Institution: Bournemouth University

Unit of Assessment: General Engineering (UOA 15)

a. Overview

We focus on societally relevant research at the interface of engineering and computing. Our research activity has increased significantly since RAE2008 reflecting growth and the convergence of separate submissions under a single management and investment structure in the School of Design, Engineering and Computing at Bournemouth University (BU). Key highlights include:

- **An 83% increase in research council funding,** primarily from EPSRC, and a rise in income from UK charities most notably from the Royal National Lifeboat Institution (RNLI).
- **Growth in research income from EU** grants (£1.8m since 2008), with increased bidding supported by development initiatives in bid writing and strong internal peer review and investment in dedicated EU research officers.
- **A 143% increase in PhD registrations** from 25.5 FTE in 2007 to 62 FTE in 2013, with 26 completions (2008-13), reflecting the strength of our research community.
- **Over £1.5m BU investment** in state-of-the-art laboratories and equipment, including a specialist suite of cyber-security and thermodynamic labs in 2013.

Our submission of 24.8 FTE spans the full breadth of UOA15 focusing on:

- **Design Engineering.** Computational and Experimental Mechanics; High Value Manufacture; Medical Engineering; Simulation and Sensory/Electronic Technologies. (Noroozi, Dupac, Dyer, Sewell, Velay).
- **Autonomous Systems & Robotics**. Sensory/Electronic Technologies, Signal Processing, Robotics, Intelligent Computing, Bio-medical Engineering, Control (Yu, Dubey, Cobb, Swain);
- **Sustainable Design.** Tribology, Corrosion, Nano-coatings and Renewable Technology (Khan, Hadfield, Tabeshfar, Williams, Thomas);
- **Smart Technology.** Computational intelligence, Big Data, Data Science, Informatics and Complex Adaptive Systems (Gabrys, Bouchachia, Budka, Fay, Krol, Ma);
- **Software Systems & Creative Technology.** Systems Engineering, Software Modelling, Business Software Process and Quality, Games and Animation (Phalp, Ali, Faily, Lim, Xu, Tian, Davies).

BU organises research into cross-university research themes, with our research sitting within Technology and Design and Creative, Digital and Cognitive Science.

b. Research strategy

Since 2008 our strategy and its success are evidenced by the increased FTE, PhD numbers, research income and high quality publications. RAE2008 funding (c. £300k per year) supported our strategy through four key Early Career Researcher (ECR) appointments (Section b), averaging four PhD studentships annually, and via staff mobility and networking grants underpinned by a new BU Strategic Plan (BU2018) with an investment of £200m in estate and £20.9m in IT infrastructure.

We have focused on four key priorities: (1) pursuing research excellence to enhance reputation and sustainability; (2) interdisciplinary research (e.g. engineering and computer science); (3) engagement with external stakeholders to facilitate societal relevant research, and (4) raising our international profile.

1. Pursuit of excellence

We have engaged in a major programme of growth, investing QR funds in ECR staff and growing PhD numbers. The impact of our ECRs is evidenced by Xu who has attracted Visiting Professors (Groningen, the Netherlands, RMIT University, Australia, Xidian University, China and Wuhan University, China) and by Thomas cementing collaborative links with the RNLI (REF3). Our Professoriate mentor staff on journal selection, supported by BU investment in a publication management system (BRIAN; Symplectic, £300k) allowing academics to monitor their bibliographic metrics to guide their publication strategy. BRIAN is linked to our external staff web pages to promote staff research profiles to collaborators and prospective research students. BU supports open access publishing via a dedicated, central fund (c. £100k per annum); since 2011

we have published 11 papers in open access outlets in: *Wear, Renewable and Sustainable Energy Reviews, Journal of Biomedical Science and Engineering, Entropy, IEEE Transactions on Neural Networks and Learning Systems* and *Artificial Intelligence Review*.

