Institution: London South Bank University

Unit of Assessment: General Engineering

a. Overview

This statement covers engineering research within the Departments of Applied Science, Engineering and Design and Urban Engineering in the Faculty of Engineering, Science and the Built Environment (FESBE). Following the approach used for RAE2008, a single submission in General Engineering is being made. Since then there has been significant investment in staff and facilities leading to 33.5 FTEs being submitted in the present exercise. The investment has been prioritised to support the activities of 5 multidisciplinary, cross-departmental research groupings, with 3 groups being added to the 2 in the 2008 submission. The groups are described below and form a vibrant research community with a high level of national and international visibility. Highlights since 2008 include: £14.1M in research grants and contracts including 20 new KTPs, research income of £7.39M and 635 research publications. Several major honours have been bestowed on staff, recognising significant achievements and professional standing.

b. Research strategy

Research strategy and vision is developed and set by the Faculty Executive and Faculty Research Committee (FRC). It is overseen by the FRC, chaired by the Director of Research (currently **Maidment**) who reports to the Faculty Dean. The following strategic aims identified in the RAE2008 submission have been achieved:-

- A significant increase in income/year from external research grants/contracts and KTP awards leading to strengthened industry interactions and national/international collaborations (£1.48M pa compared to £0.86M pa, exceeding the 30% target set in RAE2008)
- A significant investment in new staff including 6 Professors and 6 Senior Lecturers has enabled existing research areas to be strengthened and new activities to be established
- Staff development - promotions of 2 Readers to Professor and 3 Senior Lecturers to Reader
- The research student cohort increased to 92 in 2012/13 compared to 70 in 2007/08, an increase of 31 % (2008 target, 25% increase)
- Increased intra- and cross-Faculty collaboration as exemplified by the joint LSBU/Essex EPSRC funded DANCER project (see below) which involves 4 Departments across two Faculties at LSBU including the Centre for Efficient and Renewable Energy in Buildings (CEREB) which played a key role in securing the bid – another 2008 aim
- £4.43M investment in research facilities and infrastructure
- Increased national and international visibility of research as illustrated by the quality and quantity of outputs, the prestigious honours/prizes won, leadership of professional institutions and invitations to lead/join national and international research programmes/networks

Our research provides solutions to practical problems in society, business, the economy and the environment, with material use, process optimisation, health and environmental sustainability at the heart of the research groupings as detailed below:-

Research Groupings

Chemical and Process Engineering (CPE)

Dr P Battersby, Dr P Holborn, Dr F Jahanzad, Dr S Kellici, Prof P Nolan, Dr D Patel, Dr N Power, Prof B Saha, Dr D Zhao.

CPE has two main research themes: a) ***Explosions and fires*** – including the properties of hydrogen-air mixtures, the mitigation of hydrogen explosions using inert agents, run-away "red-oil" reactions and the modelling of fire and smoke spread in buildings b) ***Green process engineering*** – development and integration of new, environmentally-friendly chemical routes and technical innovation to achieve green chemical processes. **Key Achievements:-**

- £1.98M in external research grants/contracts and 105 publications
- Over £1M of funding from Sellafield Ltd to research hydrogen mapping and mitigation, saving the company £550M. Awarded Centre of Expertise status by Sellafield in 2011
- Ground breaking research for the National Nuclear Laboratory to define the characteristics of runaway "red oil" reactions has significantly improved process safety
- Innovated a patented, continuous, clean alkene epoxidation process technology recognised by the Royal Society Brian Mercer Feasibility Award as an outstanding scientific breakthrough
- Pioneering work on protein crystallisation with calixarenes published in Nature Chemistry

Environmental and Energy Engineering (EEE)

Dr E Aristodemou, Dr T Hong, Dr M Mavroulidou, Prof S Zheng, Prof J Zhou.

The EEE group work within three main focus areas: a) ***Water and air quality*** - development of analytical methods, computational modelling and technology for water and air quality and water resources; wastewater treatment process design and control b) ***Geo-environmental engineering*** - numerical modelling and laboratory testing of unsaturated soils and waste materials c) ***Energy engineering*** – numerical well testing procedures and wavelet algorithms for reservoir monitoring and management; bio energy and energy recovery from waste. **Key Achievements:-**

- £1.22M in external research grants/contracts and 82 publications
- Pioneered a new, patented and commercialised upflow multi-layer bio-reactor/oxic process for treating high-strength wastewater currently producing a turnover of £3.2M pa for Ecodigm Ltd
- Synthesised a new environmentally friendly disinfectant which is in commercial production
- Developed a wavelet data processing algorithm licensed by a software Multinational (EPS Weatherford) and now used by the oil industry worldwide

Health, Acoustics and Communications Engineering (HACE)

Dr S Dance, Dr S Dudley-McEvoy, Prof M Ghavami, Prof B Shield, Dr P Xiao, Dr J Zhang.

