Institution: Glasgow Caledonian University

Unit of Assessment: 11

a. Overview

This submission covers the research activities and future plans of the Computing research unit within the School of Engineering and Built Environment. The overarching framework for the Unit's work is in the cognate area of: Interactive Systems and Communications. The area has three themes, namely: Network and Communication Systems (NACS), Interactive and Trustworthy Technologies (ITT), and Visual, Affective and Pervasive Systems (VAPS).

Network and Communication Systems (NACS) investigates new models of efficient data communications to support exponential growth of internet usage. Specialisms include: network protocols and architecture, digital communications, sensor networks, wireless networks, on-chip networks and systems, network monitoring and measurement and network modelling, analysis and optimisation.

Interactive and Trustworthy Technologies (ITT) investigates new secure interactive technologies and the opportunities, challenges and impact they can have on people e.g. health, convenience, usability, interactivity, performance and security. Specialisms include: Human Computer Interaction, Mobile Applications and Networks, Assistive Health Technologies, Digital Security, Software and Systems and Information Retrieval.

Visual, Affective and Pervasive Systems (VAPS) investigates immersive mixed reality. Specialisms include virtual and augmented reality, 3D visualisation, affective systems, simulation, 3D audio, ubiquitous systems, music emotion classification and games.

These three themes provide a cohesive framework to explore the area of Interactive Systems and Communications.

The Unit has consolidated and enhanced its research position and international status by: i) increasing the number of staff to 13 FTE being submitted for consideration by the panel (an uplift of **63%** on RAE 2008, from the then 8 FTE) ii) increasing the number of outputs by **52%** from 31 to 47 iii) having a 367% increase in our PhD completions (from 3 to 14) iv) increasing research income by **51%:** from £1,053,724 to £1,594,005**.** The Unit has also consolidated and enhanced its research position by increased staff resources (e.g. 1 Reader, 2 Professors and 4 Lecturers).

Our current research strategy is clearly communicated to all members of our research themes and kept under regular annual review: it is informed by metrics derived from PURE on research performance, and monitored targets and KPIs (e.g. journal outputs, high level conferences, PhD completions, and applications to "blue chip" funders), which helps guide our progress. Membership of the Scottish Informatics and Computer Science Alliance (SICSA) links our research with complementary activities at other Universities in Scotland.

Three pan-University multidisciplinary research institutes have been created as foci for thematic research across discipline boundaries. Specifically related to this submission is the Institute for Sustainable Engineering and Technology (ISETR) which supports and promotes research excellence within the School of Engineering and Built Environment; encompassing three themes: Engineering and Energy Systems, Sustainability in the Built Environment and of particular relevance to this UoA: Interactive Systems and Communications.

b. Research strategy

The Unit's research strategy since RAE2008 has evolved from two main themes Network & Grid Computing and Human Computer Interface to three: Network and Communication Systems (NACS), Interactive and Trustworthy Technologies (ITT), and Visual, Affective and Pervasive Systems (VAPS). The enabler for this change was the formation of a new large school which allowed us to strategically revise our research themes in order to (i) build on existing strengths but to also address our key research objective of a cohesive framework to explore Interactive Systems and Communications (ii) attract high calibre new personnel and PhD students (iii) respond to new emergent funding opportunities from public bodies e.g. MRC, EPSRC, EU and NHS (iv) address priority problems that our industrial partners required to solve (v) shape research policy and

practice through our engagement with the Scottish Informatics and Computer Science Alliance (SICSA) (vi) extend our international peer support networks.

Looking forward, our strategic objectives are to:
(1) Increase the scale, quality and impact of the Unit's activities through greater industrial collaboration with our current partners (our industrial collaborators can be seen in section e) and seek new partners.
(2) Enhance the research environment, culture and structure to underpin internationally excellent research through work with our colleagues in the newly created institute (ISETR) and also continue our current work with our colleagues in Health (see impact case studies).
(3) Increase the volume of research income by increasing the number of peer-reviewed research grant application successes, ISETR has a peer review college which assists PI's in reviewing their proposals.
(4) Grow the numbers of postgraduate research students, but at the same time improve the quality of their training through our award winning graduate school and facilitate their completion rates (see section c).
(5) Strengthen our international collaborations, firstly through our existing EU partners and then more widely, in order to address problems that require solutions that work in multiple contexts e.g. home, work, whilst on the move.
(6) Strategically engage with beneficiaries and research users to ensure that our work achieves maximum impact.
(7) Build on our existing business relationships and create new ones. We are supported by the University structure to achieve this aim with there being a Vice Principal (executive level), Associate Dean (at school management level) and managers of Business Development.