Growth in EU funding is driven through: (1) BU's Grants Academy staff development programme; (2) involvement in the EU Academic Development Scheme and the EU Networking Fund (Yu, Gatzidis, Feng and Khan); and (3) staff mentoring which led to EU awards (Section d; Marie Curie IAPP INFER €1.55m (BU: €895k) Gabrys, 2010-14; EPP €273k Gabrys and Krol, 2012-14; RABOT €310k Yu, 2012-16; cLINK €340k, Yu, 2013-16; FUSION Erasmus Mundus €3.05M (BU €600k) 2013-17, Yu, GameIT €25k Gatzidis, 2009-11; GameWise €35k, EU Gatzidis, 2012-4). Initiatives for Research Council PGR support includes: (1) Winning 3 EPSRC CASE awards (Section d); (2) shortlisted for an EPSRC CTC in Data Science (2013); (3) participating in an IDTC award with the Media School (Digital Entertainment 2013-2020, Tian).

2. Interdisciplinary research

Research in the School in computer science and engineering has been brought together into one management/investment structure, supported with a targeted staffing strategy, creating one cognate research environment. Strategic appointments have been made to further this agenda, particularly in applications of computing to medical engineering and mechanical systems, and include Yu (robotics, intelligent computing) and Budka, Fay and Bouchachia (data science and analytics). Large interdisciplinary grants include the EC-funded INFER project Computational Intelligence Platform for Evolving and Robust Predictive Systems (Gabrys; €1.55m, BU €640k, 2010-14) and the RABOT project on networked control of rescue robots (Yu; €310k; 2012-16). Our success is further illustrated by Noroozi (two EPSRC CASE awards in prosthetics (BAE Systems; £65k; 2010-13; Blatchford; £87k; 2011-14)), and a match-funded studentship with the Anglo-European College of Chiropractic around medical engineering continuing a tradition established by Swain.

3. Business engagement

Collaboration with external stakeholders is central to our research and we have consolidated and grown this engagement by developing new relationships and strengthening existing ones. A multi-strand strategy is used to achieve this:

- Business & Policy Briefing/Projects: We hold regular industry briefings to disseminate and listen to local business needs (since 2008: 14 briefings, c. 330 delegates; 11 awareness events, c. 610 delegates). Noroozi is policy advisor to the International Paralympic Committee and has a long standing collaboration with BAE Systems around composite materials. Our Knowledge Transfer Partnerships (KTPs) include: Chantacre (x2), Consolor, Electronic Technicians Ltd, Morning Data, Hark Solutions, Time and Data Systems International Ltd (TDSi) and Farley & Thompson LLP. Within the EU INFER project we have carried out a major transfer of knowledge and collaborative research through a secondment scheme with 13 industrial researchers spending over 91 months at BU and seven academic researchers spending 54 months in the Research & Engineering Centre in Poland and Evonik Industries in Germany working on development and implementation of adaptive soft sensors for industrial processes.
- Dissemination & Public engagement: Our annual Festival of Design & Innovation has attracted over 8,000 delegates since 2008, (circa 100 companies) and sponsorship from: Institute of Directors, Holton Crest, Business Link Iracroft, Grid Law Solicitors, DEK, Tesco, Nokia, Every Creative, Gelert and B&Q. We also have a presence at high profile forums (the West of England Aerospace Forum, Business South, Dorset Engineering & Manufacturing Forum and Business Link). A master class was delivered at the Carbon Reduction Conference 2012 (Khan, Hadfield). Staff contribute to the University's Café Scientifique series and the annual BU Festival of Learning (attracting 4,000 delegates in 2013). Industry has access to our research through our institutional repository (BURO which now holds c. 400 full-text outputs linked to the unit) and BU Open access funds.
- Long term relationships: We have actively sought out long-term collaborative stakeholder relationships, each managed by a senior academic champion and strengthened through

