Institution: University of Southampton

Unit of Assessment: 15 General Engineering

a. Overview: Our UoA is the Faculty of Engineering and the Environment (FEE) at the University of Southampton, which was formed on 1 August 2010 as a result of the restructuring of the University and the merger of the School of Engineering Sciences (SES), the Institute of Sound and Vibration Research (ISVR) and the School of Civil Engineering and the Environment (SCEE). In RAE 2008, SES and ISVR submitted to Sub-panel (SP) 28 (mechanical, aeronautical and manufacturing engineering), and SCEE to SP 27 (civil engineering). Our UoA is a large, multidisciplinary group covering a range of engineering and applied science disciplines. There is a strong emphasis on the interactions between engineering, the environment and people. In addition to traditional engineering disciplines, our UoA includes staff working at the interfaces between physical engineering and complex biological systems, for example in environmental and ecosystem management, human factors and performance sport. Together, we address key challenges facing society today such as sustainable energy, green transport, resource efficiency, resilient infrastructure, bio / medical engineering, and mitigating and adapting to climate change.

Table 1: Research outputs by theme, 2008-13

Theme	Returned staff: primary theme	PhD/EngDs completed[1]	Total research income[2]	Journal papers	Impact case studies (ref nos)
Acoustics	17	26.5	£12.8M	248	08,40
Bioengineering & Human Factors	26	36	£6.3M	424	03,04,08,12 20,21
Computational Engineering	13	16.5	£12.8M	181	02,18,22
Energy & Climate Change	20	29.5	£13.0M	522	31
Fluid Dynamics	29	28	£14.9M	410	06,15,40
Geomechanics & Geo-enviro Engng	11	18.7	£10.0M	158	32,41
Materials & Surface Engineering	23	20.2	£11.6M	740	16
Mechatronics, Signal Proc & Control	15	26	£4.3M	276	24
Structures & Solid Mechanics	21	28	£5.8M	278	01
Transportation	7	13.5	£6.1M	148	33
Water & the Environment	12	23.5	£5.6M	168	36,41
All themes	194	266.4	£103.2M	3553	Total 20

[1] 1 Aug 2008 to 31 Jul 2012, fte by supervisor [2] 1 Jan 2008 to 30 June 2013

Solving societal problems requires a flexible structure that enables engineers to work together and across disciplines in responsive and changing collaborations, whereas people management requires stability and consistency. To provide that stability, each member of staff is assigned to an academic group within one of four academic units (AUs). Academic staff are line managed by their group Chair or AU Head and senior staff by the Dean. Staff development is through mentoring, regular informal discussion and support, and a formal annual Personal Performance and Development Review (PPDR). Academic and leadership duties are allocated with reference to common workload norms to ensure an equitable distribution across the Faculty.

Research projects are organised more flexibly into eleven themes covering but transcending the traditional disciplines of aeronautical, civil, environmental, maritime and mechanical engineering. Each member of staff has a primary theme, but may be active in others. Staff, students, key outputs and research grant income are summarised by theme in Table 1.

b. Research strategy

The Faculty's *MISSION* is to change the world for the better through our research, innovation,

enterprise and education in engineering and applied environmental science, by the application of new knowledge and methods to the solution of practical problems for the benefit of society. We nurture and develop talented individuals to form effective and coherent groups and themes across areas of internationally leading strength; ensure that they are well supported with high quality facilities and equipment; and engage closely with industry and government in the definition, funding, execution and uptake of our research (see REF3a).

EVALUATION OF CURRENT POSITION : Our 2008 RAE submission to SP28 (mechanical, aeronautical and manufacturing engineering) described "a culture for innovation, enterprise and entrepreneurship….with the generated knowledge transferred into education and industry"; "continued investment in experimental, computational and manufacturing facilities [that] enhance the student experience, increase entrepreneurship and sustain a high quality research base"; "a commitment to maintain a world-class computational and experimental infrastructure"; and "the development of key strategic partnerships providing a framework for increasing integration of research and enterprise". Our submission to SP27 (civil engineering), said we would "continue research that has global impact in our key application areas, while advancing fundamental scientific knowledge and understanding in core civil and environmental engineering disciplines".

Planned areas of activity, with an indication *in italics* of how they have been taken forward, were as follows. Areas in which we are already producing real impact are indicated by superscript Impact Case Study reference numbers. Relevant themes are in bold.

- vibroacoustics including biologically inspired structures for control of sound and vibration, incorporating human response metrics into the design of isolation systems, and aeroacoustics(15-40). *These have been taken forward through four appointments in the* **Acoustics** *and* **Computational Engineering** *themes, and the establishment of the Airbus Noise Technology Centre in 2008 complementing long standing links with Rolls Royce via two University Technology Centres in gas turbine noise and computational engineering.*
- bioengineering including orthopaedic biomechanics(15-12, 15-20), "smart" prosthetics and engineering for micro-biology, novel ways of detecting patterns in brain activity to operate computers by severely paralysed patients, human response to motion (balance, gait) and vibration(15-21), and biomimetic solutions in structures/transportation/sensors(15-08). **Bioengineering** *is an identified Faculty research theme with six new staff appointments and research grants as in Table 1. The Faculty participates in the cross-University Institute for Life Sciences (IfLS), established in 2011.*
- cochlear implants; increasing our fundamental knowledge of hearing and improving the performance of hearing aids and cochlear implants(15-03).
- energy technology encompassing renewables(15-31, 15-36, 15-41), technology for a hydrogen economy, photovoltaics, efficient combustion including systems level issues of technology integration and public policy; advancing sustainable energy technologies including marine (ocean current, offshore wind and wave), low head hydropower, waste and crop biomass(15-41), carbon sequestration (with Ocean and Earth Sciences)(15-08) and microgeneration(15-31); improving understanding of the impacts of climate change, and developing appropriate responses at local to global scales. *These have been taken forward through six new staff appointments, grants and extensive government and industry advisory work within the* ***Energy and Climate Change*** and **Water and the Environment** *themes.*
- hydrosciences including the engineering implications of a changing environment, technologies to enhance satellite observation of the oceans, the development of bioinspired sonar systems(15-08); human body hydroacoustics(15-08), and space acoustics(15-08). *This area has been progressed through research and nine new staff appointments in* **Fluid Dynamics**, **Water and the Environment**, **Energy and Climate Change**, and **Acoustics***, establishment of the MoD/Lloyds' Register Centre of Excellence in Marine Structures (2008), the BAE Systems University Technology Partnership in Maritime Systems Design (2010), the Southampton Marine and Maritime Institute (SMMI, 2012), the Shell Shipping Research Centre (2013), performance sports engineering (Queen's Anniversary Prize 2012), and the new fluid dynamics facility on the Boldrewood Engineering Campus.*
- developing improved strategies for sustainable built environments including quality of life, energy (*taken forward in* **Energy and Climate Change**), resource management (**Water and the Environment**)(15-08; 15-36), road and rail transport and infrastructure(15-01, 15-32) (*nine new staff*

in **Transportation, Structures** and **Geomechanics**, *major collaborative grants including TRACK21, Network Rail Strategic University Partnership in Future Infrastructure Systems*).

- tiny technologies: from nanotechnology to distributed systems of small vehicles incorporating activities in systems and devices, nanomaterials, metrology and characterization, modelling and bioengineering at small scales. *Key elements have been taken forward through the* **Materials and Surface Engineering, Mechatronics** *and* **Bioengineering** *themes with six associated new staff appointments*.
- improving understanding of the impacts of hydraulic structures such as dams, turbines and artificial reefs on ecosystems and biodiversity[15-36]; *four new staff in* **Water and the Environment** *and development of the International Centre for Ecohydraulics Research.*

Our commitment to developing career pathways for our most able post-doctoral researchers has been taken forward through a Faculty investment of £1.9M over five years, bringing the eleven most promising Early Career Researchers into tenure track positions through our *New Frontiers Fellowship* scheme. Growth and investment in physical infrastructure has continued, as exemplified by the major new experimental facilities currently under construction at the Boldrewood Engineering Campus, outlined in section **d**.

STRATEGIC PLANS: The five key elements of our strategy are:

- to recruit and develop able and committed academic staff, who either already are or have the potential to be of internationally leading standard within their field (the number of staff entered in UoA15 is 192.23 fte, up from 168.2 fte in SP27 and SP28 in RAE2008).
- to encourage and facilitate staff to come together to form teams, both within a discipline area to ensure long term stability and across discipline areas to give the flexibility needed to address society's global grand challenges, evidenced by the development of themes and cross-disciplinary University Strategic Research Groups including SMMI and IfLS.
- to support our academic staff with world class experimental and computational facilities, at Southampton and through collaborations with other research institutions, evidenced by recent investments in high performance computing, imaging, autonomous vehicles, fluid dynamics and infrastructure research and the £200M+ Boldrewood Engineering Campus (see below).
- to engage with industry in recognising, defining, analysing and solving major engineering challenges of practical relevance and societal importance, and ensuring that the solutions are implemented in practice to change the world for the better (the twenty Impact Case Studies we have submitted were taken from a shortlist of forty-one).
- to work in partnership with other higher education and research institutions, both in the UK and internationally through the *Worldwide Universities Network* (WUN) and individual local arrangements, to ensure that our research is of world-leading quality and relevance.

