Impact template (REF3a)

Institution: University of Glasgow
Unit of Assessment: B11 Computer Science and Informatics
a. Context

Glasgow CS is a top-ranking research School that is committed to applying its research - every group works on ground-breaking research which has direct application and impact in industrial and societal challenge areas. Our industrial engagement is in part enabled by the fact that 6 members of academic staff had industrial careers before joining the School, bringing an awareness of industrial priorities, and high-level contacts. The impact takes the form of fielded software systems, changes to regulations and standards, legal and engineering advice, improvements in educational practices, updated company roadmaps via research prototypes and economic impact via spinouts. The significance of the impact includes life-saving technology, improved efficiency and safety and faster innovation, as illustrated in the case studies.

In the REF period, the School worked with 28 Industry partners and in 10 projects with government agencies and international standards bodies. Our industrial application includes examples from major international corporations, SMEs, start-ups and spinouts: including Nokia, Matrixware, Cisco, Bang & Olufsen, Orange/FranceTelecom, Syntonetic A/S, Samsung, Ericsson, NATS, Microsoft, Google, IBM and AT&T. The School's government projects include work with the NHS, schools, regulatory agencies, police force, military and emergency services, air traffic control, Railtrack and International Standards Organisations.

b. Approach to impact

The School's strategy of combining deep theoretical work with practical applications means that many staff focus on problem-driven theoretical topics, which demand new theory to address major challenges of the day. The School has a range of appropriate mechanisms for engaging with different sizes and types of organisation over different timescales. This includes: 1. Consultancy, 2. Collaborative research projects funded by industry or government agencies (with mechanisms to pump-prime engagement, and provide co-funding support for industrially-funded Ph.D. studentships) 3. Releasing IP (licensing IP generated in basic research projects and open-source software) 4. Creating spinouts and 5. Outreach work.

1. Consultancies & Professional services. Via its reward structures, the School encourages its staff to engage with industry and government by providing expert advice and consultancy up to 30 days a year. This often acts as a first point of engagement with a company, for short projects with clear deliverables. Staff worked on 35 consultancies with 21 different companies/agencies (£320k) since 2008. Staff have also had £140k of seconded work with industry, and £1.085M of academic positions with industrial or government sponsorship (including a Chair in IR sponsored by Microsoft and the Royal Academy of Engineering and Chief Scientific Advisor role). Other consultancies were with Government agencies, e.g. **Johnson**'s *European Network and Information Security Agency* consultancy set up the European Cybersecurity incident reporting system used by EU states.

2. Collaborative funded research with Industry: The School had 28 funded research projects with industrial partners, including world-leading companies, and 10 funded research projects with government agencies. Many of these are fully-funded by the external party, but early stage collaboration often requires pump-priming support. A number of support mechanisms have been used: The EPSRC *Knowledge Transfer Account* (KTA) mechanism has encouraged closer collaboration with industry between 2011-13 and a follow-on EPSRC project, *Impact Acceleration Accounts* (IAA) for a total of £1.3M. The University recognises the value of such a flexible and responsive mechanism and has invested ca. £1M in an internally funded initiative, the Glasgow *Knowledge Exchange Fund*, which extends the IAA to non EPSRC-funded academics.

The School's approach to engaging with large organisations has been one of gradually building trust, demonstrating added value and then engaging at wider and deeper levels. An example of that approach is in **Mobile Interaction:** The collaboration with Nokia started by **Murray-Smith** and **Brewster** began with student internships and staff exchanges. At the time, manufacturers or

operators were the only channels for academics to get new interaction concepts into wide-scale use with the public. Because of the impact of their work within Nokia, this grew into a series of 25 projects, including consultancy projects, medium-scale research projects, staff training, equipment exchanges, secondments (e.g. **Murray-Smith** was seconded to Nokia Denmark for 50% of a year in 2008-09 to help develop Nokia's sensor strategy and novel interaction techniques), successful IP licensing of products (e.g. a novel message notification method developed by **Murray-Smith** and **Williamson** was licensed and distributed on Nokia phones in 2010), sponsorship of Ph.D. students (to a value of £415k since 2008) and **Murray-Smith** being appointed to Nokia's Scientific Advisory Board in 2008-09 to help guide the development of Nokia Research Centre. The pedigree of collaboration with the dominant market leader, Nokia, opened up collaborations with Samsung, Orange/FT, Bang & Olufsen, Microsoft and Syntonetic A/S. 5 million Nokia users installed the Moodagent software that Glasgow helped develop. Placement in Nokia phones via Glasgow contacts gave Syntonetic a significant market expansion. The long-standing research leadership and collaboration with commercially relevant topics also meant that **Brewster**, **Murray-Smith** and **Williamson** have been frequently called to act as expert advisers in high-profile, high-value legal IP disputes in the mobile domain. It was also a factor prompting Glasgow to start the first B.Sc. in Mobile Software Engineering in the UK in 2009 to help fill a skills gap in an important industry.