Visiting Professors/Fellows, e.g. RNLI (REF3; two studentships including EPSRC CASE Award; Hadfield; RNLI; £62k; 2008-11); BT (telecom industry, UK – two Visiting Professorships Prof Nauck and Prof Azvine); Lufthansa Systems (airline industry, Germany), Evonik Industries (process industry, Germany) and SAS Institute (a major business/predictive intelligence software and solution provider, UK/USA). With these partners we have open long term collaborations including joint projects, short/medium term consultancy, co-supervision of research students, delivery of short courses on the company premises and joint publications. All our industrial partners actively participate in and support our initiative for establishing The tRegional Centre for Big Data and our application for an EPSRC Doctoral Training Centre (DTC) in Data Science. Recently recruited staff brought industrial/commercial contacts and collaborate with a range of major commercial partners, including: Bouchachia (Philips); Fay (Deutsche Telekom Labs and through Information and Communication Technology for Sustainable and Optimised Building Operation (ITOBO) at the University College Cork, collaborations with United Technologies RC and INTEL); and Ma (through the Centre for Secure Information Technologies at QUB and collaboration with IBM, Thales). Since 2008 we have established an on-going relationship with local NHS (Poole, Royal Bournemouth and Christchurch, and Salisbury Hospitals) generating income of c. £175k, including funding for six PhD studentships undertaking research including clinical trials (Dubey, epidural simulators; Swain, Functional Electrical Stimulation (FES); Noroozi, internal prosthetic implants). Other examples of our on-going relationships with external stakeholders include BAE Systems, SKF, Defence Science & Technology Laboratory, Schaeffler and AIRBUS UK (including a three year Continuing Professional Development (CPD) contract, Noroozi).

4. International profile

Our work has a strong EU dimension, illustrated by our collaborative networks and funding (Section d). We support staff to raise our international profile through attendance at international conferences/workshops, delivering keynote speeches, and by driving strategic academic partnerships (Section e) through investing QR funds (£50k per annum) and through the BU Fusion Investment Fund (£3m annual funding supporting match-funded studentships, staff mobility, study leave and pump-priming projects) e.g. Khan (funded for collaborative research with PES Institute of Technology, India). These initiatives resulted in collaborative seminars, publications, postgraduate researcher (PGR) mobility and funding applications (Section e). Collaboration is illustrated by the work of Noroozi (Malaysia Penang University and industrial links with Quadrant-2 in Malaysia, which supports its oil and gas industry) and by eight journal articles, staff exchange, joint PhD supervision and PhD exchange. We have five PhD students with overseas Government sponsorship from Kuwait (x3), Egypt and Nigeria.

BU PG Development Funds also facilitated the presentation of our research at major international conferences (Section e) such as the World Tribology Congress 2013 and the International Astronautical Congress 2012. We have organised international conferences including PRO-VE'12 13th IFIP Working Conference on Virtual Enterprises (Xu) and Tribology and Design 2012 (Kos) with Wessex Institute of Technology (WIT); ECR Budka chaired a workshop on Life-Cycle of Social Networks (LCSN 2013) at the ICCS 2013; Gabrys co-chaired the International Conference on Computational Intelligence and Intelligent Systems series (ICCIIS'08 - '13), part of the yearly World Congress on Engineering. We have developed international partnerships such as the recent agreements with Beijing Jiaotong and Xidan Universities in China (Xu), Malaysia Penang (Noroozi), and PES Institute of Technology, India (Khan). Since 2008 we have established a strong record of leading and participating in international research projects, including three FP6/7 projects (Vincent, Ncube, Gatzidis), four Marie Curie actions (Gabrys, Yu, Ali) and two Erasmus Mundus networks (Yu); these projects include European, North American and Asian partners. We have expanded our visiting professorial faculty; examples of engagement in the area of tribology include collaborations at People's Education Society Institute of Technology India, National Institute of Technology India, Oviedo University, University of Ulster and Wisconsin University-Milwaukee (USA). Prof. Viesca, a visiting professor from Oviedo University (Spain) received a 6 month funded secondment through an ERASMUS relationship.