Our mission and strategic aims are achieved through a combination of recruitment, retention and staff development activities; a rolling programme of upgrading and refurbishment of our facilities and estate; continued development of strategic, corporate-level collaborative agreements with key industry and academic partners in the UK and internationally; and the vigorous pursuit of the funding needed to maintain a world-leading quality of research. Exemplars are given later, but the spirit and ambition are encapsulated by the opening in 2014 of the new Boldrewood Engineering Campus (BEC), which will see part of the Faculty co-located with engineers from Lloyd's Register (LR) and the Southampton Marine and Maritime Institute (SMMI) at its heart. The first phase of the BEC represents an investment of over £210M (£119M from LR and the rest from other sources), and includes a state of the art Experimental Fluid Dynamics facility along with laboratories for UAV, infrastructure and performance sports engineering research. It coincides with the establishment of formal links between SMMI and the Singapore national research funding body A*STAR, which with the recent opening of the University of Southampton Malaysia Campus (USMC) reinforces the University's global engineering presence.

The BEC will place users at the centre of our research and education community, whence they may inform, help shape and employ our outputs of both people and knowledge.

c. People

i. STAFFING STRATEGY in relation to research and infrastructure and staff development: The University is committed to research excellence and the Faculty aims to sustain and improve

research performance by attracting, developing and retaining high-achieving staff, and nurturing those in early career. Our aim is to grow and develop our strengths, ensuring critical mass in key research areas.

The UoA has complete control and autonomy in its management and staff appointments, subject to an annual business review. New appointments are planned with reference to Faculty requirements and opportunities, and approved with reference to the Strategic Plan. Teaching rightly has an influence, but we rarely have to make new appointments on this basis alone and the research quality of an individual is paramount. All appointees must either already be performing at an international level or have the potential to do so. Over the REF period, our 45+ new appointments (equivalent staff turnover ~5% p.a.) have reinforced and enhanced areas of research strength or enabled us to move into new but related areas of research opportunity.

Appointments in support of key themes (in bold) and major facilities (section **d**) include

- Fazi (2010), Kingan (2010) and Hussein (2013): experimental **acoustics** facilities.
- Glynne-Jones (2012 to NFF), Sengers (2009), Stoodley (2009), Zhang (2010), Heller (2012) and Dickinson (2012): **bioengineering** laboratories.
- Richardson (2010): IRIDIS supercomputers in **computational engineering**.
- Kramer (2010), Armstrong (2012) Jiang (2013) and Kahanda Koralage (2013): electrochemistry facilities in **energy technologies**.
- Myers (2010) and Teli (2012) in **energy and climate change**.
- Philipps (2009), Ganapathisubramani (2010), Niu (2011), Angland (2012) and Weymouth (2013): wind tunnel facilities in **fluid dynamics**.
- Loveridge (2013), Smethurst (2012): **geomechanics**.
- Roose (2009) and Schneider (2013) μ-VIS imaging centre; Limbert (2009), Ratoi (2009), Stoltz (2009) and Polcar (2011), nCATS tribology and surface characterisation experimental facilities in **materials and surface engineering**.
- Daley (2010), Gandchi-Tehrani (2010), Laila (2011), Shu (2011), Blumensath (2012) and Cruden (2012): **mechatronics, signal processing and control**.
- Acintha (2011), Clubley (2011), Pierron (2011), Thomsen (2011) and Hussein (2013): infrastructure and composites experimental facilities in **structures and solid mechanics**.
- Box (2008) and Stanton (2009) in **transportation**.
- Schreckenberg (2009), Manes (2011), Zhang (2012), de Almeida (2013) and Liu (2013) in **water and the environment**.

CAREER DEVELOPMENT SUPPORT: Our UoA aims to develop an ethos and culture of entrepreneurship in research and teaching in all academic and research staff. In addition to the themes (for flexibility) and groups (for stability) described in section **a**, the UoA participates strongly in cross-University bodies, e.g. *Southampton Rail Systems Research* (SR^2); the μ-VIS imaging centre; University Strategic Research Groups in *Energy* and *Sustainability Science*; SMMI; and the *Institute for Life Sciences* (IfLS), all providing platforms for cross-disciplinary work. The strength of these initiatives is illustrated by the size of the membership: SMMI and IfLS each have over 200 academic and research staff members, with 75 and 32 respectively from the UoA. We expect staff to apply their skills to solving problems that are intellectually challenging and important to society, and develop new skills through action learning and formal training. Research plans form an essential part of the annual PPDR for all staff. Workloads for established staff are managed with reference to Faculty norms, with the balance between research, teaching and administration varying between individuals but with the expected overall contribution being consistent for staff at a given level.

New academic staff have a mentor to support them in the supervision of research students, the development of projects and the preparation of research grant applications. They have a reduced teaching and administrative load for the first 1-2 years of their appointment, and priority access to Faculty research studentships. Although allocated for management purposes to a single Group, all staff are encouraged to join cross-cutting themes where this supports their research. Pump-priming funding is available for new members of staff to initiate research, with achievements and requirements being assessed through ongoing mentoring and annual PPDRs.

We have established a successful *Fellowship Network* to mentor, encourage and support new

academic and early career staff to apply for major external fellowships (EPSRC, Leverhulme, Marie Curie, RAEng, Royal Society, etc.). We currently have ten such Fellows, with seventeen having been held or awarded over the REF period (see later). We have also developed the post of *New Frontiers Fellow*, a lectureship-track appointment with an enhanced period of support for the development of independent research and teaching based on the RCUK "Roberts" model.

Effective integration of early career researchers (ECRs) into our research community is a key objective. On arrival, ECRs are provided with a personalised, targeted induction programme to introduce them to the University, the Faculty and their academic group / unit. In addition to the normal line management structure, we operate an ECR mentoring scheme whereby senior colleagues from other areas of the Faculty give career guidance, review long term objectives and act as general confidante. ECRs are invited to Academic Unit and Faculty Forum meetings, and are fully integrated with academic staff in research and education matters.

The University's *Professional Development Unit* (PDU) offers a dedicated workshop programme with events themed within the four domains of the *Researcher Development Framework* (RDF): knowledge and intellectual abilities; personal effectiveness; research governance and organisation; engagement, influence and impact. The RDF supports ECRs in undertaking self-evaluation and identifying their individual needs to achieve academic and professional career goals. ECRs with significant teaching responsibilities undertake a *Postgraduate Certificate in Academic Practice* (PCAP) leading to Higher Education Academy accreditation. All ECRs, including postdoctoral research assistants (PDRAs), are encouraged to develop supervision and team management skills by co-supervising PhD students alongside more experienced colleagues. Guidance in writing funding and fellowship applications is provided through mentoring and the Fellowship Network, and research-focused secondments to research partners are encouraged. The UoA ensures that ECRs are engaged with the global research community through regular attendance at national and international conferences, and through University level collaborations including the *Worldwide Universities Network* (WUN), a consortium of leading higher education research institutions of international standing from around the world whose mission is, through collaboration, to accelerate the creation of knowledge and develop leaders able to address the significant challenges and opportunities offered by our rapidly changing world.

Continuing development needs are met through a combination of central and local provision of courses, workshops, mentoring, PPDR and peer to peer learning. The University's PDU offers courses, resources and advice to all staff in line with the *Vitae* initiative. As an example, the PDU Leadership Programme helps staff develop skills in managing teams from small research groups to academic units or faculties; the workshops and programmes provide information and support to staff at all levels of management. The *Researcher Mobility Programme* and the *Career Destinations* service are available to ECRs alongside other staff and students.

THE CONCORDAT to Support the Career Development of Researchers (hereafter referred to as "the Concordat") is a key policy driver for ensuring we place researchers at the heart of our strategic ambition. As a signatory to the Concordat, the University is actively implementing its seven principles through the PVC for Research, Professor Philip Nelson, supported by Human Resources, the PDU and the *Advisory Group on the Implementation of the Concordat* (AGIC). AGIC comprises a range of stakeholders including research managers, administrative staff and research staff representatives from across the University. This ensures that the principles of the Concordat are applied across the University in an equitable and meaningful way, making a genuine difference to the experience and employment prospects of research staff in that:

- all research staff and their PIs understand, appreciate and apply the principles of the Concordat in their working relationships across all academic units.
- HR processes and policies are applied to research staff, without exception.
- all research staff have the opportunity to build their CVs, develop their professional skills and enhance their career prospects.
- all PIs and line managers are supported to apply the principles of the Concordat to their staff.

We recognize both the crucial importance of our research staff and the need to ensure that clear and appropriate career pathways are open to them. The Faculty is large enough to provide financial buffering for staff whose circumstances prevent them from applying directly for RCUK funding, and opportunities for researchers to develop skills by working between and across

disciplines. The UoA works proactively with ECRs in seeking funding and positions to retain and develop talented researchers: academics are alerted to ECRs becoming available for new projects as soon as vacancies arise. Our Concordat Champion, Dr Emiliano Rustighi, leads the UoA's mentoring programme for all ECRs and our *Diversity Working Group* (DWG, see later).

Generally, research posts fall into one of three categories: (i) a training post, from which someone would be expected to move on at the end of the term. This might be associated with an opportunity to enrol for a PhD or to achieve some other specified career goal, for example the publication of key outputs and papers; (ii) a higher level post doctoral researcher, responsible for looking after a particular facility and assisting with the supervision of a number of PhD students; (iii) an academic career track position, such as a New Frontiers Fellow. Staff may progress through the range of categories, facilitated by PPDR and mentoring. The size of the UoA coupled with Faculty policy gives the 97 fte staff in category (ii) excellent career prospects.

