Institution: London Metropolitan University

Unit of Assessment: 11 (Computer Science and Informatics)

a. Overview

London Metropolitan University (LMU) was formed in 2002 by the merger of London Guildhall University and the University of North London. The School of Computing (SoC) in the Faculty of Life Sciences and Computing (FLSC) is responsible for the disciplines covered by UoAs 10 and 11. The SoC is comprised of four research centres, namely: Intelligent Systems Research Centre (ISRC); Centre for Communications Technology (CCT); Informatics Research Centre (IRC); and, Statistics, Operational Research and Mathematics research centre (STORM). The current centres at the SoC have been established by the academic members of staff based directly on their research background, expertise and academic experience. Research expertise of academic staff is instrumental to the design and development of UG and PG courses within the SoC. Contribution to UoA 11 is put forward from members of ISRC, CCT, and IRC. Although there are many researchers within these Centres there has been a highly selective process in choosing outputs for submission.

b. Research strategy

1. Research strategy

The Faculty of Life Sciences and Computing of which the School of Computing is a part, implements a strategy to maximise the support for selectively developing strands of internationally excellent research by both experienced researchers and early career researchers. Since 2008, the SoC has aimed to maintain a high research profile in all its main subject areas, and in pursuance of this aim has supported applied research having clear relevance to the community and industry (especially KTPs and commercial projects harnessing our research); to fund the growth and maintenance of research centres and groups wherever they evidence excellence; to encourage and mentor promising new areas of research/ers; to actively pursue sources of external research funding; to contribute essential underpinning for the undergraduate and postgraduate learning experience by demonstrating the relationship between research and learning; to support the professional and academic development of its staff by establishing a research environment conducive to the pursuit of excellence. Total research generated income from 2008 to 2013 is in the order of £2.156m. This is accumulated from £666k of research grants and the rest is from other funding in support of research activities.

In the future the research strategy will also include: **(i)** development of new multidisciplinary activities with mathematical and life sciences; **(ii)** improve the collaborative research in bioinformatics and further increase the teamwork between the School of Computing and the School of Human Sciences of the Faculty of Life Sciences and Computing; **(iii)** increase the number of research grants and third stream income such as KTPs; **(iv)** increase in the number of PhDs awarded through formal progression monitoring; and **(v)** increase research studentship funding at PhD and post-doctoral levels.

2. Mechanisms for the development, promotion and dissemination of research

FLSC and SoC make significant effort to expand an active research culture by supporting various research activities, encouraging intellectual exchange within the faculty and with national and international communities of scholars. In order to achieve this SoC has annually applied appropriate quantifiable targets for research active staff within the school. The research targets are aimed at individuals, groups and centres. Targets include: the number of PhD students and completions; the number of publications; the number of external funding bids; and similar metrics. These targets have been set and reinforced through the academic staff appraisal scheme.

Staff are encouraged and supported to actively seek external funding to support their research activities and third stream income generation via industrial projects. It is normal practice within FLSC for research staff to interact with a wider research community to disseminate their research by giving seminars and invited talks at other universities and at conferences.

3. Mechanisms and practices for promoting research

There is a vibrant program of research seminars, workshops and symposia operating across the

University. This enables staff to share ideas and reinforces the collegiate institutional ethos. SoC researchers organise weekly seminars, where staff can discuss their research as well as other research related matters such as grant application, scientific paper writing, or exploration of a new research ideas. Any member of staff who attends a conference is required to give a seminar. External guest speakers are periodically invited from industry and commerce to talk about their research work and potential joint initiatives. Staff and students benefit greatly from such activity, broadening their horizons and enhancing opportunities for cross-topic discussion. To further enhance and promote research within the faculty top post-doctorate students are regularly recruited, e.g. CCT's Pillow Postdoctoral Research Fellowship was awarded to Dr S. Mushtaq in Nov. 2011 who obtained his PhD from Imperial College London.

