Building strong cybersecurity for the EU