PERSONAL RESEARCH FELLOWSHIPS: Our Fellowship Network was established to identify outstanding junior academics and post-doctoral researchers, and support them to secure prestigious externally-funded fellowships and permanent academic posts in our own and other universities. The Network reviews applications, helps to secure academic and industrial partners, allocates significant Faculty support (typically a 3.5 year PhD studentship plus consumables, travel and equipment costs), organises mock panel interviews and review training, and assists with pre-application reviews. In addition to the normal mentoring and support provided for early career academic staff, externally-funded Fellows meet as a group with our New Frontiers Fellows.

The approach has led to the award of major research fellowship over the REF period by:

- EPSRC (Shrimpton, Advanced, 2007-8; Wilson, Advanced, 2010-2; Richardson, Career Acceleration, 2010-5; Renno, Early Career, 2013-7).
- EU (Tiwary, Marie Curie, 2013-5).
- Leverhulme Trust (de Kat, Early Career, 2014-7; Bhaskar, Senior Research, 2011-2).
- NERC (Czerski, 2010-3).
- RAEng (Sandberg, 2007-12; Sobester, 2007-12; Fazi, 2010-5; Loveridge 2013-8).
- RCUK (Xhang, 2006-12; James, 2007-12; Taunton, 2008-12).
- Royal Commission of 1851 (Sinayoko, 2013-6).
- Royal Society (Roose, 2009-13; Chen, Newton International, 2012-4).

Sandberg, Ganapathisubramani and Roose have since been promoted to chairs, Shrimpton to a readership and Sobester to a senior lectureship. PDRAs promoted against external competition to academic posts include Angland, Armstrong, Dickinson, Fazi, Box, Czerski, Glynne-Jones, James, Limbert, Loveridge, Myers, Priest, Sengers, Smethurst, Toal, and Zhang. Pierron won a Wolfson Research Merit Award (2012-7), and Ganapathisubramani an ERC Starting Grant (2012-6).

INTERNATIONAL RECRUITMENT: The international standing of our academic staff at all levels is demonstrated by the appointments we have made from non-UK universities and industry over the REF period, and the number of our staff who have left for higher level posts outside the UK. Appointments include Heller (from Charité-Universitätsmedizin Berlin, 2012); Liu (Nanyang Technical University, 2013), Manes (Politecnico di Torino, 2011); Pierron (Arts et Métiers ParisTech, 2011); Polcar (CTU Prague, 2011); Shu (Hamilton Institute, National University of Ireland, 2011); Stolz (University of Basel, 2009); Stoodley (Montana State University, 2009); Thomsen (University of Aalborg, 2011); Weymouth (MIT, 2013); Richardson (Sandia National Labs California, 2010); Czerski (University of Rhode Island, 2010); Schneider (ETH Zürich, 2013). Leavers (to at least Associate Professor level or equivalent industrial roles) include Coleman (NASA, 2012); Jentsch (Bauhaus Universität Weimar, 2012); Karlin (ETH Zürich, 2011); Mace (Auckland, 2010); Nair (Toronto, 2010); Priest (Calgary, 2013); Stoodley (Ohio State, 2013); Taylor (Flinders, 2012); Thurner (Vienna University of Technology, 2013).

INTERNATIONAL VISITING SCHOLARS include Professors Suman Chakraborty and Tapas Maiti (Indian Institute of Technology Kharagpur), Larry Kazmerski (National Renewable Energy Lab, Colorado), Colin Woodroffe (University of Woolongong), John Schoon (Northeastern University, Boston, Mass); Qingjie Cao (Harbin Institute of Technology); Ying Ye (Zhejiang University); Drs David Bolzonella (Univ. of Verona), Lyubov Pak (Almaty Institute of Power

Engineering & Telecommunications), and Margarida Pinho-Lopes (University of Aveiro).

EQUALITY AND DIVERSITY: The University of Southampton has a track record of early and consistent engagement with initiatives to support and enable the progression of researchers' careers. The University was a founder signatory to the Athena SWAN charter in 2005, receiving a Bronze award in 2006 (renewed 2009 and 2013). In 2010, the University signed up to the *Concordat to support the Career Development of Researchers*. In 2012, the University was one of 12 institutions (there are now 57) to receive the *European Commission Human Resources Excellence in Research Award* in recognition of its commitment to supporting the personal, professional and career development of its researchers. This award acknowledged our alignment with the principles of the *European Charter for Researchers and Code of Conduct for their Recruitment*, which incorporates both the QAA *Code of Practice for Research Degree Programmes* and the Concordat. Our UoA supports these objectives completely, and is fully committed to equality and diversity (E&D).

Our UoA as a Faculty achieved an Athena SWAN Bronze Award in 2013. Our Diversity Working Group (DWG) develops and oversees E&D policy implementation and monitors our Athena SWAN action plan. The DWG reports regularly and directly to the Faculty Management Team. Membership of the DWG comprises ten staff at all levels including HAUs, the Associate Dean Research, Director of the Graduate School, enterprise staff, New Frontiers Fellows, ECRs and PGRs, and is strongly committed to implementing new initiatives as well as monitoring outcomes. Our Bronze award submission reflected our new structure and enabled us to strengthen our commitment to E&D. In preparing the application we carried out a complete review of our recruitment, retention, recognition and reward systems to ensure they are fair and transparent and well understood by all staff. On-going work as part of the Athena SWAN Action Plan includes further support for our outreach programmes aimed at increasing the number of female undergraduates, and training for all members of selection panels to overcome unconscious bias.

Our Athena SWAN action plan commits us to a number of actions over the next three years:

- to increase recruitment of female students and staff at all levels, through outreach and positive action programmes
- to provide improved support for career development and promotion, including the Faculty Fellowship network, career coaching via mentoring and developing action learning materials
- to ensure that the University's flexible and family-friendly working policies are properly understood and valued by all staff in the UoA, to facilitate greater uptake.

We aim to be able to apply successfully for an Athena SWAN Silver Award for the UoA in 2016.

To ensure that research staff on fixed-term contracts have similar maternity / paternity / adoption entitlements to those on permanent contracts, the Faculty has set aside funding to cover such payments where the funding body does not do so. We also provide the same systematic assistance with a return to work. All PGRs are covered by a Faculty parental leave and sickness leave policy that mirrors staff provision. There have been 16 periods of maternity leave in FEE in the current REF period and 39 periods of (2 week) paternity leave.

Our commitment to E&D is further evidenced by our continuing support of *Theano*, a networking group bringing together women that is open to all female students and academic staff across the University, founded in the 1990s. *WiSET*, founded 2002, is a group that helps shape the policies and culture of our University for women in science engineering and technology. Members of the UoA sit on the WiSET steering committee and have chaired this group. WiSET hosts the prestigious annual Campbell lecture and helped to develop our ECR mentoring programme.

ii. RESEARCH STUDENTS: Research student recruitment, training, support and progression is overseen by the UoA's *Graduate School* (GS), established in 2011 following the reorganisation of the University. Policies, procedures and processes that are uniform across the Faculty draw on previous experience and best practice within the Academic Units. The GS ensures that University quality frameworks and regulations are applied rigorously, including in monitoring progression, training, supervision, changes of registration status, and receiving and acting on student feedback. The GS also devises and oversees Faculty- and Group-led support and training for postgraduate research students (PGR). The GS committee meets formally twice a term, and reports to the Faculty Programme and Research Committees and thence to the Faculty

Management Team. Formal GS membership includes the Graduate School Director, a deputy director from each academic unit, the Associate Dean Education, the Faculty Education Manager, PGR administrators, the EngD Director, and finance staff involved with studentship payments. The GS takes a strategic overview of PGR admissions, studentship allocations, training provision at Faculty and University level, PGR progression and external examiners comments. Recent initiatives include establishing a quality framework and regulations for the provision of joint PhD programmes, both internationally and within the UK. These programmes are designed to support strategic collaborative research initiatives of importance to the Faculty, and to provide the students with a high-quality research and training experience. International collaboration is supported by split-site PhDs with King Abdulaziz University, Saudi Arabia, University of Tripoli (Libya), our Malaysia Campus (USMC) and A*STAR in Singapore. PhD student representatives input into the PGR Staff Student Liaison Committee and thence to formal GS events.

PGR RECRUITMENT AND ADMISSIONS are coordinated across the UoA to allow the systematic advertising of opportunities, although individual academics are encouraged to advertise further in specialist forums. Funding for students is provided through a variety of routes including the EPSRC doctoral training grant (DTG), a wide range of industry, the Faculty, the University, and the students themselves (most commonly through Government sponsorship of international students). The GS facilitates the funding of individual studentships from multiple sources, to broaden access and enhance the student experience e.g. by involving industry. Over 67% of the total Faculty spend on research studentships comes from external sources.

To attract the best students, we offer scholarships for international and EU students and enhanced stipends with industry sponsorship (e.g. CASE conversions) for UK students (for whom EPSRC Doctoral Training Grant funding can be used). University scholarships are allocated on a competitive basis with a GS panel judging applicants on academic quality and aptitude, the strategic importance of the research, and the availability of funding from external sources.

FEE PGR recruitment events are widely advertised online and in relevant magazines. We hold two open days p.a. to enable students to see our facilities and meet potential supervisors. Our PGR reps participate in these open days, giving talks and conducting tours. Applicants visiting in person will meet and discuss a number of projects with potential supervisors. Our summer internship scheme gives undergraduates (both internal and external) a taste of the University research environment, and has been an effective recruitment tool.

