Institution: University of Strathclyde

Unit of Assessment: 11 Computer Science and Informatics

a. Context

UoA 11 works with three main non-academic user groups:

(1) **The software engineering industry** through our research on typed systems, computer security and large scale distributed software engineering. These non-academic groups, including Microsoft, HP and IBM are aligned with our Software Systems and Theoretical Computer Science themes leading to improved ways of creating large software systems, improving information security and producing more accurate code.

(2) **Information providers** through our research on data intensive systems and human information access. This is aligned with our Information Systems theme leading to impact in areas such as improved visitor numbers and feedback, improved engagement with the arts, and increases in social equality and inclusion.

(3) **Users of mobile systems** through our research on interactive mobile technology. This is aligned with our Information Systems theme leading to impacts in terms of quality of life and public service accessibility through our collaborations with the NHS and economic impacts through collaboration with companies such as KeyPoint in providing new text entry techniques.

b. Approach to impact

The successful transfer of knowledge from the University to business, public and third-sector organisations is a fundamental objective of the University of Strathclyde. This is inherent in the founding mission of the University to be a 'place of useful learning'. UoA 11's approach sees impact and research as symbiotic activities. Strong fundamental research leads to the potential for excellent impact and useful impact partnerships inform excellent research, enabling greater impact. In UoA 11, we promote a strategy of embedding impact within excellent research and use real-world problems as a stimulus for research excellence. 65% of our research grants in the REF period have non-academic partners and 60% of PGR students who started within the REF period have external partners supporting or directly funding their research.

Embedding impact within excellent research

The strongest non-academic impact comes from excellent research conducted in cooperation with strong external partners. We have chosen to work with partners that have strong influence within non-academic communities and who offer multiple routes for impact.

The Mathematically Structured Programming group, for example, has a substantial connection with Microsoft, which has funded a PhD scholarship (2009) and two internships for our graduate students (2012, 2013), and is a project partner on a newly funded EPSRC grant involving Ghani (awarded 2013). McBride is in weekly contact with Microsoft's Peyton Jones and Vytiniotis concerning the ongoing evolution of Haskell's type system. One demonstrable outcome is the recent "DataKinds" extension to Haskell, which adopted the key functionality of the Strathclyde Haskell Enhancement. Haskell is widely used in the financial sector, including by major banks such as Credit Suisse, Deutsche Bank, Barclays and ABN AMRO, to reduce risk in processes such as share trading.

The i-Lab group have created new strategic partnerships with East Renfrewshire Council Education Services (ERCES) and Glasgow Life (GL). Several ERCES education services are nationally recognised as best in Scotland, and GL is the largest cultural organisation of its kind in the UK. Both partnerships have led to grant applications, PhD placements and collaborative doctoral award applications, the latest being an ESRC collaborative doctoral award in 2013 to help public libraries develop better services for young people with visual impairments.

Our newest collaboration is with NHS Greater Glasgow and Clyde arising from our participation in the Technology and Innovation Centre (TIC) at Strathclyde (section c). Initial collaborations in 2013 used our research expertise in mobile systems to design new mobile applications for patients, including patients with chronic pain conditions (20% of the UK population) and stroke patients. Successes in these initial activities led to larger collaborations on modeling organisational system behaviour, interactive medical information processing and the creation of the Glasgow Centre of Excellence for Applied Informatics, a unique partnership in the UK between the NHS, Glasgow City, and university researchers researching intelligence-based care management. UoA

11 is the technological partner in this new initiative.

Other research partners within the REF period have included major industrial organisations such as Rolls Royce Marine, IBM and BAE systems and third-sector organisations such as NASA, the Maritime and Coastguard Agency, and the Metropolitan Police all of whom have wide reach, enabling substantial impact from our research outcomes.

Using real-world problems as a source of research excellence

Strong impact comes from excellent research being applied to real world problems. A key mechanism for this impact route is the selection of PhD projects that incorporate end-user partners who can provide challenging problems for students and direct routes to end-user impact. Since 2008, 60% of our studentships have involved end-user partners, either directly funding PhDs, acting as hosts for fieldwork or as sources of placements or internships. The latter are valuable mechanisms for disseminating and applying research findings. In this we have deliberately chosen research problems that have high reach and significance. Wilson's research into database indexing, for example, facilitated Foley's PhD on data representation for drug discovery which has now led to a licensing deal with Serometrix Ltd (2013) that funds a post-doctoral position for Foley into the discovery of new medicines for cholesterol control and prevention of heart disease. Ruthven's theoretical research on information poverty informed Henderson's PhD research (2010-2013) on the barriers to accessing health information faced by the Black and Minority Ethnic (BME) community in Scotland (2% of Scottish population). The outcomes from this research are now informing policy for BME ehealth engagement within NHS Scotland's eHealth Person Centred Strategy, the development of BME services within NHS 24, and the Scottish Association for Mental Health's 'Know where to go' campaign to help BME groups' access to mental health services.