The HACE group has three main research themes: a) ***Acoustics*** – effects of noise on health, hearing and education; speech intelligibility b) ***Communication systems*** - ultra wideband (UWB), wireless and optical systems and their applications in communication networks; design and development of medical and healthcare instrumentation c) ***Bioengineering*** – non-destructive measurement technologies for in-vivo skin and physiological studies. **Key Achievements:-**

- £1.71M in external research grants/contracts and 168 publications
- £1.6M collaborative EPSRC grant for research on remote techniques for more intelligent energy usage within dwellings (DANCER project, £0.91M to LSBU)
- £0.66M EPSRC funding (£0.29M to LSBU) for collaborative research on acoustic design of secondary schools informing the revision to Building Regulations
- New prediction and testing methodology, and guidelines, for speech intelligibility of voice alarm systems now applied to 74 stations on the London Underground
- Recognition of research through 6 prestigious national and international awards and prizes

Materials Engineering (ME)

Dr A-K Axelsson, Prof Y Bao, Prof L Dunne, Dr J Gao, Prof D Gawne, Prof H Reehal, Dr J Selig, Prof T Sattar, Prof R Xiao.

The ME group's research is focussed within three main areas: a) ***Electronic and functional materials*** - thin film and nanostructured materials for photovoltaics (PV); electroceramic materials processing and applications; condensed matter theory b) ***Surface engineering and structural materials*** - novel polymeric and glass-based coatings for higher performance materials and more efficient processes; composite structures and materials c) ***Robotics and materials testing*** - intelligent robotic systems for the non-destructive testing of safety critical infrastructure and materials in hazardous environments (Robotic NDT). **Key Achievements:-**

- £2.50M in research grants/contracts and coordination of 2 major EU grants; 174 publications
- Innovative precursor materials and solvent-free thermal-spray process as alternative to painting
- New nanostructuring processes to increase light absorption and efficiency in thin film solar cells
- World's first electrocaloric analysis instrument developed with the multinational NETZSCH, as well as new significant theories of the electrocaloric effect, for solid state cooling research
- Pioneered a new generation of high performance fibres for concrete applications and design software for the multinational Propex
- Three innovation awards for Robotic NDT and recognition of research by the Royal Society

Refrigeration and Air Conditioning (RAC)

Dr T Brown, Dr I Chaer, Prof J Evans, Dr E Hammond, Dr G Lowry, Prof G Maidment.

The RAC group work collaboratively in four main focus areas: a) ***Food refrigeration*** b) ***Low carbon technologies*** c) ***Modelling, thermoeconomics, optimisation/controls*** d) ***Mapping and minimizing energy use and carbon emissions from RAC***. **Key Achievements:-**

- £6.78M in external research grants/contracts including £1.2M as part of the EPSRC i-STUTE

consortium and £800K from the European Commission; 106 publications
- £3.25M of new research facilities including CEREB and Bristol food refrigeration laboratories
- Pioneering novel cooling techniques to reduce energy consumption of cooling systems and food wastage with companies such as Hewlett Packard (Palo Alto) and Tesco
- Investigations on large scale emission reductions through joint international projects e.g. Improving Cold Storage Equipment in Europe (ICE-E)
- Research leading to the development of policy through the International Working Group on Refrigerant Containment; advising Government on heat pump emissions (DECC) and air conditioning systems (LDA - London Development Agency)
- National and international recognition of research through 11 awards and prizes

Future strategic aims/goals

We will build on progress since the RAE2008 in widening the breadth of our portfolio, and will align into the three broad applied themes of Energy and the Environment, Health and Food, and Infrastructure and the Built Environment to target the needs of future generations to 2030 and beyond. We will also continue to exploit our strong relationships with industry and professional institutions, including our international collaborations, whereby we influence research agendas and carry out applied research to meet specific needs. We will continue to provide pathways between fundamental research, applied research, knowledge transfer and enterprise through the newly created Nat Puri Institute and Clarence Centre for Enterprise and Innovation (£13M investment, opened in September 2013). This connected approach will deliver impact, which we will measure, as well as income which we will invest back into research. Specifically we will:-

- Actively pursue collaborations with world leading teams in the priority areas
- Grow research teams in each of the priority research platforms through internal investment and new appointments and increase the size of the submission in REF2020
- Further strengthen research groups by enhancing research facilities and infrastructure
- Attract both public (e.g. EPSRC, EU Horizon 2020) and private external funding including matched funding schemes for joint research projects with businesses
- Continue to use knowledge transfer programmes such as KTP to develop funding
- Increase PhD student cohorts by 50% over the coming REF period and increase completion rates to at least 15 per year
- Increase engagement with industry with 50% more projects through staff incentive schemes and exploit the “research tax credit” scheme to build research capacity
- Extend the outreach of our research to include developing nations
- Ensure strong linkage between our research and our teaching

c. People, including:

i. Staffing strategy and staff development

Our staffing strategy reflects the aims described above and has three main strands:-

