Institution: Durham University

Unit of Assessment: General Engineering UoA 15

a. Overview

Durham's School of Engineering and Computing Sciences is one of 7 academic units within the University's Science Faculty and is a thriving centre for both education and research. This document refers to the activities and profile in Engineering; the Computer Science staff are represented in a submission to the appropriate UoA. Engineering academic staff comprise 12 Professors (one Emeritus), 2 Readers, 7 Senior Lecturers and 19 Lecturers. We teach around 420 fte undergraduates 4 year M.Eng and 3 year B.Eng courses. The School has had an ethos of General Engineering since its formation in 1965.

In 2009, the School was formed from the former School of Engineering and Department of Computer Science. The integration of computer scientists within the School has led to key benefits: (i) prompting a research focus in High Performance Computing (HPC), and (ii) acting as a driver for the development of the new University Institute for Advanced Research Computing (iARC) in 2012.

Engineering research is coordinated by three Research Groups (RGs): Mechanics, Energy and Electronics. Research activities are managed by our Research Committee, which reports directly to the Board of Studies. The Director of Research (DoR) is a member of the School Management Group, which is guided by specific targets captured in an annually-updated 5 year School plan. Research Centres and Institutes are monitored by the Faculty Research Committee and University Research Committee respectively, on which the School has representation.

b. Research strategy

All key decisions in the School are informed by an internal, rolling 5-year School strategic plan. This REF5 document addresses the main research oriented elements of that plan where we set out our aim to exploit the subject-specific strengths of our three RGs and the collaborative opportunities that arise from strong integration with other units in the Science Faculty and beyond, including external strategic partners and industry.

As a small to medium sized Engineering School we focus our research in order to be recognised for international excellence in selected areas. Thus, one major strategic aim of the School is to attain critical mass in these areas, which broadly correspond to the research "clusters" listed in Table 1. This is being achieved through strategic academic appointments (see Section c). PhD studentships are allocated on a preferential basis to students applying to work in these areas. RG Heads are responsible for encouraging the staff in their RGs to become involved in cluster activities. We have successfully followed this direction while maintaining breadth of expertise to provide a balanced General Engineering curriculum to our taught students.

Current areas of focus and strategic aims closely follow those laid out at RAE 2008, with adjustments where staffing changes or research developments have led to new opportunities.
The areas of research excellence identified in our RAE 2008 submission were:

(i) Molecular Electronics – this has expanded into a wider range of cleanroom activities, strengthened by the appointment of new staff,
(ii) Biomechanics – this has evolved into more fundamental scientific research we carry out as part of the university's Biophysical Sciences Institute (BSI)
(iii) Computational Fluid/Solid Mechanics – this has expanded into a wider range of numerical methods, and much strengthened by the appointment of new staff,
(iv) Renewable Energy – this has expanded into energy markets, smart grids and the mathematics of energy networks and systems.

Cleanroom Activities, Computational Mechanics and Energy continue to be identified as the current research areas of focus. Section c presents details of staff appointments in all areas.