The GS ensures that all PGR students receive a full induction programme on arrival. In addition to a broad University induction, a Faculty-level induction explains the progression stages towards successful completion of their PhD and outlines the transferable skills training available to them throughout their studies. Induction activities include a cross-Faculty team building day, and sessions on *Managing your supervisor* and *Settling in*. Particular attention is paid to the training needs analysis and one month report (research plan). Teaching, demonstrating and conference attendance opportunities, and the use of the library and other resources are also covered at this stage. Induction within the academic Group provides more in-depth guidance on facilities-specific training they will receive. A number of Faculty, AU, and Group social meetings are held during and after induction, at which students get to know each other and members of staff. AUs and some programmes (e.g. the EngD) hold regular student-organised seminars and conferences.

TRAINING AND SUPPORT: The UoA is an active participant in the University's *Researcher Development & Graduate Centre* (RDGC), which provides a broad range of courses to enhance research-centred learning and provide transferable skills training so as to optimise the personal development of postgraduate students. Each student draws up a personal development plan, which provides them with a framework for reflection on their own learning, performance and achievement, and their personal, educational and career development. The GS coordinates cross-Faculty networking events throughout the year on academic integrity, preparing for progression milestones and viva examinations, writing up, writing papers, Faculty strategy and feedback on actions proposed in the light of our annual PGR supervision questionnaire. The PGR reps organise a "best supervisor" award each year (based on the results of the questionnaire). Subject-specific training is delivered via the Academic Units, Groups and research themes: this comes in a range of formats including seminar programmes from invited speakers, access to selected M-level modules, and further personalised directed reading. Each PGR student has a

Research Training Support Grant (RTSG) of at least £750 (which they are encouraged to supplement through additional funding applications) to attend and present papers at national and international conferences, and attend relevant summer schools.

CAREER DEVELOPMENT: Engagement with employers is an essential part of PGR career development. Many students within the UoA are working on topics that are highly relevant to industry and their research in most cases involves collaboration with these industrial partners. Students frequently attend conferences at which there is a large industry presence, while industry-based researchers are regularly invited to give seminars to the PGRs. Many PGRs go on to work for these companies as a result of engagement during their studies. All PGR students are encouraged to contribute to Faculty- and University-organised *widening participation* activities, at which they both lead activities and mentor young students considering university study. Our UoA runs an active schools outreach programme (N^3) in which many of our PGRs participate. Our PGRs also play an important role in our regular residential courses such as *Dragonfly* (aimed specifically at girls), *Headstart* and those run with the Smallpeice Trust. PGRs are also encouraged and trained to take part in teaching activities, such as undergraduate laboratory demonstration and small group tuition. This enables them to start to develop the teaching skills needed for an education-based career. We use the EPSRC-sponsored Doctoral Prize to help high-achieving PGR students start a research career (11 awardees in the past 3 years). While some alumni have moved institution or into industry, others have matured into an academic career track role (e.g. one as a New Frontiers Fellow).

PGR Internships provide an experiential learning environment through which research students contribute towards a project delivery and/or the strategic direction within a host organisation. As part of this, interns are expected to reflect on their experience and undertake a skills audit to assist in their personal development. Our researchers are all individuals with differing time commitments; we therefore negotiate a range of bespoke PGR internship opportunities with a range of organisations, available throughout the year. The WUN *Researcher Mobility Programme* (RMP) offers travel grants enabling PGRs and ECRs (senior PGRs, postdocs and junior members of Faculty) to visit an international WUN partners in Europe, the Americas, China, South East Asia and Australasia to establish and cultivate research links at both institutional and individual level. Many awardees credit the programme with having had a significant impact on their research and international career development. Our PGRs also participate in the Japan Society for the Promotion of Science Postdoctoral Fellowship for North American and European Researchers scheme. The *Career Destinations Service* includes dedicated PGR and international student web areas, holds careers fairs and events, provides training on CVs, applications and interviews, helps with work placements, and puts current students in contact with alumni offering careers advice, both individually and through careers talks and publications. Despite recent economic problems, industry demand for FEE students remains extremely strong.

PROGRESS MONITORING: We use a web-based system, *PGR Tracker,* to support progression monitoring and formal recording of all the training activities undertaken by each student. The system prompts students, supervisors, and examiners when various tasks are due for completion within the formal progression stages. Students submit reports at key progression points and supervisors/examiners give feedback on the reports and any subsequent viva, all through PGR Tracker. This ensures that a permanent, personalised and easily accessible record of the progress of every student is maintained. PGR Tracker automatically records university level training activities undertaken at the RDGC and allows the student to enter additional training and other activities to maintain a full record of their personal professional development. Students may also build up a record of personal development activities that complements their academic studies, through the University's Career Destinations service *Graduate Passport* initiative.

d. Income, infrastructure and facilities

Staff are encouraged to access facilities at other institutions around the world via collaborative research projects, but the infrastructure and facilities we own should be world-class and fully utilized. Major facilities (by theme), with related ICS numbers in superscript, include:

- One of the largest and most comprehensive suites of experimental **acoustics** laboratories in Europe, including large (55 m^2 / 348 m^3) and small (32 m^2 / 131 m^3) reverberant chambers, a large anechoic chamber (working area 54 m^2)$^{(15\text{-}24,\ 15\text{-}40)}$, the Doak jet and valve noise

laboratory (anechoic down to 400 Hz)[15-24, 15-40], and the A B Wood underwater acoustics laboratory with an 8 m × 8 m × 5 m deep water tank[15-8]. Equipment includes an array of microphones giving a complete 3-dimensional sound field for jet and valve noise, and various microphone and hydrophone based acquisition systems[15-8, 15-24, 15-40]. These facilities form the backbone of much of our pioneering research in sound and vibration, including the Rolls Royce and Airbus UTCs in aircraft noise. The AB Wood deep water tank is currently being used for research with DSTL (target detection), Statoil (gas pipe leakage), NERC (quantifying seabed methane)[15-8], and Kongsberg / Network Rail (sonar detection of bridge scour).

- **Bioengineering and human factors** facilities including biomechanics, cell culture and tissue laboratories; category 2 biocontainment rooms equipped with a multiaxial servo hydraulic test machine[15-20] and an electromechanical tissue testing machine, incubators, an atomic force microscope and a range of optical microscopes; -20°C walk-in and -80°C freezers; an extensive hearing and balance laboratory suite[15-3], and (for researching human responses to vibration) a 6-axis motion simulator; 12 m, 6 m and 1 m horizontal shakers; and a 1 m vertical shaker, with associated dynamic actuators and acquisition systems[15-21].
- **Computational engineering** facilities including the IRIDIS 3[15-15] and IRIDIS 4 super-computers and the Spitfire computer cluster. With 12200 cores (250 TFlops), Iridis 4 is the most powerful academic supercomputer in England, in the top 10 in Europe and top 100 in the world (based on a comparison with the June 2013 Top 500 list). The Faculty's Spitfire cluster has a total of 864 cores, approximately 20Tflops peak performance, 4Tbytes of RAM and 30Tbytes of (RAW) disk storage. These facilities underpin the Rolls Royce UTC in computational engineering, and are used in research across the Faculty.
- Facilities in **energy and climate change** include one stand-alone and two building-integrated instrumented photovoltaic arrays of 7.2 kiloWatt peak (kWp) and 12.5 kWp; various environmental data analysis and data logging systems; an experimental low head hydropower installation in Bulgaria; engine testing laboratories with Maxsys 900 raw exhaust analysis systems; extensive cryogenic laboratories used in the design of the superconducting magnets for CERN; a thick film fabrication facility for sensor research; and electrochemistry laboratories for battery and fuel cell research. In renewable energy, extensive use is also made of our hydraulics flumes and computational facilities, e.g. for the computer based modelling of tidal currents and the simulation of marine current energy converter arrays.
- Our **fluid dynamics** facilities comprise five wind tunnels including the R J Mitchell (test section 3.5 m × 2.4 m × 9 m) and another of cross section 2.1 m × 1.5 m (7' × 5'); a 26 m Lamont towing tank; a high pressure Ludweig tube; a 6 m × 1.2 m × 0.8 m optical flow flume; six water flumes shared with **water and environment**; and associated laser Doppler analysis and particle image velocimetry equipment and data acquisition systems. These facilities are used in our award-winning work in performance sports[15-15], aircraft noise, turbulence and renewable energy; and developing work on high speed train/track interactions with HS2 Ltd.
- **Geomechanics and geoenvironmental engineering** facilities include geotechnical laboratories equipped with resonant column, cyclic triaxial, hollow cylinder and cyclic simple shear apparatus; a low temperature / high pressure rig for testing gas hydrate bearing sediments; the internationally known Pitsea compression cell and consolidating anaerobic reactors used to investigate waste compression and degradation (on which similar equipment around the world is based); and in-house digital image analysis-based strain measurement equipment. The geomechanics laboratory and our associated field measuring expertise supports our work in waste mechanics, landfill engineering[15-41] and geotechnical transport infrastructure[15-32]. An environmental analytical suite is shared with **water and environment**, and an infrastructure laboratory shared with **structures and solid mechanics** houses a railway test facility used in the EPSRC Programme Grant *TRACK21* and to investigate the effect of sand ingress on a desert railway for Saipem-Dodsal-Technimont JV[15-32].
- **Materials and surface engineering** facilities have benefitted from investments associated with both the μ-VIS imaging centre and *nCATS*, the National Centre for Advanced Tribology at Southampton. Equipment includes a Nikon 225/450kV 'Hutch' walk in CT scanner; Nikon 225 kV HMX ST & Nikon CT160Xi CT scanners and an associated analysis suite; a Jeol JSM-6500F field emission scanning electron microscope; micro powder processing and microfabrication facilities; 3D contacting and non-contacting profilometry; a range of optical

microscopes; and associated metallography equipment. Equipment in *nCATS* includes pin-on-disc test rigs; a twin disc roller tribometer; and various wear, abrasion and erosion test rigs[15-16]. Much of this is used in other themes, from **geomechanics** (characterizing the structure of railway ballast using CT scanning) to **bioengineering** (prosthetic joint wear).

