Institution: University of Greenwich
Unit of Assessment: (UoA 11) - Computing and Informatics
a. Overview

In terms of this unit of assessment (UoA), all staff being returned are employed within the School of Computing and Mathematical Sciences (CMS), and their research takes place in a number of research groups, namely:

• The Centre for Computer & Computational Science (CCCS)
• eCentre (eC)
• Computational Mechanics & Reliability Group (CMRG)
• Fire Safety Engineering Group (FSEG)

Some staff from these groups will be returned under other units of assessment, as much of this research is applied and multidisciplinary. However, the majority of the research environment is common for all staff across these groups.

b. Research strategy

Within CMS there has been a concerted effort to develop a coherent strategy for computer science and informatics research incorporating the various strands already identified. This has led to a two-pronged approach: on the one hand supporting world-leading dedicated research teams in the areas of fire safety engineering, computational mechanics and reliability, and computational science and engineering, while on the other hand developing a research agenda predominantly focusing on social responsible computing. To achieve this we have also sought to support on-going fundamental computer research in a variety of areas as described above, and have developed support mechanisms for both staff and students to engage more broadly with community and social enterprise. This strategy has already led to the development of a number of research initiatives which address social and community issues. Additionally our world-leading research groups continue to prosper and provide high quality cutting-edge research ideas into our teaching and applied research.

Progress since RAE2008

In RAE 2008, the forward strategy for each group was:

- CCCS**:** Continued development of existing research base, in particular in artificial intelligence, graph partitioning, and sensor analysis. Research funding was sought from the Engineering and Physical Sciences Research Council (EPSRC) and the European Union (EU) for this work; findings were published appropriately and support taken from relevant national and international conferences.
- eC: The eC was not returned in RAE2008 and although there was some internal activity there was no external research presence at that time.
- CMRG: To extend existing PHYSICA software for better prediction of multiscale physics, and continue development of a suite of software tools for predictive reliability and real time prognostics; to extend application to the high technology and heritage conservation sectors.
- FSEG: To extend capabilities of existing software suites, EXODUS and SMARTFIRE, to handle a wider range of simulation events, and elements of those simulations; to provide more sophisticated physics, chemistry and numeric techniques within the software.

Significant progress has been made towards all of the above objectives through support from external funding, training and graduation of postgraduate students, and strategic investments in infrastructure (see section (d) below). As a result, the number of staff overall being returned to various units of assessment from the research groups has grown; the return to UoA11 has reduced to 14.2 FTE staff on the basis that the overall quality of the research being returned is significantly higher.

i. Forward strategy and vision

Each of the groups has plans in place to develop and grow their research activity over the next five years, as part of the overall strategic planning at School and University level. The intention is also to grow research activity and capabilities in UK government and EU high priority areas, such as smart systems, cybersecurity, healthcare and energy.

- CCCS: Continue to support existing areas of research in AI and graph partitioning, seeking to link temporal reasoning work to the spatial informatics work being led by **Professor Worboys**. Expand and develop existing expertise in sensor technologies and networks to build smart systems capabilities, and seek EPSRC and EU funding for this research. Develop research base in cybersecurity through growing existing staff team in this area and extending from current teaching and short course provision, seek further EU funding in this area.
- **eCentre:** Focus research activities on 'connected digital world', building relevant software and online tools and facilities to support multidisciplinary communities of teachers and researchers. Continue to develop APT international conference, run by eCentre, and seek to launch journal. Significant focus on healthcare activities, building on existing tools and extending range and capabilities, seeking funding from UK government and research councils and EU.
- **CMRG:** Further develop our multiphysics and multi-objective optimisation capabilities for materials and advanced manufacturing processes as well as embed these capabilities into our software tools such as PHYSICA, SPHINX, ROMARA and POWERLIFE. Further develop our reliability and failure analysis modelling capabilities in electronics product design and in particular the electronics-energy (power electronics) and electronics-bio (medical devices) sectors. Combining the latest advances in 'internet-of-things' and 'cloud computing' with our modelling tools for real time prognostics and health management of engineering products in the field.
- **FSEG:** Further developing our understanding of human behaviour associated with wayfinding, and the decision making process associated with using lifts or stairs for evacuation; better characterise and quantify the evacuation performance of people with disabilities; understand the impact of social culture on evacuation behaviour; explore the concept of multiscale evacuation modelling to represent evacuation in large urban scales for disaster management planning. These techniques will be embedded into our EXODUS software to better represent human behaviour and widen the scope of its application. Further developing the capabilities of our CFD fire modelling to include improved representation of the generation and propagation of fire smoke, improved representation of the generation of toxic products of combustion such as HCN and improving the computational efficiency of CFD fire modelling through the use of the hybrid discretisation concept and GPUs.