Research strategy 2013-2018 and beyond

Going forward, our plans embrace three of the eight Great Technologies (Willetts, 2013); (1) The Big Data Revolution; (2) Robotics and Autonomous Systems; and (3) Advanced Materials. Our expertise in autonomous systems, robotics, big data, cyber-security, renewable technology and medical engineering are all relevant and our tactics will continue to:

1. Maximise our academic reputation. We will prioritize global networking and research and agenda setting outputs, building on existing success. We will work at the engineering-computing interface with a focus on areas of autonomous systems, robotics and intelligent manufacturing, facilitated by the BU Technology and Design research theme, alongside biomedical engineering (Noroozi), renewable technology (Khan), and Big Data (Gabrys). Our work in the area of Big Data was shortlisted to interview stage by EPSRC for a DTC and was identified as an area for future University investment (via a BU Institute for Data Science capitalising on collaboration with a range of external partners). Collaborative partners include: SAS Institute, BT, Science & Technology Facilities Council, Bournemouth Borough Council, IBM, Bell Labs, C4L, University of Southampton, Kings College London, and University of Reading. We will capitalise on success with EU funding and particularly with Erasmus Mundus (e.g. the recently funded FUSION project working with 11 Asia and 9 EU partners in education and research training) to extend our international links. BU is currently investing through Higher Education Innovation Funding in a Cyber Security Unit, focusing on Information Assurance, Enterprise Assurance and Cyber Security. Headed by Richardson the unit has won its first KTP with TDSI (Yu). We will continue to support staff with their research and bidding to create a foundation for growth. By 2018 we aim to have more academic staff engaged in research (from 70% to 90%), to increase annual research income (from £0.6m to £1m) and to increase PhD registrations (from 62 to 90) through maximising the staff development opportunities (including the BU's Grants Academy); internal peer review schemes (Section c), rationalising teaching to avoid duplication; continuing established staff doctorial study and recruiting new staff with research portfolios. Success will be measured regularly by the proportion of staff bidding, grants awarded, research income, PhD registrations and completions, research outputs and research impact.

2. Maximise our societal impact & business engagement. Industry/business relevant research is a collective strength across the UOA and REF3a details our strategy to maximise this. We will continue to understand our user needs through user engagement, produce high quality research and communicate this research and its adaptation to promote non-academic impact. We will enhance our public engagement activity (BU signed the National Coordinating Centre for Public Engagement (NCCPE)'s Manifesto for Public Engagement in 2012) and public engagement is embedded throughout our institutional strategy (2012-2018). We will continue to contribute to the BU's Café Scientifique series and annual public engagement event (Festival of Learning).

3. Capitalise on our breadth of expertise. We will continue our research across the whole range of UOA15, focusing on the collaborative potential of engineering and computing. We will grow a portfolio of interdisciplinary activities which will fulfil the need for truly autonomous systems taking advantage of sensory technologies, availability of huge amounts of data in diverse disciplines and proliferation of a variety of devices with significant computational capacity. We will engage fully with frontiers of advanced materials where complex software prediction platforms require a multi-scale and multi-physics approach (e.g. nano-composite & nano-coatings modelling taking into account the physical and chemical properties at the atomic scale to enhance society resource utilisation). Research in the application of artificial intelligence in mechanical engineering will continue to expand and will involve high level optimisation and novel statistical approaches, to create functional systems such as 'Intelligent prosthetic socket', or track side systems for assessing the Dynamic Elastic Response of the composite foot used by amputee runners.

c. People, including: Staffing strategy and staff development

BU is recognised as a Mindful Employer, actively promoting diversity and equality (http://www.mindfulemployer.net/). Its approach to the employment and career development of disabled individuals is recognised by the DWPs' award of Disability Two Ticks Status. Our employment strategy adheres to the Concordat to Support the Career Development of

Researchers, implemented through the BU's Concordat Action Plan which achieved the European Commission HR Excellence in Research Award in 2013. BU abides by the provisions of the Fixed-Term Employees Regulations (2002): its Code of Practice–Use of Fixed-Term Contracts gives clear guidelines for their use. BU is committed to creating an ethical, egalitarian workplace that values its staff and supports all aspects of skill and career development.

