Institution: University of Leicester

Unit of Assessment: UoA 11 Computer Science

a. Context

The Department has several world-leading areas of expertise that lead to impact based on software engineering, algorithms, and applications in socio-technical systems and interdisciplinary research. During the REF period we have addressed stakeholders such as:

- *SMEs and local business*. The provision of consulting, training and co-supervision of final-year projects under the umbrella of the Innovation and Knowledge Transfer Partnerships programme, as well as the recently approved ERDF PA2 grant SME Support to Growth, focussing on enhancing the export potential of Leicester companies provide examples of impact in this domain. Two of these examples are discussed in the impact case studies on Security Alarm Systems with VDomain Ltd. and Software Companies with ATX and Hunter Systems.

- *The IT industry.* This is evidenced through research funded directly by companies, such as two Microsoft Research PhD Scholarships, and departmentally funded work such as in the case of the *Succinct Data Structures* project where basic research has been developed into an industry-strength implementation as part of the open-source Zorba XQuery engine, a widely adopted infrastructure component to query and update large XML files.

- *Defence and technology companies*. Contractual research for the University of Urbana-Champaign in a project funded by Lockheed Martin, where expertise in model transformations was provided, is an example of impact in this area, as is the research-council funded work on Evolutionary Algorithms for Dynamic Optimization Problems undertaken in close cooperation with British Telecom (2008/10).

- *Government agencies.* Research undertaken in conjunction with the government's Defence Science and Technology Laboratory as part of a project on Building Adequate Test Sets by Reverse Engineering in 2012 provides one illustration of impact in this sector. Two projects on Mesh Networking Using Chirp Spread Spectrum (2010/11) and Mesh Networking II (2011/2012) have helped inform a central government department on the cyber security of machine-to-machine (M2M) technologies and in particular the underlying issues for the Internet-of-things (IoT).

- *Education and culture.* Impact emanating from research on the evaluation of usability and user experience, involving schools and government, as reported on in the case study on Educational Games and Learning Tools, is directly linked to this sector, as is that resulting from interdisciplinary projects with the departments of Archaeology, History of Art and Museum Studies based on research in and applications of Semantic Web technologies (for example, the Leverhulme Trust Research Programme project *Tracing networks: Craft Traditions in the Ancient Mediterranean and Beyond* (2008/13) and the EPSRC/ARC funded *Representing Re-Formation: Reconstructing Renaissance Monuments* project (2010/13)).

b. Approach to impact

The department engages specifically with industry, government and policy makers through a variety of channels.

Innovation partnerships (a Leicester-specific programme to support consulting, training and secondments) as well as *KTPs* target directly the needs of companies based on our research-related expertise. Staff engagement in IPs and KTPs is supported by financial incentives. This has led to 13 IPs and KTPs in the last 3 years, with ca. £115K spent on a combination of consulting, secondments and training. Staff contribution is encouraged by incentives, such as consulting fees, being made available for travelling or hardware purchases, for example.

Employer and alumni relations arising from academic activity are used to engage with companies and organisations, learn about their interests and present our research expertise, both to inform our research and seek applications. Our Industry Advisory Board is one of the platforms used, in addition to individual encounters at careers events and visits to students on their industry placements, all of which provide starting points for engagement. One such example is the originally teaching and employment-related contact with JADU (a Leicester SME providing CMS solutions) which has led to joint grant proposals.

The *co-supervision of final-year and PhD projects* provides a platform for exploring and developing joint interests. An external partner can provide a problem or case study and a context to evaluate the solution, often leading to tangible economic benefits. Cooperations with VDomain Ltd and Hunter Systems Ltd, as reported on in the case studies, were partly facilitated though joint MSc projects.

Departmental support for transition can be sought to develop basic research to attract external transition or industry funding. Over the last two years, support has been provided for a graduate internship and graduate teaching assistant to transfer research in Succinct Data Structures into industrial applications.

