Institution: University of Warwick

Unit of Assessment: 15 General Engineering

a. Overview

The University of Warwick submission to UOA15 consists of 98 (94.75 FTE) Category A staff drawn from the **School of Engineering** (SoE), **Warwick Manufacturing Group** (WMG) and the **Depts. of Physics and Chemistry**. Compared to figures returned in RAE2008 there has been significant growth in General Engineering at Warwick and a step-change in research performance: numbers of Cat. A staff, RAs, PGR students and annual research income have increased by 36%, 28%, 102% and 88%, respectively and research awards for 2012/13 of £49M represent a 4-fold increase. Growth is set to continue with a further 16 approved academic posts. A consequence of this expansion has been the restructuring of Engineering, in 2010, into two complementary departments, SoE and WMG, enabling each to develop their individual research strategies.

SoE is an integrated School, in which engineering disciplines are co-located, comprising; 63 submitted Cat. A staff, 35 technicians, 29 administrative staff, 55 RAs and 123 PGR students. Research is organised in a matrix structure: Three cross-cutting research themes; *Energy*, *Biomedical Engineering* and *Sustainable Cities* facilitate multidisciplinary research across research groups and are coordinated by a Research Theme Leader. Seven research groups of *Electrical Power*, *Thermofluids*, *Chemical*, *Systems Modelling & Measurement*, *Sensors & Devices*, *Communications & Signal Processing*, and *Civil* provide core expertise in specific engineering domains. Every academic is assigned to a research group and contributes to one or more research theme. Due to close interdisciplinary activity at Warwick 7 staff from the **Depts. of Physics and Chemistry** are reported within the Sensors & Devices research group.

WMG is a multidisciplinary academic department, comprising 28 submitted Cat. A staff, 25 technicians, 75 managerial/support staff, 65 RAs and 144 PGR students. Research is organised into 13 research groups covering 5 areas: *Design* (experiential engineering, visualisation); *Materials* (engineering materials, multifunctional systems, sustainable materials, materials processing & electrochemical engineering); *Manufacturing* (net-shape manufacturing, metrology, automation systems, digital lifecycle management); *Systems* (energy & electrical systems, biomedical engineering & medical informatics); *Business* (business transformation). Cross cutting activities, such as the High Value Manufacturing (HVM) Catapult, the Institute for Digital Healthcare, and the Institute for Product and Service Innovation, enable achievement of the impact agenda into the main application areas of automotive, aerospace, construction, environment, the NHS and healthcare technologies.

b. Research strategy

The restructuring of Engineering into two departments has enabled a step-change in performance through the formal adoption of independent but complementary research strategies that have benefited significantly from enhanced resource allocation under Warwick's 'strong department' governance structure. Key to both strategies is the strengthening of world leading research, expansion into new areas of global relevance and a joint commitment to develop critical mass in two key priority areas; Energy and Biomedical Engineering. Monthly meetings between the Head of SoE (*Stocks*) and WMG's Academic Director (*Dashwood*) identify areas of synergy and enable alignment of objectives. In SoE research strategy is the responsibility of the Head of School and Deputy Head (Research) and is informed by the School's Management Committee and Research Committee. In WMG research strategy is the responsibility of the Academic Director in collaboration with the Executive Chairman (*Lord Bhattacharyya*) supported by the WMG Board and Research Strategy Group.

SoE research strategy. In 2010 SoE developed its **2015 Vision**, which advances the mission to be a recognised international leader in engineering education, research and innovation. Six inter-related research objectives were identified to strengthen and expand the research base and enhance the research environment. Objectives/targets for 2015 relative to 2010 are:

- Enhance internationally leading research by increasing academic staff numbers by 25%.
- Strengthen the School's research base by doubling research income.
- Exploit the School's *integrated* structure by strengthening interdisciplinary research.

- Increase engagement with industry to enhance knowledge transfer, innovation and impact.
- Increase the quantity and quality of research students (exceed 2.5 students per academic).
- Improve mentoring and career development for all academic and contract research staff.

The research objectives have fed into an ambitious upgraded academic strategy resulting in a significant restructuring and re-focusing of research. The three pillars of the strategy are to develop; i) interdisciplinary research themes that deliver research of global relevance; ii) world leading research groups ('hubs') that are nationally and internationally networked and iii) industry facing research centres and initiatives.