Table 1	
Research Clusters	**Strategic Aims**
Computational Mechanics (Lead RG Mechanics: *Trevelyan, Augarde, Deeks, Mao, Seaïd, Giani, Koziara, Akkerman, Coombs, Coates*)	To develop numerical methods to solve some of the most challenging problems currently posed in solid and fluid mechanics. To develop advanced algorithms and to make use of appropriate High Performance Computing (HPC) resources.
Geotechnical Engineering (Mechanics: *Toll, Coombs, Augarde, Johnson, Osman*)	To develop a greater understanding of unsaturated soils, their use as construction materials, their remediation following contamination, the associated material models devices for measurement of the suction that is key to maintaining strength and stability and applications to climate impacts on transportation infrastructure and the built environment.
Renewable Energy (Energy: *Dominy, Crabtree*, *Hogg*)	To build on established strengths in cleaner power generation and maintain positioning as a partner of choice for related industrial and academic R&D projects.
Energy Networks (Energy: *Bialek, Dent, Sun*)	To develop mathematical methods for decarbonisation of energy networks, including collaboration with mathematics and statistics. To expand our industry and policy collaborations in these areas.
Turbomachinery and Aerodynamics (Energy: *Hogg, Sims-Williams, Ingram, Dominy, Mao, Berson, Gaskell*)	To improve the efficiency and flexibility of conventional power plant for systems with highly variable/uncertain renewables penetrations. To develop deeper understanding of complex unsteady flow in applications including road vehicles and wind turbines through development of research tools including the Durham wind tunnels, CFD and road / track tests.
Molecular and Nanoscale Electronics (Electronics: *Petty, Groves, Zeze*)	To exploit organic electroactive materials in electronic and opto-electronic devices. Much current activity is focused on understanding the role of nanoparticles and carbon nanotubes on device performance.
MEMS devices (Electronics: *Wood, Gallant*, *Balocco, Racz*)	To use MEMS fabrication processes to create sensors and actuators for industry and research; to understand how best to achieve fundamental measurements; to realise actuation in difficult environments; to identify key applications e.g. in energy harvesting.
Communication systems (Electronics: *Salous, Purvis, Baxendale, Sun*)	To design and implement novel electronic and radio systems; to understand and model propagation in various frequency bands; to study the impact of the radio channel on the design of wireless communication systems; to study and design self-healing systems; and the use of holographic lithography for wireless antenna arrays; to inform international telecommunication union recommendations.

However, research is not wholly focussed on the above clusters; indeed, we have achieved research excellence in other areas, especially where staff collaborate with other departments and/or universities. This is particularly evident in our work under the auspices of the various university Institutes. Examples include the collaboration of Wu with Chemistry and the Biophysical Sciences Institute, and of Johnson with the Institute of Hazard, Risk and Resilience.

A strong School ethos exists for collaborative research, and is reflected in the way our research is structured. While individual academics are members of only one of the three RGs, they are encouraged to enter into research collaborations with academics from other groups (elsewhere in the University, nationally and internationally). Such collaborations are enabled by the promotion of research seminars and by a range of other vehicles, e.g. the presentation at School level of significant projects. Examples of this interdisciplinary RG activity include:

- Kotsialos (Mechanics) bringing expertise in numerical optimisation and neural networks to the work in the Electronics RG on the evolution of materials to perform computations,

- Trevelyan (Mechanics) bringing expertise in short wave modelling to the analysis of sensors to detect cleanliness of molten steel in a project initiated by Electronics RG, and
- Wood (Electronics) and Sims-Williams (Energy) collaborating on MEMS sensors for fluid flow, e.g. wall shear stress sensors and plasma actuators for airflow control.

Several research activities are closely aligned with larger research Centres or Institutes. In Durham, Centres typically involve 2–3 departments collaborating in a specific research area while Institutes are inter-Faculty and cover wider areas. A detailed description of the School's interaction with the University Institutes is presented below, and further descriptions of wider collaborative research activities are presented in Section e.

Dissemination of research outputs is achieved through seminar series and the showcase Higginson and Roberts annual lectures. Recent speakers include academics of international reputation from other universities (e.g. Prof. Sir Richard Friend FRS, Prof. Roger Owen FRS).

Strategic partnerships: The School has a strong focus on strategic partnerships with key industrial organisations with research interests that overlap our major research areas. Notable among these is a new partnership (since 2011) with DONG Energy, who have provided funding of £1M to endow a Chair in Renewable Energy. Research in the areas of energy delivery and computational geomechanics have further enabled another new strategic partnership with Ikon Science, who have part-funded a lectureship. Our staff are actively working with these organisations to develop new solutions to pressing societal and technological problems.

We maintain School relationships with other blue chip engineering companies (e.g. BAE Systems, Rolls Royce) and SMEs. Our impact cases provide other examples. Notable is our link with ALSTOM, to whom we provide two-week steam turbine technology courses which have become part of the company's CPD portfolio. Participants have come from the main sites in Rugby, Mannheim & Baden as well as other sites in India, USA, China and South Africa. The School appointed Hogg (formerly Engineering Director, ALSTOM steam turbine retrofit) to a Readership in 2009; he now plays a key role as Director of Strategic Partnerships. The School also benefits from Faculty-level strategic partnerships. Examples include links with Proctor & Gamble, IBM and, through the "Science without Borders" programme, BGBrasil.