We focus on career development support to increase staff capability and confidence. BU is creating a new career framework to ensure: successful ECRs achieve senior status; senior staff continue to build their careers; and capable staff produce research meeting our quality thresholds. A number of mechanisms are in place to achieve these goals:

- **Recruitment.** To appoint academics with an aptitude for research, and ideally a track record of, or potential for, research excellence. Our strategy has been targeted at appointing academics undertaking research at the interface between engineering and computing, such as Yu (2012), Tian (2009) and Dupac (2008). This has enabled us to achieve our aim of converging the previously disparate computing and engineering research groups.
- **Dedicated ECR support.** ECRs have reduced teaching loads and are given sufficient time to establish their research programmes. Within a month of arrival, a research briefing by a senior colleague introduces them to the comprehensive support framework, including assistance with grant writing, internal peer review, funding for equipment purchase, study leave, collaborations, and conference attendance and then provides them with mentors.
- **BU Researcher/Academic Development (BRAD) Framework.** This skills identification and training framework, is based on Vitae's *Researcher Development Framework* is targeted at ECRs and PGRs and provides an on-going programme of workshops and online courses open to all staff e.g. Interferometric microscopy in the tribology area.
- **Informing.** BU's award-winning BU Research Blog (HEIST Awards 2012) plays a key role in creating an energetic, collaborative University-wide research culture. It acts as the portal for all information regarding funding opportunities, internal research and collaboration activities, research events and provides access to the BU's central Research and Knowledge Exchange Office (RKEO) — a highly effective support team.
- **Staff Development.** School budget (£50k per annum) for development needs including networking and mentoring. Research themes share £30k for staff networking and £20k for a staff incentive scheme based on publications and grant applications.
- **Study Leave.** Study leave (1-6 months) is funded (e.g. Dubey's sabbatical to the University of Delaware (USA) to research stroke rehabilitation resulting in a patent (US patent 8409118, Upper arm Wearable Exoskeleton); Noroozi's sabbatical to University of Malaya (Malaysia) resulting in collaborative publications in the area of structural dynamics).
- **Support for developing research bids**. In addition to School-based mentoring, BU provides extra support: e.g. seed-corn funding and investment; grant writing support from an external peer review panel; targeted help in matching researchers to appropriate funders (Research Professional) and potential collaborators; and staff training in specialist bid preparation.
- **Mandatory training.** All academic staff must undertake online training and development on research ethics and equality and diversity. All new academics are required to complete a Postgraduate Certificate in PhD Supervision. Experienced PhD supervisors must attend staff development refresher programmes every three years.

c. II. Post-Graduate Research (PGR) students

The BU Graduate School has provided access to over £5m in fully- and match-funded PhD studentships since 2008, and is committed to fund 50 per year to 2018 plus 50 doctoral (fee waive) scholarships per year. Our 143% growth in PhD registrations is due to increased external and BU funding (Section 5d). A distinctive feature, enhanced by the match-funding model for BU studentships, is the number of PhD projects that are in collaboration with industrial partners. Our PhD students spend extended periods of time in industry (e.g. Eastwood, Le - BT; Riedel, Lemke - Lufthansa Systems; Kadlec, Salvador - Evonik; Apeh – Screwfix). We have close links and shared supervision with the EPSRC funded Industrial Doctorate Centre in Digital Entertainment (UOA34; jointly with Bath University, £6.3m), which has just been renewed. BU has invested £290k in state-of-the-art PGR monitoring software (ResearchPAD, provided by Converis) and we have a dedicated administrator to support our PGRs. Awards for scientific merit are regularly won by our PGRs, for example, Winner - Best Student Paper Award 32nd SGAI ICITAAI 2012

conference (Lee), Best student paper award (Huda) at the 2012 UKACC.

- **Recruitment.** PhD studentships are advertised internationally via online systems, on the BU's website and through our research networks. Interviews include an independent professor.
- **Supervision and monitoring.** Students have up to three supervisors (one primary) and supervisory training is mandatory for all staff. A three month review ensures that the student has a clear overview of their subject area and the steps to complete their PhD. A 12-18 month transfer review, to progress from MPhil to PhD, confirms there is a clear path to completion.
- **Development and funding.** Development events, including induction, are offered by the Graduate School based on Vitae's Researcher Development Framework. Students have access to funds to support research, conference attendance and placements. All BU funded PGRs are required to undertake at least two public engagement activities during their studies.
- **Integration with the research community.** PGRs are part of the School research community. There is a PGR representative on the School Research Committee and all PGRs are invited to Research Centres meetings and there are weekly research seminars by PGRs and staff which PGRs are expected to attend.
- **Seminars and conferences.** Students hold annual School-wide PGR conferences (including poster competitions judged by industry experts: e.g. BAE Systems Surface Fleet, BT Intelligent Systems Research Centre and Qinetiq) allowing PGRs to showcase their research and a popular monthly PGR Forum takes place in addition to biannual away day events.

