Institution: University of Bath

Unit of Assessment: 13: Electrical & Electronic Engineering, Metallurgy & Materials

a. OVERVIEW

Our research has a central focus on academic excellence, evidenced by publications in leading international journals and the award of eight prestigious Fellowships and personal research awards from EPSRC, the Royal Society, the University, the European Research Council and the Royal Academy of Engineering. Strong academic leadership to deliver this excellence is provided by our Professors (Aggarwal, Bowen, Li, NJ Mitchell, C Mitchell, Taylor and Wang). Targeted Visiting and Honorary appointments closely link each Centre to key academic and user communities, thus ensuring the delivery of the maximum research impact.

Our research is organised into three Centres totalling some 20.5 FTE academics. Of these, 18.5 are from the Department of Electronic & Electrical Engineering, one is from the Department of Mechanical Engineering and one is from the Department of Physics. The membership and research interests of the Centres are as follows.

The Centre for Advanced Sensor Technologies (CAST)
Director: Taylor; **Members:** Allsopp, Bowen (Mechanical Engineering), Clarke, Estrela, Shields, Soleimani, and Wang (0.5 FTE)
CAST researches a wide range of modern semiconductors, biomedical sensing applications and associated technologies.

The Centre for Space, Atmospheric & Oceanic Science (CSAOS)
Director: NJ Mitchell; **Members:** Astin, Blondel (Physics), Forte, Füllekrug, C Mitchell, Smith and Watson
CSAOS researches the effects of the natural environment on the propagation of the radio and acoustic waves used in communication, navigation and remote-sensing systems and uses these remote-sensing systems for scientific studies.

The Centre for Sustainable Power Distribution (CSPD)
Director: Aggarwal; **Members:** Dunn, Le Blond, Li and Yuan
CSPD researches the next-generation smart-grid technologies needed to increase the flexibility of energy generation, transmission and distribution for the efficient integration of renewables.

b. RESEARCH STRATEGY

Our vision is to deliver fundamental and applied research addressing problems at the frontiers of engineering. We recognise the importance of forging strong interdisciplinary connections with science and mathematics, which is a key recommendation of the Royal Academy of Engineering and EPSRC report, *The Wealth of a Nation*. Our research is thus frequently at the interface of engineering with physics, geophysics, biology, chemistry, economics, mathematics and medicine.

To deliver this vision we employ an eight-point **Research Strategy** which is to:

R1. Build coherent, critical-mass teams of researchers with strong academic leadership
R2. Deliver maximum impact to industrial and other users through our **Impact Strategy** (REF3)
R3. Appoint "rising stars" to academic posts, selected for their outstanding research potential
R4. Develop future research leaders through mentoring, staff development, workload allocation, support for Fellowship bids and by helping them build their research teams
R5. Take leadership roles in national and international collaborations
R6. Invest in the laboratories, workshops and other facilities required by our researchers
R7. Produce outstanding PhD graduates at the forefront of their research areas
R8. Publish our work in the most prestigious international journals

Evidence of the success of our strategy is provided by: i) the volume of outputs in the leading international peer-reviewed literature (some 300 journal papers in the assessment period, ii) the impact of this work on academic and user communities, iii) our rising grant portfolio which now exceeds £9.2m and iv) prestigious Fellowship and Merit awards secured by staff, including two EPSRC Advanced Research Fellowships, a University of Bath Prize Research Fellowship, two Royal Society Wolfson Research Merit Awards, one European Research Council Advanced Investigator award, one £1m EPSRC Challenging Engineering Award and one Royal Academy of Engineering Research Fellowship.

Since RAE2008 this strategy has significantly strengthened our research. In particular, we have:

1. Recruited seven outstanding young academics across all three Centres (Estrela, Shields and Soleimani in CAST, Forte and Smith in CSAOS and Le Blond and Yuan in CSPD), thus increasing our submitted FTE to 20.5, a 31% increase compared to RAE2008 (**R1**, **R3**)
2. Reinforced leadership by the promotion of Bowen, Li and C Mitchell to Professor, Allsopp and Füllekurg to Reader and Estrela and Soleimani to Senior Lecturer (**R1**, **R4**)
3. Increased the fraction of our outputs published in the most prestigious international journals (aiming to advance from the 30% of outputs rated 4* in RAE2008) (**R8**)
4. Grown the mean income/FTE by 30% to £116kpa (**R6**)
5. Added new interdisciplinary research themes in materials, biosensors, superconductivity in power systems, imaging, space weather, inverse methods and data assimilation (**R1**, **R5**)
6. Expanded and deepened collaboration with key non-HEI partners by strategic appointment of visiting and honorary professors from these partners (see Sect. e) (**R1**, **R2**)
7. Secured two Marie Curie Initial Training Network Grants: PROSENSE addressing cancer biosensors and TRANSMIT addressing space-weather impacts on GNSS systems, a NERC DTP in collaboration with Exeter, Bristol and Cardiff and capitalised on the resources and support offered by the new Faculty Graduate School (**R7**)
8. Invested more than £5.5m in new laboratories, facilities, equipment and workshops (**R6**)
9. Engaged with the new Faculty Fellowship Academy to support academics, postdocs and PhD students in securing prestigious Fellowships (**R4**, **R5**, **R7**)
10. Formed a spin-out company, NanoGaN, to capitalise on our semiconductors research (subsequently acquired by IQE for £4m in 2009) (**R2**)

Our **Future Strategic Aims** will be delivered by this research strategy. In future we aim to:

- **F1.** Capitalise on the University's £24m investment in the forthcoming building for the Faculty of Engineering & Design, ready in 2015, which will host flagship new laboratories in interdisciplinary research themes aligned to the interests of our Centres (see Sect. d)
- **F2.** Expand existing research strengths through sustainable new academic appointments made in carefully selected research fields
- **F3.** Deepen engagement with and impact on selected external stakeholders and partners
- **F4.** Increase the number and quality of our PhD students by taking leadership roles in Research Council DTP schemes, such as the GW4+ NERC DTP secured in 2013, and EU schemes including further Marie Curie Initial Training Networks
- **F5.** Develop the careers of our researchers through intensive mentoring, through Bath's new Fellowship Academy (see below) and by fostering a research-led culture across the Unit

Steps to deliver these aims are already in progress. For example, a second University Prize Research Fellow joins CSPD in early 2014 and a further new lecturer in CSPD is being recruited.

c. PEOPLE

i. Staffing Strategy & Staff Development

We expect, encourage, support and reward excellence in research from all our academic staff, including Early Career Researchers (ECRs). We use a six-point **Staffing Strategy** to deliver this excellence. The strategy is to:

S1. Appoint only academic staff who can deliver 4* research outputs and who already are research leaders or who have the potential to become research leaders
S2. Focus appointments to grow capacity in the critical research interests of the Centres
S3. Use a research-led workload model to reduce teaching and administration loads in direct proportion to the time spent on research, including proposal development, writing outputs and mentoring ECRs, as well as externally-funded research hours
S4. Provide dedicated laboratories and workshop support as required by all researchers
S5. Support the research career development of all staff, including dedicated support packages for ECRs (see **E1**-**E8** below)
S6. Appoint outstanding ECRs as research-focussed University-funded Prize Research Fellows, who then transition to lecturer after two years

All academics, postdoctoral researchers and postgraduate research students (PGRs) can be enrolled in the Faculty of Engineering and Design's Faculty Fellowship Academy (**R4**, **F5**, **S6**). The Academy was launched in 2010 and is managed by the Associate Dean for Research. The Academy identifies outstanding candidates and accelerates their research careers by providing specialist training and mentoring in areas such as proposal writing, creativity, team working, adventure in research and research vision to develop their leadership capabilities. In this Unit, Forte and Yuan secured Fellowships with the assistance of the Academy.

Our **ECR Development Strategy** supports, develops and mentors all ECRs. The strategy is to:

E1. Award a University-funded, full-fees-plus-stipend PhD research studentship to all ECRs
E2. Assign a personal mentor who is an established research leader
E3. Protect ECRs from significant administration and teaching loads for an initial three years
E4. Resource all ECRs with £10k start-up funds
E5. Develop professional skills on the Bath Course on Enhancing Academic Practice, which includes modules on research management
E6. Support in attending research sandpit and networking events
E7. Support, through the University's Research Development & Support Office (RDSO), in pre-award and post-award finance, project management, knowledge transfer, IP, contracts and commercialization
E8. Provide dedicated laboratory and research space as required

In the assessment period, dedicated new laboratories founded include Biosensors (Estrela), Remote Sensing (Füllekrug), Semiconductors (Shields), Tomography (Soleimani) and Superconducting Energy Systems (Yuan).