To facilitate interdisciplinary research, three cross-cutting research themes have been introduced; Energy**,** Biomedical Engineering and Sustainable Cities. The themes build on existing research strengths, align with three of Warwick's Global Research Priorities (GRPs) and link to national stakeholder priorities. The Warwick GRPs provide support to build intra- and cross-faculty multidisciplinary research teams that tackle research problems of global societal significance.
Energy was identified as a strategic priority in RAE2008 and is now well advanced. Capital investment of £6M secured through the Birmingham Science City Research Alliance (SCRA) Energy Efficiency Programme has established world class facilities in power electronics and silicon carbide (SiC) research and in advanced capabilities for thermal technologies. Two 'energy focused' groups, Electrical Power and Thermofluids, have been established. These initiatives link with WMG's UK Energy Storage R&D Centre and Vehicle Energy Facility and position SoE and WMG as leaders in energy conversion, devices, systems and storage. The Warwick Institute of Sustainable Energy and Resources (WISER), identified as a strategic priority in RAE2008, has grown into the University GRP in Energy with *Mawby* (SoE) its director.
Biomedical Engineering was established to recognise, consolidate and expand on the medical engineering base identified in RAE2008. The Warwick Engineering in Biomedicine (WEB) theme provides a strategic footing for this activity and, through the University's Science and Technology for Health GRP, links with complementary activity in WMG's Institute of Digital Health, the Warwick Medical School (WMS) and the School of Life Sciences (SLS). A £1M CIF investment has established three laboratories: Trace Metals in Medicine, Nanobiomechanics and Biomedical Sensors and SCRA funding secured under the translational medicine programme has established a gait laboratory to advance ambitions in biomechanics and link to the European leading orthopaedics centre at WMS and University Hospital Coventry & Warwickshire. A joint post in tropical diagnostics has been approved to further strengthen collaboration between the Biological Sensors laboratory and Warwick's new Centre for Applied Health Research & Delivery (CAHRD) – a joint initiative with the Liverpool School of Tropical Medicine.
Sustainable Cities was established in 2012 as a key element in the University's strategic ambitions in urban science. The Warwick Institute for the Science of Cities (WISC) and a Warwick GRP in 'Cities', co-directed by *Guymer* (SoE), has recently been created to build on the University's strategic alliance with the Centre for Urban Science and Progress (CUSP) in Brooklyn, New York. CUSP, headed by New York University (NYU), is a consortium of seven universities of which Warwick is the single European member. The mission of CUSP and WISC is to pioneer the field of urban informatics and develop a new 'science of cities'. An EPSRC CDT, co-led by *Guymer*, has recently been awarded and will fund over 50 PhD students. The SoE has appointed 'CUSP' Assistant Professors in the areas of urban communications and structural health monitoring.

An Electrical Power group has been established to complement existing internationally leading research in Silicon Carbide (SiC) power devices and further strengthen ambitions in Energy. Five new academic posts and 2 SCRA Research Fellows provide expertise in power systems, electrical machines, power devices and energy storage with a mission to develop internationally leading research in support of the automotive, renewable energy and the power generation sectors.
Thermofluids brings together existing laboratories in fluid dynamics and thermal engineering to align with Energy. Three new appointments have strengthened existing expertise in heat pumps, refrigeration and end-use-energy-demand (concentrating on domestic and industrial sectors) and expanded into combustion and hydrogen transportation (serving the oil and gas industry). A group in Chemical Engineering, focusing on catalytic reaction engineering (CRE) and industrial biotechnology, has been established to capitalise on existing strengths in fluid dynamics, surface engineering and catalysis (Chemistry Dept.) and to strengthen energy research. Two professorial

appointments established CRE with an emphasis on sustainable feedstocks, energy efficient processes and nano -material production. A Chair in industrial biotechnology has been created that will link CRE to the newly established university centre in Industrial Biotechnology and Biorefining. The Systems, Modelling and Measurement group has been significantly enhanced through six new posts to strengthen internationally leading research in systems medicine, synthetic biology, medical imaging, nanobiomechanics and biomedical stochastic modelling. In 2013 coordinated appointments in SoE and SLS establishing the Warwick Centre in Integrative Synthetic Biology (WISB), co-Directed by *Bates* (SoE); Synthetic biology is one of the 'eight great technologies' identified in the UK Government's Industrial Strategy. The Sensors & Devices group are recognised leaders in the development of chemical and ultrasonic sensors. Recent CIF investment has established a new laboratory in Biomedical Sensors that applies electronic nose technology developed at Warwick to the early diagnosis of pathologies including TB, colon cancer and Crohn's; this activity will be strengthened through the joint appointment with LSTM. Two new industry-facing centres, the £1.4M CIF2 funded Mesoscopic Electronic Engineering Centre (MEEC) and the £800k industrially funded Centre in Industrial Ultrasonics (CIU), have also been established (details below) and strengthened through two academic appointments. The Communication & Signal Processing group leads research in optical wireless, nano-communications and network coding. A recent appointment in 'urban communication' links to the Sustainable Cities research themes and expands expertise to the communication and collection of Big Data through CUSPs 'living laboratory' project in Manhattan. An additional post in nano-communications strengthens an area in which Warwick currently has an international lead. Five new posts in Civil Engineering build on two additional Assistant Professor posts from 2007. This re-established group will develop the Sustainable Cities research theme, link strongly to the University's initiatives in WISC, CUSP and the Cities GRP and align teaching resource to the strong undergraduate recruitment in this discipline. Academic recruitment has strengthened world class research in resilient structures and geotechnics.