- Increase the number of research active staff in strategically important areas
- A recruitment and promotions policy that takes into account research track record, research fit and research potential, including the potential to win funding and establish/lead research
- Provide mentoring and support, particularly for those in the early stages of their research career, and opportunities for development for all staff

Evans, Ghavami, Saha, Zhou, Zheng and **R Xiao** were recruited externally to professorial posts during the REF period to grow/support research in areas highlighted in the Faculty’s research strategy. **Aristodemou, Axelsson, Hong, Jahanzad, Power and Zhao** were recruited to Senior Lecturer positions taking into account their research track record and potential. **Bao** and **Sattar** were promoted internally to Professor with **Chaer, Dance** and **P Xiao** promoted to Reader, demonstrating staff development and the recognition of research achievement by the University. Thus, we are able to submit a significantly larger group to the present exercise despite the fact that 7 of the staff submitted to RAE2008 have since retired or left LSBU.

Encouraging and developing research-active staff is facilitated by a formal staff appraisal process. New or early career staff are encouraged to affiliate with a research group and to access research facilities/infrastructure. A senior colleague is assigned as a mentor who can provide advice on the suitability of research ideas for external funding, the structure of applications and external contacts. A successful exemplar of this is **Dudley-McEvoy** who, working with **Ghavami**,

has secured the EPSRC DANCER project. The Faculty also runs a funding competition for small items of equipment to encourage and support research, aimed primarily at early career researchers. In the last year alone small items of equipment to the value of ~ £150K have been supported. A centrally run Research Opportunities Fund has provided pump-prime funding with grants of up to £5K. FESBE staff secured a total of £48.4K for 12 projects with **Chaer**, **Jahanzad**, **Mavroulidou** and **Zhang** being amongst the beneficiaries. These schemes complement the University's Research Capital Investment Fund (RCIF) award system which is aimed at larger items of equipment. Since 2008, the Faculty has also funded 16 research staff positions in strategic subject areas and has invested ~£570K annually using QR funds. Many of these staff are being returned for the REF2014 or have supported staff who are being returned.

The Faculty and University provide research seminars and complementary skills training for staff and students. University seminars generally focus on generic development needs such as proposal writing, communication and IPR issues. Supervisor training workshops are run for new or less experienced supervisors. Bi-weekly seminars are run to encourage networking, interdisciplinary research and cross-fertilisation of ideas amongst all researchers. For example, **Kellici** is now working with **Reehal** on developing graphene-based nanostructures for devices.

The University is fully committed to The Research Concordat to support the career development of researchers. Information and training events are provided, overseen by a central Concordat Group. Each Faculty has a Concordat coordinator (currently **Shield** for FESBE) who acts as the main point of contact for researchers within their Faculty. The University is also fully committed to equality for all, valuing diversity across all dimensions of difference. A Code of Practice for selection for REF2014 reflecting the University's equality and diversity policy was developed, circulated to all academic staff, and implemented.

Several personal research fellowships have been won by staff including **Ghavami** (German Academic Exchange Service Fellowship, 2011; JSPS and Keio University Research Fellowships, 2010, 2012) and **Zhang** (Chinese Academy of Sciences Visiting Research Fellowships, 2009-12). **Saha** was appointed Visiting Professor at the University of Barcelona in 2011. **R Xiao** has held Visiting Professor positions at the University of Western Sydney (2010), the University of Rome (2012) and the State Key Laboratory of Natural Disaster and Mitigation, Shanghai (2012-13). **Dunne** holds a Visiting Professorship at Imperial College London (2009-14).

Exemplars of incoming international staff appointments include Marie Curie Fellows from Italy and Portugal (2011) and EPSRC funded research officers from Algeria and China (2012). Fourteen visiting professors and researchers have been hosted. Visiting Professors include **Astolfi** and **Carullo** (Politecnico di Torino), **Chen** (UCLA), **Kalogirou** (Cyprus University of Technology), **Liu** (Beijing Normal University), **Rizzi** (University of Rome), **Sanada** (Keio University, Japan) and **Tleukenov** (N. Gumilyov Eurasian National University, Kazakhstan).

