Institution: University of Leicester

Unit of Assessment: 15 General Engineering

a. Overview: The UoA is a general engineering unit and includes the Centre for Systems Neuroscience, which grew from Engineering during the REF period. The research groups are: Bioengineering (**Quian Quiroga**, **Schlindwein**, **Pearce**, **Ison**, **Rey** and **Pedreira**), Control Systems (**Gu**, **Turner**, **Lecchini Visintini**, **Prempain**, **Morales Viviescas**), Electrical Power and Power Electronics (**Dodd**, **Lefley** - with new appointments agreed), Embedded Systems and Communications (**Warrington**, **Vladimirova**, **Pont**, **Stocker**, **Siddle**, **McEwan**), Mechanics of Materials (**Atkinson**, **Pan**, **Hainsworth**, **Dong**, **Gill**, **Sinka**, **Weston** and **Williams**), and Thermofluids (**Garrett**, **Rona**, **Gao**, **McMullan**, **Bagdanavicius**). 7 staff are ECRs and 9 are profs.

The UoA is part of the College of Science and Engineering with Chemistry, Computer Science, Geography, Geology, Mathematics, and Physics & Astronomy. The College has developed cross-disciplinary themes: Astronomical, Earth and Planetary Science (**Atkinson**, **Siddle**, **Stocker**, **Vladimirova**, **Warrington**, **Williams**), Environment, Energy & Climate Change (**Atkinson**, **Bagdanavicius**, **Dodd**, **Dong**, **Gao**, **Garrett**, **Gill**, **Hainsworth**, **McMullan**, **Siddle**, **Stocker**, **Warrington**, **Weston**), Life Sciences Interface (**Gill**, **Ison**, **Pan**, **Pearce**, **Pedreira**, **Prempain, Quian Quiroga**, **Rey**, **Schlindwein**), Materials & Nano-Materials Science (**Atkinson**, **Dong**, **Gill**, **Hainsworth**, **Pan**, **Sinka**, **Weston**, **Williams**), and Landscapes & Communities (**Vladimirova**).

UoA staff play a major leadership role in several College centres: Advanced Microscopy Centre (**Hainsworth** - Director), Forensic Science Institute (**Hainsworth**), Materials Technology Integration Centre (**Hainsworth**), Mathematical Modelling Centre (**Dong**, **Gill**, **Pan**) and the Centre for Systems Neuroscience (**Quian Quiroga** - Director). UoA staff also contribute to the Landscape and Climate Research Centre (**Vladimirova**), and to the Space Research Centre (**Atkinson**, **Vladimirova**, **Williams**). **Hainsworth** is the lead for the new Advanced Structural Dynamics Evaluation Collaborative (ASDEC) Research Centre (with **Rona** as co-I).

b. Research strategy: Our overall strategy, with 32 academic staff covering a wide range of engineering curricula, is to punch above our weight through international, national and industrial collaborations, and through cross disciplinary links. Leicester is a research-intensive institution and is in the top 10 UK and top 100 worldwide for citations.

A major part of the University's research strategy has been a centrally University funded £1M investment in the **Centre for Systems Neuroscience** with the appointment of Prof. Rodrigo **Quian Quiroga** to a research chair with new dedicated facilities. The focus is on computational neuroscience and the analysis of neurophysiological data. New methods of analysis of neural signals based upon time-frequency decompositions, statistical mechanics, and dynamical systems, including chaos and synchronisation phenomena, are investigated. These methods are routinely applied to electrophysiological and EEG data for the analysis of visual perception and memory, learning, and visuomotor transformations. Analysis of single cell recordings in humans is of interest - epilepsy patients are studied with intracranial recordings to determine the focus of epileptic seizures for potential curative surgery. The Centre produces high-profile papers including in *Science*, *Nature Neuroscience*, and *PNAS* attracting high media attention.

Bioengineering focuses on signal processing and modelling of biological systems. It has established an international reputation for applying this approach to the heart, brain and nervous system. A core aspect is real-time signal processing applied to the study and treatment of atrial fibrillation. This involves characterising the behaviour of the electrical activation of the heart (starting with the atria), developing a methodology to help decide who should receive an implantable cardiac defibrillator, and the study of the *inverse problem in cardiology* by which body surface potential mapping is used for the study and treatment of cardiac arrhythmias. This interdisciplinary research is undertaken in collaboration with Cardiovascular Sciences based at Glenfield Hospital. Understanding and applications of models of neural mechanisms of sensory processing to real-world behaving artefacts is another theme. Current work is on the neural processing of chemical information in insects and mammals.

We intend to ensure continuing strong interaction between **Bioengineering,** the **Centre for Systems Neuroscience**, and other departments (Cell Physiology and Pharmacology, Biology, and Cardiovascular Sciences). We aim to secure funding from: BBSRC for basic life science; MRC for clinical projects; EPSRC for technology driven work; EC as part of large consortia; and charities (British Heart Foundation, Wellcome, Leverhulme).

