Institution: Staffordshire University

Unit of Assessment: Computer Science and Informatics (B11)

a. Overview

The unit of assessment is firmly situated within the School of Computing, which is one of three constituent schools in the Faculty of Computing, Engineering and Sciences (FCES) which was formed in September 2012, following a period of restructuring across the University. Following the research strategy of thematic development, already in place and used in RAE2008, FCES has continued to give support to selected thematic areas which have the potential to produce high quality publications, collaborate with industry or academia, and become self-sustaining by attracting external research funding. The corresponding strategic actions which have been implemented include the recruitment of new research active staff and research students, and nurturing research active staff through mentoring, provision of seed research funding (through internally funded studentships, for example) and allocation of time to staff for conducting research. Following the departure of some key staff (for example, Shah), the Faculty took the decision to realign information management research more centrally within the unit, while retaining its distinctiveness as an important theme.

Research in the University is organised into eleven 'Applied Research Centres' (ARCs). The Faculty ARCs are: the 'Centre for Information, Intelligence and Security Systems' (CIISS); the 'Mobile Fusion Centre' (MFC); the 'Centre for Energy Efficient Systems' (CEES); and the 'Centre for Applied Sciences Research' (CASR). Normally, staff are assigned to one ARC but cross-working of ARCs and themes within ARCs is encouraged. The research work returned in this submission falls under CIISS and MFC.

Research in the Faculty is managed strategically by the Faculty Research, Enterprise and Scholarship Committee (FRESCO), which is responsible for developing the research strategy, monitoring and overseeing all aspects of research conducted in the Faculty. The activities of the unit are clustered into five thematic areas, as given below:

Image and Video Processing (Chibelushi, Sharp, Wu)
This theme has three main research strands, which are: image analysis under adverse conditions [Chibelushi 2, 2012], [Chibelushi 4, 2011]; optimal sensing of camera position, for applications such as augmented reality [Chibelushi 1, 2013], [Chibelushi 3, 2008]; and decision support for medical imaging [Sharp 1, 2013].

Applied Artificial Intelligence (Atkins, Benkhelifa, Sharp, Trigg, Wu)
This theme has four main strands of work: intelligent environmental systems [Trigg 1, 2011], [Trigg 2, 2013], [Trigg 3, 2011]; natural language processing [Sharp 3, 2008]; multi-agent systems [Sharp 2, 2011]; and soft computing for clustering and optimisation [Wu 1, 2011], [Wu 2, 2011], [Wu 3, 2008], [Wu 4, 2008], [Benkhelifa 1, 2011].

Information Systems (Atkins, Eardley, Mills)
Work under this theme has two main strands: strategic information systems and knowledge management [Eardley 1, 2008], [Eardley 2, 2013], [Atkins 3, 2012]; electronic marine systems [Mills 1, 2008], [Mills 3, 2011].

Health Informatics (Atkins, Eardley, Mills, Sharp)
The unit's research under the Health Informatics theme has two main strands: artificial intelligence supported health-care [Atkins 1, 2012], [Atkins 2, 2011], [Sharp 1, 2013], [Sharp 4, 2013]; well-being and technology [Eardley 3, 2013], [Eardley 4, 2013], [Mills 2, 2011], [Mills 4, 2013].

Wireless Networks (Hasan)
This theme focuses on the application of wireless networked control systems: [Hasan 1, 2009], [Hasan 2, 2010], [Hasan 3, 2013]. It should be noted that the Faculty has taken a strategic decision to maintain this area of research in spite of key staff gaining employment elsewhere.

b. Research strategy

Vision, including strategic plans

Over most of the assessment period, the research strategy of the Faculty has been focussed on the following vision statement: *'Create and transfer knowledge of high quality to public, private and voluntary sectors, focusing on applied research and helping all our customers to succeed.'* Within the unit, this vision has been linked to strategic themes of national and international importance, which, in turn, have created, transferred and exploited high-quality knowledge application areas such as healthcare, the environment and the digital economy. In addition, the strategic objectives listed below, from the University's Strategic Plan for 2007-2012 and the University's Commerce & Enterprise Strategy (2012), have focussed the unit's research work including encouraging impact in society and focussing upon niche areas.