ii. Research students

The research student cohort has grown from 70 in 2007/08 to 92 in 20012/13, an increase of 31%. PhD students are funded through a variety of national and international sources including research organisations such as EPSRC and EU, industry, overseas governments and self-funded. EPSRC CASE awards (including industrial CASE) have been secured with partners such as Hewlett Packard, The Institute of Refrigeration (IOR), Bond Retail Services, Adande Refrigeration, London Underground and Hubbard Refrigeration (**RAC** group); Nuclear Decommissioning Authority (**CPE** group); Arup Global Healthcare, Brookfields Multiplex (**HACE** group); RJB Composites (**ME** group). EPSRC studentships have also been secured through large national research consortia such as the PV21 SUPERGEN project (**ME** group). The **ME** group has also secured 3 PhD students from the FP7 Initial Training Network (ITN) programme. In many cases PhD projects have been in conjunction with industry with full or 50/50 matched funding. Partners have included Sellafield Ltd, Purolite International Ltd and MEL Chemicals Ltd (**CPE** group); InnoTecUK Ltd (**ME** group); New Heat Development and TOTAL (**EEE** group); London Underground (**RAC** group). Sponsored International students have been recruited from China, Turkey, Pakistan, Malaysia and Brazil. Three collaborative PhDs with Kazakhstan have recently started in the **HACE** group. Some 50% of PhD students are overseas students with a number recruited through international collaborations.

Upon recruitment each student is assigned to a supervisory team consisting of at least two academic supervisors (a Director of Studies and a second supervisor). A third supervisor (e.g. from

industry) is assigned if appropriate. The recruitment process is supported by the University's Central Research Support team (CRS). The FRC monitors regularly thereafter (at least 2 times/year), including an annual report and transfer report from MPhil to PhD. Registration and transfer are overseen by the FRC and the University's Research Degrees Committee with the assistance of the CRS team. Besides specific research training, students attend appropriate Masters modules, external courses, industrial secondments and key skills training. The latter was commended by the QAA in the University's 2011 audit. Students are required to present their work in Faculty research seminars and forums and to take responsibility for their PhD projects. An annual student seminar competition is run by the Faculty with cash prizes. This complements an annual, University-wide research student summer school providing training events/opportunities and a conference where students present their research through oral and poster presentations.

The Faculty has actively supported the PhD cohort over the last 5 years, with more than 25 students receiving financial support for fees and stipends. This represents an investment of £800K. The students have also benefited from an annual funding system set up to support travel, conference fees, small items of equipment and consumables. In the last year this has supported 30 students (£60K). Students are supported locally through a Faculty Student Forum set up to inform and train students. The research student cohort is an active part of the Faculty and contributes to teaching through a laboratory demonstrator system after appropriate induction and training.

d. Income, infrastructure and facilities

Investments in infrastructure and facilities

The UoA has extensive specialist research facilities and infrastructure which has been enhanced via substantial investment since the last exercise through various sources including the RCIF scheme and Faculty/University support (total £4.43M including £1.03M from RCIF)

The **CPE** group has received £170K towards a Green Process Engineering Laboratory equipped with various flow reactors as well as new analytical equipment. Laser particle sizing equipment and high speed cameras have been purchased for particle size and explosion behaviour characterisation.

EEE secured investments of approximately £300K from the Faculty for water analysis facilities and system modelling software. £140K has been obtained from RCIF and EPSRC funds for equipment for the testing of hydromechanical properties of soils.

HACE's acoustics research facilities have been upgraded with a refurbished reverberation chamber and audiometry booth. A fully instrumented anechoic chamber has been installed for communications research with associated characterisation/test equipment. Research in skin bioengineering gained new photothermal radiometry facilities. The total investment from RCIF funds has been £168K.

The **ME** group has benefited from RCIF funding of £454K which includes equipment for materials characterisation (nano-indentation system, spectroscopic ellipsometer, electron backscatter diffraction) and a new plasma spray gun with robotic control. Robotic NDT research gained infrastructure for wireless communications and intelligent control as well as a 3D spatial positioning Faro arm (value £90K) donated by TWI Ltd.

RAC secured RCIF investments of £245K for an environmental chamber, a CO_2 refrigeration system and related instrumentation. £2M was secured from HEFCE and £950K from the LDA for the CEREB facility which became operational during the assessment period. The group has also benefited from the comprehensive laboratories in Bristol which were acquired in 2009 and include refrigerated test and development facilities.

Research funding portfolio, including future plans

Grants/contracts with a total value of £14.1M have been gained over the review period.

The **CPE** group has secured £1.98M in grants and contracts of which over £1M has been won from Sellafield Ltd to continue research into hydrogen mapping and explosion mitigation. This has supported plant safety and decommissioning. £170K has been secured from the National Nuclear Laboratory to further define the characteristics of runaway "red oil" reactions. Research in green process engineering has been supported by the EPSRC, The Royal Society, EU, industry and overseas governments (Nigeria, Malaysia). An example is EPSRC follow-on funding (~£109K) to further develop a continuous clean alkene epoxidation process technology in collaboration with the University of Strathclyde and Purolite International which led to the Royal Society Brian Mercer Feasibility Award (£30K). Patents have been filed world-wide and commercialisation is being

explored with epoxide manufacturing companies. With external funding (£150K) the group has also developed an improved biodiesel production process (meeting EN14214 standards) from used cooking oil in collaboration with UpTown Oil and PwC (PricewaterhouseCoopers).