Each group will also seek to continue collaboration on UK/overseas government (e.g. EU, DoD, etc.) funded projects with leading research organisations, and continue to use HEIF and RCIF funding to support enterprise and new infrastructure requirements. These activities are being supported by the University through the appointment of a business development manager in CMS, who works closely with research staff to identify funding opportunities and assist in developing proposals.

c. People, including:
Staffing strategy and staff development

Key staff:
The CCCS is led by **Dr Jixin Ma**, with support and oversight from **Professor Lachlan MacKinnon**. It has focused on the development of a combination of fundamental computer science research in areas such as temporal logics, led by **Dr Jixin Ma**, graph theory, led by **Dr Chris Walshaw**, autonomic computing, led by **Dr Richard Anthony**, and some growing activity in security, led by **Professor Lachlan MacKinnon**. This group has recently been extended by the

introduction of a new thread of research in spatial informatics and GIS, led by **Professor Mike Worboys**. In REF2014 CCCS has submitted 7.2 FTE staff in UoA11.

The eC, was founded in 2005 and has been led jointly by **Professor Liz Bacon** and **Professor Lachlan MacKinnon** since 2010. The centre has a pan-University membership and a number of research groupings under its aegis in applied computing research, such as serious games, social and community systems, e-learning, led by **Professor Liz Bacon**, e-Assessment, led by **Prof Lachlan MacKinnon**, Digital Film and TV, and social networking, led by **Dr Ed de Quincey**. In REF2014 eC has submitted 3 FTE staff in UoA11.CMRG, founded in 2004, has research interests in the development of computer models for multiphysics/multiscale predictions, numerical optimisation, failure analysis, reliability and maintenance of engineering structures. Core activities relate to the development of software tools, such as PHYSICA, ROMARA, and POWERLIFE. In particular, work on modelling and analysis of components to support optimisation and prognostics, which was applied in the Cutty Sark case study, has been led by **Dr Stoyan Stoyanov**. CMRG work is applied to a number of sectors including medical, aerospace, automotive, telecommunications. In REF2014 CMRG has submitted 6.45 FTE staff into three UoAs, one in UoA11.FSEG, founded in 1986, has research interests in the development and application of computer models for evacuation, combustion, fire/smoke spread, and fire suppression. Its core activities relate to the development and application of the SMARTFIRE CFD fire modelling tool, led by **Dr John Ewer,** and the EXODUS evacuation tool, a senior contributor being **Mr Lazaros Filippidis**, and FSEG's work has application to aerospace, maritime, rail and built environments. In REF2014, FSEG has submitted 9.5 FTE staff into three UoAs, three in UoA11.

Staffing strategy and staff development

Staffing strategy

The University of Greenwich has made the decision to operate as a research-informed institution, which means that research is important in the provision of cutting-edge knowledge and activity, and has a prominent role in our staffing strategy, alongside high quality teaching. Therefore, in developing the staffing strategy for computing research, consideration for academic appointments is based on teaching capability in equal measure to research capability, although all new academic staff are expected to have a PhD. Staff are appointed directly to research contracts, on research assistant grades, on the basis of funded research grants, but academic posts follow the strategy defined above. As a result, there are some large research groups within this unit of assessment, namely CMRG, FSEG and CSEG, where staff are predominantly researchers, however the majority of the academic staff who are research active operate within the other two umbrella groups. PhD studentships are described later in this section. In terms of support for research infrastructure, there are approximately 1.5 FTE technical support staff dedicated to maintaining and enhancing the research hardware and software.

Staff development

The University of Greenwich has a policy of encouraging staff development and providing facilities for staff at all grades. In terms of the Concordat to Support the Career Development of Researchers, the university is fully compliant and seeks to ensure that the potential exists for research staff to have clear and well-defined career progression opportunities.To this end, staff development opportunities are made available to research and academic staff alike, and within reasonable budget constraints, external opportunities for training and development are also made available.

The university, in keeping with many other institutions at this time, has revised the offering of PhD sponsorship to staff, but still on the basis of free tuition, and other internal training and educational opportunities are still available freely to all staff. Development is underway to implement the researcher development framework developed by Vitae, providing a systemised development tool for researchers from postgraduate through to professorial level to allow researchers to identify their expertise and capabilities. It aims to personalise their professional development and to allow them to set themselves personal targets so as to cultivate all the attributes that make a successful researcher. These include communication, impact planning, financial understanding, innovation and entrepreneurship. This framework enables the University to have a strategic and coherent

approach to researcher development and links up the training that is being undertaken centrally with the bespoke training offered within research units.