- Establish a regional, national and, in a small number of areas, an international reputation for end-user, practice-based and community-engaged applied research. (University Plan 2007-12)
- Monitor our social, economic and environmental impact on local and global communities through education and research. (University Plan 2007-12)
- Undertake research and scholarship which supports curriculum development and Faculty delivery. (University Plan 2007-12)
- Support effective synergy between scholarship, research and practice to advance professionalism, knowledge transfer and the customer experience. (University Plan 2007-12)
- Develop successful applied research projects within all Faculties that add commercial value. (Commerce & Enterprise Strategy 2012)

Future strategic aims and goals for research

At an individual staff level, the unit will continue to publish in high quality journals and further increase its rate of research degree completions. The unit will also seek to increase external funding to support research activities. While applied research will continue to be disseminated through teaching and other enterprise work, the unit's focus will be on developing outputs in real-world contexts which have gained financial support through external funding bodies such as research councils, industry, government, private funding bodies, and the EU.

The University recognises that in order to underpin applied research, it needs to promote and support promising new pure research, while growing existing exploratory research in emerging areas. A further key strategic action for the unit in the next five years is to support research activities through retention and promotion of existing research active staff and new appointments, so that continuity of high quality research is ensured. In addition, PhD studentships will be an important mechanism for developing activity in specific areas, and initiating or strengthening research collaboration. Early career researchers will be mentored through joint research student supervision and joint bids for external research funding.

Evaluation of the unit with reference to RAE 2008

The number of category A research active staff submitted for REF 2014 (7.8 FTE) has increased slightly over that submitted for RAE 2008 (7.00 FTE). To strengthen the sustainability of the research environment, the School of Computing has recruited new staff at early stages of their research career (e.g. Benkhelifa and Hasan). Wu and Atkins are included for the first time in REF2014. As may be expected over a five year period, some staff have retired (e.g. Uden) or left the University (e.g. Yu) and others have reduced to 0.6FTE (Atkins, Mills, Sharp). In addition, two staff (Moniri and Patwary) submitted in RAE2008, have since realigned their research and are being submitted in the General Engineering UoA for REF2014.

As noted in the Overview (REF5a), staff (Eardley, Shah and Sharp) submitted in RAE2008 to UoA37 (Library and Information Management) are now included in this submission. Atkins has joined these staff, and Shah has left the University. This has allowed a growth of research into AI applications in healthcare while also supporting other work in Information Systems. Aligned to the AI staff, Trigg is continuing the work in artificial intelligence for river water quality assessment previously led by Walley. This work is complemented by that of Wu on intelligent techniques for urban water distribution infrastructures.

PhD completions have continued to be buoyant throughout the period, surpassing those returned in RAE2008. Research income has dropped compared with the one returned in RAE2008.

c. People, including:

i. Staffing strategy and staff development

The School of Computing has a clear strategy of staffing those areas of research which support the teaching and learning experience of all levels of students. This policy works well since the portfolio of awards and modules is wide, embracing most of the QAA benchmarks for Computing. The research unit is situated within the CIISS Applied Research Centre, with support from staff in the MFC Applied Research Centre. Within the unit, staff work in cognate areas which are aligned to the themes in this submission. However, following a University wide restructure in 2011/2012, the School of Computing now has academic subdivisions known as Groups, each of which has a Group Leader. Research is now also encouraged within each Group, particularly in a mentoring role for those teaching staff who would like to develop research skills and experience. To date, this has worked well since each Group also has a senior researcher who is able to nurture these staff on a one-to-one basis, while encouraging research within the selected theme.

The Faculty recognises the need to bring new researchers into the unit, especially in terms of early career researchers (ECRs). Since RAE2008, the Faculty has appointed a number of early career researchers and has promoted some established researchers. For example, Benkhelifa, and Hasan were recruited as early career researchers during the assessment period, to strengthen research in intelligent systems, and mobile wireless systems. Benkhelifa was initially appointed as a postdoctoral researcher and later promoted to lecturer during the assessment period. These ECRs work alongside established research staff while being able to explore their own areas of research beyond that of their PhDs. This may be through funded project work where more experienced ECRs may be deemed able to lead substantial parts, for example. For more experienced researchers, calls for professorial conferment are held annually in the University and strict rigour is applied to applications, with independent external assessors being involved in the process, besides the need for external referees of professorial standing. The midway role of Reader is usually made at Faculty level, again, after a rigorous process of internal recruitment and selection. Thus, early in this assessment period, both Atkins and Eardley were promoted to Readers, recently gaining further promotion to Professors. Retired researchers, such as Walley, may continue to contribute to the Faculty's research interests as Emeritus Professors.