University Institutes: Multidisciplinary collaboration is achieved through the following University research institutes: Durham Energy Institute (DEI), Biophysical Sciences Institute (BSI), Wolfson Research Institute (WRI), Institute for Hazard, Risk and Resilience (IHRR), Institute of Advanced Study (IAS) and the Institute for Advanced Research Computing (iARC). School academics are heavily involved in the activities of DEI, and are actively contributing to research projects under the umbrella of all others. Each Institute provides a comprehensive, cross-disciplinary platform to support networking, education, knowledge exchange and research dissemination.

- The DEI has, in the three years since its inception, developed into a leading UK energy research institute that is differentiated from others in its focus on both the social and technical aspects of energy. Taylor was a founding co-director, and numerous other staff are active members, bringing research skills in renewable energy and energy networks. Through the DEI, the School has formed key partnerships with Department of Energy and Climate Change (DECC) (see Bialek secondment under "Public Policy") and DONG Energy. The Institute has also facilitated the awards of significant research grants, many of which appear in Section d.
- Under the auspices of DEI, we have launched a multidisciplinary Centre for Doctoral Training (CDT) in Energy (2009-14) with funding from EPSRC. This offers interdisciplinary training to students from eight departments spanning the Faculties of Science and Social Sciences & Health. The students then follow a programme of research leading to a PhD, the majority of which are linked to companies active in the energy sector, e.g. Alstom and SKF.
- The BSI aims to solve large research questions in the life sciences by developing and applying physical science expertise alongside life science researchers and clinicians. An example of the School's BSI related work is the research by Wu into tissue engineering on collagen scaffolds, polymeric biomaterials and a bioengineered lens for the eye.
- The WRI works on research to improve human health and wellbeing. Gallant and Johnson work within the WRI's cross-cutting theme 'optimising population health'. Ongoing initiatives include the project 'examining the association between brownfield remediation and public

health' (Johnson with Geography & IHRR); the team is located within the IHRR building.

- IAS fosters collaboration across all of Durham's disciplinary areas, and with the international Fellows whom it brings to Durham. For example, we have supported the IAS Fellowship visit of Prof. Ronaldo Borja (Stanford) in 2008, and will work with Prof. Mark O'Malley (UC Dublin) in 2013. IAS's COFUND scheme has brought €4M of European funding to bring Senior and Junior Research Fellows to Durham such as Dr Boian Alexandrov (Los Alamos National Laboratory) who was hosted by the School in 2012/13.
- The School led the formation of the new iARC in 2012, with the aim of enabling researchers across the University to use cutting edge computational techniques to generate transformative research results that have been previously unobtainable. The Director (Computer Science Chair Theodoropoulos) is a member of the School. With advanced computing being a central theme in research clusters across the School, staff benefit from and contribute to many activities in iARC, such as interdisciplinary workshops and seminars, large scale research collaborations and bootstrapping innovative research projects, through seedcorn grants, e.g. three such grants in Computational Mechanics in 2013 (awarded to Coombs, Koziara & Trevelyan).

Enabling new directions and interdisciplinarity: The University Research Seedcorn Scheme funds initial investigations, feasibility studies, networking and other activities that will enhance the quality of external grant applications. Over the REF period, this has supported seven pilot research projects through investment of £70k. The average success rate of seedcorn-supported proposals is more than double that of others; this is especially important in interdisciplinary work. For example, we have a project investigating natural fractures in shale, funded by the DEI and Geospatial Research Ltd., and co-supervised with Durham Earth Sciences academics.

c. People
Staffing strategy and staff development

Permanent/PDRA/ECR Staff: Our strategy to invest in areas of strength (the key research areas introduced in Section b) has led to growth in expertise in algorithms for computational modelling (linking to other Faculty initiatives including iARC), energy (linking with DEI) and electronic devices (building on investment in state-of-the-art cleanroom facilities).