d. Income, infrastructure and facilities

Income. Since 2008 the profile of our research income has changed with an 83% increase in funding from UK research councils and success at attracting EU funds (£1.8m since 2008). This is due to stringent internal peer review, staff development schemes, dedicated support for EU funding and pump-priming initiatives (Section 5c), and has enabled us to increase the international significance of our work.

External competitive grants. We have won high-profile funding throughout the UOA.

- **RCUK**. Since 2008 we secured two CASE studentships in prosthetics (Noroozi; BAE Systems; £65k; 2010-13; Blatchford; £87k; 2011-14), a CASE studentship on the durability of marine launching equipment hydraulic components (Hadfield; RNLI; £62k; 2008-11) and a grant on using sensors and actuators to improve function in people with neurological disease (Cobb; £21k; 2008-2012).
- **EU.** Coordinator of Marie Curie IAPP INFER project on Computational Intelligence Platform for Evolving and Robust Predictive Systems (€1.55m, BU €895k). FP6/7 grants on developing infrastructures for broadband access (£55k), Error Propagation Phenomena in Modern Network Structures (€273k), VIDE (£161k), Trans-Atlantic research (£73k), and GameWise (€35k). Leonardo Transfer of Innovation funding for Game-IT (€25k). Marie Curie grants for social adaptation (£80k) and rescue robots (€310k). Erasmus Mundus student and research exchange projects with HEIs in Asia (FUSION €305m BU €600k) and cLINK (€2.5m, BU €340k).
- **Other Funded PhDs.** Funding from Great Western Research (two collaborative projects with Bristol University and Screwfix, £67.2k and BT £67.5k); SKF (£71k) and Future Energy Source (£48k and £49k). Co-funded PhDs: Royal Bournemouth and Christchurch Hospital NHS (x3 c. £23k each); Poole Hospital (£23k); RNLI (£30k); BAE Systems Ltd (£26k); Odstock Medical Ltd (£26k); Naim Audio Ltd (£21k); DSTL (£23k); Tank Museum (£25k); Longitude Engineering (£23k); Balmain Charitable Trust (£30k); Schaeffler Technologies (£24k); Anglo-European College of Chiropractic (£28k); Inspire (£23k); Lufthansa Systems (€60k); Degussa GmbH (€45k); Zhongyuan University of Technology (£24k) and Chiang Mai University (£24k).
- **Other research grants and contracts.** National Institute for Health Research (£118k), Royal Academy (x3 £80k, £37k and £13k), British Council (£37k), Energetix Group (£16k), Western Union (£9k), National Institute of Academic Anaesthetic (£4k).
- **Knowledge Transfer Partnerships (KTP).** We have a significant portfolio of KTPs including: Consolor (£131k); Chantacre (x2 c. £38k each); Hark Solutions (£126k); Morning Data (£126k); Electronic Technicians (£126k)k TDSI (£130k) and Redmayne Engineering (£99k). The KTP with Morning Data led to an increase in turnover of £200k, which is significant for a company of 11 employees. This project was put forward by the Technology Strategy Board as an exemplar.
- **International travel grants.** Staff have won travel grants to go to Norway (Royal Academy

of Engineering x4, £0.4k each), Italy (Royal Academy, £0.8k), China (British Council, £2k), South Africa (Royal Society, £2.5k),

- **Enterprise and knowledge exchange.** We value our close ties with industry and our long-standing collaborative relationships. Consultancy (e.g. My Floodmate Ltd, Sunseeker International and Bionic Fighter) and specialist training (e.g., AirBus, Sunseeker International and Canon) all link to our research and we run Cisco short courses.