The University recognizes that most academics must contribute to teaching activities and appointments are encouraged where staff are willing to contribute to research as well. The Faculty also encourages staff, who do not hold a research degree, to enrol on part-time postgraduate research programmes and make the most of Faculty support provided through the research time allocation scheme and tuition-fee waiving. On completion of their research degree, staff are able to be mentored in terms of producing outputs and PhD supervision. This non-compulsory strategy works well in maintaining the unit's research profile through active staff development. All staff within the University have a six-monthly appraisal in which any issues concerning the Concordat to Support the Career Development of Researchers can be discussed; of course, in many cases, this is implicitly understood and implemented as staff develop their research skills and experience within the unit's research environment. For instance, Trigg who graduated as a PhD student in the School was subsequently employed as a post-doctoral research assistant and he is now the lead researcher in CIES.

Visiting researchers are encouraged through the University's Visiting Research Fellows and Professors Scheme which is implemented and monitored under the University's Research, Enterprise and Scholarship Committee. The mobility and living expenses of some visiting researchers are supported by EU programmes; the researchers may work within the Faculty and unit for several months or shorter periods. These post-doctoral researchers are a welcome addition to the Faculty as they bring opportunities for cultural learning beyond their academic specific disciplines. Postgraduate students are also included in the EU programmes (notably eLINK – east-west Link for Innovation, Networking and Knowledge exchange (5.5 million Euro, funded by EU, March 2009 – Feb 2013); Sustainable E-Tourism (2.5 million Euros, funded by EU,

Oct 2010 – Sept 2014)). These programmes have enabled more than 20 researchers from countries including China, Thailand and Pakistan to work in the unit over the assessment period.

The University has an active Diversity Section within its Personnel Services and this group provides compulsory training for all new staff, as well as updating all staff. For example, in 2013, the University invested in compulsory on-line training in diversity and equality for all staff.

ii. Research students

The Faculty Research Degrees Sub-Committee (FRDSC), which reports to the University Research Degrees Sub-Committee while also having representation on FRESCO, oversees all matters relating to research students, including recruitment, registration, annual progress monitoring, mandatory training in research methods, and the promotion of good practice in research supervision. FRDSC includes three student representatives (one from each School).

The number of postgraduate research students in the Faculty was 66 in 2008-2009, rising to 78 in 2012-2013. The number of doctoral degree completions returned for the Computer Science and Informatics UoA in RAE 2008 was 16; this has risen significantly to reach 24 for this submission. The research degree completion rate is 0.6 per staff per year, for the 7.8 FTE returned staff employed continuously during the assessment period.

The Faculty has made a significant investment by providing scholarships, research equipment and facilities and funding for conference attendance. The Faculty also offers a distance-learning PhD programme which has registered students from Europe, the Middle East and North Africa.

The unit often runs near full supervisory capacity and so external supervisors or advisors are added to supervisory teams, especially where there is insufficient academic or domain expertise through a strategic wish for growth. This enables informal staff development for the supervisors as well as widening the student experience through interacting with other HEIs or organisations.

It is mandatory for students to complete the University's Postgraduate Certificate in Research Methods (PgCRM), which includes a faculty specific module. Research students also have access to University resources and initiatives, such as on-line tools for personal development planning and the Careers and Employability Service. Similarly, all inexperienced supervisors must undertake formal research supervision training which is overseen at University level.

d. Income, infrastructure and facilities

Research Income

During the assessment period, the research funding needed by the unit was mainly for providing staffing, equipment and facilities for research projects, and for supporting networking and conference expenses for staff and students. Most of these needs were covered by external funding but internal research funding also supported and pump primed newer research activities. Most of the international collaboration (see Section REF5.e) has been funded through competitively sourced income, as summarized in REF4b. External funding has increased during the period, particularly from various EU programmes but also from governmental organisations, regional development agencies (e.g. AWM), the Environment Agency, and industrial organisations. For example, research on AI techniques for river health monitoring [Trigg] was supported by several external research contracts totaling £230k over the assessment period.