- In 2011-13 the School has undergone a period of planned expansion through a combination of strategic appointments, and key areas of our research have been further strengthened. We currently have 36 full time academic staff, one Emeritus Professor and two part time academics. In 2013-17 we will nurture our relatively young cohort of staff, and fully embed recent key senior appointments (e.g. Hogg, Gaskell and Bialek).
- During the REF period, 6 members of academic staff have left to take on more senior roles elsewhere: Crouch to a Dean position at City University, Ran, Mahkamov and Taylor to Chairs at Warwick, Northumbria and Newcastle, Long to a Readership at Sheffield, and Johnstone to the private industrial sector. Two other staff (Scott and Tavner) have retired.
- Fourteen lecturer-level appointments have been made in the period to strengthen research clusters: Coombs to the newly endowed Ikon Science lectureship in computational inelasticity, Koziara and Akkerman (computational mechanics), Giani (HPC), Berson (thermo-fluids), Mao (computational fluid dynamics), Sun, Crabtree, Dent and Kazemtabrizi (energy) and Balocco, Gallant, Racz and Groves (electronic devices).

Career Development: We have a strong commitment to staff support at all levels. Our School policies for staff development are guided by the principles laid out in the Concordat to Support the Career Development of Researchers, and include the following practices and approaches:

- All lecturers and staff on probation are assigned a mentor with whom to discuss their career development. All staff, including senior academics, may also opt to have mentors identified.
- All staff have an Annual Staff Review (ASR), conducted by a senior member of staff, to set goals for the upcoming year. These are all forwarded to the Head of School and appropriate action plans developed; feedback is provided at various stages in-year. We have clear guidance mechanisms for academic probation and promotion, which are discussed in ASRs.

- Academic staff develop annual Personal Research Plans (PRPs) as part of their ASRs, giving the opportunity to discuss goals for current projects and opportunities for the future.
- All junior staff are required to attend the Postgraduate Certificate in Academic Practice course, which covers a range of topics in teaching and research useful to new academics. They are also encouraged to attend modules on student supervision, running research projects and a mentored programme on raising research funds. Durham has won national awards (2009 Outstanding Support for Early Career Researchers award from Times Higher Education) for these activities which are also available to PDRAs and other ECRs.
- A scheme established in 2011 supports PDRAs who are considering applying for RCUK, Royal Society and Royal Academy of Engineering Fellowships. A senior academic acts as a mentor throughout the application process. The School makes an up-front commitment of a lectureship on completion to the applicants who successfully obtain a fellowship, provided satisfactory progress is shown. The scheme has received 8 applicants (5 external to Durham), 3 of whom were selected for further support.
- PDRAs and postgraduate students are represented on both the School's Research Committee and Board of Studies, and thereby contribute both to the management of research and to the development of more general School practices.
- The School is committed to advancing women's careers in academia via the Athena Swan Charter. The University as a whole has received a Bronze award and the School is now working towards a Bronze award.
- We have enjoyed successful fellowships in the REF period: Zeze has been awarded a Royal Academy of Engineering Leverhulme Trust Senior Research Fellowship (2013-14) to undertake semiconductor nanowires research and Wu was awarded a Royal Academy of Engineering Global Research Award (2009-12) to undertake research on ocular tissue engineering.
- We have an internationally diverse staff (both fixed term and permanent). Our permanent staff originate from: the UK, Australia, Canada, China, France, Greece, Hungary, Iran, Italy, Ivory Coast, Morocco, Netherlands, Palestine, Poland, Sudan and USA.

Research Students

The School supports a lively community of over 100 PhD students. Many are former Durham undergraduates who have been inspired by their final year research project. Recruitment is largely through web-based publicity about current research areas and available projects. Undergraduates attend the School's Research Day and talk to current postgraduate researchers. PhD students receive the majority of their generic training via University-level courses, but School-specific research training is given not only by academics but also by technical staff.

- Students are members of one of the RGs in the School and contribute to RG activities such as seminar programmes and discussions about research topics.
- Students are monitored through frequent meetings with their primary supervisors and the supervisory team. Formal records are kept of meetings on a monthly or bi-monthly basis, containing actions for both student and supervisors. Our supervision practices are highly regarded in the university: Unsworth won the Durham University Excellence in Doctoral Supervision Award (2009) and Trevelyan has contributed to university training on PhD supervision. We have close links to Faculty developments in PG provision and training through Augarde's role as Deputy Head for Postgraduates.
- Students receive many opportunities to contribute to teaching in the School and develop skills of use beyond the PhD. The vast majority of students undertake laboratory demonstrating for which they receive both University and School training.
- Students lead the organisation of the annual School Research Day. Students are nominated by their associated RG to form a small organising committee. All students present their work at these events, providing excellent experience of presenting to an audience of their peers and academics in the School.
- Approximately 4 students per year benefit from extended funding through the Energy Centre for Doctoral Training to which they can apply for an extension of six months to their funding.