The Institute (ISETR) will enable and support the relatively small group of UoA11 staff to address more major challenges than would have been possible if this unit was to work on its own. It is only by working closely with our colleagues in engineering and the built environment that we will be able to identify the global challenges facing Interactive Systems and Communications. The Unit's work benefits from being part of the Institute by developing innovations at cross-disciplinary research boundaries, by establishing strategic collaborations with a broader range of private, public and third sector organisations, and by the peer supported recruitment, retention and career development of researchers. IESTR will provide guidance on the Unit's strategy, the quality of its outputs and their impact, the strategic and targeted response to research priorities, the development of career pathways for all researchers, and knowledge of best practice around the world. The Institute also provides the Interactive Engineering and Communications area funding for up to 2 PhD studentships per year for projects that fit its' strategic priorities. We will also be active participants and partners in projects involving two national Scottish Innovation Centres that have recently been approved by the Scottish Government: Digital Health and Sensors & Imaging (CENSIS) and for which the full funding proposition will become clear in 2014, currently projected funding is £5-10m over 5 years.

Research Performance since RAE 2008

Compared to the position at RAE 2008, it can be seen that we have grown and enhanced our unit:

- The unit is submitting the research work of 13 FTE staff for consideration by the panel (an uplift of **63%** on RAE 2008, from the then 8 FTE).
- We have increased our number of outputs from **31 to 47**.
- Our PhD completions have also increased by 367% (from 3 to 14).
- Income has increased by 51%: from £1,053,724 to £1,594,005.
- Notable increases have been from: UK research councils (e.g. EPSRC & MRC) +71%, UK industry +36%, UK Government +15% and the EU +728%.

In addition the Unit has increased staff resources by the recruitment of: 1 Reader and 6 Lecturers.

c. People, including:

i. Staffing strategy and staff development

Of the 8.0 FTE submitted in RAE2008, five are being returned again (e.g. Baillie, Buggy, Cassidy, Shahrabi and Tianfield), 1 has retired, 1 has left the university and 1 has taken up a senior

management position. We have recruited 1 Reader and 6 Lecturers five of which are being returned and 3 from our existing staff that we have supported to become more research active. The result is an increase in our staff meeting the internal and external review GPA threshold enabling us to return 13.0 FTE.

UoA11 fully endorses and utilises '**The Concordat to Support the Career Development of Researchers'** and gives due recognition to the importance of recruiting, selecting and retaining researchers with the highest potential to achieve excellence in research. The University's Dignity at Work and Equality and Diversity policies and practices are deployed across all aspects of the recruitment, career management and exit of all of our researchers and PhD candidates. All staff subscribe to these policies and undergo training to ensure that individual and collective approaches to such matters are robust. The policies ensure that decisions made are transparent and sound. All university policy documents are available on the GCU website, staff are encouraged to take part in engagement sessions and there is regular updates provided to staff groups. The University continues to be an active member of the Athena SWAN Scottish Regional Network and we will submit our application for the Athena SWAN bronze in April 2014. Our REF2014 submission will be underpinned by our high percentage of female professors in Computing 2 out of 7 which is approx. 29% compared to a sector average of 13%. In addition, GCU have recently been awarded the HR Excellence in Research Award by the European Commission in recognition of our adherence to the principles of the European Charter for Researchers and the Code of Conduct for their Recruitment.