External research income has a proportionally higher amount of funding coming from applied research funding sources such as the KTP scheme, reflecting the engagement of the unit to contribute to the local economy (for example, the KTP with Peak Pursuits Ltd). This strategy of increasing externally-funded applied research has been supported by the Faculty appointing, during the assessment period, specific staff (called 'Enterprise Readers' and 'Innovation Development Consultants') whose roles are focused on increasing enterprise and research funds and facilitating internal and external collaboration with research and industrial partners.

Further details of selected projects and finance are given in REF5e, Table 1.

Research Infrastructure and Facilities

Each full-time research active staff or student has dedicated computing equipment, allocated according to their research. The computers are updated approximately every 3 years. Full-time staff and research students also have full access to shared Faculty and University equipment and facilities used to support teaching, learning and research. In particular, Staffordshire University opened in October 2012 its multi-million pound Science Centre. This new building hosts specialist science and technology laboratories to accommodate teaching and research. Moreover, staff and student all have access to a well-stocked library, which also subscribes to many e-resources, such as IEEExplore, ACM Digital Library, ScienceDirect, and Web of Knowledge.

To foster social and intellectual exchanges with other students or researchers, and to reduce feelings of isolation, full-time research students are based in an open-plan research centre, which can cater for up to 50 people. Some hot desks are provided for part-time students. The Faculty annually disburses more than £100k for research students and conference attendance as well as other resources, including research equipment.

e. Collaboration and contribution to the discipline or research base

Collaboration

Part of the mechanism for international collaboration is joint Ph.D. supervision; for example, with staff at Chiang Mai University (Thailand), the Arab Academy for Science, Technology and Maritime Transport (Egypt), and from the Asia Pacific Institute of Information Technology (India). Collaboration has also been underpinned by research visits funded by various sources, such as the EU-funded eLINK and e-Tourism projects, mentioned in REF5c. In addition, collaboration extends beyond joint research student supervision, to real development of knowledge through exploring leading edge research with other academics, research institutions and industry. Table 1 gives examples of such work.

Table 1: Examples of national and international collaborations, including outputs returned in this submission, where applicable.

Unit Member(s) [returned outputs]	*External Partners*	*Project*	*Funding to the Unit or SU (Staffordshire University)*
Atkins and Sharp [Atkins 1, 2], [Sharp 4]	Chiang Mai Uni., Thailand	Fall risk screening for the elderly	EU: eLink, €5.5M in total; £700k to unit
Benkhelifa	Forensic Pathways, New Scotland Yard, Europol Homicide Working Group	Cloud based digital forensic gateway	TSB: £643k in total; £154k to unit
Benkhelifa	D2 Network Associate Ltd	Cloud monitoring system	Growth Accelerator: £3k to unit
Benhelifa [Benkhelifa 1]	Cranfield Uni., UK	Design optimisation framework	EPSRC and EnginSoft (Italy) -
Chibelushi	BMW, Munich, Germany	Intelligent motor vehicle safety systems	BMW: £20k to SU
Chibelushi	Staffordshire Police, UK	Digital media	-