4. Research initiatives and interdisciplinary developments

FLSC is a recent merger of two former faculties (The Faculty of Computing and Faculty of Life Sciences), which took place on 1st Aug 2012. This has helped to reinforced cross fertilisation of ideas which has resulted in greater interdisciplinary research projects between engineers, computer and life scientists, e.g. on using artificial intelligence to predict and analyse transmembrane regions and signal peptides in protein sequences by Prof. H. Kazemian and Dr K. White. Another example resulted from a scientific conference organised by CCT (Prof. E Steers) in Sept. 2012 for the European Working Group on Glow Discharge Spectroscopy. At the meeting a new EC funding initiative for Industry Academia Partnerships and Pathways (IAPP) was discussed. As a consequence of this the faculty is participating in this venture and a funding bid was submitted in Jan 2013. Participating companies include: Horiba Jobin Yvon GD, France, and AQura GmbH, Hanau, Germany.

5. Structure of research centres and groups

5.1 Intelligent Systems Research Centre (ISRC) - (Members: Prof. H. Kazemian, Prof. K. Ouazzane, Prof. D. Palmer-Brown, Dr Y. Jing, Prof. M. Wright, Dr K. White, Dr K. Fisher, Dr F.F. Cai, Dr V. Vassilev, Dr. Qicheng Yu, Dr A. Khossousi, Dr N. Medhurst, Dr V. Hargy)

ISRC was founded in Oct 1999 and since then has made significant contributions to RAE 2002 and RAE 2008. Research in the Centre is focused on the theoretical analysis and practical applications of intelligent and adaptive systems, which includes fuzzy logic, neural networks, genetic algorithms and machine learning techniques. Examples of the Centre's research activities are: applications of soft computing to prediction and analysis of transmembrane regions and signal peptides in protein sequences; applications of soft computing to wireless/wired networks, IT and information security, video streaming and distribution, location-based service and mobile computing; data-mining, VLE, pattern recognition, natural language processing, cognitive science, biometrics, parallel distributed systems and agent based approach for building data warehousing; advanced web technology and its applications such as e-commerce, CMS, web-3 and semantic web.

5.2 Informatics Research Centre (IRC) - (Members: Dr Y. Xue, Dr Y. Jing, Dr R. Mikusauskas, Dr S. Siva, Dr Q. Yu, Dr F. Cai, Prof H. Kazemian, Dr G McLean, Dr K. Ouazzane, Dr T. Wang, Dr K. White)

This inter-school University research centre in FLSC epitomizes LMU's interdisciplinary culture. Informatics is an interdisciplinary and complex area of study by integrating technology-centred and human-centred approaches from the perspective of information system science. The Informatics Research Centre (IRC) conducts research into: fundamental research questions, both in theoretical and practical aspects, related to processing (the creation, capture, storage and conversion of knowledge from implicit to explicit), mapping, codifying, extracting, and utilising various forms of knowledge in firms and organisations; developing innovative methods, models and tools for the reporting and management of Intellectual Capital (IC), innovation and learning capability to help UK enterprises sustain their core knowledge-based competencies and competitiveness advantage in the knowledge economy.

5.3 Centre for Communications Technology (CCT) - (Members: Prof. B. Virdee, J. Wu, Dr. S. Salekzamankhani, Prof. M.E. Brinson, Dr H. Nabijou, Dr S.M. Vaezi-Nejad, Dr S.R. Taghizadeh, Dr P. Shukla, Prof. E. Steers, Dr N. Ioannides, Dr J. Munisami, Dr S. Mushtaq)

The Centre's research activities are organised in the following groups:

- Microwave Wireless Systems: Research in this area focuses on 5G, UWB, satellite and navigation. A sample of innovative research include: (1) novel miniature monopole antenna that operates across an UWB and has reconfigurable band-notch properties to eliminate interferences from co-existing WLAN and Hyperlink systems; (2) a technique for complete identification of scattering objects assuming no prior knowledge of the scatter's material properties like electric permittivity and conductivity; (3) ultra-wideband bandpass filter based on composite right/left handed metamaterial transmission-line unit-cells; and (4) a technique to significantly enhance the performance of wideband travelling wave power amplifiers.
- Wireless Networks: Research in this area mainly focuses on: (1) authentication technologies; (2) intrusion detection and response; (3) mobile and wireless security; (4) femtocell; (5) power control and dynamic channel allocation strategies to mitigate interference; (6) mobile networking; (7) congestion in wireless environments; and (8) optoelectronic and nanotechnology (includes atomic spectroscopy). Since 2008 CCT's members have published 129 peer reviewed articles and 3 book chapters.

c. People, including:

i. Staffing strategy and staff development

The unit (UoA 11) has a well-established and inclusive staffing strategy and staff development in place. With regards to staffing strategy, the unit endeavours to recruit new members of staff, as and when required, with appropriate research background and qualifications directly related to the needs of SoC in order to improve the unit's research profile. Although some staff within the unit have an established research track record, the unit is building the research profiles of other staff in order to enhance successful grant applications.

The annual staff appraisal system is an established mechanism for proposing and monitoring staff development. Directors of research centres predominately appraise and line-manage researchers. During the appraisal, staff development is identified and appropriate tasks are actioned as deliverable targets. Researchers are given time, between 20% to 40%, for staff development. The unit has mentoring systems and Professors regularly mentor Early Career Researchers (ECR). The unit is part of the faculty's Industrial Liaison Group where industrial research and secondment to industry is identified and brought to the attention of line managers and Directors of research centres for approval. Members of staff with no PhDs are encouraged to engage in research. Three members of staff have successfully completed their PhD in the current REF period, i.e. Dr Lyn Rees, Dr Qicheng Yu and Dr Shahram Salek Zamankhani. Some of our PhD students are funded by the University, and ECR are actively encouraged to act as part of supervisory team. Staff are regularly funded by the Faculty to attend research conferences. The University's Research Office provides training for staff such as supervisory training, sessions on chairing the PhD viva, research philosophy, critical review of the literature, research ethics and research project management. All research active members of staff, whether experienced researchers or early career researchers, are also given opportunities for a sabbatical period on a regular basis. Furthermore, research members of staff are encouraged to attend courses to enhance their skills in various areas, such as writing a successful research bid.

The School of Computing proposes six researchers for UoA 11, which include three from ISRC (Prof. H. Kazemian, Prof. D. Palmer-Brown, Prof K. Ouazzane), one from IRC (Dr. Y Xue) and two from CCT (Prof. B. Virdee and Mrs J. Wu). Some of their research achievements since 2008 are outlined below:

(A) Prof. Hassan Kazemian leads ISRC. Since 2008, he has published 24 international refereed journal papers and 21 international refereed conference papers and three book chapters predominately in the applications of AI to membrane protein, Wifi, Bluetooth/ZigBee, IT security and intelligent keyboard. He is a member of the Editorial Board of ICTACT Journal of Soft Computing and has experience of eight international conferences as program committee member, chair of organising committee and chair of conference workshop. He has obtained three grants and one KTP: **(i)** Emerald Fund-Mini in 2008, for patent and marketing of an integrated membrane protein prediction and analysis for commercialisation purposes; **(ii)** Development Fund in 2009, for a research project in the applications of AI techniques to membrane protein; **(iii)** Emerald Fund-

Standard in 2009, for a prototype for an integrated membrane protein prediction and analysis; **(iv)** KTP in 2010 in collaboration with LifelineIT Ltd, to develop software and reference material for small businesses to produce an IT security policy and network protection. He was lead academic for one KTP between 2007-2009 with Disability Essex Ltd. The KTP team was congratulated in the Queen's official citation in 2011. He filed a patent on 16-12-2011 in the applications of AI to transmembrane protein prediction, patent number is 1121695.9. He is peer review college member for EPSRC and regularly reviews grant proposals. Prof. Kazemian has eight PhD completions since 2008. He has supervised two postdoctoral research fellow/assistants: Dr. Z. Yang and Dr. S.A. Yusuf from 2008 to 2011. He has examined 15 internal and external MPhil/PhDs during this period. He is a CEng, FBCS, FIET, SMIEEE and MINNS.