Control Systems has a broad repertoire, ranging from systems biology to stochastic systems centring on the development and application of advanced control techniques to aerospace systems. The underlying ethos is to develop practically relevant control system design and analysis tools. Its theoretical contributions to control theory are widely recognised, with four of its members serving as associate editors for international control journals. Research includes fundamental control theory and the application of advanced tools to novel practical control problems. This diversity is reflected in its broad income base: EU and government bodies (e.g. EPSRC, TSB, FP7); industry (e.g. Agusta-Westland Helicopters, MBDA, Aero Engine Controls); joint BAE Systems and EPSRC sponsorship. A key strategic goal is the development of autonomous control systems, mainly for Uninhabited Air Vehicles (UAVs) to raise their autonomy level in highly uncertain operating environments, providing superior functionality in a real-time flight environment.

Within **Electrical Power and Power Electronics**, Fothergill has been appointed PVC at City, London (remaining as an Honorary Visiting Professor) and a replacement agreed. Work on high voltage DC (HVDC) transmission led to a KTP with Alstom Grid on developing techniques for selecting HVDC power cables, and PhDs with Borealis and Nexans on understanding charge movement. Research on failure mechanisms in DC power capacitors led to new techniques for characterising the failure of metallised film capacitors and significant industrial consultancy. Nano-dielectrics work was supported by exchange visits with the Institute of Electrical Technology, Valencia. Exploitation of experimental PV arrays for shading-optimised array topologies and converter assignment informed practice in the use of distributed maximum power point trackers to optimise efficiency under varying irradiation conditions. Innovation Partnerships were undertaken with Pura Filters, building on work in electrostatic precipitators (see Impact Case Study), and with Farsan on improving the efficiency of refrigeration plant by applying new technologies to motors and their control. Collaboration with MIRA resulted in a continuously variable electromagnetic gearbox. A patent has been granted in the area of pulsed induction heating. Future plans include investigation of HVDC ageing of nano-dielectrics using multi-scale modelling combined with experimental verification, and in the area of ageing mechanisms, metallised film capacitors.

Embedded Systems and Communications has been reinforced by the appointment of a new professor of embedded systems (**Vladimirova**). Work has continued on high latitude HF propagation modelling and has incorporated studies combining trans-ionospheric and HF propagation measurements in the polar cap (with Istituto Nazinale di Geofisica e Vulcanologia, Rome and St Petersburg University). EPSRC funded experiments (2 PDRAs and a self-funded PhD) on the applicability of MIMO techniques in the HF band have been undertaken with Durham. A further PhD studied over-sea VHF and UHF propagation. Wireless networking is a new area and includes a successful PhD on ad-hoc networking, a current PhD with MIRA, and an externally funded project with Computer Science on mesh networking. The development of time triggered embedded systems has been the focus of the activity of TTE Systems, a spin-out company.

We have EPSRC funding for the development of high latitude HF forecasting methods to support civil aircraft operating on polar routes with Lancaster, Natural Resources Canada and Solarmetrics Ltd. HF-MIMO investigations will continue, initially addressing the problem of realisable scale antenna arrays. Expansion of our wireless networking activities is also planned. The European Space Agency (ESA), EADS Astrium UK, the University and EPSRC doctoral funding are supporting a recently initiated CubeSat project evaluating advanced space systems and technologies, e.g. sub-kg satellites (PCBsats), reconfigurable computing onboard spacecraft, and distributed embedded systems for space applications including wireless networks for space weather monitoring. Collaboration with EADS Astrium UK, SSTL, ESA and the US Air Force Academy has been established. Work on efficient algorithms and advanced embedded processor architectures for multi-sensor data fusion and image processing in aerospace and robotics applications is underway. This will provide high-performance computing capabilities with increased reliability and low power consumption in demanding applications and harsh environments. Initially this work will be supported by FP7 projects SWIPE and DBOX. We will continue developing high-integrity FLASH file systems for use in space and other hostile environments.

Mechanics of Materials spans two College themes: Materials, and Computational Modelling. It is the lead for an EPSRC CDT in Innovative Metal Processing. Two lecturers (**Weston, Williams**) have been appointed with strong links with Chemistry and Physics. The Group (with Honorary Visiting Profs Strang and Ennis, and RAEng Innovation Visiting Prof Carter) has worked on damage evolution in power generation materials (TSB with EoN, Alstom, QinetiQ, NPL, Doosan

Babcock and an EPSRC Case supported by Corus and DTI), and are now developing a rig for testing microstructural degradation in abradable seals (EPSRC Case with Alstom). The Group has led a major 4-year FP7 project on modelling of welding (MINTWELD) with 11 partners from 7 countries. A 2-year Royal Society Industry Fellowship at Rolls-Royce focused on improving processing of single-crystal turbine blades leading to papers and two patents [EP2166133B1, **Dong** *et al.*; US008192564B2; **Dong** *et al.*]. A theoretical framework for computer modelling of bioresorbable medical devices has been implemented for targeted degradation rate. Multiscale and multiphysics models for the evolution of nanostructures was the subject of a Royal Academy of Engineering-Leverhulme Senior Research Fellowship. There has been major growth in forensic engineering activity (characterising stabbing forces for the justice system, optimising the resistance of beer glasses to breaking in such a way as to be used in violent incidents, characterisation of dismembered bodies, and the sharpness of tools). This is part of the Alec Jeffreys Forensic Science Institute (established 2012). The University has invested £1.1M, together with £1M from RGF, in a major initiative on advanced structural dynamics (ASDEC) in partnership with MIRA.