Glasgow also secured over £3M in the past 6 years to support academic engagement with SMEs (*SIGMA, Innovation Network* and *First Step Awards* (FSA)).Computing had 4 FSA projects (£20k) ranging from Information Retrieval (IR), for insurance fraud, mobile Human Computer Interaction to matching of professionals at events. 2 IAA projects (£30k), and 3 projects with £10k of SIGMA/Innovation network funding, supported work in IR supporting online search for property rentals and tools for social networking development. Scottish Enterprise funded *Smart Tourism* projects led by **Chalmers**, **McGookin** and **Brewster** have added value to an important Scottish industry. E.g. **Chalmers'** projects served to document the Edinburgh Festivals' internal infrastructures and interactions with visitors, and allowed a number of iPad-based prototypes to be built, evaluated and demonstrated.

The School uses some of its EPSRC DTA funding to cover 50% of industrially-funded Ph.D.s, encouraging staff to use this mechanism to create longer-lasting engagements with companies. This has been used with Nokia, B&O, BAE, Freescale, Strathclyde Police, Fire Service, National Australia Group, Sciencesoft, Ciboodle, Cisco, NATO, Codeplay for a total of 15 Ph.D. studentships. Some companies found engagement with the School so valuable that they sponsored their own research staff to study for a part-time Ph.D. in Glasgow. Nokia sponsored two of their research staff and predominant Russian search engine Yandex, one.

3. Licensing IP and Open Source software: The College supports and encourages researchers in the identification, evaluation and protection of IP generated from research, selecting high value commercial propositions for spinout or licensing, including investment in patent applications, marketing, business development, incubation, business planning and venture capital partner IP Group plc. The MINERVA project (**McGookin** and **Brewster**) engaged local museums and companies in the development of multimodal techniques to support visits to historical sites, focussing on unstaffed, rural archaeological sites, and the software developed is being licensed to Interpretive Media for commercial exploitation.

Commercial licenses, like those used in the MINERVA and Nokia examples, are not the only way to achieve impact - the **open source** *Terrier* search engine developed by the IR group (**Ounis** and **Macdonald**) has been downloaded over 25,000 times worldwide and is used by industry and government organisations, including Yahoo! Research, the National Archives, and the Italian National Centre for ICT in Public Administration. Terrier has been deployed in commercial settings, including, with support from IAA funding, the TripDatabase.com medical search engine (a major system, which had served over 100M searches) via an Easy Access IP license. University of Glasgow has pioneered a new form of licensing and knowledge transfer; Easy Access IP usually concludes licensing within 28 days, transferring the IP to the company against an exploitation plan. Used in 20 universities worldwide, it will be mandatory for all Scottish universities.

4. Creating spinouts. The *Kelvin Connect* REF case study provides a detailed example of a major spinout from the School. Others include **Chalmers'** joint research on fitness and football fans with Glasgow Rangers FC which led to the setup of an SME, *Dynamically Loaded,* by **Bell**, which developed the Rangers app in 2009, which in turn helped to set up a wider partnership with the Scottish Premier League, in an EC-funded project, EuroFIT which started in 2013.

5. Outreach work. To achieve meaningful impact on special-needs user groups requires on-going engagement with end-users and institutional stakeholders. Examples of this include **Cutts'** outreach work, which helped set the educational agenda for CS in schools (see the REF case study). **McGee-Lennon** and **Brewster** worked with elderly users and shaped Scottish Government policy for supporting vulnerable people at home, and **Brewster** continued funded research on ACM prize-winning tools to help blind children visualise mathematical graphs and learn to write.

To implement all of the mechanisms above, the School benefits from access to internal Business Development support, and nationally from Scottish Informatics and Computer Science Alliance (SICSA) and Informatics Ventures (since 2008). Informatics Ventures was set up to support the SICSA community, by inspiring and developing software start-ups via a range of activities and events including: the MIT Entrepreneurship Development Program; DEMOfest; Engage, Invest, Exploit. Glasgow's business development team is experienced in identifying and matching researchers with the needs of Industrial and Government funders. The team provides support and guidance through the plethora of Scottish, National and European schemes and facilitates opportunities for collaborations, through organising events ranging from large-scale industry open days (>500 participants) to individual company visits, e.g. sandpits organised by the university are used to bring together industry with academics, and in Computing, **Brewster** developed a jointly-funded studentship with Freescale on multimodal feedback in cars after a sandpit.

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c. Strategy and plans

We will continue to lead in key technology areas, and collaborate with the top worldwide companies, but will improve our knowledge exchange with local companies, government agencies and cities, by 1. *Developing partnerships*, 2. *Internationalisation* and 3. *Developing people.*