(B) Prof. Dominic Palmer-Brown is the Dean of FLSC and a member of ISRC. He has an outstanding research track record and has led the research programme in modal learning neural computing which switches and combines modes of learning in a single neural computing framework, including the creation of the snap-drift and adaptive function neural networks, which have been successfully applied to many difficult classification and pattern recognition problems. Most recently, he has focussed on a novel method for diagnostic feedback within virtual learning environments which harnesses snap-drift. Prof. Palmer-Brown has 8 paper publications during the REF period and has been the Guest Editor of special issues of the Journal of Neurocomputing; the Journal of Information Sciences; and the Journal of Neural Computing and Applications. He was General Chair of Engineering Applications of Neural Networks (EANN) conference in 2009 and has delivered several invited keynote speeches, including at EANN, and at Artificial Intelligence Applications (AIAI) conference 2009. He led the participation of LMU in a multi-institutional JISC Learning Object Repository grant. He acted as Lead Academic for a KTP with a company called New Brand Vision Ltd, who are deploying snap-drift in their search engine optimisation product. He collaborates widely, both with colleagues at LMU and beyond, for example as an associate member of SMARTLab, in Dublin; and is regularly asked to examine PhDs (eg, at Birkbeck, Plymouth, Oman).

(C) Prof. Karim Ouazzane is a member of ISRC. Since 2008, he has published 18 international refereed papers in areas such as e-business and cyber security using AI techniques. He has three PhD completion during the REF period. His research has led to outputs of commercial significance and had an impact on specific communities through 3 KTP programmes. **(i)** In 2009, he completed a KTP as a knowledge base supervisor in collaboration with Disability Essex Ltd in the application of NN and language modelling to intelligent keyboard in order to help disabled community to use Qwerty keyboard to improve their life style. The KTP won Queen's award and the charity's CEO was honoured with an OBE for the impact of the intelligent knowledge portal and search engine for disabled community. The KTP associate also obtained his PhD under Prof. Ouazzane supervision. **(ii)** In 2010, he acted as a KTP knowledge base supervisor in partnership with Ask electronics Ltd. A new CRM system was developed which enabled the company to double its online sales and trebled its profits. The outcome of this KTP project provided a significant amount of data for the development of an innovative e-business framework for a PhD student who completed in 2013. **(iii)** In 2011, He led a KTP programme as a knowledge base supervisor in partnership with LifelineIT Ltd which resulted in the development of security policy framework to help SMEs to protect their assets.

(D) Dr. Yong Xue leads IRC. His research focuses on Geocomputation. The aim of the research is to develop a collaborative environment enabling service-oriented remote sensing information service. Dr. Xue has published 29 international refereed journals and 74 international refereed conference papers since 2008. He has contributed to four grant applications since 2008, namely:

- EC 7th Framework Programme (2014-2016) for monitoring and assessment of regional air quality in China using space observations. He is a Co-Principal Investigator (Co-PI). €10k is awarded to LMU.
- ESA-NRSCC Dragon Cooperation Programme (2012-2016) for non-linear dynamics of the remotely-sensed atmospheric data and modelling. He is a Co-PI. Free use of ESA satellite data is granted to LondonMet.
- ESA-NRSCC Dragon Cooperation Programme (2012-2016) for air quality monitoring and forecasting in China. He is a Co-PI. Free use of ESA satellite data is granted to LMU.
- ESA-NRSCC Dragon Cooperation Programme (2008-2011) for low lying water bodies and wetland monitoring exploiting in situ data and earth observation imagery. He was a Co-PI. LMU

was given access to use free ESA satellite data.

Dr. Xue has one PhD completion from LMU in 2009, and he collaborates with Chinese Academy of Sciences where he has 9 PhD completions as first supervisor since 2008. He is visiting Professor at Chinese Academy of Sciences and Chongqing University. He has been the chapter chair of the joint IEEE Oceanic Engineering Society/Geosciences and Remote Sensing Society since 2004. He is Editor of International Journal of Remote Sensing and International Journal of Digital Earth.