Plans for the future include: forensics (quantification of weapon impact on the body); alloys for high temperature operation; automotive tribology (decreasing carbon emissions through minimising frictional losses); modelling degradation of bioresorbable materials; multiscale modelling of complex molecules; mechanics of granular and porous materials; modelling interaction between nanoparticles; modelling self-organisation of nanostructures; properties of nanostructured materials (including CoW coatings for recording media); processing of nanocomposites including via semi-solid processing; multiscale modelling of welding; development of hard wear resistant electrodeposited coatings for replacement of hard chrome; multifunctional materials and systems.

Thermofluids spans Engineering and Mathematics. A pulverised fuel classifier test rig identified technological improvements to achieve significant gains in thermoelectric power stations. Lung health research with Mechanics of Materials developed the first patient-specific dynamic model of the upper bronchial tree, giving a firm base for exploring stenotic induced breathing diseases (e.g. asthma). Work with the National Research Council Canada led to the identification of previously unappreciated streamwise flow patterns that are being investigated by analytical, computational and experimental techniques. AeroTraNet (Marie Curie) concluded with 15 PhD graduates across the network (4 in Leicester) and led to €2.8M AeroTraNet 2 which is now underway investigating shock-associated jet noise (Leicester is the lead partner).

Plans include development of: advanced LES/DES models and simulation techniques for complex industrial flow and heat transfer applications, such as mixing layers, jets, non-Newtonian flow and multiphase flow systems; flow control technologies in drag and noise reduction including collaborations with Warwick; an industrial calibration standard for water metering in collaboration with Severn Trent Water, based on advanced LES/DNS study of unsteady flow in pipelines of large diameters; the in-house CFD software Cosmic (AeroTraNet 2) and the software LeicesterCAA through collaborations with other universities; industrially relevant flow control mechanics, motivated by closer links with industry; stability properties of boundary layers over rotating bodies (KTH and Cambridge). The Group is part of the Advanced Structural Dynamics Evaluation Centre.

c. People, including:

i. Staffing strategy and staff development

Academic staff are appointed on research merit, whilst ensuring that all aspects of the curriculum are delivered to a high standard. The Head of Department is responsible for consulting and recommending to the College where and at what level new appointments should be made. Alignment with the College research themes influences new posts. All academic staff appointments are advertised internationally, and academic staff represent 15 different nationalities spanning South America, Europe and the Far East. Highly specialised experimental officer and technical staff support the research. 5 new lecturers, 1 research lecturer and 2 professors have been recruited, with 3 research excellence promotions to Reader and 5 to Professor.

Academics may apply for study leave for 1 semester in 8, the application requiring a statement of their research strategy and how this will be developed by the leave. Typically 2 or 3 staff take study leave each year. New academics are given lighter teaching loads. Early career researchers have mentors and receive support organised by their research group head, including for writing papers and research applications. Training is also organised centrally by the University on these and related areas, such as the supervision of PhD students.

A number of staff have been awarded fellowships: Royal Society Industry Fellow for 2 years

(**Dong**); Royal Academy of Engineering / Leverhulme Senior Research Fellow for one year (**Gill**); MRC 3-year Special Research Training Fellowships in Biomedical Informatics (**Pedreira**, **Rey**); 6 month Royal Academy of Engineering Industry Secondment with St. Jude Medical UK (**Schlindwein**). Staff who gain fellowships are relieved from teaching. In addition **Turner** and **Prempain** had relief to work on a UK MoD/French DGA funded project. **Quian Quiroga** has been promoted to Research Professor and has established the Centre for Systems Neuroscience. He has no teaching and his position within the Department will be replaced.

The University has staff dedicated to achieving equality and diversity, and has been awarded Athena Swan Bronze. Engineering will submit for Bronze in 2014. There is a very active working group involving both staff and students. The UoA has 3 women professors, one of whom (**Atkinson**) won a national award as a 2010 Woman of Outstanding Achievement in Science, Engineering and Technology for "leadership and inspiration to others". Another (**Hainsworth**) was nominated as one of the Women's Engineering Society's Inspiring Technical Women in 2009. The staff and PhD students come from diverse ethnic backgrounds.

Support for researchers at Leicester builds on Vitae's Researcher Development Framework to develop the skills and capabilities required of researchers from PhD to academic and as leaders of large research programmes. The programmes are highly focused and aim to add value to individuals' CVs, as well as institutional performance. There are four core programmes delivered centrally: **Research Leadership and Management:** aiming to help researchers become more effective in critical leadership roles (e.g. as heads of department or PIs), gain a good grasp of the current and evolving research environment and gain skills to effectively manage their work and their teams; **The Intrepid Researcher:** an annual series of 10-12 taster sessions presented by eminent scholars and experts in particular methodological areas, often working at the boundaries between different disciplines; **The Enterprising Researcher:** focusing on developing personal entrepreneurial behaviours, skills and attributes and enabling them to deal with uncertainties and complexities; **Skills for the Professional Researcher:** training providing basic and more advanced research (including IT) skills. The University is a signatory to the **Concordat to Support the Career Development of Researchers**, and has recently been awarded the *HR Excellence in Research Award*, acknowledging the University's alignment with the principles of the European Charter for Researchers and Code of Conduct for their Recruitment. The Concordat Action Plan 2011-13, examines where Leicester is in line with, or goes beyond, the requirements. Areas for further work have been identified, and these are being monitored by the Concordat Steering Group chaired by the Pro Vice Chancellor for Research and Enterprise, with College representation.

ii. Research students

Within the Department, research students are recruited on the basis of research grants and contracts, industrial fellowships, DTA income, and through funding from the University, College and UoA. Approximately 60% of our PhD students are full fee-paying students, generally from overseas. Research scholarships are built into the University and College financial plans and the UoA has been successful in competing for these.