CROS and PIRLS survey results

The results from the Careers in Research Online Survey (CROS) and Principal Investigators and Research Leaders Survey (PIRLS) undertaken by Vitae have been used to inform the strategic direction of the University in the development and leadership training and to ensure that equality and diversity is adopted and maintained across the Institution as whole.

Research students

Training of postgraduate researchers

The University has a well-developed procedure for monitoring PhD research programmes, administered by campus Research Degrees Committees. There is also a postgraduate tutor, **Professor Pericleous**, to monitor PhD student progress and provide pastoral care, and each student is assigned at least two research supervisors. Supervisors are required to have undergone a specified training programme within the University (or its equivalent) and have specific experience of research supervision before becoming a lead supervisor. PhD students can attend appropriate MSc courses, or other appropriate short courses, as part of their studies. Presentation of their work in internal seminars hones their presentation skills in front of peers and supervisors, prior to making external presentations. A regular programme of invited external speakers enhances awareness of relevant research beyond the university. All PhD students have access to state-of-the-art computational and laboratory facilities supported by RCIF funds.

d. Income, infrastructure and facilities

Research income

Research income for all staff in the unit of assessment is described in the REF4b section of this submission. In terms of the Computer Science and Informatics unit of assessment there is a considerable level of income associated with the research groups CMRG and FSEG and, while the principal investigators have been returned in a separate unit of assessment, the research active staff returned from those groups in this unit of assessment represent a significant proportion of the investment of the funds generated. In addition, a lower level of funding has been achieved through the CCCS and eC groups, and this represents a maintenance of existing levels of funding since the last RAE for CCCS, while eC is steadily growing its funded research activity. However, as described in our impact statement much of the applied research work being carried out by these groups is in the area of 'socially responsible computing', which, while providing significant returns in reputational benefit and social return on investment, does not generate significant research funding. However, this does not preclude these groups from seeking more major research funding through national bodies and EU, and there has been some success in this area, reflecting a growing research income profile.

1) Infrastructure

Research infrastructure is continuously being renewed and enhanced. All research staff/students have their desktop computers upgraded as part of a rolling programme. The School-based research network is continuously upgraded by the addition of equipment, e.g.: 6 Tb SAN storage has been upgraded to 10TB this year; off-site backup/replication for maximum resilience of storage area; 1GB comms backbone has been upgraded this year to 10GB; 1GB switches and dedicated research servers. Other facilities include a dedicated server room space in Dreadnought Library which has been enhanced to cater for HPC servers, two distributed memory high performance clusters, a 40-processor system and a high performance shared memory 64-processor Linux cluster, implementation of Virtual Desktop Environment and virtualisation of servers enabling research groups the ability to demonstrate software to clients and development of their specialised software. These provisions have been made available via RCIF expenditures of £802k since January 2008. Additionally, a small grid cluster has been purchased to support parallel and

distributed computing research in the Greenwich campus. A ubiquitous computing software-hardware lab has been built and equipped at Greenwich using University and RCIF funds. A mobile computing lab, forensics lab and MAC lab for film, TV and animation work have been equipped. Additionally, £160k has been spent on specialist software to support research activities within the centres.

2) Facilities

In addition to all the above, research staff have access to library facilities, video conferencing facilities, and secretarial support. Our researchers are all located in close proximity to each other providing an environment for cross fertilisation of ideas and knowledge between the groups in the Centre. Each researcher has their own desk and a dedicated computer to undertake their work. This is also the case for PhD students within the Centre.
Research staff also have access to extremely well equipped state-of-the-art TV and Film studios offering the latest digital equipment and 3D facilities. Work in the area of games and animation is supported by a high quality animation suite, incorporating motion capture capabilities, and the latest gaming and animation tools.