Student experience: The impact of our PhD training is demonstrated by the career destinations and achievements of our alumni. Our PhD students are in high demand after completing their

studies.

- Many students enter career paths in academia, taking up both postdoctoral and lectureship positions at universities in the UK and internationally. This provides evidence that the School is: (i) inspiring its postgraduates to choose academia as their chosen career path, and (ii) equipping them with the skills necessary to become successful research leaders of the future. Exemplars graduating in this REF period include Dr. Xiaoying Zhuang (2010, now Associate Professor in Geotechnical Engineering at Tongji University, Shanghai) and Dr. Robert Simpson (2010, now Lecturer at Glasgow School of Engineering).
- Many students enter the industrial sector after obtaining their PhD, demonstrating that the School equips students with the skills they require to apply their advanced knowledge to significant engineering projects. Exemplars graduating in this REF period include Dr. Sam Jupe (2010, now Senior Power Systems Engineer at Parsons Brinckerhoff), Dr. Adam Sprot (2013, now Experimental Aerodynamicist at Sahara Force India Formula 1 Team), and Dr. Giovanni Airoldi (2010, now Design Engineer at Siemens Wind Power, Denmark).

d. Income, infrastructure and facilities

Research portfolio: Over the REF period, the School has maintained a diverse and extensive research portfolio that is primarily supported by EPSRC and the EU. The major grants (where the total project value >£1M) are usually consortium based, involve collaboration between several Durham academics, and include research topics that stem from our strategic clusters.

For example, in renewable energy research, Durham coordinated the EU FP7 Reliawind consortium (€5.55M, 2008-11) and leads EPSRC Supergen Wind (£4.8M, 2010-14). For existing generation technology, a five year Durham-led, £4M EPSRC grant to address the Development and Evaluation of Sustainable Technologies for Flexible Operation of Conventional Power Plants will start in 2013. We are the sole academic partner in the UK's largest Smart Grids project (£54M total value), Customer-led Network Revolution, supported by the Ofgem Low-Carbon Networks fund; the School receives a £3M share. Research to secure the future power network capacity has been funded by the £1.1M EPSRC Preventing wide-area blackouts grant (2009-13), where Durham leads a collaboration with mathematicians from Southampton and Edinburgh. For more long-term research impact, we are a partner in the EPSRC Autonomic Power Systems project (2011-16), a £3.4M project (£0.5M to Durham) where engineers, mathematical scientists, economists and social scientists from six universities investigate intelligent control techniques for the electrical network in 2050. The School is also a partner in the EPSRC Energy storage for low carbon grids project (2012-17), which has a project value of £5.6M (£0.5M to Durham).

With strong industrial relevance and the aim of reducing the whole life cost of high value engineered components, the School is a partner with Cranfield University in the EPSRC Centre for Innovative Manufacturing in Through Life Engineering Services (£5.77M, 2012-17). This is in collaboration with 17 industrial partners including Rolls-Royce, BAE Systems and Siemens.

In environmental engineering, the £1M ROBUST project (2009-14), an EPSRC Challenging Engineering award, explores the use of industrial 'waste' for the regeneration of brownfield sites. It was listed as one of RCUK's Big Ideas in 2011 and won Johnson the Philip Leverhulme Prize in Engineering in 2011. Building on our expertise in the development of emergency response planning algorithms (EPSRC REScUE project 2009-13, £465k), the School leads a £1.36M EPSRC programme (2012-15), Organisational Operational Response and Strategic Decision Making for Long Term Flood Preparedness in Urban Areas. Further description of the collaborative features of this project appears in section e. In geotechnical engineering, we are a partner in the £1.7M iSmart project (2013-16, £0.3M to Durham) that will provide the knowledge to develop assessment and adaptation strategies for the UK's transport infrastructure to cope with future climate impacts.