The University has a strategy to support major initiatives with matching funding, and has committed over £1M to the successful UoA-led CDT bid (with 87 PhD students, ~40 to Leicester, over the next 5 years and a new collaborative PhD structure with taught modules shared with Nottingham and Birmingham). The CDT draws on cross-College expertise, including Chemistry, Physics and Mathematics. We are a partner in the PhD student-focussed National Structural Integrity Centre led by TWI to address the shortage of qualified structural integrity specialists.

PhD students, like early career researchers, are integrated into research groups. Each group runs a series of seminars. Strong technical support is available at laboratory and UoA level in mechanical, electrical, electronic and IT areas. As well as a supervisor, they are assigned a co-supervisor and a separate internal examiner who oversee their progression. Progress is formally assessed at the end of the first and second years.

We provide a nurturing and robust programme of research skills training delivered through the Department, the College and centrally, building postgraduate research students (PGRs) up as effective and confident researchers, whilst also enhancing their transferable skills and future employability. Intrepid Researcher, Enterprising Researcher, Skills for the Professional Researcher, and Leadership and Management are also available to PGRs. PGR-specific centrally offered training includes: **Managing your Research** - small group activities and support directly related to their thesis, their project and their time management, and highlighting the important

milestones on the journey; **Communicating your Research** - a comprehensive programme of transferable skills training; **Employability and Career Management** - a range of events/activities, training, and advice and guidance sessions to help researchers enhance their employability.

d. Income, infrastructure and facilities: The UoA has received grant income of £8.27M (see REF4b) and the University has invested £4.8M in infrastructure and facilities directly supporting the UoA in the REF period (£1M MaTIC; £2.2M ALICE; £0.77M ASDEC laser vibrometry; £0.5M departmental investment in research group facilities; £0.1M University central research infrastructure support for small items of research equipment).

The Department has a range of laboratories and specialist equipment supporting its research programme. The **Bioengineering Laboratories** include a Wam Robot Arm, High-density Biosemi EEG system, Eyelink Eye Tracker, robot plume wind tunnel, robot platforms, real-time neuromorphic hardware, Ensite 3000 system (for atrial electrograms), 4 high-performance computers. **Control Systems** has experimental facilities that include an autonomous systems laboratory which houses a team of Traxster robots; a high-precision robot arm and a refurbished flight simulator. It also has access to wind tunnel equipment for modelling and testing of advanced flight control systems. The Group has recently had £20K infrastructure funding to purchase a small fleet of UAVs. The **Electrical Power and Power Electronics Laboratories** include 400 kV high voltage testing equipment (unique in Europe), broadband dielectric spectroscopy, space charge measurement using pulsed electroacoustic (PEA) techniques, high sensitivity electrical treeing and electroluminescence equipment with application in electrical treeing detection, equipment for the development of electronically controlled drives and generators, 50 kVAp PV array, equipment for the development embedded generation systems (including: photovoltaic, wind power and variable speed generation and a large scale wind turbine simulator), large and small electrical machines and drives test facility with a 200kVA 3 phase supply, 3000 amp pulsed power generator, and a large battery charge/discharge unit designed for fork-lift truck and submarine batteries. **Embedded Systems and Communications** has access to various field sites for radio research. The Group's own site includes an HF multi-channel receiving system capable of direction finding. Equipment is deployed overseas at: Nurmijärvi, Finland; Ny-Ålesund, Svalbard; Ottawa and Alert, Canada (with others to deploy shortly); Qaanaaq, Greenland. The Embedded Systems Laboratory has a range of test facilities, including an advanced vehicle hill simulator, a 5 DOF articulated robot arm, and an advanced twinhead MIMO model helicopter. The Group is establishing an Advanced Space Systems Development Laboratory to support research in technologies underpinning space-based wireless sensors. **Mechanics of Materials** lead the Advanced Microscopy Centre and the Materials Technology Integration Centre (see below). There is extensive rig building expertise that made it possible to develop novel equipment for wear testing, abradable seal testing, a single pan scanning calorimeter, a small scale thixoformer, and powder processing (powder flow, compaction and triaxial testing). The labs also include standard mechanical testing systems, a high performance nano-indenter and a differential scanning calorimeter. The **Thermal and Fluid Engineering Laboratories** include two low-speed wind tunnels, a gas dynamics laboratory equipped with one transonic cascade tunnel, two Mach 1.8 closed-circuit wind tunnels, a combustion test cell, a hemi-anechoic chamber, and a water flume. Laser based diagnostics include standard and high-speed PIV for velocity field imaging and PLIF for chemical species and temperature field imaging. This is complemented by continuous and spark Schlieren, and shadowgraph systems for compressible flows.