- **Mechatronics, signal processing and control** facilities include three laboratories used mainly for research into the active control of noise and vibration and novel developments in personal audio, equipped with a variety of multi-channel rapid prototyping control systems based around dSPACE and National Instruments hardware, Data Physics and LMS signal analysers and a range of microphones, loudspeakers, accelerometers and actuators. These underpin maritime noise and vibration control research that has attracted £1.5M in support from BAE Systems since 2010. Specialist electro-mechanical laboratories including thick-film and nanometrology clean rooms are used in research on novel actuators and vibration energy harvesting devices funded by the EPSRC Programme Grant in *Engineering Nonlinearity*.
- Facilities in **structures and solid mechanics** include a 36 m full-scale railway test track[15-01] and research laboratories housing a variety of computer controlled servo-hydraulic testing machines ranging from 1 kN to 1.5 MN in capacity; a 100 kN high strain rate test machine; and bi-and tri-axial loading machines. Facilities for stress analysis and crack / damage monitoring include ultrasonic scanning, and a suite of CCD and high speed infrared cameras with associated image-based strain measurement software. Composite fabrication and processing facilities include vacuum assisted resin infusion and an autoclave (1 m dia. × 1.5 m long). The infrastructure laboratory (shared with **geomechanics**) has a strong floor able to accommodate reaction frames for testing columns up to 6 m high and beams up to 5.5 m long.
- Facilities in **transportation** include a driving simulator and STISIM Drive™ simulation software. Our unique on-road instrumented vehicle[15-33] has been developed in-house over the past decade for use in driver behaviour analysis; it is equipped with a Race-logic VBox III dGPS system, IBEO ALASCA laser rangefinders, TRW auto-cruise radar sensors, a Seeing Machines faceLAB system, digital video recording equipment and data loggers. The transportation data analysis facility has a range of planning and modelling software and traffic data collection and processing equipment, including a continuous data feed from the Southampton Urban Traffic Management Centre (City Watch).
- Facilities in **water and environment** comprise a bioreactor laboratory (used in the development of anaerobic digestion from bench-scale to a commercially viable technology for the treatment of biodegradable municipal solid waste)[15-41]; a large-scale (100 m^2) raceway reactor; a 320-litre photobioreactor; an analytical suite (shared with **geoenvironmental engineering**) housing a range of gas chromatographs, mass spectrometers, atomic absorption and near infrared spectrophotometers, calorimeters and autoclaves)[15-41]; a 24 m tilting flume; 60 m outdoor flumes used in ecosystem / infrastructure interaction experiments[15-36]; 8 m and 12.5 m wave flumes; and field equipment e.g. drones for remote sensing.

An Area Academic Lead (AAL), supported by an Area Technical Lead (ATL) and an Area Safety Officer (ASO), is responsible for the operation and development of each facility or laboratory area. Facilities operate as profit centres in the Faculty financial model. They are credited with income earned from research and teaching, from which they meet the day-to-day running costs including consumables, routine equipment purchase and maintenance, and technical support. The AAL is charged with keeping the facility up to date with state-of-the art equipment, ensuring that the facility is efficiently utilized with a user consultative group and fair access for all. The ATL is responsible for the day-to-day safe and efficient running of the facility, with the ASO having an oversight and advisory role. Major investment in new equipment can be supported by the Faculty or the University centrally (e.g. through the *Multi User Large Scale Equipment Research fund*, MULSER), subject to a sound business case aligning with institutional strategy. Our infrastructure is supported by more than 60 technical staff, with a direct annual salary cost (met by the Faculty) of £2M.

INVESTMENT: The Faculty has a rolling programme of estate and infrastructure improvement worth ~£2M p.a. in addition to investments by the University and external sponsors. Prioritisation is led by the Associate Dean for Infrastructure (ADI) in consultation with the Dean and the Faculty Management team (FMT), through the annual business planning process. Recent projects funded in this way have included the modernisation of our laboratories for structural testing (including the

Testing and Structures Research Laboratory), mechatronics, materials and combustion; the RJ Mitchell wind tunnel (£0.75M); the Spitfire computer cluster (£0.25M); the μ-VIS suite; and our facilities for advanced manufacturing and associated research.

Faculty funding for equipment is often used to match or enhance external funding, and in collaboration with others, in line with our strategic objectives, giving a total equipment spend of typically £2-3M p.a. Examples include

- a Faculty-led grant of £2.8M (Cox, 2012) from EPSRC to develop a regional (South East) high performance computing consortium, with Oxford University and UCL, to exploit opportunities for the co-development and sharing of e-infrastructure capabilities including the IRIDIS 4 computer cluster.
- formation of SES-5 for equipment and research sharing between the Universities of Cambridge, Oxford and Southampton, UCL and Imperial College.
- a £1.9M capital grant and recurrent annual grants of £700k (Sinclair, 2009-14) from EPSRC for a multi-disciplinary centre for high resolution X-ray computed tomography, μ-VIS (Multidisciplinary, Multiscale, Microtomographic Volume Imaging at Southampton).

In June 2013, the University approved a £25M investment in a new centre for experimental fluid mechanics as part of the Boldrewood Engineering Campus (BEC) and the Southampton Marine and Maritime Institute (SMMI). A new, purpose-built 3,995 m^2 laboratory complex will house a cluster of facilities including a 138 m towing tank, a recirculating water tunnel, an anechoic wind tunnel, a hydromechanics laboratory, a shallow wave basin, a matched refractive index facility, a high pressure laboratory and an extensive suite of state-of-the-art diagnostic tools. The new complex will become operational in the autumn of 2014, and will further strengthen our work in all aspects of fluid dynamics from turbulence through performance sports engineering and aircraft noise to marine renewable energy.

During 2014, we will also be investing in the development of facilities in robotics and autonomous systems (jointly with colleagues in Electronics and Computer Science and Oceanography), facilitated by a £3.5M capital funding award from EPSRC; and a new Infrastructure Laboratory at BEC funded through a £10M grant from the UK Research Partnership Investment Fund (RPIF).

RESEARCH FUNDING PORTFOLIO: Our UoA has maintained a research economy of between £16M and £20M p.a. over the REF period. RCUK (notably EPSRC) is consistently the single biggest sponsor, accounting for about 45% of UoA research income. A further 40% comes from the EU government (primarily via the Framework programmes), UK industry, public corporations and central government sources. Industry income reflects our links with major high-level, high-impact collaborators including Airbus, LR, Network Rail and Rolls-Royce. A breakdown by theme is given in Table 1. Income includes £6.7M from five EPSRC Platform Grants in structural acoustics, waste and tribology, and £3.8M from three EPSRC Programme Grants in future spatial audio, engineering nonlinearity and railway track for the 21st century (*TRACK21*).

We aim to grow our research income by approximately 10% p.a. by increasing academic staff numbers and exploiting our research strengths. We also expect to see the positive impact on research income of recent appointments in areas such as **structures and solid mechanics** (Pierron, Thomsen) and **bioengineering** (Heller, Schneider); rising stars in **fluid dynamics** (Ganapathisubramani, Sandberg) and other areas (Roose et al.); and the developing careers of fellowship holders (Fazi, Loveridge et al.). The overall portfolio composition is unlikely to change materially, with EPSRC still seen as the most significant single sponsor of research. However, increasing emphasis will be placed on developing European funding opportunities to coincide with the launch of the Horizon 2020 funding programme, and on strengthening relationships with key industry and international collaborators. Our growing presence in Singapore and Malaysia, through a collaborative research agreement with A*STAR in maritime engineering worth about £5M to the UoA over 4 years (2013-18) and the University of Southampton Malaysia Campus, is a significant step towards increased internationalisation of our research income.

CONSULTANCIES AND PROFESSIONAL SERVICES: All staff are encouraged to carry out consultancy that involves exploitation of their previous or current research or the generation of new research ideas - usually through one of the enterprise units (*RIfI* and *E&E Partners*) we have established to facilitate this. Examples include advice on:

- aircraft noise management, for the UK Civil Aviation Authority, and Heathrow, Stansted, Gatwick and Helsinki Vantaa Airports (Flindell).
- sea level rise and coastal adaptation to climate change, for the US Army Corps of Engineers, the World Bank, the Asian Development Bank and the Singapore Government (Nicholls).
- the In Salah gas pipeline project, for Schlumberger (Armstrong).
- the Talisman oil rig off Norway, for Atkins; and riser interactions for Petrobras (Chaplin).
- the structural integrity of a preferred wave energy device, for the Carbon Trust (Hearn).
- ground energy systems (Crossrail) and earthworks management (Network Rail), for Mott MacDonald (Loveridge).
- Magnox waste handling and storage, for Sellafield Ltd. and NNL (Powrie, Wharton, Wood).
- groundwater control associated with a large drydock at Grays Harbor, for the Washington State Department of Transportation / Landau Associates; and the Dublin Metro for Jacobs (Powrie).
- temporary works associated with the St Germans pumping station (then the largest cofferdam in Europe), for Costain (Richards, Powrie).
- infrastructure /ecosystem interaction issues, for Scottish Natural Heritage, Spey District Salmon Fisheries Board, and SEPA / SNIFFER (P Kemp).
- high speed rail operations and economics for Strathclyde Partnership for Transport, Railtrack and HS2 Ltd (Preston).

and expert witness work in connection with alleged drainage system defects and aspects of bored pile retaining wall design at Wembley National Stadium (Powrie, 2008); engineering design and management issues at the Cranbourne landfill, Victoria, Australia (Powrie and Beaven, 2011-2); crankcase wear and failure in the vessel *Union Power*; Dalmere Spa *v* Union Maritime Ltd (Wood and Mellor, 2011-2); and recycling of waste lamps under the WEEE Regulations 2006, involving Philips Electronics UK Ltd, General Electric Lighting Ltd and Osram Ltd (Williams, 2012).

