Institution: University of Bath

Unit of Assessment: B11 Computer Science and Informatics

a. Context

Our range of user groups is very broad: any industries or organisations in which software plays a critical role can be a user of our research. We have regular and direct contact with industrial users including the visual effects and communications industries, the defence, health, energy and education sectors, and the software industry itself. Impacts of this work will include economic impact, through improved technical infrastructure and novel products; impact on the environment, through novel energy monitoring and demand-reduction interventions; impact on health and quality of life through assisted living technologies and novel education tools; and societal impact via our public engagement work.

Our main route to impact is the delivery of specialised computing systems directly embodying the results of research. This includes: the deployment of algorithms and programming techniques discovered in our research in Intelligent Systems, Graphics and Vision, and Mathematical Foundations; and the design of tools, policies or processes embodying models of collaboration and exploiting advances in human-computer interaction generated by our HCI research.

b. Approach to impact

The unit's approach to impact during the period 2008-13 has centred around generating and nurturing relationships between our researchers and external stakeholders in industry and government. To this end, we:

- provide low-entry-cost ways to establish new research relationships with industry, for instance via our industry-based Engineering Doctorate programmes and the novel "research bench" activity described below
- access and exploit institutional and external support for projects involving both co-production of research with industry and knowledge exchange
- allocate resources to impact-generating activity and recognise such activity in workload and promotion criteria
- integrate impact into the research leadership of the UoA.

Examples of **significant, active relationships with external stakeholders** over this period:

- O'Neill has a longstanding collaboration with Vodafone, formalised via a Royal Society Industry Fellowship that seconded him there for 50% of his time from 2008-2012.
- Cosker was a visiting researcher at Double Negative visual effects studio and formalised his research collaborations with them in a Royal Society Industry Fellowship (2012-2016).
- Stanton Fraser has been working with ScienceScope since 2004 on the use of sensors in education. The SME has funded collaborative PhD studentships, hosted EngD students, and participated in a knowledge transfer project.
- P. Johnson was a member of the Defence Scientific Advisory Council (DSAC) and since 2012 has been on a 20% secondment to the Defence Science Technology Laboratory.
- H. Johnson collaborated with Hewlett-Packard Labs on the TSB-funded *Trust Economics* project and has developed a continued research relationship.
- Davenport began collaborating with Maplesoft during his sabbatical at Waterloo, Canada in 2009, building on links established in 2000 during a visit to University of Western Ontario.
- Brown is CTO of Cloudburst Research Inc, whose products are consumer applications based on his computer vision research, notably the iOS application "Autostitch".

These relationships are often **supported by external funding for research co-production**. Examples include the TSB-funded projects *Trust Economics* (with HP Lab; H Johnson, £255k); *Vector Streaming Video Pipeline* (with root6, Smoke and Mirrors, Ovation Data and Wavecrest; Willis, £210k); EU FP7 project *ALIVE* (with Thales and Calico Jack; De Vos and Padget, £285k to Bath); and EPSRC funded projects ENLITEN (with Building Research Establishment, Buro Happold Ltd, Exeter City Council, Low Carbon South West, Navetas Energy Management, ScienceScope and Wessex Water Services Ltd.; Brown, O'Neill, Padget, £1.5M) and E-Viz (with C3 Resources Ltd, Carbon Action Network, Cornwall Development Company, Energy Saving Trust Ltd, Plymouth City Council, Regen SW, Schneider Electric Ltd UK, Tekla and The Eden Project; Johnson and Johnson, £1.5M total.)

We also pursue **research projects funded by industry**, which are naturally tailored to the requirements of the sponsors: In 2008 McCusker and Collomosse (who has now left the University) each held a HP Labs Open Innovation Award (£37k each); O'Neill holds a research grant from Google, Inc (£30k); P. Johnson has multiple awards from BAe Systems (£350k total).

The University of Bath provides strong support for knowledge exchange activities. The Research Development Support Office assists researchers in accessing TSB-funded Knowledge Transfer Partnerships, and holds funding from EPSRC explicitly to support impact-generation activity in its Knowledge Transfer Account and Impact Acceleration account. Examples of **Knowledge Exchange and Impact projects**:

- O'Neill ran a project with Vodafone, funded via the University's Knowledge Transfer Account, investigating how to adopt his research to develop new web services that intelligently sense and adapt to the user's environment.
- Stanton Fraser used Knowledge Transfer Account funds to work with ScienceScope to help teachers integrate their sensor products into science teaching.
- A KTP with Altran UK (formerly Praxis) developed software verification tools using Answer Set Programming, building on work of De Vos et al. This work has been integrated in the latest release of Spark Pro 11 as the *Riposte* tool.
- Davenport holds a University Impact Acceleration Award to work with Maplesoft on further integration of his Computer Algebra research into the Maple tool.
- Proulx has an Impact Acceleration award to develop a popular version of his "seeing through sound" software as an Android app that translates images into sound, to raise the public profile of such sensory substitution devices. This research has already been featured in the media, including BBC One's "The One Show" (May 15 2013).

In total the UoA has made use of over £118,000 of institutional funding in support of these activities. Such funding makes possible not only significant projects such as the above but also smaller scoping and networking meetings with new and potential research users such as Barchester Care Homes, the BBC, and the Department of Education.