Our researchers are openly recognised and valued as an essential part of the human resource pool and vital components in achieving the university's overall strategy for development and delivery of world-class research. All our researchers are supported in their efforts to be flexible and adaptable in what is an increasingly global, diverse, and mobile research environment. We encourage researchers to take, and share, responsibility for being pro-active in engagement with their life-long learning, career, and personal development. We deploy a Performance Development Annual Review process (PDAR) that examines, encourages, supports and rewards research achievements including: publishing, conference presentations and attendance, grant applications, editorial work and review work for research councils and other grant bodies. PDAR supports the maintenance and enhancement of research standards while our research ethics committees – at university and school level – monitor and safeguard university and sector standards in the conduct of all research and student projects as well as applications for external research funding.

Researchers and in particular (ECRs) are provided with additional support through their Research themes (e.g. their research proposals and outputs are reviewed and mentored by established staff). The Research Theme Leader (RTL) advises the Head of Department on appropriate relief from normal duties to allow the researchers to focus on their research. A managed formal Staff Development & Performance Review take place each academic year. Formal, confidential, records are maintained and submitted to the university's HR department. As regards ECRs a specific programme has been developed by the Graduate School, so that all new lecturing staff undertake the University's new lecturer training programme. In addition, all new Computing lecturers are expected to take an active part in the SICSA new lecturer training that explains the role of SICSA and the expectations of them in the wider Scottish computing academic community and their continuing contribution to achieving excellence in research and teaching in Computing.

At a more strategic level a co-ordinating group known as CREDO (Caledonian Research Excellence Development Opportunities) guides our academic and research staffs career development under the aegis of the University Research Committee. The group, chaired by the Director of Academic Research Development, includes School Associate Deans of Research, members of the GCU Research Peer Review College, the Graduate School, the Research Institutes and colleagues from HR. CREDO draws on the expertise of these staff in seeking to enhance career pathways and staff development opportunities for all research staff across the university at all levels (contract research staff, early career researchers, principal investigators, and research theme leaders). The University has also engaged in cross-sector research staff development and sharing of training provision with other Scottish HEIs via the Scottish Researcher Career Developers Forum.

We encourage our staff to be accredited members of the following professional bodies in the Computing area: BCS (Chartered Institute for Information Technology), Engineering Council, and IET (Institution of Engineering and Technology). In order to encourage this CPD and engagement we often provided free facilities for BCS organised talks. Since RAE 2008 the school has provided £650,000 in staff development for research active staff to support travel to conferences, Doctoral Studies and CPD courses.

Research students

We have had a 367% increase in the number of PhD Completions since RAE 2008 from 3 to 14. We currently have 51 PhD research students. All candidates have a Director of Studies and supervisors who have secured PhD's in their own cognate areas and who undergo initial and on-going training in the guidance and management of PhD candidates. The Graduate School at Glasgow Caledonian University ensures that this training regime is consistent, coherent and fair across all disciplines.

All PhD students are assigned to one of our research themes and they are co-located with their fellow research theme students. They are also encouraged to take part in activities (e.g. school poster colloquium) from other parts of the Institute (ISETR), thus they benefit from cross-disciplinary exchanges within the school.

Our PhD students undertake formalised training throughout their PhD, which includes:

- Personal, professional and research methods skills training workshops
- Seminars, lectures and events on themes of relevance to the development of postgraduate research students and staff
- Training workshops on research leadership and applying for research grants
- Social and intellectual events (e.g. the graduate school annual conference) to facilitate collaboration and knowledge exchange.

The University has actively enhanced support for the PGR student community by creating an institution wide Graduate School that works with all supervisory teams to plan and deliver research training programmes aligned with the Vitae Researcher Development Framework. All PhD students must satisfactorily complete a research skills programme prior to completion. The University Higher Degrees Committee oversees the process of progression though to the award of research degrees. In 2010 the Graduate School received a UK Times Higher Education Award for its Outstanding Support for Early Career Researchers. In the recent HEA Postgraduate Research Student Survey 2013, 82% of postgraduate research students were satisfied with their student experience.

Within the School of Engineering & Built Environment dedicated administration staff track the Unit's PhD students and support the supervisory team in maintaining a student's progress by ensuring the student is fully aware of various progress reporting deadlines and training opportunities. Since 2008 some of our forms have been reviewed and updated, an end of first year viva has been put in place and monthly reports on their progress are required from each student. Each student must give one talk each year at their research themes seminar series. The students are provided with funding to attend one national and one international conference during their studentship. The students also elect a member of their cohort as a representative to sit on the school research committee. Since forming our new school we also run a research colloquium every semester with poster presentations and prizes.