EEE has secured £1.22M in grants and contracts. These include an EPSRC research award involving hydro-mechanical properties of lime-treated UK soils, completed in 2011 (£221K). Funding from Elsan and New Heat Development Ltd (£160K) has led to the development of an environmentally friendly disinfectant and a portable device for heat generation, respectively. Four KTPs in the energy and environment theme have been delivered. A new project on water management catchment has recently commenced in collaboration with the National Institute of Water and Atmospheric Research, New Zealand who have donated equipment to the value of £215K. In addition, an EU FP7 project (€180K) involving 3 UK academic, 3 EU and 2 industrial partners was completed in 2011 and involved transfer of emerging pollutants in the aquatic food web.

The **HACE** group's grants and contracts total £1.71M and include the EPSRC funded, collaborative and interdisciplinary DANCER project. As well as Essex and 4 departments (Psychology, Engineering and Design, Urban Engineering and Information Theory) at LSBU it involves British Gas and Croydon Council. The £0.29M EPSRC project in acoustics, completed in 2012, was in collaboration with the University of Salford and the Institute of Education. It focused on the effects of noise and acoustic design on pupils and teachers in secondary schools. Skin bio-engineering has attracted support from the SEEDA and Biox Systems Ltd (£120K) for skin hydration research. Three KTPs have been won in the area of acoustics.

Grants and contracts totalling £2.50M have been won by **ME**. In surface engineering the Group is coordinating a €2.3M (LSBU share €621K) EU FP7 ITN project in processing nanostructured materials which ends in 2015. A FP6 project (Flexicoat, 10 partners) with a value of €317K was completed in 2010 and has enabled the construction of an industrial-scale PVD machine at low-cost and high energy efficiency for SMEs. A KTP to apply surface engineering technology to food processing machinery (value £188K) was successfully completed in 2013. The group was a partner in the EPSRC PV21 SUPERGEN consortium on thin film inorganic PV devices (contract value £140K) involving 10 universities and 7 industrial partners. Funding for composite structures research has included £82K from the Nigerian Petroleum Technology Fund for studying the performance of high strength concrete under fire. A €2.2M EU STREP programme (LSBU share £750K), completed in 2009, was coordinated in Robotic NDT research involving mobile wall climbing and swimming robots.

The **RAC** group has secured £6.78M in grants and contracts since 2008 and currently has £3M of funding. Four EPSRC responsive mode projects have been won with a total value to LSBU of £2M including Sustainable Innovation in Refrigeration and Air Conditioning, Mini Refrigeration Systems for Microprocessor Cooling (with Oxford and Newcastle) and the Interdisciplinary Centre for Storage, Transformation and Upgrading of Thermal Energy (i-STUTE). Five EU projects have been won (total value to LSBU £800K) - Food Refrigeration Innovations for Safety, Consumers' Benefit, Environmental Impact and Energy Optimisation Along the Cold Chain in Europe (FRISBEE); Improving Cold Storage Equipment in Europe (ICE-E); LowEHotels, and two projects leading research on refrigerant emissions and leakage. Funding from DEFRA (£246K) has included fostering the development of technologies and practices to reduce the energy inputs into the refrigeration of food, the demonstration of spray freeze drying for the manufacture of food ingredients and products and the development of integrated, rapid heating and cooling systems for the food industry. Funding from DECC (£35K) has investigated leakage of refrigerant from heat pumps and is informing Government policy on heat pump usage. The Carbon Trust has funded the investigation of refrigerant leakage (REAL Zero), the development of the Carbon Trust 'Retail Road Map' and the Carbon Trust code of conduct for refrigeration (total £120K). Direct industry funding has been received from London Underground to investigate novel dynamic methods of cooling underground railways (£500K). Research knowledge developed has been transferred via KTP Schemes with Pastorfrigor UK Ltd, Bond Group, Adande Refrigeration, Powrmatic, BSRIA, NBS Cryo, Payestone and Parsons Brinkerhoff.

Future plans – all groups are actively engaged in seeking external funds from the Research Councils, industry and other external sources. Preparatory work for the EU Horizon 2020 programme is underway. To enhance income generation the UoA will be making major investments in research infrastructure including (1) a £1.2M Petroleum Engineering laboratory,

which will facilitate joint research projects with partners such as SINOPEC and TOTAL (2) an upflow multilayer bioreactor to treat wastewater continually and recover energy (3) a laboratory for concrete technology and (4) a £1.5M virtual engineering laboratory that will benefit all groups.