Our state-of-the-art cleanroom facilities were used in another £1M EPSRC Challenging Engineering award, Next Generation Bio-Inspired Sensors and Smart Materials (2008-12) as well as hosting several smaller EPSRC projects. The cleanroom is pivotal to the delivery of two EU FP7 Initial Training Network grants: *NanoEmbrace* – nanowire based devices (€3.5M, 2013-17) and *Notedev* - THz technology development (€3.8M, 2013-18). Both of these projects are led by Durham and have international academic and industrial partners. Other examples of European funding success include the €2.9M EU *NASCENCE* network (evolving nanosystems) and also the €1.6M EU *FUST* project (tracking food contamination). Further details on these projects appear in

section e. Another example in electronics is the EPSRC-funded (£1.1M, £125k to Durham) PATRICIAN project on body centric wireless communications at mm wavelengths.

Infrastructure and facilities: The School has been awarded financial support from Durham University in addition to RCUK, national and regional sources, to set up and maintain state of the art research space and facilities. Some examples:

- In 2012 the University invested £4.2M in infrastructure refurbishment for the School; work is under way and will be completed by mid-September 2014. Four new open plan offices provide desk space for 76 postgraduates, and a boardroom style Focus Room (with an advanced projector system) that will be a state-of-the-art facility for research presentations, computational modelling and our seminar series. Adjacent to the Focus Room are new design studio spaces and multiple PC-equipped touchdown areas.
- Smart grids laboratory, containing equipment valued at £1.2M, funded by Durham University (£0.5M), EPSRC, One North East (RDA) and industry.
- Cleanroom, (equipment valued at £1M), funded partly by £0.5M from Durham University.
- XRCT scanning facility, funded by EPSRC (£0.5M) and Durham University (£0.2M) used for interdisciplinary research (Engineering, Earth Sciences, Archaeology)
- THz research laboratory funded by £0.4M from Durham University.

The research and education activities of the School are supported by a team of 15 administrative and 16 technical staff. IT support is provided by a member of University Computing and Information Services staff embedded within the School.

Consultancy and Public Policy: Examples of our activities in these areas are given below (more detail is included in Ref3a):

- Consultancy: Academic staff have provided consultancy to 36 organisations during the REF period. The School benefits from 10% of the fees, which is used to fund research facilities. Highlights: support for the Red Bull Racing F1 team in track tests, instrumentation and data collection at races and full-scale wind tunnel testing; services to the International Energy Agency and European Commission on renewable energy sources and smart grids; computational analysis of railway sleepers for CEMEX; THz non-destructive testing methods for ceramic body armour for DSTL Porton Down; software development for multibody contact dynamics to assist EDF in the context of UK nuclear safety; consultation for DECC and seven other international energy councils, and leading an expert panel to review the Northern Powergrid's £350M p.a. business plan for 2015-2023; biomaterials characterisation studies for Biomet Healthcare, Invibio and Morgan Ceramics Ltd.
- Public Policy: Bialek was an EPSRC Science Policy Fellow at the Department of Energy and Climate Change (June-Dec 2012) advising on technical issues related to Electricity Market Reform, with significant contributions in Capacity Market design. This is the biggest reform (estimated £110bn) to the GB electricity market since privatisation in 1990 (aimed at moving to a low carbon future at reasonable cost without endangering security of supply). It puts GB at the forefront of electricity markets development. Bialek has also contributed a chapter to a high-impact International Energy Agency report: "Next generation of RES-E policy instruments (RES-E-NEXT)" which supported high-level international political discussion on how policies can support a rapid transition towards energy systems with high shares of renewable in an efficient, secure, sustainable and affordable way. Further submissions were made (on behalf of the DEI) to the following public consultations: Project TransmiT (Ofgem, 2010), Electricity Market Reform (DECC, March 2011), Renewables and the Grid: Access and Management (All-Party Parliamentary Renewable and Sustainable Energy Group PRASEG, January 2010), Project DISCOVERY (Ofgem, November 2009). In addition, Dent has been contracted by National Grid and Ofgem to design technical modelling for the Electricity Capacity Assessment Study, which will be vital to the operation of any future Capacity Market. Purvis chairs an EPSRC manufacturing centre "think-tank" which has led to the engagement for our research with the new High Value Manufacturing Catapult centres.

e. Collaboration and contribution to the discipline

As detailed in Section b, collaborative research lies at the core of many research activities and our

academic staff make contributions to engineering locally, nationally and on the world stage.