e. Collaboration and contribution to the discipline or research base

1. Arrangements for the exchange of people and ideas with research user organisations

CMS offers the opportunity for visiting researchers and scholars to spend time with research groups and staff within the institution. This can be accommodated under a variety of schemes including the EU/Erasmus and Marie Curie initiatives, US visiting scholar schemes and other schemes worldwide. Research and academic staff within the School are also encouraged to investigate opportunities to visit other research groups and institutions, and to seek funding for this both internally and through the various external schemes offered by organisations such as the Royal Academy of Engineering and Leverhulme Trust. A number of staff in previous years have taken up this opportunity. In addition, senior academic staff can take up visiting professor status at other institutions worldwide, and this is currently the case in CMS.
The research groups within CMS are all actively engaged in collaborative research with national and international colleagues, particularly through funded programmes with EPSRC and the EU. For example, the EPSRC HEED project involved collaboration not only with Ulster and Liverpool Universities in the UK, but also with two US universities, Polytechnic University of New York and John Jay College, The City University of New York. We have also been involved in initiatives such as Marie Curie (e.g. Pb-Free project which supported close collaboration with City University, Hong Kong) and the Prime Ministers International Research Collaboration Initiative, which supports staff exchange visits between CMRG and Kyoto University, Japan. We also engage with the wider community through our visiting professorships which includes Professor Peter Mason (Royal Academy of Engineering Visiting Professor at Surrey University), Professor Nihal Sinnadurai (President IEEE UK &RI Reliability and CMPT Societies), Associate Professor Yuki Akizuki (University of Toyama, Japan), a social scientist, who spent 10 months working with FSEG in 2010 and Dr Jun-Ho Choi, a National Research Foundation of Korea Scholar and Architect (Kyungpook National University, Korea) who spent 10 months working with FSEG in 2012. **Professor MacKinnon** is a visiting professor at the University of Abertay Dundee since 2010, and at Buskerud University College in Norway since 2008.

2. Public engagement

One key aspect of the strategy for research in CMS described above is that engagement with socially responsible computing naturally leads to a higher level of public engagement, since the vast majority of the projects undertaken in this space will impact on services, facilities, and outcomes, which directly impact the general public. Clearly, this requires greater levels of training for academic and research staff in dealing with the variety of issues that arise when undertaking public engagement, and that training is being developed and provided for staff in this unit of assessment. We have worked closely with the University publicity department to engage with the public through press, radio and TV. Examples of this include our work on the Cutty Sark which has received significant amounts of publicity (http://bbc.in/15nnzXq), and FSEG's work on fire and evacuation has attracted considerable media interest, with staff appearing in more than 60

television and radio programmes to discuss their research and its impact since 2008. Examples include a BBC Horizon documentary based on FSEG research, entitled, 'How to Survive a Disaster' (10/03/09, BBC1, http://bbc.in/15noerY) which attracted 1.7 million viewers or 7% of the audience (http://bit.ly/17BHAJx). Other programmess include the Channel 4 documentary 'Terror at Sea' (31/01/12, http://bit.ly/17BIXHU) which followed the sinking of the Costa Concordia, attracting 3.4 million viewers (http://bit.ly/17BJjP1). A string of other press interviews followed on this topic including BBC Radio 4 Today, SKY News, ABC News (USA). These appearances and those in the international print media, e.g. The Guardian, Wall Street Journal and India Times, demonstrate the vitality of our research, assist in improving the public understanding of science, attract the next generation of engineers and help shape public policy.

3. Support for interdisciplinary and collaborative research

Academic and research staff within CMS are encouraged to work with colleagues from other disciplines, both within and outside the university, and this is best evidenced by the growth of the activities of the eC, which was initially a small research group within CMS with an interest in the application of computing technologies in multimedia, games, animation and e-learning. This group has grown to be a University-wide research grouping, with direct engagement from the University educational development unit and academic membership from every school within the institution and some partner colleges. There are also regular cross-disciplinary, inter-School research meetings held throughout the University in which academic and research staff from this UoA actively engage. This provides clear evidence of the commitment of both staff and management to support and develop collaborative research, in both single disciplinary and multidisciplinary areas.

Externally, this is best evidenced by the large number of EPSRC, TSB and EU funded multidisciplinary projects that have taken place since 2008. For example FSEG has six EU FP7 projects, which have run through the assessment period (SAFEGUARD, FIREPROOF, BeSeCu, AIRCRAFTFIRE, IDIRA and GETAWAY). These projects involve interaction between physiologists, engineers, naval architects and computer scientists, e.g. BeSeCu, GETAWAY, FIREPROOF and SAFEGUARD. Additionally there has been collaboration with emergency services and disaster planning agencies, e.g. IDIRA. Another example is our collaborative work in the EPSRC Innovative Electronics Manufacturing Centre, where we are undertaking interdisciplinary work with a number of universities and companies. This has supported a number of joint university/industry research projects including the Power Electronics Flagship project, PEMREL and FAMOBS which led onto a EU-FP7 project with four research organisations and 10 SME associations. The eC has had three EU FP7 projects running through the period, in particular the PANDORA project which involved collaboration with researchers in crisis management and emergency services, and has now led on to the development of commercial software for crisis management training. CCCS has also been involved in a number of funded multidisciplinary projects during the period, and all groups have also been engaged in external consultancy with a wide range of clients.