Consultancies and professional services

The total value of consultancy contracts has typically been £300K pa over the review period. Examples of consultancies include work for Sellafield Ltd advising on specific plant-related issues (**CPE** group). Other exemplars include heat recovery from waste with New Heat Development Ltd and environmental impact assessments for TT&E Environmental Consultants, Athens (**EEE** group); rooftop wind turbine performance with Southwark Council, risk to hearing of musicians with the Royal Academy of Music and the London Philharmonic Orchestra, skin hydration imaging with Glomax Aesthetics (Singapore), Johnson & Johnson (Paris) and DSM Nutritional Products (Switzerland) (**HACE** group); low temperature Si epitaxy for solar cells with Echerkon Ltd (**ME** group); Eurofighter wing tip pod cooling and sustainable low carbon and renewable electrical and mechanical technologies for use in the retail sector for Tesco Ltd (**RAC** group).

e. Collaboration or contribution to the discipline or research base

Exemplars of collaborations, interdisciplinary research and informing research/strategy

The **CPE** group's collaborations with Sellafield have informed and directed research strategy leading to the development of a hydrogen technical guide and roadmap for hydrogen safety which is now used across the Sellafield sites. Research findings have been disseminated internationally including to the US Department of Energy. Collaboration with the London Fire Brigade on analysis of reported arson is influencing policy and development of standards. Research on polymerisation and emulsification is being carried out in collaboration with Kings College London. Collaborations on calixarene derivatives with the National University of Ireland (Galway) and the Universities of Michigan, Edinburgh and Missouri-Columbia are informing new research and applications in protein mapping, protein crystallisation, molecular magnets and potential catalyst development.

EEE's collaborative projects include climate change impact analysis and modelling of water resource systems with the Institute of Geological and Nuclear Sciences, New Zealand. Additional exemplars are Arup Corporation (urban flooding modelling) and UK Wind Energy Ltd (developing an online wind farm power forecasting system). Petroleum engineering research for un/conventional reservoir management has strong collaborations with SINOPEC, TOTAL and China University of Petroleum. Interdisciplinarity is exemplified by emerging pollutants research which involves environmental and bio sciences, analytical chemistry and mathematical modelling. The group's research has led to new procedures for numerical well testing and endocrine disruption regulations for DEFRA.

Exemplars of the **HACE** collaborative and interdisciplinary research include work with Telent (formerly Marconi) on improving the public address system for the London Underground. Prediction and testing methodology, and guidelines, have been developed for speech intelligibility of voice alarm systems. Collaboration with the London Philharmonic Orchestra, Royal Academy of Music and the Royal College of Music is addressing hearing loss in musicians. Research into the effects of noise in secondary schools has informed revision of the Building Regulations on acoustic design of schools. A new design for hospital wards has resulted from research on hospital acoustics with Arup Global Healthcare and leading UK hospitals. Collaborative research in skin bioengineering includes work with the pharmaceutical and material science departments of UCL to study solvent penetration and skin water holding capabilities. Research outputs have been transferred into commercial products through the spin-out company Biox Systems Ltd which now has customers in over 70 organizations worldwide. Improved radar algorithms have been developed for Time Domain Products, Huntsville, USA.

The **ME** group's EU ITN FP7 project in nano-structured materials involves 5 universities, 3 research institutes and 6 companies from 5 EU countries. It covers chemistry, physics, materials characterization, instrumentation, computational modelling and design exemplifying a high degree of interdisciplinarity. The multidisciplinary EPSRC PV21 SUPERGEN research has informed advanced approaches to light harvesting and management in solar cells and future EPSRC policy for PV research. International collaborations in PV include the University of Technology, Malaysia (plasmonic solar cells) and Philips Innovation Services, Netherlands (microstructured solar cells). Electroceramics research for applications such as solid state refrigeration and electronic devices involves materials processing, device engineering and theory, in particular the theory and

understanding of the electrocaloric effect. Collaborators include the University of Nova Goricia (Slovenia), Imperial College, UCL, University of Delft, Ecole Polytechnique (CH) and Elletra Sincrotrone (Trieste). Robotic NDT research is highly interdisciplinary with several EU companies and universities as collaborators. International academic collaborations are with Colombia, Mexico, New Zealand and Brazil. The research has informed the power, oil and gas industries about the advantages of using mobile NDT robots to reduce down-time during planned power outages. Composite fibre/concrete material behaviour in buildings under extreme conditions (e.g. fires) is being studied by modelling and simulation in collaboration with Manchester University and the State Key Laboratory for Natural Disasters and Mitigation, Shanghai.