Future plans for income generation are focused through the BU research theme in Technology and Design with a concentration on biomedical engineering, renewable technologies, interface engineering, (big) data analytics, autonomous systems and robotics.

Infrastructure and facilities

BU is committed as part of the BU2018 plan to investing £200m in its estate and £20.9m in its IT infrastructure over the next four years. The Design area continues to receive internal investment for physical laboratory equipment and computing equipment (c.£1.5m). In 2012/13 we have invested £1.5m in networking labs (from where Cisco short courses are taught), specialist software development labs, and a new specialist suite of security labs used for research and consultancy, teaching forensics and security students, and CPD courses. We have specialist modelling software for computational fluid and solid analysis, for example CFX, Ansys, Abacus, Forge 3, Mathematica, CES, COMSOL Multi-physics & corrosion simulation tools, TRNSYS (thermodynamics & heat transfer tools) and life cycle analysis (£130k).

We use our collaborative links to access specialist facilitates (e.g. in the area of Interactive Technologies Simula and the universities of Valencia, Birmingham and Brazil; in tribology, RNLI (Poole); BP provided in-kind support for lubricant analysis, and X-ray photoelectron spectroscopy (XPS) surface analysis through Oviedo University (Spain)). At Salisbury NHS Trust the unit has the use of specialist experimental facilities associated with the FES research. We have solar-thermal heat transfer & thermal expansion labs funded by Future Energy Source Ltd and a dedicated team of demonstrators/technicians (15 FTE) play a vital role in supporting research and knowledge exchange activities. The Library has specialised research support e.g. IEEE full publication access (£50k pa) and £30k pa for library resources such as online publication support.

e. Collaboration or contribution to the discipline or research base

Collaboration and contribution is supported by initiatives to fund international networking and profile building, prioritise impact-led and practice-relevant research, and build research strengths (Section 5b) evidenced by awards, honorary/elected positions, income and outputs (Section 5d) and societal impact (REF3a).

Collaborative research with national & international companies. Examples include SKF (Netherlands); Defence Science & Technology Laboratory (MoD); Federal Department of Energy (USA); RNLI (UK); Smith & Nephew (UK); BT (UK); Lufthansa Systems (Germany); Evonik Industries (Germany); SAS Institute (UK/USA); BAE Systems (UK); Blatchford (UK); Airbus (UK); Schaeffler (Germany). These examples include joint projects, co-PGR supervision and short courses.

Collaborative work with other universities. Examples include Oviedo University (Spain); Bremen University (Germany); Lyon II University (France); Romania Academy of Sciences (Romania); PES IT (India); National Institute of Technology Srinagar (India); University of Wisconsin-Milwaukee (USA); Texas A&M University at Galveston (USA); Qinghua University (China); Universities of Malaya and Malaya Phang (Malaysia); Anglo European College of Chiropractic (UK); Shanghai Jiao Tong University (China); Chinese Academy of Sciences (China); Tokyo Denki University (Japan); University of Cambridge; KCL; University of Southampton; University of Reading; Queen Mary University (UK); University of California, Riverside, (USA)., European Centre for Soft Computing (Spain).

Incoming visiting faculty. The visiting fellow and honorary Professoriate community has grown to over 26 in number since 2008 and fosters an active community (nationally and internationally) including Prof. Cripps (BAE), Prof. Penny (Penny and Giles plc.), Prof. McKeag (Queens University) and through the Royal Academy of Engineering visiting Professor Scheme with Howarth (sustainable development); Vaitkevicius (innovation) and Visiting Fellow; Conrad (enterprise).

Outgoing visiting faculty. Khan has links with University of Wisconsin-Milwaukee, NIT Srinagar, Texas A&M and Qinghua University. Prof. Abdul Ghaffar Abdul Rahman, (University of Malaya) invited Noroozi for a research sabbatical. Dubey (University of Delaware, USA, Silesian University of Technology (Poland), Ecole Polytechnique (France) and Heidelberg University (Germany). Our Senior staff hold visiting professorships e.g. Gabrys; Oviedo (Spain) WRUT (Poland) and Burgos (Spain) Universities and Yu; Lyon (France) and Chiangmai (Thailand).