The University fully implements the Concordat to Support the Career Development of Researchers. At University level, the Research Staff Working Group, the Pro-VC Research, Human Resources, RDSO, Researcher Development Unit and Academic Staff Development have developed an implementation strategy for the Concordat resulting in Bath being awarded an HR Excellence Badge in 2011 from the European Commission recognizing alignment with Concordat.

Our research culture strongly promotes and supports bids for **Fellowships and prestigious personal awards**. During the assessment period those secured by staff have included:

1. EPSRC Advanced Research Fellowship, 2005-2009 (C Mitchell)
2. EPSRC Challenging Engineering Award, 2006-2011 (C Mitchell)
3. EPSRC Advanced Research Fellowship, 2007-2011 (Li)
4. Royal-Society/Wolfson Research Merit Award, 2009-2014, (C Mitchell)
5. Royal-Society/Wolfson Research Merit Award, 2013-2018 (Li)
6. European Research Council Advanced Investigator Award, 2012-2017 (Bowen)
7. University of Bath Prize Research Fellowship, 2012-2015 (Forte)
8. Royal Academy of Engineering Research Fellowship, 2013-2018 (Yuan)

Visiting and honorary appointments are targeted to foster collaboration with key academic and

industrial partners and end users. These appointments include **CAST**: Visiting Professor Shi Liu, North China Electric Power University; Senior Visiting Fellow, Dr Tom Marchant, Medical Physics and Engineering, The Christie NHS Foundation Trust. **CSAOS**: Visiting Professor David Jackson, Manager of Stratosphere and Large Scale Dynamics, Met Office; Visiting Professor Jacques Guigné, CEO of Acoustic Zoom Inc. (Canada); Honorary Professor Charles Curry, CEO Chronos Technology Ltd.; Visiting Researcher Dr Alec Bennett, Senior Engineer, Biral Ltd.; Visiting Professor Michael Rycroft, CAESR Consultancy. **CSPD**: Visiting Professor John Scott, formerly Technical Director of Ofgem; Visiting Professor David Tolley, formerly Technical Director with RWE npower.

The Centres actively collaborate with the most highly-regarded international institutions. This results in regular visits by leading international researchers and numerous outward visits. Recent visitors have included Dr Gary Bust, Johns Hopkins University (USA); Dr Chris Coleman, University of Adelaide (Australia); Dr Anthea Coster, MIT (USA); Dr Scott England, University of California, Berkley (USA); Dr Biagio Forte, Visiting Marie Curie Researcher, Abdus Salam International Centre for Theoretical Physics, Trieste (Italy) (now appointed Prize Research Fellow); Prof Zechun Hu, Tsinghua University (China); Prof Erhart Kohn, University of Ul (Germany); Dr Aleksandra Kruss, Institute of Oceanology (Poland); Prof Janice Limson, Department of Biochemistry, Microbiology and Biotechnology, Rhodes University (South Africa); Dr Massimo Matterassi, Complex Systems Institute, CNR (Italy); Dr Ben Oppermann, South African National Space Agency (SANSA); Prof Jin Keun Seo, Yonsei University (South Korea); Prof Hongbin Sun, Tsinghua University (China); Prof Vitali Topolov, University of Rostov-on-Don (Russia); Prof Marko Vauhkonen, University of Eastern Finland; Prof Xifan Wang, Xi'an Jiatong University (China); Dr Weijiang Yang, Beihang University (China); Dr Ping Yin, Civil Aviation University (China); Prof Y Zhang, Hunan University (China) and Dr Jiahui Zhu, China Electric Power Research Institute.

Equality and diversity policy is integral to all research activities. All staff have passed the University's online Equality & Diversity Training module. One academic serves as Equality & Diversity Officer and liaises with their peers across the University through Bath's Equality & Diversity Network. They also perform equalities monitoring and statistics gathering. The University Equality & Diversity Manager briefs Heads of Departments at regular intervals and Equality and Diversity is a standing issue at Departmental Executive Committee Meetings. One academic is a member of the University's Athena Swan Committee (C Mitchell) and the Department is currently preparing a submission for an Athena Swan Bronze award.

ii. Research Students

Postgraduate research students (PGRs) are recruited on the basis of outstanding academic potential and the strategic fit and value of the research project to the Centres, Faculty and University (**R7**). The training and career development of PGRs is overseen by the Faculty Graduate School (led by the Associate Dean for Graduate Studies) and monitored by a dedicated Director of Postgraduate Study (Research) based in each Department.