RAC has a strong record of collaborative and interdisciplinary research including the FRISBEE project involving 25 other EU partners. It has led to several spin-off project proposals and potentially new work on air cycle refrigeration. The £5.2M EPSRC i-STUTE interdisciplinary centre integrates heating and cooling technologies with 4 UK Universities and 4 overseas partners. It involves a wide range of behavioural, economics and technical disciplines. ICE-E involved 7 partners across Europe and led to a new EU proposal (ICE-PLUS) that was submitted in 2013. The REAL Zero project with the IoR, Carbon Trust and 2 industrial partners has been cited in the revised EU FGAS2 proposals on HFC refrigerant use. The group is also leading an international working group on behalf of the International Institute of Refrigeration (IIR) on minimizing emissions due to leakage from refrigeration systems. The EPSRC funded network SIRAC involves the IIR and 20 universities in the UK and overseas specializing in refrigeration and air conditioning. A London Development Agency project on emissions from air conditioning systems has led to the development of a low carbon cooling guide published by the LDA.

Exemplars of leadership

Journal editorships and participation in editorial boards

Assoc Ed: Multiferroic Materials 2010-, Ed Boards: J. Ceramics 2010-, Indian J Mat Sci 2012- (**Axelsson**); Ed: Int J Sustainable Energy Dev 2010- (**Chaer**); Ed Board: Int J Quantum Chemistry 2003-08 (**Dunne**); Ed: J Food Engineering 2005- (**Evans**); Ed Board: Surface Engineering 1997-2010 (**Gawne**); Regional Ed: Int J Ultra Wideband Comms and Systems 2008- (**Ghavami**); Ed: J Loss Prevention Process Industries 1987-2009 (**Nolan**); Ed Board: J Solar Energy 2012- (**Reehal**); Ed Board: Green Processing and Synthesis J 2012-**;** Assoc Ed: Canadian J Chem Eng 2009-12**;** Int Advisory Board: Canadian J Chem Eng 2013- (**Saha**); Assoc Ed: ASME J Mechanisms and Robotics 2012-; Ed Board: Robotica 2005- (**Selig**); Ed Board: Cosmetics 2013- (**P Xiao**); Ed Boards: ICE Structures and Buildings 2013-16, Advanced Material Research 2013-, Prog in Steel Building Structures 2008- (**R Xiao**); Ed Board: Acta Photonica Sinica 2008- (**Zhang**); Ed Boards: Scientific World J 2009-, Sciences in Cold and Arid Regions 2006-, J Aquaculture Res Dev 2008-; Exec Ed: J Chromatography and Separation Techniques 2008- (**Zhou**).

Invited talks and keynote presentations at international conferences

Plenary talks: Int Symp Physics Technol Sensors (ISPTS) Pune, India 2012 (**Axelsson**); 12th and 13th Int Conf Civil, Structural & Environmental Eng Computing, Madeira 2009, Crete 2011 (**R Xiao**); Keynote talks: Int Conf Nanotech (NANOCON 10), Pune, India 2012 (**Axelsson**); Int Symp Signal Image Video Comms, Valenciennes 2012, Int Symp Wireless Personal Multimedia Comms, Brest 2011 (**Ghavami**); 26th Int Conf CAD/CAM Robotics & Factories of the Future, Kuala Lumpur 2011 (**Sattar**); Invited talks: 7th Int Conf Adv Materials, Brasov, Romania 2012***;*** Int Conf Physics Materials & Material Based Device fabrication, Kohlapur, India 2012***;*** 2nd Int Meeting Innovations in Adv Materials for Optics & Electronics, Shanghai 2008 (**Axelsson**); 4th Int Conf Photonics, Melaka 2013; Int Conf Transparent Optical Networks, Athens 2008 (**Dudley-McEvoy**); 10th Int Conf Calixarenes, Seoul 2009 (**Power**); Int Conf Solar Energy Materials, Solar Cells & Solar Energy Applications, Kandy, Sri Lanka 2011 (**Reehal**); 3rd Int Conf Flow Chemistry Society, Munich 2013, 3rd Int Cong Green Process Engineering, Kuala Lumpur 2011, 5th Int Conf Ion Exchange, Melbourne 2010 (**Saha**); Int Symp Automation Machine Vision Robotics & Control, Bogota 2012 (**Sattar**); Inst Acoustics Gerry McCullough memorial lecture (postponed to 2014) (**Shield**); 16th Int Conf Photoacoustic & Photothermal Phenomena, Mexico 2011 (**P Xiao**).

Conference programme chairs, session chairs, scientific committees and organisation

Programme Chairs: Int Cong Noise as a Public Health Problem, London 2011, Inst

Acoustics/Belgian Acoustical Soc Conf on Noise in the Built Environment 2010 (**Shield**); 10th USA Cong Computational Mechs, Columbus 2009, 9th World Cong Computational Mechs, Sydney 2010 (**R Xiao**); SPE Appl Tech Workshop, Well Testing for Reservoir Management, Malaysia 2010 (**Zheng**); Session Chairs: at 39 int conferences; Scientific/Organising Committees Served; at 43 int. conferences; Organisation:7 national meetings (IOP, IChemE), 1 int workshop (SPE).