		analysis	
Chibelushi	Baden-Wuerttemberg Cooperative State Uni., Germany	Lossless compression of astronomical images	-
Eardley	Riga Technical Uni., Latvia; Uni. of Lodz, Poland; Uni. of Southern Denmark; Centro Studi ed Iniziative Europeo, Italy	WBLQUAL – Work based learning	EU: £183k to unit
Eardley [Eardley 2]	Masaryk Uni., Czech Republic; KDU Uni. College, Malaysia	Knowledge management in ASEAN service-based SMEs	-
Hasan [Hasan 1]	Uni. of Sussex; Bournemouth Uni., UK	Human adaptive mechatronics; Wireless networked control systems	EU: E-Tourism, €2.5M in total; £402k to unit
Mills	Legendary Games, UK	Development of game	TSB: £30k to SU
Mills	Birmingham Children's Hospital, UK	Virtual Religions	NHS: £9k to unit
Mills	Uni. of Gorizia, Slovenia; Vilnius Business College, Lithuania; Uni. of Turko, Finland; UNG, Slovenia	IDEATE – Entrepreneurial experiences for students	EU: €124k to SU
Sharp [Sharp 1]	Great Ormond Street Hospital; Inst. of Child Health, Uni. College, London; Bristol Royal Infirmary, UK	Image analysis of histological features in molar pregnancies	-
Trigg [Trigg 1 - 3]	Environment Agency, UK	Various projects related to AI and river quality	Environment Agency, UK: £159k to unit
Trigg	Environment Agency, UK	Automated biotope classification system	Joint Nature Con. Committee: £30k to unit
Wu	Monumental Games, UK	Browser based delivery of virtual world	TSB: £100k to SU
Wu [Wu 1 - 4]	Harbin Inst. of Tech.; Qingdao Technological Uni., China	Intelligent monitoring, assessment and optimisation of urban water infrastructures	European Next Generation Infrastructure Foundation: £122k to SU; EU (for WatERP

			project): €380k to SU
Wu	TUDelft, Netherlands; Cranfield Uni., UK; Dalian Uni. of Tech.; Tsinghua Uni.; Harbin Inst. of Tech., China	Smartwater project	EU: €157k to SU

Indicators of contributions to the discipline or research base

Staff returned in the unit have experience which extends beyond the University, making contributions such as editorial roles of peer reviewed journals, keynote addresses, and chair or programme committee roles at established conferences. Examples are listed in Table 2.

Table 2: Selected indicators of contributions to the discipline or research base

Indicators	*Unit Members and Contributions*
Editorial roles	• Benkhelifa: *Editor* – Int. J. of Artificial Intelligence and Application (SERSC). • Chibelushi: *Editorial Board* - Image Processing Journal (IET). • Eardley: *Editorial Advisory Board* - 'E-learning 2.0 Technologies and Web Applications in Higher Education'. IGI Publishing, Pennsylvania. Oct. 2012. • Mills: *Editorial Board* – Journal of Navigation. • Sharp: *Guest Editor* – Int. J. of Agile Systems and Management, Vol. 6 (1), Inderscience Enterprises Ltd.; 2013. • Wu: *Associate Editor* – Int. J. of Computer Application in Technology, 2011.
Invited keynote lectures / speeches / addresses	• Chibelushi: HCI through the 'HC Eye' (Human-Centred Eye): Can Computer Vision Interfaces Extract the Meaning of Human Interactive Behaviour? IADIS Int. Conf.: Informatics 2009, Algarve, Portugal, 17-19 June 2009. • Eardley: 'Negotiated Work-based Learning and Organisational Learning: The Relationship between Individual and Organisational Knowledge Management. 5th Int. Joint Conf. Knowl. Discovery, Knowl. Engineering and Knowl. Management (IC3K 2013). Vilamoura, Portugal 19-22 Sept. 2013.
Conference organisation	• Benkhelifa: *Co-Chair* - Cloud Security Track, IEEE Global Communications, 9-13 Dec 2013, Atlanta, USA. • Benkhelifa: *Session Chair* - IEEE Technically Co-Sponsored Science and Information (SAI) Conf. 7-9 Oct 2013 London, UK. • Eardley: *Session Chair* - Work-based Learning Session, 5th Int. Conf. on Educational Research and Innovation (ICERI 2102). Madrid, Nov 2012. • Eardley: *Programme committee* – Int. Conf. on Knowledge Management and Information Sharing (KMIS – IC3K 2012) Barcelona. Oct 2012. • Sharp: *Chair* - Int. Workshop on Natural Language Processing and Cognitive Science (NLPCS), 2008-2010 • Sharp: *Senior Programme Committee* – Int. Conf. on Enterprise Information Systems (ICEIS), 2008-2010 • Wu: *Program Chair* – Int. Conf. on Automation and Computing, 2011 • Wu: *Chair special session & Programme committee* - IEEE Int. Conf. on Networking, Sensing and Control (ICNSC), 2011.