University Research Scholarships (URS) are available to support outstanding PGR candidates. Further studentships are secured from EPSRC and NERC doctoral training partnerships/centres, industry and from Marie Curie Initial Training Networks. The University allocates URS awards in support of larger research grant applications at a rate of one URS per £1m awarded and the Faculty allocates all ECRs a full URS scholarship.

All PGRs are assigned lead and second academic supervisors. There is a strong focus on PGRs authoring academic outputs in the leading international literature. PGRs encounter international research frontiers via collaborations and presenting papers at international conferences and workshops. External specialist training is funded as required on a case-by-case basis.

The Faculty Graduate School delivers an intensive PGR induction, followed by a tailored programme of generic skills and career development in which PGRs take a minimum of 10 days training per year composed of modules such as Academic Integrity, Writing Papers for Publication,

Project Management etc. The Faculty Research Students Committee, chaired by the Associate Dean for Graduate Studies, carries out PGR progress monitoring. It has responsibility for i) the assessment of candidature, ii) MPhil-to-PhD transfer and regular 6-monthly progress reports, iii) dissemination of good practice in PGR progression, iv) annual monitoring and review including statistics for rates of completion and submission, v) analysis of feedback from internal and external stakeholders and examiners, vi) annual review of induction activities, vii) monitoring of the take-up and effectiveness of all skills training, viii) monitoring of supervision to ensure the provision of a high-quality experience for PGRs, and ix) monitoring of PGR recruitment and admissions.

Our PGRs demonstrate their excellence by winning prizes and awards. These include First Prize for Engineering and the Westminster Medal at the SET for Britain awards 2010 (PGR Rose), Outstanding PhD Paper Prize, International Conference on the European Energy Market 2010 (PGR Gu), a Schlumberger Foundation Fellowship 2013 (PGR Ma) and an Outstanding Student Award from the Institute of Acoustics, 2012 (PGR Merchant). The TOPCAT GPS receiver payload designed by a PGR has been selected for flight on the UKube-1 satellite, the Pathfinder mission for the UK Space Agency's proposed National CubeSat Programme, 2012 (PGR Jayawardena).

d. INCOME, INFRASTRUCTURE & FACILITIES

Investment in specialist infrastructure and facilities is targeted at sustaining and growing the capabilities of each Centre. A Faculty Research Equipment & Facilities Management Strategy, coordinated by the Dean, ensures that investment needs are identified early, that maximum benefit is derived through shared use and that external partners/user communities are engaged for joint purchase wherever appropriate - this latter point is illustrated by our access to sophisticated facilities owned by IQE and used in a major agreed research collaboration.

Significant specialist research facilities are available to and operated by all three Centres under this strategy. Funding for provision and operation of facilities is sourced from external bodies, including research councils, and from strategic University funds. Over the assessment interval these combined investments totaled about £4.5m. Considering each Centre:

CAST - Facilities include state-of-the-art clean rooms, X-ray/optical/electrical characterisation laboratories, GaN growth reactors, dedicated laboratories for tomography (ECR Soleimani) and biosensors (ECR Estrela) and a Micro-CT scanner suite. General laboratories host facilities including GaN epitaxial growth reactors (Veeco D180 MOVPE), Anritsu Optical Spectrum Analyser, Cu-vapour laser, Andor Shamrock 303i spectrograph with iDUS 420 CCD, three probe stations and Keithley 2520 pulsed laser and LED test systems.

The device fabrication laboratories are ISO-Class-6 cleanrooms hosting equipment including an Oxford Instruments System 100 ICP and PlasmaPro 80+ plasma etchers, Nordiko 3000 ion-beam sputtering system, Karl Suss MJB3 Mask Aligner, Heidelberg uPG 101 direct laser writer, Edwards 306 e-beam and thermal evaporators, Raith ElphyPlus for electron beam lithography mounted on a Hitachi S-4300 FE-SEM and Veeco multimode scanning probe microscope. Raman micro-analysis, TEM and SEM characterisation is hosted in a dedicated Materials Analysis Suite.