College-wide facilities also form an important aspect of our research infrastructure. The **Advanced Microscopy Centre (AMC)** was developed under Engineering leadership funded through SRIF 2. The AMC supports major experimental research activities in Engineering, Chemistry, and Physics and Astronomy and advances multidisciplinary research activities across the Physical and Biological Sciences. The AMC comprises: a UHV STM, an SPM, a FEGSEM with EBSD and EDX, an Environmental SEM, a TEM with EDX and the associated specimen preparation equipment. The TEM, FEGSEM and AF are hosted within Engineering. The **Alec Jeffreys Forensic Science Institute** (Alec Jeffreys discovered DNA fingerprinting at Leicester) is a multidisciplinary centre coordinated jointly with the College of Social Sciences. The UoA plays a leading role in the management of the Institute. The goal of the Institute is to bridge the gap between academic research and forensic practice, and it is playing a key strategic role in response to the evolving forensic science and engineering landscape linking research into police initiatives (see Impact Case Study). The **Materials Technology Integration Centre (MaTIC)** is a £1M high-

tech engineering centre, led by Engineering, that works with industry to drive innovation in materials technology. The aim of MaTIC is to provide expertise to solve complex engineering and scientific problems. It facilitates collaboration across the College and supports activities in Engineering, Geology, Chemistry and Physics. The Centre is funded by the HEFCE's Capital Infrastructure Fund and the University. Equipment includes a laser Raman spectroscope, a micro-computed X-ray tomograph, calorimeters, and facilities to quantify the sharpness of knives and other weapons used for inflicting injury. The **Mathematical Modelling Centre (MMC)** unites researchers with shared interests in advanced modelling and simulation methods. Cutting across traditional disciplinary boundaries, the MMC facilitates active, funded collaborations between this UoA and Mathematics (e.g. **Dong** and **Pan** with Davidchack, **Rona** with Georgoulis and **Garrett**).

Many UoA research projects require significant computing resources for modelling, simulation, data processing and analysis that are satisfied by the University's **High Performance Computing** systems. ALICE (£2.2M - >3300 cores) primarily provides a batch service, and SPECTRE (>2600 cores) an interactive environment. Leicester is also a partner in the Midlands Centre of Excellence for High Performance Computing (£1M - 3000 cores) funded by the EPSRC with **Dong** and **Rona** as co-investigators. The College invests significantly in the maintenance of these computers.

£0.5M has been invested from departmental funds for research equipment across all groups, including X-ray computer tomography (£75k), servohydraulic tester (£71k), neuroprosthetic system based on the iCube robot arm (£62k), EEG system (£32k), eye tracker (£31k), CNC centre lathe (£29k), combustion laboratory unit (£29k), digital microscope (£23k), EDM spark eroder (£18k), and dielectric spectrometer interface (£14k). Research grants have funded, e.g., NeuroPort 64 channel system for single cell recordings in epileptic patients (£56k), FLIR Systems Thermacam SC640 (£29k), programmable logic and wheeled robot equipment (£23k), EyeLink 1000 Desktop System for eye-tracker recordings (£21k), 128 channel Biosemi ECG system (£10k), Thermo-Calc thermodynamic prediction software.

In 2011 the University established a fund for equipment and related infrastructure, prioritising strategic and interdisciplinary initiatives. £2.5M p.a. is currently allocated through open calls, with plans to extend the fund in future. Departmental and College plans include proportionate commitments. Successful UoA bids include: low-speed, closed loop wind tunnel refurbishment (£21k); body surface potential mapping (£26k); high temperature mechanical testing (£31k); UAV helicopters (£20k); CubeSat project (£21k); advanced hardness tester (£25k). Also funded is 3D laser vibrometry equipment for ASDEC, a unique UK facility (£770k). The University is a member of the M5 group of research-intensive universities aiming to facilitate the sharing and procurement of expensive research equipment.

External funding has included: TSB (**Atkinson**, **Gill**, **Hainsworth**), EPSRC (**Dong**, **Gu**, **Ison**, **Lecchini Visintini**, **Pan**, **Prempain**, **Quian Quiroga**, **Rona**, **Siddle**, **Stocker**, **Turner**, **Vladimirova**, **Warrington**), MRC (**Ison**, **Pedreira**, **Quian Quiroga**, **Rey**), AHRC (**Quian Quiroga**), STFC (**Dong**, **Hainsworth**, **Weston**), EC (**Atkinson**, **Dong**, **Lecchini Visintini**, **McEwan**, **Rona**, **Vladimirova**), Royal Society (**Atkinson**, **Dong**, **Quian Quiroga**, **Warrington**), Leverhulme Trust (**Gill**, **Quian Quiroga**), BBSRC (**Quian Quiroga**), HFSP (**Quian Quiroga**), Royal Academy of Engineering (**Schlindwein**), ERDF (**Hainsworth**), industry including MBDA, DSTL (**Prempain**, **Turner**), ESA (**Prempain**, **Vladimirova**) and STFC "in-kind" funding for DIAMOND, ISIS and ILL (**Dong, Hainsworth)**. We have recent success with the EPSRC in responsive mode.

Our future strategy includes the development of collaborative relationships with other universities. We are the overall lead (**Dong**) for a successful CDT bid with Nottingham and Birmingham (£7.8M in total, of which £3.2M EPSRC, £1M Leicester, £0.5M Nottingham and £0.8M Birmingham, £2.3M cash industrial contributions from Alstom Power, Doncasters, Welding Alloys (SME), Rolls Royce, Tata Steel, TWI and Isis). Strategic framework partnerships with key industrial players are being developed (Alstom Grid, Alstom Power and TWI).