Other companies and organisations for whom staff have carried out specific individual projects over the assessment period include ABP-mer, Adams Kara Taylor, Aesculap, Agusta-Westland, Airbus, Arterius Ltd., Arup, Astrium, Association of Train Operating Companies, Atomic Weapons Establishment, BAE Systems, Baxter Healthcare, Biocomposites Inc., BioSurface Technologies, Bodycote, Boeing, BP, BTG plc, Casmir Inc. (India), Cochlear AG (Switzerland), Crompton, DePuy Orthopædics, DECC, DEFRA, DFID, DSTL, Dyson, Edwards Vacuum, E.ON, European Investment Bank, European Space Agency, GE Aviation, Gill Instruments, GKN Aerospace, GSK plc, Honeywell, HR Wallingford, IBM, Jaguar Land Rover, Johnson Matthey, Kind Consumer Ltd., Kongsberg, Larsen & Toubro Ltd. (India), Le Creuset UK, London Underground Limited, Luxfer Gas Cylinders, McLaren, Microsoft, National Audit Office, NHBC, NHK Laboratories (Japan), Philips Oral Healthcare, QinetiQ, Raddix Traffic Ltd, Ramboll Gifford, Rolls-Royce, Schlumberger, Semprus BioSciences; Skanska, Southampton City Council, Speedo, Transport for London, TRL, TWI, UK Environment Agency, UK MoD, Valam Inc., Veolia, Williams F1, World Health Organization and Ziyang Precision Machinery Co Ltd.

e. Collaboration or contribution to the discipline or research base. The UoA has an outstanding record of leadership of collaborative EPSRC-funded research consortia, including:

- Rail Research UK: two grants aimed at developing railway related research in UK universities, £8.2M, 2003-10, involving 12 research groups from 7 universities led jointly by Southampton and Birmingham. Led to the formation of the Rail Research UK Association.
- *Sustainable Urban Environment* programme consortia in waste (£1.6M, 2004-8, 6 universities), transport (£1.5M 2004-09, 3 universities), and innovation in the design, construction and operation of buildings for people (£1.7M, 2004-9, 4 universities).
- the *UK Turbulence consortium*: three grants involving up to 14 universities, £1M cash plus over £11M in access to supercomputing facilities, 2006-18.
- *iConnect:* engineering interventions to promote active travel (£2.3M, 2008-13, 8 universities).
- *TRACK21*: programme grant on railway track for the 21st century (£3.14M, 2010-15, with the Universities of Birmingham and Nottingham).
- *Sixth Sense Transport,* developing flexible 24/7 transport (£0.7M, 2011-14, 5 universities).

In addition, the UoA is currently a key partner in collaborative EU and EPSRC grants including:

- *UK Infrastructure Transitions Research Consortium* (*ITRC*): Long term dynamics of

interdependent infrastructure systems (£4.7M, 2011-6, 8 universities led by Oxford).
- *Engineering nonlinearity* (£4.2M, 2011-16, 5 universities led by Bristol).
- *Transforming the engineering of cities* (£6.3M, 2012-7, 4 universities led by B'ham).
- *International Centre for Infrastructure Futures* (£3.4M, 2013-6, 5 universities led by UCL).
- *ISMART* (***I**nfrastructure slopes: **S**ustainable **M**anagement **A**nd **R**esilience assessmen**T***) (£1.7M, 2013-6, 5 universities and BGS, led by Newcastle).
- *Advanced structural materials for marine renewables* (£1M, 2013-6, 3 universities led by Strathclyde).
- *Assessing the Underworld*: an integrated performance model of city infrastructures (£5.8M, 2013-17, 6 universities led by Birmingham).
- *S3A*: *Future spatial audio for an immersive listener experience at home* (£5.4M, 2013-8, 3 universities led by Surrey).

The UoA also plays a key role in the establishment and organisation of specialist international research workshop and conference series, e.g. hydro-physico-mechanical properties of wastes (Beaven / Powrie / Richards; Braunschweig 2009, Santander 2011, Edinburgh 2013); aero-acoustics (Joseph; 2008, 2009, 2010, 2012); composites testing and models (Pierron; Dayton Ohio 2008, Lausanne 2011, and Thomsen; Aalborg 2013); zero waste in industrial networks (Williams; Southampton 2010, Vienna 2010, Berlin 2012, Budapest 2013); and competition and ownership in land passenger transport (Preston; Delft 2009, Durban 2011, Oxford, 2013).

INTERDISCIPLINARY RESEARCH: In October 2010, the University launched the Institute for Life Sciences (IfLS), which represents a University-wide multidisciplinary collaboration drawing together expertise in science and engineering to address the life sciences. IfLS has fostered strong links between NOCS and the main University Highfield campus, as well as Southampton General Hospital, including access to state-of-the-art imaging, bioinformatics, proteomics and lipidomics facilities and expertise. October 2011 saw the establishment of the *BioXneT* initiative, which has provided an identity and focus for bioengineering in the Faculty and stronger links across the University in medicine, healthcare, and the life sciences. BioXneT has enhanced our participation in the IfLS, and facilitated the award of a £550k research grant on sensors for lower limb prosthetics from the MRC (MR/L013096) with an Engineering PI (Jiang) in 2013.

The Southampton Marine and Maritime Institute (SMMI) was established in March 2012 with a mission, in partnership with LR and other business, civic and industrial societies, to become the world's leading institute for marine and maritime research, innovation, education and expertise. LR is investing ~£119M in this largest single joint venture between business and a University. SMMI incorporates a unique cross-disciplinary spectrum covering humanities, natural, physical, and social sciences, engineering, and law, where knowledge is acquired and applied in a collaborative manner with business and civic and industrial societies to reach common objectives. Our UoA provides the Director of SMMI (Shenoi); we also engage strongly in other University Strategic Research Groups in *Ageing and lifelong health*, *Complexity in real world contexts* (Vice Chair Fangohr), *Computationally intensive imaging* (Co-Chair Sinclair), *Digital economy*, *Energy* (Co-Chair Bahaj), *Health technologies*, *Nano-science*, *Neurosciences*, *Population health*, *Sustainability science* and *Work futures*.

Coastal research led by Nicholls and carried out in collaboration with colleagues in the Faculties of Natural and Environmental Sciences, and Human and Social Sciences addresses coastal morphodynamics, coastal flooding, and the future evolution of delta areas, which provide homes to 500M people worldwide. Major current funding is from NERC (iCOASST, £2.9M) for research in collaboration with the Environment Agency on coastal erosion and accretion to support flood risk management; and the £3.8M ESPA Deltas project analysing coastal Bangladesh, whose results are being used by the Planning Commission for Bangladesh in its new 100 year Delta Plan.

As a Faculty with a mission to change the world for the better, research collaborations with users including industry and government are central to the development of our research projects, priorities and strategy. **Mechanisms by which users inform our research agenda** and benefit from our research include formal corporate level strategic research partnerships (e.g. with Airbus, Rolls Royce, LR, Microsoft, Network Rail, RNLI); collaboration on individual research projects including through EngD / PhD student sponsorship and KTPs; and industry / user advisory boards

at project, programme and strategic level. Exemplars are given in REF3a.

National and international advisory board memberships include:

- **Cox,** chair of UK National Grid Service Collaboration Board, and member of the International Microsoft Technical Computing Executive Council(2010ff).
- **McDonald**, Vice Chair of the European Road Transport Research Advisory Board (2004-10).
- **Nicholls**, member of the British Energy Climate Change (BECC) group (2008ff), advising on climate change issues for nuclear new build (Sizewell and Hinkley Point); member of the EA / DERA Coastal Research Development and Dissemination Advisory Group (2011ff); leader of the coastal scenario guidance on the Intergovernmental Panel on Climate Change (IPCC) Technical Group on Impacts and Adaptation (2011ff).
- **Powrie,** chair of the Technologies Advisory Committee for DEFRA's Waste Implementation Programme demonstrator programme for new technologies for the treatment of biodegradable MSW (2004-10); member of the Rail Technical Strategy Steering Group (2010-2).
- **Preston**, member of the Netherlands Institute for Transport Policy Analysis, which advises the Ministry of Transport and the Environment (2011ff).
- **Shenoi,** member of the Standing Committee of the International Ships and Offshore Structures Congress (ISCC), 2009ff. **Blake**, **Boyd**, **Temarel** and **Xiong** (2012ff) and **Turnock** (2006-2009) are also or have been ISCC committee members (2012ff).
- **Temarel**, chair of the Loads Committee of the International Ships and Offshore Structures Congress (2006-9, 2012ff).
- **Thomsen,** chair of the Danish Council for Independent Research, Technology and Production Sciences (Det Frie Forskningsråd, Teknologi & Produktion, FTP), 2012ff (member 2011ff).
- **Y Yang,** member of the Steering Committee and Collaboration Board for the Large Hadron Collider high luminosity upgrade, 2013ff.