(E) Prof. Bal Virdee leads CCT. His research is in the area of microwave wireless communications encompassing 3G Mobile phones to satellite technology. He pioneered the development of: (1) ultra-broadband (2-18 GHz) amplifier technology; (2) high dynamic range amplifiers to enhance the sensitivity of radars which enables the detection of very weak to strong signals; and (3) a novel current sharing technique for RF/microwave amplifiers. The current sharing technology developed drastically reduces power consumption by 50% prolonging battery life of wireless handheld devices. The reduction in power consumption also translates into significantly lower CO_2 emissions. Prof. Virdee is Director of LMU Microwaves which is a third stream income generation activity that has generated a turnover of £116,640 since 2008. He is a peer-reviewer for prestige journals and international conferences, such as IET and IEEE. He is on the Editorial Boards of: (1) Wiley's International Journal of RF and Microwave Computer-Aided Engineering; (2) Far East Journal of Electronics and Communications; and (3) International Journal of New Organizational Trends and Researches. He is a member of the Program Committee & Conferences Co-Chair for The World Congress on Engineering. Prof. Virdee is in the Executive Team of the IET's RF & Microwave Committee. He is a CEng, FIET, and MIEEE. Since 2008 he has successfully supervised to completion 5 PhD students, funded by Early Stage Researcher (ESR) EC Framework-VI, Marie Curie Research Training Networks (Project ref: 35459). Prof. Virdee manages Dr Mushtaq since Nov 2011 who is a Pillow Postdoctoral Research Fellowship. He has examined 4 external PhDs. Since 2008 he published 46 international peer reviewed journal papers.

(F) Joyce Wu is member of CCT. Her research interest include: (1) wireless communications and networks: radio propagation modelling, planning & optimisation of wireless communications networks such as 3G/4G, WLAN/WiMAX; and (2) femtocell technology: analysing the interference between femtocells and macrocells in the context of OFDMA-based networks. Her research includes investigation on how femtocells affect each other, as well as power control and dynamic channel allocation strategies to mitigate interference. Since 2008 her achievements include the development of: (i) a new approach to enhance quality-of-service over WLANs; (ii) a decentralized strategy for femtocell-access-points to self-regulate its transmission power and usage of radio resources depending on its distance from the closest macrocell base-stations; and a resource allocation scheme for OFDMA downlink of a shared-spectrum macro/femto network in order to avoid inter-cell interference. Since 2008 she has published ten peer-reviewed papers.

ii. Research students

- **Training and supervision of postgraduate research (PGR) students**

As part of a strategy for transferable skills training, the University provides students with opportunities to learn skills, which may help in the achievement of personal and career development goals. Research students are expected to discuss their training needs with their supervisory team and identify which activities are appropriate/necessary for their research and personal and career development.

The University wide Researcher Development Programme provides a range of training and development opportunities for PG research students. The courses are designed to support researchers in developing a full range of transferable professional, personal, research, and career skills and knowledge. The Programme offers a range of courses in four domains: Knowledge and Intellectual Abilities – the knowledge, intellectual abilities and techniques needed to carry out research; Personal Effectiveness – the personal qualities, and career and self-management skills needed to take ownership of and engage in professional development; Research Governance and Organisation – the knowledge of the standards, requirements and professional conduct needed for the effective management of research; and, Engagement, Influence and Impact – the knowledge, understanding & skills needed to engage with, influence and impact on the academic, social, cultural, economic and broader context.