Of particular note where a Leicester researcher is the overall lead for significant multi-partner project (e.g. FP7): €3.6M FP7 Mintweld project (**Dong**) to deliver accurate, predictive, and cost-effective welding models that will find widespread application in the relevant European industry for penetrating novel markets of high economic and strategic importance enabled by a new capability for intelligent design of high performance welded systems and structures; €3.2M EC FP6 AeroTraNet consortium (**Rona**) for the assessment of aerodynamic noise from airframe recesses in wide-body civil aircraft wings (2006-2010); €2.8M EC FP7 AeroTraNet 2 consortium (**Rona**) that addresses shock-cell noise at cruise (2013-2016). Other prestigious grants include: To the Control

Systems Group, a UKIERI Programme grant, funded by the UK and Indian Governments (£552k) and an EPSRC Platform Grant (£435k); EPSRC Systems Engineering Doctoral Centre - Bath, Leicester, Loughborough, Queens Belfast, Strathclyde; TSB project on materials modelling (£2.2M, of which £412k to Leicester); Centre for Systems Neuroscience including MRC fellowships (>£2M).

The UoA has undertaken a number of consultancy contracts during the assessment period with a total value of over £200k. As confidentiality is involved with these, full details are not included but work has been undertaken for a number of industrial concerns and government agencies. The power industry is a major consultancy customer.

e. Collaboration and contribution to the discipline or research base: The University actively encourages interdisciplinary collaborations. In the REF period, research centres have been established across the University, and members of the UoA are working with and leading several of these. In addition, the College has identified a number of research themes that span its constituent departments that include a number of our research areas. Other internal collaborations occur outside of these more formal frameworks. Research collaborations with organisations outside the University are also encouraged and supported.

The **Centre for Systems Neuroscience / Bioengineering Research Group** has collaborations with Cell Physiology & Pharmacology studying imaging and electrophysiology recordings in the mice hippocampus, with Biology on a study of multiple single-cell recordings from the locust motor system (BBSRC), and with Museum Studies on the study of visual perception of art (AHRC and Leverhulme). National collaborations with Glenfield Hospital, Leicester on atrial fibrillation, King's College Hospital on recordings of single-neurons in epileptic patients to study neural correlates of perception and memory processes (MRC), Imperial College and Newcastle on the development of a wireless on-chip implementation to transmit neural signals to external devices (EPSRC). International collaborations include: UCLA Medical Center and Caltech & Allen Institute, USA on recordings of single-neurons in epileptic patients to study neural correlates of perception and memory processes (EPSRC), Universidad de Buenos Aires, Argentina on a study of simultaneous EEG and eye-tracking recordings, URGS, Brazil on visualizing intracardiac atrial fibrillation electrograms using spectral analysis, Max-Planck Institute for Chemical Ecology, Germany on new technologies for communicating with chemicals, Tufts University, USA on biological principles of olfactory processing to achieve performance advantages in optical chemical sensor arrays, and the Autonomous University of Madrid on information theoretic concepts applied to chemical sensing instrumentation. The group is also heavily involved with a diverse range of industrial partners.

Control Systems actively works with BAE Systems, as its Preferred Academic Capability Partner, on projects in the UAV and complex systems area. These include FLAVIIR (FLapless Air Vehicle Industrial Integrated Research programme), ASTRAEA (Autonomous Systems Technology Related Airborne Evaluation & Assessment, Phase I), NECTISE (Network Enabled Capability Through Innovative Systems Engineering). "Neptune" was an EPSRC Strategic Partnership project, involving Leicester and 6 other universities (including Imperial) and 3 industrial organisations (total value: £2.3M), to provide novel pressure management tools to improve the efficiency and sustainability of water distribution systems. With MBDA, the "Dynamic Controllers" and "Robust Adaptive Control" projects (funded by MoD and the French DGA) have developed methods to enhance airframe performance using advanced robust control techniques. Two projects with Agusta-Westland ("REACT" funded by TSB and "RTVP" funded directly by AW) have applied advanced control tools for vibration reduction in rotorcraft. The EU funded project iFly, with Cambridge, was devoted to the development of innovative tools for Air Traffic Management. A new collaboration with Aero Engine Controls is being established. Academic collaborations are a valued aspect of the Group's ethic and links with the LAAS, CNRS in Toulouse are well-established with two members serving as visiting researchers in 2010. Several Chinese universities collaborate with us in the area of complex networked systems with applications in, e.g., electricity distribution networks and other complex systems-of-systems/networked systems. A new collaboration is being established with Nanjing University of Aeronautics and Astronautics.

Electrical Power and Power Electronics has collaborations that include the University of Bologna, Italy, on space charge ageing and electro-thermal lifetime models for electrical insulation, University of Toulouse, France, on charge transport in insulating materials, Wroclaw University of Technology, Poland, on fundamental aspects of dielectric spectra interpretation, University of La Plata, Argentina, on electrical degradation in silicone polymers and Xi'an Jiaotong, China on electric degradation in HV cable insulation systems. The work on sustainable insulating fluids was

interdisciplinary in collaboration with Chemistry. Much of the HV work is in electrical insulating materials and collaborations with industry have included Borealis, Sweden, a world leading producer of HV grade cross-linked polyethylene, Schneider Electric, France, a HV component manufacturer, Nexans, France, a major international HV cable manufacturer. The KTP with Alstom, UK, has established relationships with the Universities of Toyohashi and Tokyo City, Japan, IES Montpellier, France and a major international HV cable manufacturer, Viscas Corp., Japan.