LEADERSHIP ROLES IN INDUSTRY AND COMMERCE, RESEARCH COUNCILS, LEARNED SOCIETIES OR PROFESSIONAL BODIES include **Acoustics**: Honorary Secretary, Institute of Acoustics 2008-10; Chair, Institute of Physics Physical Acoustics Group 2010-4 (Humphrey). Royal Academy of Engineering Fellowship Panel 2, 2013ff; Ministry of Defence Scientific Advisory Council 2004-8 (Leighton). EPSRC User Panel 2009-11, and Strategic Advisory Network 2011ff (Nelson). **Bioengineering and human factors**: Chair, British Society of Audiology APD SIG 2012-4, (Campbell). Treasurer, German Society for Biomechanics 2010ff (Heller). Chair, Professional Practice Committee of the British Society of Audiology 2008-12; Trustee, British Society of Audiology 2010-1 (Rowan). Secretary General, European Alliance of Medical and Biological Engineering and Science 2011-3; Institute of Physics and Engineering in Medicine Council 2006-9; Bioengineering Society Council 2009ff (Simpson). **Computational engineering**: Chief Scientist, Dezineforce 2007-11 (Cox). **Energy and climate change**: EPSRC appointee on the RCUK's Tyndall Centre for Climate Change Supervisory Board 2005-10 (Bahaj). Executive Board, European Quantum Solar Energy Society 2008ff (Markvart). **Fluid dynamics**: RINA / iMarEST Southern Branch Council 1997ff and Chair 2006-9, Technical Committee Chair 2002-11 (Hudson). LR Technical Committee 2011ff (Shenoi). LR Offshore Technical Committee 2013ff (Temarel). EU-PRACE (Partnership for Advanced Computing in Europe) Engineering Access Panel Chair 2012ff (Sandham); EPSRC Resource Allocation Panel 2011ff; PRACE Distributed European Computing Initiative (DECI) 2013ff; CCP12 (Collaborative Computational Projects in Engineering) 2012ff (Sandberg). Secretary (2008-11) and Chair (2011ff), International Towing Tank Conference (ITTC) Resistance Committee (Turnock). ITTC Seakeeping Committee 2011ff (Hudson). **Geomechanics and geoenviro. engineering**: IWWG sustainable landfill and landfill modelling task groups 2009ff (Beaven). Royal Academy of Engineering Awards Committee 2010-3, Fellowship Panel 2 civil engineering 2010-2, Research Exchanges with China / India Committee 2010-3 and Chair 2013ff, Proactive Membership Committee 2013ff; Trustee, Thames Gateway Institute for Sustainability 2009ff; EPSRC Strategic Advisory Team for Engineering 2011-2 (Powrie). Association for Computational Mechanics in Engineering Board member 2004ff, and Vice-Chair 2009-10 (Zervos). **Materials and surface engineering**: Institute of Materials, Minerals and Mining Corrosion Committee Secretary 2004ff; Chair of the Institute of Corrosion Corrosion Science Division 2011ff (Wharton). Chair, UK Tribology Operations Committee 2011ff; Chair, IMechE Tribology Group Committee 2006-9; Vice President, Int'l Tribology Council 2006-9 (Wood). **Structures and solid mechanics**: Institute of

Physics Stress and Vibrations Group 1997ff, Member of Council 2005-8, Acting Chair Group Coordination Committee 2008, Chair Applied Physics and Technology Division 2007-9; Chair, British Society for Strain Measurement (BSSM) 2006-8, Honorary Secretary 2011ff; Chair, European Assn. for Experimental Mechanics Scientific and Technical Committee 2009ff; Acting President, Society for Experimental Mechanics 2011; Chair, Thermal Methods Group 2010-2 (Barton). BSSM National Committee 2008ff, Technical Activities Committee 2010ff; Society for Experimental Mechanics Executive Board 2009-11, Chair, Inverse Problem Methodologies Technical Division 2009-12 (Pierron). Vice-Chair, IMechE Structural Technology and Materials Group 2010ff (Quinn). ***Transportation***: IEEE ITS Society Board of Governors 2005-8 (McDonald). Universities Transport Study Group (UTSG) Chair 2009-12 (Preston). **Water and environment**: Member of Council, Fisheries Society of the British Isles 2013ff (Kemp). Trustee and Council Member, Freshwater Biological Assn. 2012ff and the Institution of Environmental Sciences 2009ff (Shaw). Trustee, Waste Watch 2008-11; Trustee, Keep Britain Tidy 2011-2; Chair, IWWG Education Group 2013ff; Int'l Solid Waste Assn. UK rep. 2013ff (Williams).

Staff regularly carry out reviews of research proposals for RCUK (EPSRC, BBRC and NERC) and the research councils of Canada, Czech Republic, Germany, Hong Kong, Portugal, Netherlands, New Zealand, Norway, South Africa and Switzerland. Staff have participated in visiting research review panels for FCT, Portugal (Richards, Lisboa, 2013); CORFO, Chile (Clarke, 2011); the Canadian Government (Powrie, Ottawa, 2010); the US National Science Foundation (Powrie, Washington DC, 2010); and the Italian National Evaluation Agency (VQR exercise, Pierron and Temarel, 2004-10).

Members of the UoA frequently act as *CONFERENCE ORGANISING COMMITTEE AND PROGRAMME CHAIRS AND CO-CHAIRS (*),* including CAETS/RAEng workshops on transportation noise 2008* (Nelson); 37th Scientific Assembly of the Committee on Space Research 2008 (Lewis); World Renewable Energy Congress 2008 and 2010 (Bahaj); UK-China Tribology Symposium annual meetings 2008ff (Wood); Composites Testing and Model Identification conferences 2008ff (Pierron); CAETS/RAEng workshop on machinery noise 2009* (Nelson); 5th International Conference on Hydroelasticity in Marine Technology 2009 (Temarel); Secretary General, 3rd Switzerland-Japan Workshop on Biomechanics 2009 (Schneider); 2nd International Symposium on Bulk Nanostructured Materials 2009* (Langdon); Institute of Physics 7th International Conference on Modern Practice in Stress and Vibration 2009* (Barton); IMechE international seminar on Design Search and Optimisation Techniques 2010 (Scanlan); Co-organiser, Storm Surge Congress 2010* (Nicholls); Early Career Mathematician's Conference 2011 (Armstrong); 3rd UK-China Particle Technology Forum 2011 (S Yang); 4th World Hydrogen Technologies Convention 2011 (Cruden); Universities Transport Study Group annual meetings, 2011-3 (Preston); International Conference on Human Factors in Road and Rail Transportation 2012 (Stanton); 18th meeting of the European Society of Neurosonology and Cerebral Haemodynamics, 2013 (Simpson); 6th Composites Testing and Model Identification conference 2013* (Thomsen); 13th International Conference on Competition and Ownership in Land Passenger Transport 2013 (Preston); Acoustofluidics 2013 (Glynne-Jones).

In addition to ~180 Plenary or Keynote conference addresses, and over three hundred other invited conference addresses, prestigious *NAMED LECTURES* given by members of the UOA include the Acoustical Society of America *Helmholtz-Rayleigh Silver Medal Lecture* 2013 (Leighton); the ICE *James Forrest Lecture* 2013 (Powrie); the British Geotechnical Assn. *Rankine Lecture* 2010 (Clayton); the Inst. of Metal Research *Lee Hsun Lecture* 2009 (Langdon); the Inst. of Acoustics *R W B Stephens Medal Lecture* 2009 (Leighton); and the Inst. of Sound and Communications Engineers *Peter Barnett Memorial Lecture* 2008 (Leighton).

MEMBERSHIP OR FELLOWSHIP OF LEARNED SOCIETIES: Staff hold 48 fellowships of relevant professional and learned society institutions (e.g. FICE, FIMechE, FRINA, FInstPhys, FIMMM). Over the REF period *Elliott* (2009), *Powrie* (2009), *Keane* (2011) and *Leighton* (2012) were elected to the Fellowship of the Royal Academy of Engineering (FREng).

JOURNAL EDITORSHIPS held by members of the UoA over the REF period include **Acoustics**: Subject editors for Acoustics 2008ff (Astley), and Aeroacoustics 2008ff (Joseph), *J. of Sound and Vibration*. **Energy and climate change**: Founding Editor-in-Chief, *Int. J. of Marine Energy* 2013ff (Bahaj). Editor-in-chief, *Global Atmosphere and Ocean Systems* 1999ff; Editor, European

Geosciences Union *Ocean Science* 2008-13 (Wells). **Fluid dynamics**: Managing Editor*, Int. J. of Marine Energy* 2013ff (Myers). Editor, IMechE *J. Engineering for the Maritime Environment* 2002ff (Shenoi). Deputy Editor, *J. Marine Science and Technology* 2009ff (Turnock). Editor, *Int. J. Maritime Engineering* 2003ff (Wilson). Asst. Chief Editor, *Acta Mechanica Sinica* 2008ff (Zhang). ***Geotechnical and geoenvironmental engineering***: Editor, *Géotechnique* 2009-11; Jt. Editor-in-Chief, *J. of the South African Institution of Civil Engineering* 2007ff (Clayton). Founding Editor, ICE *Waste and Resource Management*, 2005-9 (Powrie). **Materials and surface engineering**: European Editor, *J. Composite Materials* 2008ff (Spearing); Co-editor, *Materials Science and Engineering A*, 2010ff (Starink). **Mechatronics, signal processing and control**: Editor, *Microelectronics International*, 1999ff (Atkinson). **Structures and solid mechanics**: Editor-in-Chief, *Strain* 2010ff (Pierron). Founding Editor-in-Chief, IMechE *J. Engineering for the Maritime Environment* 2002ff (Shenoi). **Transportation**: Editor, ICE *Transport* 2011-4 (Cherrett). Editor, *J.Transport Policy* 1998-2010 (Preston). Editor, *Ergonomics* 2007ff (Stanton). **Water and the environment**: Editor-in-Chief, *Global Atmosphere and Ocean Systems* 1999ff (Wells).