In a major collaboration with IQE, CAST has access to facilities owned by that company. These include an Aixtron HT-200 MOVPE and HVPE equipped with a LayTec EpiR DATT optical monitoring system, a Bede D1 triple-axis X-ray diffractometer, He-Cd laser and a Plasmatherm 790 PECVD. The investment in all these facilities over the REF interval is about £2.3m.

CSAOS - Extensive use is made of international facilities such as the EISCAT radars and satellite missions including EOS Aura, TRMM, CHAMP, COSMIC and the international GNSS service. Facilities operated by CSAOS itself include world-leading arrays of ground-based atmospheric and ionospheric remote-sensing equipment deployed around the globe. In particular, five Skiymet VHF meteor radars are deployed for atmospheric research in Arctic Sweden, Utah (USA), on Ascension Island, in Tierra del Fuego and at Rothera in the Antarctic. A network of GPS receivers for ionospheric-scintillation research is deployed across the Arctic, Europe, Africa and Antarctic

(including South Pole Station). An array of radio-wave magnetometers for global lightning/sprite detection is deployed in Europe, Australia and the USA.

Other major facilities include a 93-GHz radiometer for radio-propagation studies developed with CCLRC, RF/microwave equipment including mm-wave spectrum analyser, vector network analyser, MIMO channel sounder (developed with QinetiQ) and GPS aviation receivers. The underwater-acoustics laboratory hosts several large water tanks, computer-controlled gantry and data-acquisition systems. The investment in these facilities over the REF interval is about £485k.

CSPD - Facilities include a smart low-voltage DC testbed (the University library), a machines laboratory, a microgrid laboratory for research in sustainable generation, a real-time digital-simulator system for the design and testing of novel fault-detection/location techniques in power systems, a computer cluster for modelling work, a software suite for security assessment of the entire UK national grid and an electricity-market simulator software for studies of charging methodologies in distribution and transmission systems, including mixed-energy generation (in collaboration with Western Power Distribution) and a dedicated superconducting energy-storage laboratory (ECR Yuan). The investment in these facilities over the REF interval is £1.7m.

Additional investment in infrastructure and facilities is provided as follows. Since 2010, the Faculty has received £100kpa in a Faculty Investment Research Fund to invest in its research (this rose to £200kpa in 2013). This is allocated to ECRs on a case-by-case basis. Some £115k was supplied from University Strategic Funds to equip a laboratory for semiconductor crystal growth. Some 20% of Departmental operating budgets are reserved as a flexible contingency to support research. This amounts to about £50kpa and is again primarily directed to support ECRs. Finally, each Centre has a 100% dedicated university-funded technician.

The Unit's workshops are operated as a Faculty facility and since 2008 have received a £1m major overhaul. This has provided high-quality space with ancillary equipment including suites of new machine and fabrication tools and supporting IT. A subsequent rolling programme of upgrades commenced in 2012 with investment now committed at a level of £100kpa.

Planned investment includes an allocation of £24m by the University for a flagship new Faculty building to be operational in 2015. This will provide 6,000 m^2 of space and host four interdisciplinary "research hubs" in selected themes, including Healthcare Technologies, Built Environment and Smart Grids & Energy Storage which map onto the research interests of CAST and CSPD. Each hub will have accommodation for up to 40 PGRs and dedicated research laboratories, representing a major increase in the facilities available to these Centres.

The sources of our current £9.2m **funding portfolio** reflect our focus on fundamental research. This focus has resulted in an income of £11.9m over the assessment period. This includes £7.4m (62%) from the UK research councils, £2.3m (19%) from the EU, £1.1m (9%) from UK government sources, £1.0m (8%) from UK industry and £0.1m (2%) from all other sources. Future plans include exploiting and expanding our ability to secure research funding from NERC, STFC and the EU to complement EPSRC funding. Target areas for new research funding include healthcare engineering, biosensors, mitigation strategies for space-weather impacts on navigation systems, remote-sensing inputs into numerical weather-prediction and climate models, data assimilation, energy hubs, energy storage and smart grids.

Consultancy provides another route for delivering research-based expertise to end users and often lays the foundations for research-based collaborations with external partners. Typically, the University draws 20% of consultancy income with the remainder allocated to the academic to support research travel and minor equipment items. Consultancy generated £271k over the assessment period from companies including Astrium, RWE Npower, the Met Office and Toshiba.

e. COLLABORATION & CONTRIBUTION TO THE DISCIPLINE

Interdisciplinarity is a defining feature of our research. Collaborators include UK and international

research leaders in physics, geophysics, biology, chemistry, economics, mathematics and medicine. A dedicated University Research Development & Collaborations team assists with major strategic bids and also provide professional project management. Financial support has also been received from a £3.4m EPSRC Knowledge Transfer Account (2009-2012) and follow-on £1.4m EPSRC Impact Acceleration Account that facilitates engagement with collaborating partners, including work on energy harvesting and motion tracking of the elderly (Bowen). Exemplars of collaborative and interdisciplinary work include the following.