Embedded Systems and Communications is leading activities on the design of CubeSats and establishing links with the Space Research Centre, Physics and Geography through the activities of the Centre for Landscape and Climate Research. It has a range of external academic and industrial collaborations, including with EADS Astrium, France through three current FP7 projects: ReVuS: Reducing the Vulnerability of Space Systems, DBOX Demining tool-BOX for humanitarian clearing of large scale areas from anti-personnel landmines and cluster munitions, SWIPE: Space Wireless sensor networks for Planetary Exploration, the European Space Agency on failure-detection, fault-isolation and recovery schemes for reconfigurable FPGA-based systems, and collaborations with Lancaster, Natural Resources Canada, University of St Petersburg, Solarmetrics and RAL on space weather effects on airline communications.

Mechanics of Materials led a European COST consortium on semi-solid processing of steels (2 books and an international workshop for PhD students were example outputs) and collaborates with one of the Grands Écoles on modelling and GRINM in Beijing on alloy development. On sintering science and technology, the group has led two EPSRC grants with Oxford, Surrey, Cranfield, TWI and Rolls Royce. Cambridge, Queen's Belfast, Smith & Nephew and Purac Ltd collaborated on biomaterials as well as University Hospitals Leicester. Merck and Takeda fund our work on pharmaceutical materials. A £1.07M grant from the Regional Growth Fund for developing an Advanced Structural Dynamics Evaluation Centre brings together ITP Engines, GE, Aston Martin and Jaguar. On forensic engineering, the group is a member of the Materials KTN with the Home Office. The Group has collaborated with E.On, QinetiQ, Doosan Babcock, Alstom, NPL and Loughborough on a 4-year TSB project on power generation materials, and has led the 4-year FP7 MINTWELD (rated *excellent*) on welding with Oxford, EPFL, TUDelft, NUNU, KTH, UCD, Tata Steel, TWI, FRENZAK and ISPL. The new CDT (led by **Mechanics of Materials**, and including **Thermofluids**) involves international collaboration with: Rühr University, Bochum; TUDelft; European Powder Metallurgy Foundation; European Synchrotron Radiation Facility; Diamond Light Source; and ISIS. On space nuclear power systems, the group collaborates with Physics as part of an ESA programme with Queen Mary, National Nuclear Laboratory and Astrium.

Thermofluids spans Engineering and Maths and works on adaptive high-order numerical methods. The FP7 project AeroTraNet 2 seeking low-noise jet configurations, led by **Rona**, is a consortium of 9 European partners: Leicester, CERFACS, University of Rome 3, University Paul Sabatier, von Karman Institute, Insean, Alstom, Airbus and Greenwich. Work on boundary layer transition is with Cambridge, Warwick, Birmingham and KTH Stockholm. Streamwise vorticity research is with NRC Canada, and simulation on shear flows with Loughborough.

Exemplars of contributions to the discipline and leadership in the academic community:
Our strength in depth is demonstrated through the fact that virtually every academic has evidence of contributions, and in many cases this is very strong.

Conference chairs: An Interdisciplinary Approach to Fluid Mechanics, NAIS, Cambridge, 2014 (**Garrett**); Adaptive Hardware and Systems Conf 2014, NASA/ESA (**Vladimirova**); IET Int Conf Ionospheric Radio Systems and Techniques 2009 (**Warrington**).

Conference organising committees: RNEC08, SoSE2011, ICINCO 2011 (**Gu**); 3 including 5th Int Granulation Workshop Lausanne 2011 (**Sinka**); IET Int Conf Ionospheric Radio Systems and Techniques 2012 (**Warrington**);

Conference scientific and technical committees: 7 including the Biennial Semisolid Processing Conferences (**Atkinson**); Jicable HVDC'2013 (**Dodd**); European Control Conference, 2013, 2014 (**Lecchini Visintini**); 5 UK-NFP x-noise conferences (**Rona**); 3 including UK-China Particle Technology Forum III, 2011 (**Sinka**); IEEE Confs Decision and Control (**Turner**); 4 including the Int Conf Field Programmable Logic and Applications (FPL) (**Vladimirova**); Loughborough Antennas and Propagation Conf (**Warrington**).

Plenary / major lectures: 5 on semisolid processing and 5 lectures in Belgium, China, India, Italy, S Africa, UK (**Atkinson**); 1 on sintering in China (**Pan**); 4 on neuroscience in Argentina, France, Spain (**Quian Quiroga);** 1 on particle technology in China (**Sinka**); 3 on space systems in