Academic community leadership. Three teams were short-listed for the Times Higher Education Awards 2010-2013. In 2010 Noroozi et al for "Best Research Team", EPSRC CASE PhD project with Blatchford artificial limb prosthesis; Hadfield et al for "Outstanding Contribution to Innovation and Technology", EPSRC CASE PhD project with the RNLI concerning slipway design. In 2012 Bryce Dyer (ECR) and Noroozi shortlisted for "Outstanding Contribution to Innovation and Technology" for work with prosthetic foot design for amputee cyclists.

Research Policy & Development. Gabrys led the Nature-inspired Data Technology (NiDT) focus group of 20 European Centres (NiSIS - €1m, 2005–08). The NiSIS roadmap document was used to inform EC FP7 and EPSRC in 2010 (setting research priorities for funding in the EPSRC's Artificial Intelligent Technologies and Information Systems themes). Gabrys holds joint leadership of KES International Research Organisation (Gabrys, Chair of Academic Affairs). KES International has over 3,000 members worldwide and organises a series of conferences in the area of knowledge based and intelligent engineering systems frequently attracting 300-400 participants, and transfer of knowledge promoting events (e.g. International Conference on Innovation through Knowledge Transfer - InnovationKT'2012, hosted in April 2012 in Bournemouth and co-chaired by Howlett and Gabrys). An associated KES journal published by IOS and a vibrant international research community have resulted in many collaborative activities. The Executive Chair of KES, Prof. Howlett, also holds a Visiting Professorship at BU.

Examples of Other Peer Recognition

- Prof. Swain: HEFCE Senior Clinical lectureship panel member 2011. Editorial Board: Journal of Medical Engineering and Technology.
- Prof. Hadfield: EPSRC Peer Review College member; HEFCI (Ireland): (Sustainable Design Mentor), International Conference Chairs: Tribology and Design 2009, 2011, CIMTEC 2009, Contact and Surface 2008, 2010, 2013.
- Dr Khan: STLE 2013 Track Chair, Invited keynote lectures: Institute of Physics 2011, University of Wisconsin-Milwaukee, US; Invited Expert Panel Member: Romanian National Scientific Council: Invited Vice-Chair Solicitation Technical Committee Surface Engineering: Society of Tribologists and Lubrication Engineers, USA.
- Dr Dubey: Editorial Board of four International Journals: Journal of Mechanical Sciences, Global Journal of Physics Express, Sensors and Transducers, Industrial Robot. Winner of the IET Innovation Awards 2013 - Epidural Simulation (Information Technology).
- Prof. Phalp: EPSRC Peer Review College, organising chair for Pro-VE 2012 conference on virtual enterprises, and Winner of the Michael Richey Medal for the best paper of year in the Journal of Navigation - presented by HRH the Duke of Edinburgh in July 2009.
- Prof. Gabrys: EPSRC Peer Review College, Editor in Chief of 1 (KES Journal) and Editorial Board Member of 4 International Journals; Keynote/plenary talks at 4 (ICONIP'08, New Zealand; HAIS'08, Spain, ICIAP'09, Italy; ICMMI'13, Poland) International Conferences Chair of IEEE; Intelligent Measurement and Predictive Systems Task Force.
- Prof. Yu: EPSRC Peer Review College, UKACC 2008 and 2012IPC co-chair. Gold Medal: International Exhibition of Inventors, Geneva 2010. Editorial Board for 3 journals including the International Journal of Automation and Computing.
- Prof. Noroozi: Editorial Board for the Journal of Condition Monitoring and Engineering Management. International Scientific Committee for the Boundary Element Techniques conference series. Invited keynote speaker at ICMER 2013 Malaysia.
- Bryce Dyer: Isambard Kingdom Brunel Award Lecture at the British Science Foundation 2013.
- Dr Budka: Visiting RF at Wroclaw University of Technology Poland.
- Dr Krol: Marie Curie Senior Intra-European Fellowship