Students also benefit from being part of the wider Scottish Computing research community through SICSA and have taken part in or run: research workshops, summer schools and PhD student conferences. Particularly relevant is the fact that in 2012 and in 2013 our research students were on the steering committee for the SICSA student conference, giving them experience of organising a conference and meeting speakers from around the world at an advanced level.

d. Income, infrastructure and facilities

Income

Income generated during the period has increased by **51%**: from £1,053,724 (RAE2008) to £1,594,005 (REF2014)**.** Notable increases have been from:

- UK research councils (e.g. EPSRC & MRC) increased by **71%**

- UK industry increased by **36%**
- EU increased by **728%**
- UK Government by **15%**

Infrastructure & facilities

Since 2008 the University has made over £2.3 million of strategic investments in infrastructure and capital projects to support research activities within the School of Engineering and Built Environment. Over the period covered by the REF we have (i) undertaken strategic investment in laboratory facilities (ii) improved career development pathways for staff (iii) developed stronger international and national collaborations particularly with industry (see section.e and case studies) (iv) actively engaged in the Scottish Informatics and Computer Science Alliance (SICSA) to shape Computing research policy and practice and (v) established a greater clarification of our strategic direction within the context of a new Institute of Sustainable Engineering & Technology (ISETR).
The Unit has been supported by the School's appointment of an Associate Dean for Business Development and two Business Development Managers that have helped the Unit engage with local industries to promote the research activities and to identify possible routes to impact through knowledge exchange.

The unit's researchers have also benefited from being able to use the skills in the University's Research, Innovation and Enterprise centre which provides expert support for research staff to become engaged in knowledge exchange, EU projects, and research council proposals.

The University has invested 96k in purchasing the PURE research information system and this system is used to manage research theme activity and to monitor progress by capturing and associating research activities in relation to publications, impact, academic esteem, funding applications, projects and press clippings. A linked repository system provides public access to research outputs.

The Unit uses *Research Professional* (52.5k) for identifying sources of research funding. It is integrated with the institution wide staff portal research area, which provides access to resources, and information, document sharing and discussion groups. There is a generous University provision for technologies both desktop and mobile as this is central to an enabling research environment and to networking opportunities

The unit research staff have full use of the following dedicated research laboratories:

- The Emotion laboratory: this lab is in a living room format (couch, wide screen TV, coffee table etc) with a two way mirror. The lab contains: eye tracking, video monitoring and other user capture technology and can be used to assess users interaction with new technology.
- A Mobile and Interactive technologies Lab that has up to date sensor, mobile (mobile phone and tablet handsets) and wireless body worn motion capture technology. Such technology is increasingly being used to capture free living data from users and thus this equipment is useful in live trials. This lab also has two 3D printers for rapid prototype creation.
- A Virtual Reality Lab is used for projects that aim to understand the dynamics and implications of interactions among people in immersive virtual reality simulations (VR), and other forms of human digital representations in media, communication systems, and games
- A networking lab which is enables the researcher to design and analyse the next generation of digital wired and wireless networking infrastructure. Currently it is being used for projects which focus on issues pertinent to both wireless and wired networks that include and integrate the design of physical, data-link layer and the transport layers.

The University library subscribes to key academic content in over 30,000 full-text journals, giving access to 35,000,000 peer reviewed journal articles from publishers and services including ACM, APA, BMJ, CUP, Elsevier, Emerald, IEEE, Jstor, OUP, Sage, Taylor & Francis and Wiley. We spend 47% (£1.6m) of our library budget on information provision, 84% of this spend is on access to electronic content (SCONUL mean for 2012/13 is 77%). We were early adopters of EThOS (Electronic Theses Online Service) and have over 300 PhD theses freely available for download.