National or international advisory board membership
Board member: FP7 SUNGREEN consortium 2011-15 (**Axelsson**); Advisor to the Portugal Foundation for Science and Technology 2012- (**Dance**); Member: Hydrogen London Group 2012- (**Holborn**); Exec Board Member: Asia-Pacific Coastal Aquifer Modelling and Management Association 2009- (**Hong**); Energy Inst representative: Eng Council Int Advisory Panel 2008-14 (**Lowry**); Member: Sellafield Ltd Hydrogen Working Party 2003-, Energy Inst Accreditation and Approval Panel 2000-11**,** BSI ACE Aerospace Committees-Oxygen Usage, Adviser: National Audit Office (**Nolan**); Board Member: EPSRC PV21 SUPERGEN consortium 2008-12, Invited Member: EPSRC UK-India Grand Challenges in Solar Energy Workshop, New Delhi 2009 (**Reehal**); Chair: panel advising Dept Education on revision to Building Regulations on Acoustic Design of Schools 2010-, Member: Dept Health Ad Hoc Comm on Effects of Noise 2004-10 (**Shield**); Advisory Comm: NERC Resource Recovery from Waste Programme 2012- (**Zhou**).

Leadership roles in industry, learned societies or professional bodies
President Inst Refrigeration 2013-16 (**Maidment**); President Inst Acoustics 2012-14 (**Shield**); Int rep Acoustical Soc of America Newman Trust 2010- (**Dance**); Chairman, Inst Refrigeration (IOR) Int Refrigeration Committee 2008- (**Evans**); Chairman, IMechE Bath and Bristol Young Members Panel 2009- (**Hammond**); Director, Air Conditioning and Refrigeration Industry Board 2013-**,** Chair, IOR Publications Comm 2002-12; Chair IOR research network 2008-**;** Vice-Chair Int Working Group on Refrigerant Containment 2009- (**Maidment**); Vice-Chair, IChemE Fluid Separation Special Interest Group (FSSIG) 2011- (**Saha**); Chairman, FSSIG Annual Research Events 2007, 2008, 2010-13 (**Saha**); Co-founder & Director, Biox Systems Ltd 2000-(**P Xiao**).

Awards and prizes.
Inst Acoustics R W B Stephens Medal 2011**,** Noise Abatement Soc Lifetime Achievement Award 2011 (**Shield**); IIR Clarence Birdseye Young Researcher Award 2011**,** IMechE Food Eng of Year Award 2009 (**Hammond**); 2008 & 2009 Lightfoot medal, 2010 & 2011 Cooling Industry awards including best international collaboration**,** Runner up THES Research Award for 2011 (**Chaer, Maidment**); Acoustical Soc of America Schultz Prize 2008, Student Mentoring Award 2012 (**Dance**); Runner up IChemE Research Award 2011 (**Patel**); Royal Soc Brian Mercer Feasibility Award 2011 (**Saha**); Emerald Literati Network Highly Commended Award 2008**,** Industrial Robot Innovation Awards 2008, 2010 (**Sattar**); Publications Prize Soc Cosmetic Scientists 2009 (**P Xiao**).

Participation in the peer review process for national and international bodies
EPSRC Peer Review College (**Bao, Gawne, Maidment, Reehal, Saha**); FP7 Expert Evaluator Panel (**Bao, Ghavami**); Innovation and the Built Environment Academy 2011 (**Chaer**); Natural Sci & Eng Research Council Canada 2010, Alberta Innovates-Technology Futures Gov Alberta 2011 (**Gawne**)**;** Gustav Lorentzen Medal, Sci &Technol Medal (IRC) 2011 (**Evans**); Eval Committee Cyprus Universities 2009 (**Ghavami**, **Maidment**); Global Centre Excellence Keio University, Japan 2008 (**Ghavami**); EPSRC Peer Review panels 2008-13 (**Reehal**, **Saha**); Leaders Opportunity Fund Gov Canada 2010 (**Reehal**); Research Foundation Flanders 2013 (**P Xiao**); NERC Peer Review College 2011-(**Zhou**).

Fellowships of learned societies
Inst Refrigeration (**Evans, Maidment**); Inst Materials Minerals & Mining, IMechE, Inst Materials Finishing (**Gawne**); Energy Inst (**Lowry, Nolan**); Inst Physics (**Reehal, Zhang**); IChemE (**Nolan, Saha**), Higher Ed Academy (**Saha**); British Inst NDT (**Sattar**); Inst Acoustics (**Shield**, **Hon Fellow**); Royal Soc Chemistry (**Zhou**).