CAST - Estrela coordinates the €4.0m Marie Curie Initial Training Network, PROSENSE, which researches the clinical relevance of prostate cancer biomarkers and will improve the sensitivity, selectivity, robustness and speed of biosensing technologies in the testing for this disease. Collaborators include the École Polytechnique Fédérale de Lausanne (Switzerland); The University of Applied Sciences, Kaiserslautern (Germany); Cardiff University School of Pharmacy; Applied Enzyme Technology Ltd.; Xeptagen SpA (Italy); Euroimunn AG (Germany); the University Hospital of Wales; the Bristol Urological Institute and the Royal United Hospital Bath.

CAST - Allsopp, Bowen, Clarke and Taylor participated in the EU FP7 Materials for Robust Gallium Nitride researching new materials for electronic devices/sensors for extreme conditions. The project's 22 members included Alcatel Thales III-V Labs, Aixtron AG (Germany), Element 6 Ltd., Gwent Electronic Materials Ltd., École Polytechnique Fédérale de Lausanne and the University of Ulm (Germany). Bath led research on GaN growth on polycrystalline diamond substrates, sensor design/manufacture and the additive manufacture of high-temperature packaging.

CSAOS - Astin and C Mitchell led NERC-funded research with partners at British Antarctic Survey, INGV (Italy), the South African National Space Agency (SANSA) and Siena College and John Hopkins University (USA), to build and deploy GNSS scintillation receivers across Antarctica to characterise the radio-scintillation environment for satellite-based synthetic-aperture radars and navigation equipment. Several joint publications resulted and a follow-on collaboration with the NSF has led to extended operation of the South Pole Station receivers. Forte will lead a new EU FP7 Project, MISW, of 11 institutions to exploit these data to investigate polar GNSS scintillation.

CSAOS - C Mitchell and Watson collaborate with African researchers through SANSA, funded by the Royal Society (2009-2014), EPSRC (2010-2014) and ESA (2012). Bath led a consortium of INGV (Italy) and Boston College (USA) to bring together interested parties from across Africa to a workshop at SANSA in 2013. This led to joint publications, with authors from across Africa, showing the advantages of different African instrumentation sites for mapping the ionosphere.

CSAOS - Füllekrug collaborated with CNRS (France) and the Danish Space Science Institute to define the key atmospheric electrodynamics science goals (inc. lightning and sprites) for complementary space/ground-based studies using the forthcoming TARANIS satellite and the ASIM payload on the International Space Station. Füllekrug proposed and chaired an international meeting in 2011 held at and funded by the French Embassy, London, to facilitate this collaboration.

CSPD - Dunn, Le Blond, Li and Yuan co-organised a joint Smart Grids Symposium at Tsinghua University (China) in 2013. This initiated a new research collaboration with Tsinghaua, formalised by a Faculty-level MoU. Under the Royal Academy of Engineering's Distinguished Fellowship Scheme, Li collaborated with Xi'an Jiaotong University (China) to develop low-frequency methods to transport renewable energy over long distances. Yuan collaborated with the China Electric Power Research Institution to reduce losses in super-conducting cables.

CSPD - Dunn and Li led a UK delegation to a UK/India Scientific Seminar in 2013 addressing economically-efficient and socially-acceptable energy tariff structures, co-sponsored by the Royal Society on behalf of the Department for Business Innovation and Skills and the Indian Department of Science and Technology. These collaborations helped secure three UK/China and UK/India smart-grid, electric-vehicle and energy-storage projects, HEAPD, OPEN and Smart Mobility.

Leadership in the academic and industrial community is demonstrated by the following exemplars.