- **Information on progress monitoring**

Research student progression is monitored in various ways, i.e.: (i) by the Head of School, at academic supervisors' appraisals; (ii) by the Dean of Faculty; and (iii) at Research Student Progress Group (RSPG) meetings. First year students receive an induction programme including general and specific taught courses mentioned above, and targeted Health and Safety training. Students are required to complete a post-registration progress review form twice annually. This includes: description of the progress they have made on their research project since the last report to the RSPG; identify any challenges or problems encountered for which additional support, training or guidance might be required; and, an updated outline of their anticipated timetable for completing the research. Supervisors are required to comment on the student's progress in respect of their programme of research. An independent reader also comments on the student's progress. As part of their training research students are expected to present their research at conferences and symposia, e.g. CCT's research and post-doctorate students have presented their work at 16 national and international venues.

The UoA 11 has successful PhD completions, one in 2008-2009, two and half in 2009-2010, two in 2010-2011, one in 2011-2012, and five in 2012-13 academic years.

d. Income, infrastructure and facilities

Income:

(1) Prof. F. Marir and Dr. Y. Jing: (i) Knowledge Connect **(£10k)**, mPAS: Mobile proactive anti-obesity system, 2010; and (ii) Knowledge Connect **(£10k)**, Project entitled: 'An embedded video training platform for the 'Good Vibes' gym', 2009-2010.

(2) Prof. F. Marir, Dr. S. P. Siva and Dr. Y. Jing: JISC **(£38.5k)**, eRaUI-e-Research Adaptive User Interface, 01-08-2011 to 31-03-2012. A research grant from JISC under Usability/Learnability initiative - strand C.

(3) Prof. H. Kazemian and Dr. K. White: (i) Emerald Fund-Mini **(£8k)** for patent and marketing of an integrated membrane protein prediction and analysis for commercialisation purposes, from Sept 2008-Sept 2010; and (ii) Emerald Fund–Standard **(£32k)** research grant entitled: 'A prototype for an integrated membrane protein prediction and analysis for commercialisation purposes', from Jan 2010 to present.

(4) Prof. H. Kazemian: Development Fund **(£61k)** for a research project in the applications of artificial intelligence techniques to membrane protein, obtained in Jan 2009.

(5) Prof. M. Wright: Grants and third stream income obtained by Gamelab are: (i) BBC (**£443,000)**; (ii) Guide Dogs **(£34,564)**; (iii) JiscTechdis_HEA **(£150k)**; (iv) Jisc Techdis-SBRI **(£79,652)**; (v) Welsh Assembly **(£110,025)**; (vi) Proof of Concept Innovation grant **(£3.5k)**; (vii) JISC **(£70,000);** (viii) AHRC **(£37,000);** (ix) Emerald Fund **(£40,000)** and (x) Screen South **(£43,000)**

(6) Ms. F. French: The Big Woolwich TXT Game **(£2k)**. Public event (participatory art project) funded by Stream Arts. Feb-July 2009.

(7) Dr. Y. Jing: (i) Academic supervisor for the World of Work Agency **(£5.4k)** for project entitled 'the development of an iPhone app for classical music', 2011; and (ii) Usability test for Comic Relief Website in 2013 **(£2.1k)**.

(8) Prof. E. Steers: EU "Analytical GD Research Training Network", GLADNET LondonMet share of funding: **£289k**, 2007-2011. Project reference: 35459

(9) Prof. B. Virdee: (i) Analytical Graphics, Inc. for STK donation (valued at **$3.151M**), 2011; (ii) London Metropolitan Microwaves (third stream income) - **£116,640**, 2008-2013; and (iii) Royal Academy of Engineering, travel grant **(£1.2k)**, 2009-2010.

(10) Prof. M. Brinson: (i) Industrial sponsorship of a comparative modelling study using Qucs and SimulationX (Modelica): One year full industrial level license from ITT GmBH, Dresden, Germany. Value of support **£20k**, 2010-2011; (ii) Indian National Academy of Engineering, travel grant **(£2.5k)**, 2012; (iii) COMON European Compact Modeling Network, travel grant **(£1.5k)**, 2012; and (iv) École Polytechnique Fėdėrale de Lausanne, travel grant **(£500)**, 2013.

(11) Dr Y Xue: Monitoring and assessment of regional air quality in China using space observations, project of long-tern Sino-European co-operation, 2014-2016 **(€10k**) European Commission: 7th Framework Programme for Research.