Collaborations: Our interdisciplinary research within Durham is highlighted as part of the description of University Research Institutes in Section b. The Institutes, and the associated seedcorn funding, play an important role in providing support for initiating collaborative research activities cutting across the full range of disciplines in the University. This ethos for collaborative research has led to 60% of our staff producing publications with international co-authors over the REF period; and 66% have published with national co-authors. Durham leads major national and international research projects. Here we give a few examples:

- The School plays a leading role in collaboration between Energy Systems and Mathematics research. Staff collaborate with mathematicians at Cambridge, Durham, Edinburgh, Heriot-Watt, KCL and Southampton on EPSRC projects, and have given invited presentations at institutions including Caltech, MIT and UC Berkeley. Dent co-organised Energy Systems Weeks at the Isaac Newton Institute in Cambridge in 2010 and 2013, and coordinated a Special Issue of the IMechE Journal of Risk and Reliability on Energy Systems. Durham hosts the annual Risk Day and will host PMAPS in 2014 (see below).
- Durham University was the coordinating institution for the EU funded Marie Curie Research Training Network: MUSE (Mechanics of Unsaturated Soils for Engineering). This provided doctoral training to ten Marie Curie fellows in six internationally renowned institutions. The network conducted benchmarking exercises of experimental techniques and constitutive model development that were published in the 2011 Géotechnique Symposium. Over 22,000 downloads have been made of pdf files containing presentations from the three MUSE schools that were held in Spain, France and Italy.
- The School leads two major EU FP7 projects (*NanoEmbrace* and *FunProb*) on the industrial exploitation of semiconductor nanowires. *NanoEmbrace*, an academic-industrial partnership, provides doctoral training to twelve Marie Curie fellows in ten internationally renowned institutions. The School also participates in the EU FP7 *NASCENCE* project on the evolutionary training behaviour of nanomaterial networks and building an electronic processor which exploits these architectures – in effect, a computer without transistors.
- The School leads five universities on the 3 year EPSRC funded project (£1.36M) 'Organisational Operational Response and Strategic Decision Making for Long Term Flood Preparedness in Urban Areas'. Here Durham leads a team of collaborators from Leeds, Sheffield, Kingston and UWE with the aim of creating a single framework of knowledge and procedures that can be used to influence the behaviours of businesses faced with urban flooding and flood risk, exploiting synergies between the organisational business continuity, agent based simulation, flood prediction, economic modelling and the behavioural sciences.
- In electricity generation technology, the EPSRC Supergen Wind Consortium programmes have been led from Durham (total value £7.35M over 8 years finishing March 2014) and Durham led the FP7 RELIAWIND programme (€8M). The principal academic partners in Supergen are the universities of Durham, Strathclyde, Loughborough, Manchester, Manchester Metropolitan, Surrey and the STFC Rutherford Appleton Laboratory. The consortium is supported by a large number of industry partners including Vestas, Narec, Siemens, Scottish Power and GL Garrad Hassan. The aim of the project is to undertake research to achieve an integrated, cost-effective, reliable & available Offshore Wind Power Station. Durham also leads a new EPSRC Future Conventional Power Research Consortium (£2M EPSRC plus matching support from industry) beginning Summer 2013; this builds on a long history of research in collaboration with Companies such as GE and Alstom.

Engineering Community Contributions: Our staff contribute to the national and international engineering community in a number of ways. Examples include:

- Invited Keynote/Plenary Lectures: All members of academic staff present their work at international conferences and the School makes funds available to help staff attend when necessary. Over the REF period 11 staff have given 21 invited keynote and plenary lectures at major international conferences world-wide. Additionally, our staff regularly give invited seminars at other universities. Supported by the Durham Research Leave system, staff visit other institutions for longer periods of time to help foster collaboration (including typically three

outgoing Visiting Chair positions per annum).