Advisory board, learned society and research-council service includes **Allsopp**: EPSRC Challenge LED Applied Systems Panel; Member, NSF World Materials Program review panel; **Astin**: Member, NERC Services Review Group; Member, NERC Atmospheric Radar Facilities Steering Committee; **Blondel**: Member, British Standards Institute (BSI) committee EH/1/7 on Underwater acoustics; Member, Steering Committee, Underwater Acoustics Group, Institute of Acoustics; Chief Editor for Praxis Publishing Ltd.; **Bowen**: Member, IoM3 Smart Materials & Systems Committee; **Estrela:** Member, Science Advisory Board, Institute of Biosensing Technologies; **Füllekrug**: Member, Advisory Board to the SCOSTEP Bureau of the International Council for Science; Representative of International Union for Radio Science (URSI) commission E in the UK; **Li**: Chair, International Working Group on Distribution Pricing and Tariff Structure, IEEE Power Engineering Society; Executive Member, IET Professional Network on Power Trading and Network Control; Member, UK Distribution Charging Methodology Forum; **C Mitchell**: Member of Royal Academy Engineering Committee to report on Space Weather, 2012; Member of ESA Galileo Science Advisory Committee 2009-2012; **NJ Mitchell**: Member and Chair of NERC National Atmospheric Radar Facilities Steering Committee; Invited Member, ESA satellite design feasibility study; **Shields**: Member, UK Nitrides Consortium, Management Committee; **Soleimani**: Member, EPSRC CSED SLA Steering Committee; **Watson**: UK URSI panel; **Wang**: Member, Review Panel of Finland Academy of Science; Member, Swedish Foundation for Strategic Research; **Yuan**: Member, IoP Superconductivity Group Committee.

Major conference roles include **C Mitchell**, Chair of Beacon Satellites Symposium, Bath, 2013; **Soleimani**, Chair of Electrical Impedance Tomography, Bath 2011; **Conference session chairs** include: **Aggarwal** (1); **Blondel** (14), **Estrela** (1), **Li** (5); **C Mitchell** (4), **Soleimani** (3) and **Wang** (4).

Invited international keynote & plenary talks include **C Mitchell**, 12th international conference on ionospheric radio systems & techniques, York, 2012.

Invited presentations at international meetings: **Aggarwal** (5), **Allsopp** (4), **Blondel** (8), **Bowen** (4), **Dunn** (3); **Estrela** (5), **Forte** (5); **Füllekrug** (6); **Le Blond** (1); **Li** (12), **C Mitchell** (9), **NJ Mitchell** (3), **Smith** (1), **Shields** (3), **Soleimani** (7), **Taylor** (2), **Wang** (7), **Watson** (4) and **Yuan** (1).

Invited journal & book articles were authored by **Blondel** (3), **Bowen** (1), **Estrela** (1), **C Mitchell** (3), **NJ Mitchell** (1), **Soleimani** (4) and **Yuan** (1).

Visiting appointments include **Aggarwal**: Visiting Professor Sungkyunkwan University, South Korea; **Clarke**: Visiting Expert, Nangyang Technological University Singapore; **Füllekrug:** Visiting Professor, Laboratoire de Physique et Chimie de l'Environnement et de l'Espace, CNRS, Orléans, France; **Li**: Visiting Professor, Sichuan University, China; **Taylor**, Visiting Professor Southeast University, Nanjing, China; **Wang**: Visiting Professor, National Chiao Tung University, Taiwan.

Editorships of international journals include **Aggarwal** (1), **Blondel** (4), **Soleimani** (2) and **Watson** (1).

Fellowships and personal awards include EPSRC Advanced Research Fellowships to **C Mitchell** (2005-2009) and **Li** (2007-2011); EPSRC Challenging Engineering Award to **C Mitchell** (2006-2011); Royal-Society/Wolfson Research Merit Awards to **Li** (2013-2018) and **C Mitchell** (2009-2014); European Research Council Advanced Fellowship to **Bowen** (2012-2017); University of Bath Prize Research Fellowship to **Forte** (2012-2015) and an Royal Academy of Engineering Research Fellowship has been awarded to **Yuan** (2013-2018).

Prizes and awards include **Bowen**: Donald Julius Groen Prize for Best Paper, Proc IMechE, Part I, 2011; **Li**: Winner, Rushlight Power Generation & Transmission Award, 2009; **Wang**: IEEE Spectrum, Winner of Advanced Technology 2010 Award for Advanced Lasers using Nanotechnology; **Watson**, Winner, Best KTP Building on EPSRC Funded Research, EPSRC, 2010; **Yuan**, IoP Early Career Researcher Prize for outstanding oral presentation, 2013.