e. Collaboration or contribution to the discipline or research base

Invited Talks and Visits

Halvey was a visiting researcher to FXPAL (a collaboration between Fijitsu and Xerox) in Palo Alto. The visit was funded by SICSA. During this visit invited talks were given at Yahoo! and Samsung. He also gave the following talks: Nokia Research Centre, UK; February 2011 - "Multimodal Interfaces, Catalan Broadcasting Corporation (CCMA), Barcelona; June 2008 - "Interfaces for Video search and Interaction", BBC, London; May 2008 - "Interfaces for Video search and Interaction", Telefonica Research, Barcelona; April 2008 - "Search Trails Using Implicit Feedback to Improve Video Search". Baillie has given invited talks at: The University of Texas, Heriot Watt University, IT University Copenhagen, Swansea University and Trento University (Italy), Orange Telecommunications (London). Knox has been invited to give talks at the following: Symposium on Creativity, Innovation and Labour in music. Open University, June 22nd-23rd 2009. Who are we innovating for? The need for interdisciplinary input in setting goals for Music Information Retrieval. http://www.open.ac.uk/researchprojects/music/cilm/resources.shtml; Royal Scottish Academy of Music and Drama, 4th March 2010. A composer, a psychologist and an engineer walk into a bar: Who will make Music Information Retrieval work; Audio Engineering Society lecture. The psychology of technology: Multidisciplinary approaches to developing user centred audio and music technology. 29 Oct 2012, GCU. http://www.aes-uk.org/forthcoming-meetings/psychology-of-technology. Tianfield gave a Keynote talk at: "VM consolidation for green cloud computing", Joint keynote talk for 5th Asia-Pacific Symposium on Internetware (Internetware'13), Changsha, China, 23-24 October 2013, and 2013 China National Computer Congress (CNCC'13), ACM and IEEE Computer Society, Changsha, China, 24-26 October 2013.

Editorial Boards

Crossan is on the board of the following journals: ACM Transactions on Accessible Computing; International Journal of Mobile Human Computer Interaction, IGI Global. Baillie is on the board of: Interacting with Computers Journal, Oxford University Press. Pranggono is on the board of the International Journal of Internet and Distributed Systems (IJIDS). Shahrabi is on the board of: International Journal of Cloud-Computing and Super-Computing, Journal of Information Processing Systems (JIPS). He is guest editor: Journal of Supercomputing, Journal of Simulation Modelling, Practice and Theory. He was special Issue editor Intelligent Systems and Smart Homes (IS2H). Tianfield is Editor-in-Chief of the journal: Multiagent and Grid Systems -- An International Journal (ISSN 1574-1702), IOS Press. Tianfield is: Editor-in-Chief, Systemics and Informatics World Network (ISSN 2044-7272) and International Transactions on Systems Science and Applications (ISSN 1751-1461). He is on the board of Engineering Applications of Artificial Intelligence (ISSN 0952-1976) and associate editor, Journal of Control Theory and Applications (ISSN 1672-6340 (Print), 1993-0623

External Peer Review of Research Project Proposals

Tianfield is a member of the EPSRC Peer review college, since 2010. European Commission 7th Framework Programme (2007-2013), Information and Communication Technologies (ICT), Future and Emerging Technologies (FET), 2008, 2013 and the Technology Strategy Board, Gathering Data in Complex Environments, 2008. Baillie has been an expert reviewer for the European Commission since 2011 and has reviewed for the National Institute for Health Research (NIHR)

Collaboration with other Universities

We are a member of SICSA and lead and take part in the following activities as part of that group: workshops, seminar series, researcher exchanges and conferences. SICSA has world class research capability in the following areas: Next generation internet, Multimodal Interaction Modelling and Abstraction, Complex Systems Engineering

Baillie is a supervisor for PhD students registered at the following universities: Edinburgh, Strathclyde, and Luxembourg.

We also have joint grants with several universities, some exemplars are: Just and Baillie collaborate with Edinburgh University (David Aspinall) on a Marie Curie International Fellowship: Active Behaviour Demands Active Security: New Approaches to Mobile Device Security Marie Curie Fellowship, EU, £178k. Knox and Cassidy are collaborating with Edinburgh University (Prof MacDonald) using Carnegie Trust funds to create a Scottish Music Health Research Network. Baillie has a cross research council grant (e.g. MRC, PSRC and ESRC) project with Strathclyde,

Newcastle, Glasgow University and the Glasgow School of Art. Charissis (NES?)

