**Institution: City University London**

**Unit of Assessment: 11 Computer Science and Informatics**

**a. Context**

The School of Informatics shares the commitment of the University to research which is of the highest academic standard and has practical application in both the short and the long term. Our research is "problem driven" and concentrated in areas where we can achieve impact.

The key areas of research focus of the School: Software and Systems Engineering (SSE), Human-Centric Systems (HCS) and Information Analysis and Visualisation (IAV), by their nature provide major opportunities for impact beyond academia. The main beneficiaries are:

i) Industry, in both established mass market organisations and recent start-up enterprises (SSE, IAV).

ii) Government bodies and organisations (SSE, HCS, IAV).

iii) Specific user domains, for example patients (HCS).

The key types of impact achieved are:

Economic: improvements in performance of existing business through the enhancement of existing services (Microsoft's adoption of search protocol (IAV) and spin-out company for ultra-reliable data storage (SSE)).

Public policy & services: public service improvements (Leicestershire County Council (IAV)).

Society, culture and creativity: the contribution of the School's academics to City Unrulyversity has informed public discourse (HCS, IAV).

Healthcare: handover and disease diagnosis (HCS), reduced risk for medical equipment (SSE).

Practitioners and professional services: significant safety improvements by nuclear regulators (SSE).

The environment: improved safety and reliability of nuclear reactors (SSE).

**b. Approach to impact**

(a) Development of relationships for impact

The excellent research reputation of many of our academic staff ensures that they are regularly invited to serve on the advisory boards of government, industry and international organisations. They are also actively involved with various aspects of industry. For example, we are the UK Academic lead in the NATO TTCP Supply Chain Risk Management/Assurance Cases and we participate in the Treasury Engineering Infrastructure and Interdependencies Expert Group; the Steering Committee of the Cloud Security Alliance for the development of an Open Certification Framework (OCF) for Cloud Security; and the Secure ICT Research and Innovation Working Group set by ENISA and the EU Commission on the specification of priorities for a European Network and Information Security (NIS) platform. This activity helps to provide an avenue for direct influence of our research and a means of gathering input from different perspectives on future priorities for impact. Other related activities of our staff include participation in the Technical Advisory Board of Mentor Graphics and chairmanship of the BSI Standards Committee on Information and Documentation.

Our academic and research staff have been instrumental in the recent development and success of City Unrulyversity, a free pop-up university in the heart of Tech City, established in collaboration with Unruly Media, a dynamic Tech City digital branding outfit. Its mission is to inform, inspire, and empower the next generation of Tech City entrepreneurs (www.unrulymedia.com/city-unrulyversity). Academics from the School have delivered keynote lectures disseminating their research, in particular on information visualisation, mobile interaction and creative thinking, as part of a continuing professional development programme for entrepreneurs. A respondent to a survey held in September 2013 (https://infogr.am/CIty-unruliversity/) reported "*I attended one of the*

*sessions at Unruly and was most impressed at the solid nature of the information. Solid academic content, with real world research results, which deepened my understanding of the topic and gave me better ways to think of the problems I am trying to solve. Please just do more of the same.*"

Impact in health has been achieved through continued collaboration with leading clinicians. For, example, work with Dr Jeremy Bland (Kent NHS) has established a patient-focused website for helping sufferers of carpel tunnel syndrome to diagnose their condition (http://www.carpal-tunnel.net/node/1). Since the site went live in April 2011 it has received 115,045 visitors (as of 07/07/13). This work was recently awarded the 2013 NHS Innovation Challenge Prize. Similarly, collaborative research into the complexity of patient handovers in clinical settings led to novel design combinations of interactive technologies that enhanced situational awareness. These technologies were licensed to a leading London hospital for use in its children's acute transport service. They also led to new guiding principles for patient handover, produced by the Clinical Safety Team of the UK Department of Health. Recently, collaborative research into software that combines novel data capture and analysis algorithms on low specification mobile phones has achieved impact through recording and analysing registration and verbal autopsy data about deaths in developing countries. This has been adopted by the World Health Organization. It is currently deployed in South Africa, Malawi, Nepal and India.

Research into requirements engineering, conducted in collaboration with industry, has generated novel systems that have impact in many sectors, including automotive manufacturing, media organisations and air traffic control. We have also developed new operating concepts for multi-sector gate-to-gate planning across national boundaries with Eurocontrol. The IEEE Software journal recognised the industrial impact of this work by citing it as one of the most important in its first 25 years. Our research on temporal synchronization algorithms and learning using neural-symbolic integration has been recently adopted by TNO Netherlands for Driving Training and Assessment in Simulators.