1. **Developing partnerships**: Innovation Centres in Sensors and in Data Sciences will be significant (with ca. £30M associated with each, starting in 2013) new channels for engaging with industry. With our traditional strengths in IR and our newly recruited strengths in Big Data systems, we are in a strong position to capitalise on the rapid growth of this priority area. The IR group's *Expert finder* system has been embedded into the SICSA & CENSIS (Centre for Sensors & Imaging Systems) webpages to make it easier for industry to find the right academics. The area of Smart/Future Cities/Urban Informatics has recently gained political and funding prominence - Glasgow City won a TSB Demonstrator project of £24M in 2012, with further investment at Scottish, UK and EC levels expected. Our wide range of projects and publications, from the mobile and ubiquitous HCI and IR groups (> 50 papers from over £6M funded projects over the last 10 years), and our strategic investment in Big Data and mobile sensing, means that we are in a strong position to shape developments. **Murray-Smith** was invited to join the city's *Digital Glasgow Reference Group* which will meet in parallel to the *Digital Glasgow Board* and contribute to strategy development and bring forward ideas, innovations and thinking. The *Caring computing* agenda is pioneered by **McGee-Lennon** and **Brewster** within the MATCH (Mobilising Advanced Technologies for Care at Home, 2005-13) and TSB-funded DALLAS (Delivering Assisted Living Lifestyles At Scale, 2012-15) projects, and they have already contributed to design of technological aspects of housing for older adults and disabled people with Glasgow Housing Association. **Calder**'s 60% secondment as Chief Scientific Adviser to the Scottish Government (2012-15) will continue to make an impact on the contribution of science to policy-making and to Scotland. A School business development officer, funded by Scottish Enterprise, IAA and internal funds, is being recruited to strengthen relationships with local SMEs and increase the number of start-ups.

2. **Internationalisation:** As part of our internationalisation strategy, in 2011 we established a subsidiary of the University of Glasgow in Singapore, with the Singapore Institute of Technology. Unlike most UK Universities, this initiative was not only for the delivery of undergraduate honours degrees but also for research and knowledge exchange. The Singapore Economic Development

Board will support the delivery of Ph.D. training in collaboration with industry in Singapore (co-supervised by academics in Glasgow) for 50 students over 5 years, helping us to establish research collaborations with strategic partners from the Pacific Rim who are rapidly-growing multinationals, with growing presence in the UK.

3. **Developing people:** ECRs will continue to be brought into projects run by senior colleagues with industrial partners, expanding penetration into organisations and providing younger staff with role models and support (e.g. **Brewster** and **Murray-Smith** brought ECRs **Williamson**, **Rogers**, **Vinciarelli** and **Vazquez-Alvarez** into formal projects with Nokia). We will build on the TechMeetup experience as a mechanism for everyone from undergraduate to professor to engage with local industry and start-ups. The **SICSA Knowledge Exchange Directorate** increases the economic and social impact of university research by working with industry to transfer advanced research to industry, by providing industrial and entrepreneurship training for researchers (£410k funding 2012-15). 2 Glasgow Ph.D. students took up the **SICSA Postgraduate Industry Internship Programme**. This funds research students to undertake an industrial internship of 9 months (including a period of preparation or return transfer activity). **SICSA team-based industrial placements** provide funding for teams of 4 early stage researchers to undertake 3-month industrial placements during their studies. **SICSA Elevate** is a research accelerator supporting groups of ECRs to transform promising research ideas into sound business start-ups, transfer or licensing over a 12-week period. Glasgow also benefitted from a **Distinguished Industrial Visiting Fellow** sponsored by the fund. **SICSA Postdoctoral & Early Career Researcher Exchange** funding supported **Storer** (novel management techniques for critical infrastructures, with researchers at University of Ontario Institute of Technology and industry) and **Sevegnani** (visiting UC Berkeley Engineering to use his new modelling techniques in their control systems for UAVs).

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d. Relationship to case studies

The case studies illustrate our strength in linking abstract theory to concrete challenges, and the reach of the School. They include: designing systems which save lives, creating spinout companies, driving changes to legislation and international standards and improving how we teach our children. They highlight the value of long-term engagement with stakeholders, before impact was made, as research developed. There is often a formal exchange of a licence or software, but much of the effective impact comes from academia and industry jointly reshaping perceptions of the problem domain during joint projects.

1. **NHS Kidney Exchange programme:** The collaboration with the NHS kidney exchange programme grew out of years of joint projects led by **Manlove** and **Irving** where the Algorithmics team explored a fundamental theoretical topic, then steadily built up trust with medical staff via a series of projects, including Scotland-wide matching of trainee doctors with hospitals. This required practical, robust implementations of the algorithms, followed by extensive projects to apply the techniques to kidney exchange programmes**,** and is an example of how a KTA grant brought the system to the point where a significant NHS grant funded the development of the fielded system.
2. **Kelvin Connect**, spun out in 2002, is an early example of technology developed in a basic research project being the basis of a spinout, to create software which is now in use by 10% of UK police forces and being rolled out to nursing staff in several hospitals.
3. **Johnson's** study on the **impact of defining regulations** is based on experience and connections gained via consultancies with many organisations relating to resilience of complex socio-technical systems. This led to appointments on boards which have then directly affected procedures and regulations at ESA, Railtrack and DSTL.
4. Applied research in multimedia networking by **Perkins** led to his invitation to co-chair the Audio/Video **Transport Working Group of the IETF** 1998–2008, embedding the research into a standard which is now used in millions of computers and mobile devices.
5. **Cutts'** work on how we teach programming formed the basis for outreach events with teachers and led to changes to the Scottish school curriculum and the School of Computing Science was happy to build on this impact by seconding him 60% in 2013-15 to support development of **government education policy** (funded by the Scottish Government, and administered by the British Computer Society).