To coordinate and support activities of this nature, the role of a Business Fellow has been created within the department. The Support to Growth project has a business manager to proactively identify opportunities where our expertise can be used by the industry in the region. The scheme, which has only been running since early 2013, has so far established six individual projects, with three more projects in the pipeline.

The restructuring of the University into Colleges during the current REF period has put in place over-arching mechanisms to promote and foster business engagement and deliver impact. There is a College level 3rd Stream Engagement committee, which enables academics to find funding opportunities and has metrics for business engagement. It also is a conduit for the dissemination of information, enquiries and funding opportunities. The committee has representatives from each Department and each research theme. It also germinates ideas for proposals for cross-college enterprise projects. The College also initiated a Business and Industry Advisory Board, which uses members from a wide variety of business sectors to comment on approach and engagement mechanisms. This body also reviews the Unit's impact strategy and plans as part of its twice yearly meetings.

c. Strategy and plans

The University's Enterprise and Business Development Office (EBDO) provides central support for impact related activities including the generation of opportunities by facilitating engagement with businesses and the handling of all aspects of contracts, business cases, IP protection and market reviews. Their literature contains numerous case studies as written, web and video outputs, which the Unit has successfully used in making initial contact with business. Under the "Let's Talk" brand they publicise the University's capabilities through various engagement mechanisms including information days, business breakfast meetings and Chamber of Commerce events, in which the UoA has been actively involved. EBDO has launched projects with academics to specifically enable staff to engage with key stakeholders. These include Innovation Partnerships which offer holistic, practical support from 'idea to implementation' stages to help SMEs in the East Midlands work more efficiently and productively by utilising new knowledge and technologies in the design, engineering and manufacturing processes, such as conserving energy, raw materials and reducing waste.

Building on this, the UoA is aiming to establish three **pipelines for impact**, one led by our own research (supply), one following-up on industry engagement in specific areas identified by them (demand) and one driven by interdisciplinary research across the university (mixed).

1. High quality research with a good potential for impact is identified and members of staff supported and encouraged to seek out external partners, apply for funding, possibly using PhD students or final year BSc/MSc projects as part of the process to develop feasibility studies and demonstrators. In exceptional cases, where high-level research is paired with strong potential, short-term posts can be funded through the department.

2. Different forms of industry engagement, from students' projects, placements and recruitment, via consulting and training, have led to joint research projects. To support such developments, expertise and capacity within the department will be identified and promoted with the external partners. A member of staff with a suitable research background will be appointed to manage the relationship with the partner and explore further opportunities.

3. Many practical problems require solutions from several disciplines. Members of the department are engaged in interdisciplinary research themes at the level of the College of Science and Engineering such as Environment, Energy and Climate Change or Life Sciences Interface.

With a group averaging around ten members of staff, each involved in impact activities, in order to maximise visibility, effect and return, these pipelines need to be driven by sharing information and good practice. The planned appointment of a Departmental Impact Coordinator beyond the REF submission will provide support and leadership in this key area.

d. Relationship to case studies

The case study on the Security Alarm system emerged from an Innovation Partnership created with the help of EBDO and further developed through a series of MSc projects co-supervised with the company. Another Innovation Partnership with Hunter Systems Ltd has contributed to the case study on Software Companies. Again, the combination of students' projects to provide a co-supervised development resource, with longer-term consultation and training was essential to develop a sustainable impact on the company. These two successful case studies provide an illustration of the second of the three pipelines in the strategy outlined in section **c** above.

The research work underpinning the case study on Learning Environments and Tools has been guided by a research-driven cooperation, mostly through European projects. Similarly research conducted by the UoA was fundamental to the establishment of a close working arrangement with ATX Software, representing the bulk of the case study on Software Companies. These two case studies provide examples of the first pipeline, above.

The third pipeline is not represented in the currently submitted impact case studies, however, the UoA is involved in number of collaborative interdisciplinary research projects across the University (see, for example, the last bullet of section **a**), recognising the potential of computer science as an enabling discipline. Some of these are already bearing fruit and it is felt that this pipeline will generate significant impact in future.