The UoA 11 has had four KTPs outlined follow:

(1) Disability Essex Ltd – (£116k) project entitled: 'Noisy Language Modelling Framework using Neural Network Techniques', 2007-2009. Supervisors: **Prof. K. Ouazzane & Prof. H. Kazemian**; **(2)** Ask Electronics – (£120k) to develop and implement a comprehensive marketing strategy addressing brand development and growth in traditional and online sales, coupled with the development and implementation of a host of bespoke e-business solutions', 2010-2012. **Prof. K. Ouazzane**; **(3)** LifelineIt – (£118k) to develop a package including documentation, software and reference material for small businesses to produce an IT security policy and take steps for network protection, 2011-2013. **Prof. K. Ouazzane and Prof. H. Kazemian**; **(4)** New Brand Vision (NBV) – (£115k) for search engine optimisation. Supervisors: **Prof. D. Palmer-Brown, Prof. F. Marir & Dr. V. Vassilev**. SoC has recently obtained another KTP with NBV.

Consultancies:
(1) Cockpit Arts 2010: (£2.5k) redesign and mapping of Cockpit arts' legacy database (2010); **(2)** Brian Champion Long: (£7.5k) development of strategic web application using PHP/MySQL (2013); **(3)** Toucan Roofing: (£3.5k) development of a content management system (2012); **(4)** Lloyds TSB bank: (£47k) development of online secure mobile banking (June 2013); **(5)** Roomfortea: (£3.2k) "The Response Simulations System" (E-learning responses to major emergencies services) (2013); **(6)** Axon: (£4.5k) configuration Primavera p6 enterprise portfolio management (Oracle) software using citix for virtualization security layer using windows 2008 server (2013).

Infrastructure and facilities:
The University provides truly world-class library facilities. SoC has a range of computing facilities to accommodate for research in the UoAs 10 & 11. The Tech-Tower has 800 networked machines and workstations, a number of specialist computing laboratories for networks (including Cisco), mobile and satellite communications, IT security, forensic, games, animation, and microprocessor systems. SoC has a production lab that enables research students to design and build electronic devices, which can be interfaced and linked to computer networks. Students use these facilities to create interactive games and remote sensing mobile apps using artificial intelligence techniques. The labs are supported by four specialist technicians, while university central services provide dedicated staff to support the general purpose computer science labs, networks and standard software builds for computers.

e. Collaboration or contribution to the discipline or research base

(1) Prof. M. Wright from Gamelab collaborated with the following institutions: BBC Learning, University of Surrey, University of East Anglia and European Union; **(2) Prof. E. Steers** from CCT had 16 collaborators, which includes: Swiss Federal Laboratories for Materials Testing and Research; and Leibniz Institute for Solid State and Materials Research Dresden, Germany, on EC Framework-VI, Marie Curie Research Training Network (project ref: 35459). **(3) Dr V. Vassilev** collaborated as a knowledge based supervisor with New Brand Vision Ltd on two KTP projects.

Mechanisms to promote collaborative research:
FLSC has several mechanisms to facilitate research collaboration with other institutions and industry. To aid this, the faculty hosts a weekly seminar where external guest speakers are invited from other HEIs, industry and commerce. This informal forum allows research active staff within FLSC to network and seek opportunities for collaboration. Students and staff exhibit their work through posters, demonstrations and talks at the annual Industry Day. These types of event provide our staff to discuss ideas for research, funding opportunities, KTP ventures and consultancies. Furthermore, within FLSC is embedded the WoW Agency whose role is to engage with industry and commerce to promote research collaboration, commercialisation of academic research, and KTP opportunities. Over the REF2014 period the WoW Agency (http://thewowagency.co.uk) has delivered over 100 projects valued at £335k for a wide range of businesses from start-ups / SME's / Social Enterprise through to large blue-chip organizations. Staff also regularly attend conferences and external academic/industry where there is a greater opportunity to network for collaboration.