Collaboration with industrial researchers

Michelle Govan and Tom Buggy (PI): KTP Project with ECEBS Limited. Funded by: Technology Strategy Board (100%). The output of the project was an enhanced security mechanism to protect the data held on Smartcards by utilising advances in representations of biometric information (see impact case study). Ahmadinia (KTP) work with Shearwater investigates the development of a remote access technical information database to improve diving inspection processes, business intelligence and provide efficient and added value customer reporting facilities. Baillie, undertook a collaborative project with Orange research UK entitled: EMMI: Enhancing the user Experience by Employing innovative Multimodal Methods. This collaboration resulted in new applications and innovation for Orange that was reported in the Times newspaper and presented at the leading conference on Mobile HCI. Baillie also held a consultancy with Telecommunications Research Centre Vienna, Austria from 2006-2010.

Conference Chairs

Pranggono Program Vice-Chair (Track Chair) of the 15th IEEE International Conference on High Performance Computing and Communications (HPCC 2013). Baillie has been an Associate Chair of CHI for the last three years, this is the most prestigious international conference in the HCI area; Associate Chair of ACM ICMI in 2012 and 2013. Knox chaired the 7th International Conference on Interdisciplinary Musicology (2011). Held at GCU in collaboration with Glasgow University. Just was posters co-chair for SOUPS 2013 conference and also WIPs co-chair for British HCI 2011 conference; Halvey Associate Chair of ACM ICMI in 2013 and is the Lab Chair for CLEF 2014, CLEF is a large international conference whose main mission is to promote research, innovation, and development of information access systems with an emphasis on multilingual and multimodal information with various levels of structure; local organising Chair for ACM ICMR 2014, ICMR is the main international conference concerned with search and retrieval of multimedia. Tianfield: Program Co-Chair, 2012 IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT'12), Macau, China, 4-7 December 2012. Special Sessions Chair, 2011 IEEE International Conference on Systems, Man, and Cybernetics (SMC'11), Anchorage, Alaska, USA, 9-12 October 2011. Program Co-Chair, 1st International Conference on Pervasive Networked Services and Internet of Things (PNSIOT'10), Chongqing, China, 12-14 July 2010; Executive Co-Chair, 2010 Systemics and Informatics World Network (SIWN'10), Chongqing, China, 12-14 July 2010; General Co-Chair, 2009 Systemics and Informatics World Network (SIWN'09), Leipzig, Germany, 23-25 March 2009; General Chair, 2008 Systemics and Informatics World Network (SIWN'08), Glasgow, UK, 22-24 July 2008; Program Regional Chair, 7th World Congress on Intelligent Control and Automation (WCICA'08), Chongqing, China, 25-27 June 2008.

Awards

Halvey has received: a best paper nomination at CIVR 2009 (http://dl.acm.org/citation.cfm?id=1646396&picked=prox&CFID=255916627&CFTOKEN=21608429); a best paper honourable mention at MobileHCI 2011 (http://www.mobilehci2011.org/node/127); a best paper honourable mention at MobileHCI 2012 (http://www.mobilehci2012.org/buzzy)
Shahrabi: a highly commended paper award for the paper entitled: "Modelling Differentiated Service-based QoS in Wormhole-Routed NoCs" from the 22nd IEEE International Conference on Advanced Information Networking and Applications (AINA 2008), March 2008. Baillie (with Profs Rowe and MacDonald) won the "Translating Research Award" by the Chair of "AGE" the cross research council (e.g. MRC, EPSRC, ESRC) advisory group of experts on aging (Nov 2013).

External examinations by our staff

Edinburgh Napier University, UK, June 2013; Cardiff University, UK, January 2012; Swansea University, UK, July 2011; Liverpool John-Moores University, UK, March 2011; Liverpool John-Moores University, UK, May 2009; University College Dublin, Ireland, April 2009; Brunel University, UK, December 2008; Universitat Politecnica de Catalunya, Barcelona, Spain, September 2008; University of Western Sydney, Australia, October 2007, August 2008; York University (Dec 2012, Oct 2013); Swansea (Nov 2013); Technical University of Vienna (June 2010, Sep 2011); University of Bradford (October 2010).