Australia, Germany, Jordan (**Vladimirova**); Hugh Macmillan Memorial Lecture (**Vladimirova**);
Keynote talks: 4 on sintering and on biomaterial degradation (**Pan**); 16 on neuroscience and the art/neuroscience interface (**Quian Quiroga**).
Invited papers: 2 inc. the 2nd Int Electrical Ageing Workshop, France, 2008 (**Dodd**); 1 on sintering **(Pan**); Australian Space Sci Conf 2011, IEEE Int Geosci Remote Sensing Symp 2009, SPIE Defence, Security and Sensing Conf 2009, Int Conf Earth, Energy and Eng 2008 (**Vladimirova**); Radio and Direction Finding Symp 2008, European Space Weather Week 2009 (**Warrington**);
Best paper prizes: IFAC *Automatica* 2008 (**Prempain**); US Aerospace Control and Guidance Systems Committee (ACGSC) 2008 (**Turner** and Brieger (DLR)); IET Conference on Ionospheric Radio Systems and Techniques 2012 (**Stocker**, **Warrington**); Best Student Paper Award Adaptive Hardware and Systems 2013 (Siegle, **Vladimirova**).
Journal editorships: Editorial boards - World J Eng Technol (**Garrett**); Int J Adapt Control (**Lecchini Visintini**); J Biotechnol Biomater (**Pan**); J. Bioeng & Biomed Sci (**Pan**); ISRN Mater Sci (**Pan**); Chinese J Comput Mech (**Pan**). **Associate** - IFAC Control Engineering Practice (**Gu**); J Européen des Systèmes Automatisés (**Prempain**); Computational Intelligence and Neuroscience (**Quian Quiroga**); Int J Control (**Turner**); IEEE T Aero Elec Sys (**Vladimirova**); J Eng (**Weston**). **Reviewing editor** - Frontiers in human neuroscience (**Quian Quiroga**).
Journal reviewers: All academics review for major international journals. Examples from our 7 ECRs are cited. Prog Energ Combust, Energ Convers Manage (**Bagdanavicius**); AIAA J, Comput Fluids (**McMullan**); IEEE T Control Sys Technol, Int J Control (**Morales Viviescas**); J Neurophysiol, PLoS ONE (**Pedreira**); IEEE T Signal Proces, J Neurosci Meth (**Rey**); Mater Chem Phys, Wear (**Weston**); Composites A, Composites Sci Technol (**Williams**).
Research Councils: BBSRC: Pool panel member (**Quian Quiroga**). **EPSRC:** Member 4 person Panel of Enquiry commissioned by the Council Chair on strategic advisory routes (**Atkinson**); chair mid-term review (**Atkinson**); panel member (**Atkinson**, **Pan**); College member (**Atkinson**, **Gu**, **Hainsworth**, **Pan**, **Rona**, **Sinka**, **Vladimirova**, **Warrington**); Large Facilities Requirements Capture Working Group (**Hainsworth**), Structural Ceramics Network Road Map (**Sinka**). **MRC:** Panel member, Biomedical Informatics Fellowships (**Quian Quiroga**). **STFC:** Chair, Facilities R and D Panel (**Hainsworth**); Physical Sciences and Engineering Advisory Panel (**Hainsworth**)
Overseas reviews: Research agencies (**Atkinson**, **Dong**, **Garrett, Pan, Quian Quiroga**, **Rona, Schlindwein**, **Sinka, Vladimirova, Williams**); FP7 (**Rona, Vladimirova**); Statutory Review Panel for the ESF Materials Science and Engineering Expert Committee (**Hainsworth**).
Committee service: President Engineering Professors' Council (**Atkinson**); Royal Society Research Appointment Panel A(ii) (**Atkinson**); Treasurer, IOP Dielectrics Group (**Dodd**); Board IoMMM Light Metal Division (**Dong**); Steering Committee EC EuMaT (**Dong**); NPL Industrial Advisory Group Processing Liquid Metals (**Dong**); IoMMM Structural Materials Committee (**Hainsworth**); Scientific Advisory Council, Helmholtz Zentrum Berlin für Materialien und Energie (**Hainsworth**); Vertical Lift Network (**Morales Viviescas**, **Turner**); IMechE Academic Standards Panel (**Sinka**); IoMMM Particulate Engineering Committee (**Sinka**).
Royal Academy of Engineering: FREng, Council member and Vice-President **(Atkinson)**.
Fellowship of professional institutions: IET (**Gu**, **Warrington**); IMechE (**Atkinson**); IoMMM (**Atkinson**, **Hainsworth**, **Sinka**).
Visiting professorships: Arts et Metier ParisTech (**Atkinson**), General Research Institute for Non-Ferrous Metals, Beijing (**Atkinson**), Buenos Aires (**Ison**), University of Buenos Aires, Argentina (**Quian Quiroga**); CONICET, Argentina (**Quian Quiroga**); SISSA, Trieste, Italy (**Quian Quiroga**); Leibniz Institute for Neurobiology, Magdeburg, Germany (**Quian Quiroga**); Paul Sabatier University, Toulouse, France (2010) (**Rona**), Surrey Space Centre (**Vladimirova**).
Awards: Doctor *honoris causa*, Univ. Liège (**Atkinson**), Lee Hsun Lecture Award, Institute of Metal Research, Chinese Academy of Sciences (**Atkinson**) IoMMM Rosenhain Medal (**Hainsworth**). Royal Society Wolfson Research Merit Award (**Quian Quiroga**).
European Cooperation in Science and Technology Actions: COST296 Mitigation of Ionospheric Effects on Radio Systems, UK Management Committee representative and Working Group Leader (**Warrington**); COST541 Thixoforming Steel, Vice-chair (**Atkinson**).
Framework 7: Dong led the MINTWELD consortium; **Pearce** selected as Co-leader for RTD-A11 module within Robot Companion EU Flagship initiative.