- Conference Organisation: We make use of conference facilities available in Durham to host conferences and national training schools. Conferences at Durham in the REF period include: International Conference on Computational Mechanics CM13 (2013), the annual Risk and Reliability Modelling of Energy Systems day, the 1st European Conference on Unsaturated Soils (2008) and the European Academy of Wind Energy (EWEA) PhD Seminar (Oct. 2009). Durham will host the 2014 IEEE-sponsored Probabilistic Methods Applied to Power Systems (PMAPS) conference, one of the leading international power systems events, attracting 200-250 industrial and academic researchers from across the world, and the 2014 Cooling Prize (geotechnical engineering).
- Debates: Unsworth chaired the 2009 Royal Academy of Engineering Fellows debate with HEFCE (Rosenberg, Sweeney) on the parameters for inclusion in REF2014, and represented the Engineering Professors' Council in the debate on REF2014 (with David Sweeney, HEFCE, and David Delpy, EPSRC); he also participated in "The Great Debate" (Science Museum, London, 2009) discussing future trends in artificial joints. Taylor has taken part in (i) Energy Debates, (with Energy Secretary Chris Huhne) at all political party conferences in Sept. 2011, (ii) the New Statesman/IBM Energy debate on 'Life After Oil – Smarter Energy) (Sept. 2011), and (iii) an Energy debate at the British Library (Oct 2012) with the environment correspondent from the Guardian for which a podcast is available.
- Learned Societies, Professional Institutions, Editorial Boards and Research Bodies: Highlights are: Unsworth was Vice-President of the IMechE (2008-11), and has served on the Trustee Board (2007-11) and numerous other committees. He has also served on two committees for the Royal Academy of Engineering and as Trustee of the Engineering Council (2008-2013) and has been Editor in Chief of Proc. IMechE Part H since 1993. A total of 20 Editorships or Editorial Board Memberships are held within the School. Deeks is Chair of the UK Deans of Science. Salous is vice-chair of URSI: International Union of Radio Science Commission C and will become chair in 2014. Sims-Williams is the first UK-based chairman of the Society of Automotive Engineers Road Vehicle Aerodynamics Committee. Dominy also serves on this committee, and is a committee member (and past chair) of the IMechE. Automobile Division, Tyne Tees Centre. Toll is Chair of the North East Region of the Institution of Civil Engineers and of the Northern Geotechnical Group of the British Geotechnical Association. He also chairs the International Committee for Geo-engineering Data Standards of the Federation of International Geo-Engineering Societies. In addition to holding many EPSRC awards, 17% of our staff have been elected to the EPSRC College.

Recognition: Awards for contributions to the discipline include:

- Staff awarded fellowships during the REF period: Bialek (Fellow, IEEE), Zeze (FIET), Dominy & Coates (FIMechE), Coates (FRAeS) and Toll (FICE). These are added to our profile of pre-existing Fellows (FREng: Unsworth; FIET: Petty, Purvis, Salous, Tavner, Taylor; FIMechE: Hogg, Trevelyan, Unsworth; FIEAust: Deeks; FInstP: Petty; FIMA: Coates, Gaskell).
- Tavner was President of the European Academy of Wind Energy, 2010-12, and in 2012 was elected to the Executive Committee of the European Technology Platform Wind. In the European Wind Energy Association Conferences 2012/2013 he was Scientific Track Chair.
- Unsworth was awarded the "Lifetime Achievement Award" in 2011 by the International Society for Technology in Arthroplasty at a ceremony in Bruges for research into artificial joints, and was awarded the Best Paper Prize for a paper published in Proc. IMechE Part H in 2009.
- Dent received the IET's 2012 Mike Sargeant Young Engineer Career Achievement Award. This recognises his work in energy system analysis, designing the technical modelling for the first GB Electricity Capacity Assessment Study, and also his role in promoting energy system problems within the mathematical sciences community, being General Chair of the 2014 Probabilistic Methods Applied to Power Systems conference.
- The research team supervised by Taylor won an IET Innovation Award in 2010. This international award recognised work on wind integration into power systems, in particular algorithms currently used to integrate onshore and offshore wind energy in North Wales.
- Ingram was awarded the 2008 PE Award for Best Paper in Proc. IMechE, Part A.