(b) Support and enablement of staff to achieve impact

City University London's Strategic Plan 2012-2016 stresses the importance of "maximising the impact and relevance of our work in ways that are useful to the wider economy, cultural life, public services and policy-making". To support this goal, the University has implemented a formal framework for achieving impact from research and enterprise together with financial and resource initiatives.

The potential for impact from research and the availability of resources – in terms of staff, equipment and facilities – are monitored regularly within the School and the University. The positioning and achievement of research impact within the School's strategy is assessed in staff annual appraisals and considered as one of the criteria for promotions. At the School level impact goals are monitored by the Associate Dean for Research and the School's Research and Executive Committees. These have responsibility for establishing both impact objectives and priorities for the School, reviewing progress against them and overseeing School-wide research impact activities.

The School supports staff engaged in research through reduced lecturing and administration loading and a policy for profit-sharing on income from the commercialisation of impact.

Staff are encouraged to undertake consultancy both independently and through University channels (www.city.ac.uk/research/research/support-for-staff/consultancy). The University recognises the importance of this form of impact by including provision for consultancy in employment contracts. Many members of the School provide consultancy services to industry and professional and public sector organisations, including BAE Systems, National Rail, City Bank and the UK Civil Aviation Authority. This work has generated £687,000 in income. As a further example, our work on analysing tyre test results with tyre makers Continental AG has resulted in new applications of machine learning in predicting tyre aquaplaning performance to improve road safety.

(c) Use of institutional facilities, expertise and other resources

The University's Research and Enterprise Offices support academic staff in creating impact through the commercialisation of research, providing important advice regarding investment, spin-out companies, licensing and the protection of intellectual property. These facilities have been used for filing patents, for example:
Mobile Monitoring [https://register.epo.org/application?number=EP08776086]; and
Database Replication [https://register.epo.org/application?number=EP10763407].

Staff seeking to create impact through licensing or spin-out companies are afforded support with advice and contacts for business development, market research studies and patent costs. One such example is ResilSoft Ltd., a University spin-out company in which the University has a 15% stake which has developed proprietary patented technology to offer cost-effective, high performance and ultra-reliable data storage. This technology was developed through our research and is exclusively licensed from City University London.

Our public dissemination of research benefits from the University hosting The Conversation UK (http://theconversation.com/uk), where UK academics write about their research for a lay audience.

**c. Strategy and plans**

The School's strategy for achieving improved impact in the next REF period involves:

- Setting a research agenda that considers opportunities for impact as part of the research grant application approval process
- Establishing new and developing further existing active collaborations with significant players in industry and other institutions outside academia, for example Microsoft, SAP, EDF and Tech City, that will lead to impact from research in our key areas, namely Systems Dependability and Security, Creativity, Pervasive Systems, Visual Analytics and Big Data, Cloud Computing and Healthcare
- Continuing to foster the culture of developing impact from research
- Investing in staff with strong academic backgrounds and good industrial contacts
- Encouraging staff involvement on both national/international policy and advisory bodies
- Supporting the movement of staff between industry and academia through exchanges, secondments or industrial fellowships
- Bidding for funding which will enable the demonstration and outreach of research
- Seeking to participate in collaborative research projects which will enable direct interaction with industrial partners.

Several new appointments have been made in the REF period. Many of these new staff are already active in enabling impact from their research. For example, Cheok's work on pervasive computing, human-computer interfaces and ubiquitous computing, together with Andrienko's research in data analytics, are expected to increase the impact of the HCS and IAV research areas.

**d. Relationship to case studies**

The case studies illustrate the School's approach to achieving impact. The research into ranking text documents has had huge impact in search engines for both large (Microsoft) and small companies (Grapeshot). The work on Fault Tolerance has influenced practice and regulation in UK and international industries when assessing the safety and reliability of diverse, safety-critical computer-based systems and has been used by regulators assessing the safety of critical nuclear systems, including the safety protection systems of the UK's proposed new nuclear reactors. Our research into making sense of complex data through visualisation is helping professionals, policy makers and the public alike deal with the large amounts of data to which they are exposed. Our innovative and interactive pictures of data help citizens to engage with government, analysts to inform policy and policy makers to make evidence-based decisions. Finally, the use of an assurance case approach for reducing risk in critical computer-based systems has been commercialised by a company with close links to the University and is currently used in 90% of new UK military aircraft systems, all new infusion pump designs approved by the US Food and Drugs Administration (FDA) and key elements of UK financial infrastructure.