We have significant contact with industry via our **industrially based research students.** We run the EngD Doctoral Training Centre for Digital Entertainment and are a partner in the Systems Engineering Doctorate Centre (run by Loughborough). Industrial partners in such projects include: Jaguar-LandRover, BAe Systems, Vodafone, Double Negative Visual Effects, Aardman Animation, Disney, Electronic Arts, the National Trust, Codeplay and ScienceScope. Industry partners commit £34,000 cash per studentship, plus contributions in kind (supervision, hosting). We also have a number of part-time industry-based PhD students, pursuing projects relevant to their employers.

A **significant innovation of this UoA for delivering impactful research in an agile, responsive manner** is our introduction of the **Research Bench.** This initiative currently employs one permanent member of staff full time. His role is to be available ("on the bench") to respond to the research and development needs of third stream partners. He works with them to develop their research needs, negotiate and set up appropriate research projects and, where appropriate, undertake the resulting research. Projects may be funded directly by the industrial partner, or through collaborative bids to external funders, e.g. the Technology Strategy Board (on the 'Coherence Engine' project) and Defence Technology Centre Innovation awards (for our project within the Systems Engineering for Autonomous Systems Defence Technology Centre). The flexible, responsive nature of the Research Bench has enabled us to secure research and knowledge exchange contracts with companies in domains such as safety critical software development, aviation, defence, energy and end-of-life care. Our partners in this work have included national and multi-national organisations such as DSTL, Halcro, SciSys and BAe Systems. The bench approach has also enabled us to collaborate with SME's (e.g. Ark Continuity, Vistair, and Cambridge Wireless) and charitable institutions such as St Christopher's Hospice. There is good evidence of follow-up activity: Vistair and BAe have both funded follow-on projects and small scale research bench partnerships have developed into parts of major EPSRC-funded projects on Intelligent and Autonomous Systems (*Human Autonomous Systems Collective Capability*) and Energy efficient building management (*ENLITEN*).

Patent applications have arisen from our industrial collaborations: collaboration with Vodafone led to Ashley Mills's (EngD Systems Engineering student) "CQI Adjustment" (patent application

GB1214185.9) and O'Neill's "State Transition" and "State Detection" (GB1205162.9, GB1205160.3); Disney Research are preparing a patent application based on work with Cosker.

Integrating impact into research leadership: Each Department in the University has a Knowledge Transfer Champion whose role is to raise awareness of opportunities to engage with industry and participate in selection of projects to fund from the Impact Acceleration Account. The Computer Science KT Champion is a member of our research committee ex officio, and therefore has central involvement in strategic research planning. Stanton Fraser is both Associate Dean for Research in Humanities and Social Sciences and KT Champion for Psychology. The presence of two KT champions in the UoA gives us close and regular contact with the University's KT support, making this easier to access for academics and assisting in the embedding of Impact/KT culture.

Recognising and supporting impact activity: the UoA considers impact delivery activity as valuable as standard research activity. Our flexible workload model allows us to ring-fence time for staff to pursue spin-out activity where that helps us deliver impact: Brown works 5 hours/week as CTO of Cloudburst Research, Inc. Departmental travel funds are available to support visits to industrial partners (e.g. Cosker's visit to WETA FX in New Zealand); the Head of Computer Science, Director of Research and KT Champions engage in the development of collaboration agreements (e.g. the KTP with Altran Praxis); we have a positive attitude towards industrial secondments and offer reduced teaching and administration loads for staff wishing to pursue them. The University explicitly recognises all such activity in its promotion criteria.

c. Strategy and plans

Experience from the Research Bench innovation informs our strategy for developing impact in the future. Since its introduction in 2009 it has become clear that there are a great many potential partners, from SMEs to multinationals, requiring a range of research expertise and knowledge exchange, willing and able to work with researchers in our UoA. We will seek to develop such partnerships, expand them where possible into longer-term research co-production efforts, and maintain contact to ensure the delivery of impact. We will also seek to integrate the Bench activity into the mainstream of the UoA via the research committee, to expand its scope beyond the expertise of the individual Research Bench scientist.

The contacts and research impetus generated by the Centre for Digital Entertainment provides a significant opportunity for longer-term impact. We are approaching this in tandem with a broader move to strengthen and deepen relationships with industrial contacts in our teaching activity. The Department of Computer Science's undergraduate programmes boast a highly successful one-year placement scheme, recently extended to encompass Master's degrees with placement. We now have industrial placements at Bachelor's, Master's and Doctoral level, and plan to use our Industrial Board to influence our research as well as our teaching, and enable delivery of impact.

The University Mission statement includes a commitment to 'benefiting the wider population through our research, enterprise and influence.' University guidance and support for generating, capturing and measuring impact is being developed by the Impact Sub-Group of the University Research Committee. Our integrated research information system allows the recording of impact and will provide data for the RCUK Research Outcomes System. The University is increasing its focus on public engagement, as one of eight RCUK Public Engagement Catalyst institutions. The UoA has a history of public engagement (Davenport and Stanton Fraser's work in the Bath Taps into Science events, Bryson and Davenport presenting work at Bath Science Café, Hall's presentation of his work to the BathCamp community (bathcamp.org), Proulx's BBC appearance, Bryson's appearance on SkyTV discussing her work for EPSRC on Ethical Principles of Robotics) which we aim to embed as a regular part of our activity.

d. Relationship to case studies

The case studies have arisen from the UoA's support and recognition of collaborative relationships with industry partners: Johnson's teaching and administrative load were reduced to enable his secondment at DSTL, leading to his case study; Davenport was awarded sabbatical leave to pursue his work with Maplesoft; and Padget's case study arises from our engagement with an externally-based part-time research student.