GUEST EDITORSHIPS have included themed or special issues of IET *Radar, Sonar and Navigation* **6**(6), 2012, on biologically-inspired radar and sonar systems; *Applied Acoustics* **69**(5), 2008, on detection of buried marine targets (Leighton); *Medical Engineering and Physics*, in press, on cerebral autoregulation: measurement and modelling (Simpson); *Unmanned Systems* **1**(2), 2013, on the 2012 DARPA UAV Forge Challenge (Prior); *Phil. Trans. Royal Society A* **371**(1985), 2013, on new research in tidal current energy (Bahaj); *Measurement Science and Technology* **24**(2), 2013, on advances in 3D velocimetry (Ganapathasubramani); *J. Rail and Rapid Transit* **225**(2), 2011, on Rail Research UK (Powrie *et al.*); *Wear* **267**(11), 2009; *Faraday Discussion **156** on Tribology*, 2012 (Wood); *Current Analytical Chemistry* **9**(1), 2013, on bioanalysis in microscale bioengineering (Zhang); *Civil Engineering* **161**(2), 2008, on learning from failures (Byfield); *J. Sandwich Structures and Materials* **13**(6), 2011, in honour of Professor Vitaly Skvortsov (Thomsen); *Composites Part A* **39**(8), 2008, on full-field measurements of composites, and **40(**12), 2009 (Pierron); *Experimental Mechanics* **48**(4), 2008, on inverse problems in experimental mechanics (Pierron, with Y-L Lo, Taïwan); *Phil. Trans. Royal Society*, in press, for the 100th anniversary of the Hopkinson bar (Pierron *et al.*); and *J. Engineering for the Maritime Environment* **223**(M3), 2009, on fluid-structure interactions (Temarel).

In addition to these and extensive review work, we have contributed more than a hundred assistant or associate editorships (*) and memberships of editorial advisory boards over the REF period, including the following journals: *Acta Aeronautica et Astronautica Sinica, Advanced Composites Letters, Advanced Materials Research, Advances in Water Resources*, American Institute of Aeronautics and Astronautics Journal*, Archives of Acoustics;* ***ASME Journals*** *of Solar Energy Engineering, Tribology*; Biofouling*, Biomedical Signal Processing and Control, Boundary Layer Meteorology, Brazilian Journal of Biomedical Engineering, Canadian geotechnical Journal*, Carbon Management, Chinese Journal of Aeronautics, Chinese Journal of Biology, Cochlear Implants International; Computer Methods in Biomechanics and Biomedical Engineering, Communications in Waste and Resource Management, Composite Structures, Control Engineering Practice;* ***European Journals*** *of Control**, *Mechanics B (Fluids); Experimental Mechanics*, Experiments in Fluids*, Géotechnique, Human Factors and Ergonomics in Manufacturing and Service Industries;* **ICE** *journals of Civil Engineering, Energy, Geotechnical Engineering, Maritime Engineering, Transport, Waste and Resource Management;* IEEE / ASME *Journal of Microelectromechanical Systems**, IEEE *Transactions on Components Packaging and Manufacturing Technology*,* IET *Renewable Power Generation*;* **IMechE** ***Journals*** *of Advances in Acoustics and Vibration, Engineering in the Maritime Environment, Rail and Rapid Transit*; In silico cell and tissue science;* ***International Journals*** *of Aeroacoustics, Agroforestry Systems*, Automation and Computing, Electrical Engineering and Informatics, Engineering and Applied Science, Flow Control, Heat and Fluid Flow, Maritime Energy, Micro Air Vehicles, Numerical Methods in Engineering, Rail Transportation, Ships and Offshore Structures, Solids and Structures, the Sustainable Built Environment, System Science*, Unmanned Systems, Virtual Technology and Multimedia; Iranian Journal of Science and Technology;* **ISRN** ***Journals*** *of Applied Mathematics, Ceramics, Chemical Engineering, Metallurgy;* ***Journals*** *of the Acoustical Society of America*, Algorithms and Computational Technologies, Applied Composite Materials, Applied Mathematics, Coastal Research, Crystallization Physics and Chemistry, Forming*

Processes, Friction, Magnetism and Magnetic Materials, Materials Letters*, Materials Research and Technology, Materials Science, Materials Science and technology*, Naval Architecture and Ocean Engineering, Ocean and Ship Technology, Ocean Technology, Photonics for Energy, Power Sources, Sandwich Structures and Materials, Science and Innovation, Ship Mechanics China, Sound and Vibration, Strain*, Structural Geology, the Korean Society of Ocean Engineers, the Pan-American Institute of Naval Engineering, Transport Policy, Ultrafine-Grained and Nanostructured Materials, Visualized Experiments, Wind Engineering and Industrial Aerodynamics; Materials Focus, Materials Research Letters, Materials Science and Engineering A, Materials Science Forum, Mathematical Problems in Engineering, Nanotechnology, Proc. Estonian Academy of Sciences, Renewable Energy, Renewable & Sustainable Energy Reviews*, Reviews on Advanced Materials Science, Scientia Nanotechnology, Scientific Reports, Sensors & Transducers, Solar Energy Materials and Solar Cells, Strain, Surface and Coatings Technology, Surfaces and Interfaces, Sustainable Built Environment, Sustainable Cities and Society, Theoretical Issues in Ergonomics Science, Thermochimica Acta, Tribology International, Tribology: Materials, Ultrasound in Medicine and Biology, Waste Management*

MAJOR AWARDS AND PRIZES won by members of the UoA over the REF period include:

- Acoustical Soc. of America Helmholtz-Rayleigh Interdisciplinary Silver Medal 2013 (Leighton).
- Acta Materialia Gold Medal 2012 (Langdon).
- Institute of Chemical Engineering Award for Water Management and Supply 2012 (Leighton).
- Lloyd's Science of Risk Prize 2012 (Nicholls).
- Institute of Ergonomics and Human Factors Sir Frederick Bartlett Medal 2012 (Stanton).
- Journal of Sound and Vibration P E Doak Prize 2012 (Stephen).
- Queen's Anniversary Prize for Higher and Further Education 2012.
- Institute of Metal Finishing Jim Kape Memorial Medal 2012 (Walsh).
- University College London Centre for CO_2 Reduction Gold Medal 2012 (Walsh).
- Royal Institution of Naval Architects (RINA) Small Craft Group Medal 2012 (WUMTIA).
- Institute of Physics Prize for a significant contribution by an ECR 2011 (Armstrong).
- Technology Strategy Board KTP Award for Engineering Excellence 2011 (Browne, Dickinson).
- Gesellschaft für Arthroskopie und Gelenkchirurgie (AGA) Award 2011 (Heller).
- Royal Society Brian Mercer Award for Innovation 2011 (Leighton).
- Institute of Metal Finishing Westinghouse Prize 2011 (Ponce-de-Leon, Walsh *et al*).
- NACE International Fellow Honor 2011 (Walsh).
- IMechE Donald Julius Groen Prize 2011, for outstanding achievements in tribology (Wood).
- Chartered Institution of Highways and Transportation Award for Excellence 2010 (McDonald).
- Chartered Institute of Wastes Management Waste Regulation Award 2010 (Williams).
- Institution of Civil Engineers Baker Medal 2010 (Williams).
- Geological Society Whitaker Medal 2009 (Barker).
- Royal Institution of Naval Architects Wakeham Prize 2009 (Boyd).
- Czech Academy of Sciences *De Scientia et Humanitate Optime Meritis* Medal 2009 (Langdon)
- Charles University Faculty of Mathematics & Physics Memorial Medal 2009 (Langdon).
- Chinese Academy of Sciences Lee Hsun Award 2009 (Langdon).
- Institute of Acoustics R W B Stephens Medal 2009 (Leighton).
- Confederation of European Acoustical Societies Aeroacoustics Award 2009 (Tester).
- Royal Institution of Naval Architects Medal of Distinction 2009 (Wilson).
- Institute of Acoustics Association of Noise Consultants Prize 2008 (Fazi).
- Royal Institution of Naval Architects Medal of Distinction 2008 (Hudson).
- European Academy of Sciences Blaise Pascal Medal for Materials Science 2008 (Langdon).
- Int. Assn. of Sound and Audiovisual Archives James A Lindner Prize 2008 (McBride, Hill *et al*)
- UNESCO R. Revelle Medal 2008, for outstanding contributions to ocean sciences (Nicholls).
- Institution of Mechanical Engineers Thomas Hawkesley Medal 2008 (Powrie, Richards *et al*).
- Institution of Mechanical Engineers J F Alcock Memorial Prize 2008 (Powrie, Richards *et al*).
- European Association of Structural Dynamics Junior Research Prize 2008 (Rustighi).
- Rolls Royce Research and Technology Award for Creativity 2008 (Scanlan).
- German Acad. of Osteological and Rheumatological Sci. Publication Award 2008 (Schneider).