4. Wider contributions to the research base

In addition to our subject specific research, a considerable body of the work being carried out in this UoA, particularly under the auspices of the eC, is focused on broad topics that have an impact on a large number of cognate areas, for example e-assessment, e-learning, learning styles and models, and similar areas. The research being carried out by staff in CMS in these areas makes a significant contribution not only to the development of the University of Greenwich as an educational institution, but also to the broader research base in education and learning. Also, the work in computational mechanics and reliability, although originally focused on electronic components, is now being adopted for conservation of heritage structures, and as part of our strategy is being developed towards healthcare and renewable energy systems.

5. Relevant indicators of achievement

Awards and prizes

- In 2011, an FSEG publication, which appeared in The Aeronautical Journal 2010, won the Royal Aeronautical Society's Bronze Award for the best paper in the peer-reviewed journal for 2010. The work was also short listed for the 2010 Times Higher Awards (THE) for outstanding Engineering Research project, 'Fire and evacuation analysis in BWB aircraft configurations: computer simulations and large-scale evacuation experiment', Galea, E.R.,

Filippidis, L., Wang, Z., and Ewer, J., The Aeronautical Journal, volume 114, Number 1154, pp 271-277, April 2010.

- In 2008 **Professor Mike Worboys** received the UCGIS (University Consortium for Geographic Information Science) Research Award
- In 2008, an FSEG publication, which appeared in the Journal of Fire Protection Engineering 2007, won the SFPE Jack Bono Engineering Communication Award for the advancement and application of professional fire protection engineering. 'Signage Legibility Distances as a Function of Observation Angle', Hui X, Filippidis L, Gwynne S, Galea E.R., Blackshields, D., and Lawrence P., Journal of Fire Protection Engineering, Vol 17, No1, pages 41-64, 2007. DOI: 10.1177/1042391507064025.
- In 2008 CMRG's work with the Cutty Sark Trust received the best Knowledge Transfer Partnership Award & the Outstanding Research Project

Editorship of journals

- **Dr de Quincey** was Guest Editor for Compass: The Journal of Learning and Teaching in 2012 and is an Editorial Board Member for Compass: The Journal of Learning and Teaching
- **Dr Loukas** is on the Editorial Board of the BCS-published Computer Journal
- **Professor Worboys** is the Editor-in-Chief of the Journal of Spatial Information Science

Leadership roles in learned societies or professional bodies

- **Professor Bacon** is Deputy President of the British Computer Society (BCS), the Chartered Institute for IT in the UK, and she is also a Trustee of the Society.
- **Professor Bacon** is Chair of the Board of the BCS Academy of Computing, the new learned society for Computing in the UK
- **Professor Bacon** was Vice-Chair and then Chair of the Council of Professors and Heads of Computing in the UK (CPHC) between 2007–2010
- **Professor MacKinnon** is a Board Member and Chair of the Education Committee of the BCS Academy of Computing
- **Professor MacKinnon** is currently Immediate Past Chair of CPHC, having been Vice-Chair 2009–2010 and Chair 2010–2012

National or international advisory board membership

- **Professor Bacon** is a member of the Board of EQANIE (European Quality Assurance Network for Informatics Education)
- **Professor Bacon** was Communications Officer for PITCOM (The Parliamentary IT Committee) for the UK parliament until restructuring in 2011
- **Dr Loukas** was a government-funded advisor on R&D collaborations in the defence and security industries from 2009–2011
- **Professor MacKinnon** was a member of the Steering Committee and Board for Computing at Schools from 2009–2013
- **Professor Worboys** is a member of Mapping Science Committee (MSC) of the US National Academy of Sciences/National Research Council, since 2009

Conference programme chairs

- **Professor Bacon** was co-Chair of the Academic Practice and Tools Conference in 2013
- **Dr Filippoupolitis** is Chair of IEEE International Workshop on Pervasive Networks for Emergency Management (PerNEM)
- **Professor MacKinnon** was co-Chair of the Academic Practice and Tools Conference in 2013
- **Professor MacKinnon** is National Committee Chair for the British National Conference on Databases (BNCOD) and was Programme Chair for the conference in 2010
- **Professor MacKinnon** is a member of the BCS HCI national committee and chaired the British HCI Conference in 2010
- **Professor MacKinnon** was Chair of the HCI Educators Conference in 2009

All staff submitted in this return are also engaged in reviewing papers at national and international level for conferences and journals, and reviewing for EU and national research funding bodies.