We have found consultancy and user-led knowledge exchange activities to be a valuable method of identifying useful new research problems, and in solving these problems, thus creating impact. Dunlop's research on text entry, for example, has led to consultancy relationships with mobile technology firms KeyPoint and SnapKeys where his expertise has informed the design of new text entry approaches which have been deployed in KeyPoint products used by [text removed for publication] smartphone users. The insights gained from this relationship led to a successful EPSRC grant for Dunlop with Keypoint as industrial partners. Following an industrially funded PhD studentship, Dunlop and Hornecker gained a consultancy with Rolls Royce Marine in 2012 to help redesign marine navigation dashboards to improve safety and with the Maritime and Coastguard Agency to develop early warning systems to prevent marine accidents in UK fishing vessels. Buchanan and Gibb's research on information strategy has led to consultancy relationships with a number of organisations including a review of the Royal Bank of Scotland's Enterprise Architecture in 2008 to enable RBS to develop more efficient business systems.

We have made extensive use of University expertise to enable the full life-cycle of impact. Departmental colleagues have held knowledge exchange workshops at the annual week-long Engage with Strathclyde event to initiate new collaborations. In 2013, this led to new collaborations with institutions such as Barnardo's and Royal National Institute of Blind People (RNIB) where our research will lead to the design of new information services. All staff and research students are encouraged to participate in the University's Researcher Development Programme for early career academics and the SPIRAL programme for established researchers. Many staff have engaged with the SPIRAL programme in areas such as communicating with external clients, negotiating contracts and commercialisation that can transform initial contacts into meaningful relationships. We also encourage participation in the early career research programme organised by Scottish Informatics and Computer Science Alliance (SICSA) which offers early career research exchanges with industry via PhD industrial placements, industry fellowships, and proof of concept schemes.

c. Strategy and plans

Looking forward we see three main routes for impact:

(1) **Increased collaboration with existing partners and the creation of new strategic partnerships**. We have successful knowledge exchange relationships with selected partners such as CloudSoft and ID Inquiries.. In the short-medium term we are developing these into stronger relationships such as funded PhD studentships, directly funded research projects and KTP relationships. This is already leading to success with the announcement of a new KTP (ID Inquiries) and a year long EPSRC Impact Accelerator Award (CloudSoft), both starting at the end of 2013. New partnerships are also being developed through successful nascent collaborations,

such as those described in section b., which we expect to lead to similar outcomes as our existing collaborations. Developing robust collaborative partnerships is time-consuming so institutionally we reward such activities through KE being treated equally to research and education within promotion criteria. At a UoA level significant impact activities are acknowledged in the departmental workload model on the same lines as funded research activities and we offer both research and KE sabbaticals. The interdisciplinary nature of much of our research opens up opportunities for working with end-user partners in other disciplines. Through a range of internal mechanisms such as University sponsored studentships and an EPSRC Bridging the Gap award (2007-2010), we have created new research collaborations with our Electrical Engineering, Education, Law, Marketing, English, Sociology and Chemistry departments. Each of these has added new impact routes to our portfolio.

(2) **Increased commercialisation of research outputs** such as Wilson's recent licensing deal with Serometrix and **increasing the visibility of our research** by making IPR freely available through The University Technology Scotland consortium and through end-user installations. Open-source software allows us to distribute research ideas as software and widen our impact channels. A good example is the design of the Epigram language which has impacted significantly on subsequent dependently typed languages, notably Agda (Uni. Of Chalmers), Idris (Uni of. St Andrews) and the new "Equations" package of the Coq system (INRIA). Through those channels, ideas from Epigram have seen wide non-academic use.

Many of our research partners are third-sector groups who have limited resources. We enable these groups to make use of our software providing much of it through open-source mechanisms. The open-source PuppyIR project contributed to new computer installations in the Dutch Natural History Museum to allow children to explore museum contents through touch-table technology (12,000 users since 2011). These activities serve as useful displays of our research excellence and enable new collaborations. PuppyIR, for example, led to new collaborations with Scottish Ballet to design approaches to digital marketing and audience interaction. This Green Marketing campaign resulted in 80% less leaflets and posters, and gained attention as a revolutionary approach for audience engagement with the performing arts.

(3) **Increased CPD and consultancy activity**. Based our successful experience of executive CPD and consultancy we aim to grow both of these activities in the medium term. In 2013, we launched a UoA11 model for professional doctorates to create opportunities for research practitioners to engage in research projects, and hence increase practitioner impact.

UoA 11 has a KE Committee of 5 academics to direct these impact plans, with representation from each of the research themes, and supported by a senior administrator. The administartor manages our KE activities including the preparation of specialised advertising, providing financial advice to ensure appropriate funding for impact activities and providing administrative support for activities such as practitioner workshops. At the University level, the TIC is a major initiative to support industrial partnerships and the University's single biggest investment in research capacity, enabled by an £89m investment from the University, Scottish Enterprise and SFC. The TIC spans a number of research themes and the most relevant to us are the Health Technologies and Human & Social Aspects of Technology themes. TIC will be a major source of industrial and public sector collaborators for UoA11, extending our routes to impact.

d. Relationship to case studies

UoA11's case studies illustrate the success of our impact strategy. 'Widening public access.' exemplifies the interdisciplinary nature of many of our research activities. Through collaborations with other disciplines we can translate our theoretical research into well-defined research outcomes and reach new user groups. 'Improved user experience..' highlights how our attention to providing practical outcomes, such as prototypes, gives us the ability to advise on operational systems. 'Improved video surveillance…' is an example of where university support for commercialisation and departmental support, in the form of a KE sabbatical, helped transform innovative ideas into commercial opportunities.