To increase engagement with industry a higher level Industrial Advisory Board, chaired by Stephen Burgin (ex. CEO Alstom UK), has been formed and two industry-facing Centres, MEEC and CIU, established. MEEC (led by *Ashley*) builds on the original £6m SCRA 'energy efficiency' investment through the expansion of the SiC clean room facility, and extends device research into small band gap III-V materials. Applications include high speed, very low power electronic devices for future generation computing and mobile communications and novel infrared components for thermal imaging and gas sensing. This initiative links expertise and facilities in Physics e.g. the NanoSilicon group and the Nanoscience Research Cluster and material growth in Chemistry to activities in the Sensors & Devices group. Central to the mission of MEEC is the support of industry in the development of commercial devices through applied research projects. CIU (led by *Dixon*) provides academic expertise, particularly knowledge transfer, and support to industry and pools complementary expertise between Physics and SoE; it also builds on the EPSRC funded UK Research Centre in Non-Destructive Evaluation (RCNDE) in which 4 CIU staff are involved. The CIU membership scheme launched in September 2013 will welcome around 30 companies to its first network meeting in Dec. 2013.

Vision 2015 has already led to a significant enhancement in SoE's research environment and performance. A 25% increase in academic staff numbers has been achieved resulting in; increased critical mass in strategic priority areas; enhanced research quality ('fresh blood'); the strengthening of strategic research collaborations and increased research time for academic staff through a reduced student:staff ratio. Furthermore, SoE has; achieved compound growth in research awards of 30% in 2011/12 and 90% in 2012/13; attracted energy related grants and contracts worth £20M; achieved an intake of 43 and 47 PhD students in 2011/12 and 2012/13 respectively (on target to exceed 2.5 per academic FTE by 2015); won eight consecutive EPSRC's First Grants due to improved mentoring and support coupled with high quality appointments (section c).

SoE's strategic plan post-REF2014

The present REF exercise occurs just after the midpoint for the current strategy period (2010-2015) and SoE is in the process of developing a follow-on Vision 2020 to consolidate and further strengthen its research base.

The major research themes will be further enhanced. An SoE facilitated university level strategy in

biomedical engineering will forge closer working links with the Warwick Medical School and the Institute of Digital Health (IDH-WMG). Further academic posts in Energy are planned to strengthen expertise in renewable energy generation and sustainability. SoE will continue to develop the recently introduced initiatives in chemical engineering and synthetic biology through further (already approved) academic posts. A new £3M 'research exchange' is planned that will provide 1000 m^2 to house cross-faculty interdisciplinary research. This high quality environment will: co-locate academic, research and visiting staff and PhD students; provide state-of-the-art IT and video conferencing facilities and promote interaction through meeting rooms and a social area.

WMG research strategy. In RAE 2008 WMG identified a number of key strategic objectives for the period 2008-2013. The achievement of these objectives was dependent on increasing research intensity by increasing academic staff numbers in strategic areas whilst further developing industrial partnerships and continuing to enable knowledge transfer.

In the last 5 years 23 new academic posts have been created (11 to be filled) and 7 replacement posts filled. All but three appointments have been externally recruited, leading to a dramatic change in the research environment with an increasing emphasis on high quality research with relevance and impact. Government (UK and EU), RCUK, TSB, university and industrial partner strategies have informed the research areas identified for development. Significant growth has been achieved in the five research areas of Materials, Manufacturing, Energy, Healthcare and Business Transformation.

Advanced Materials is one of the eight great technologies identified in the Government's Industrial Strategy. It is one of the University of Warwick's Global Research Priorities (GRP) and is a key enabler in Lightweighting which is one of the UK Automotive Council's five strategic technology areas. In Materials two new groups have been created (Multifunctional Systems, Materials Processing/Electrochemical Engineering) whilst the Engineering Materials and Sustainable Materials groups have been significantly strengthened. Key research programmes have been the EPSRC Warwick Innovative Manufacturing Research Centre, Premium Vehicle Centre for Lightweight Technologies, Low Carbon Vehicle Technologies, and HVM Catapult. A Tata Steel/RAEng Chair in Low Carbon Materials Technologies was recruited in 2013 as part of a strategic Tata Steel investment in a research centre for sustainable steel technologies. In addition to the new academic staff there is significant investment (£5.5m) planned in both equipment and infrastructure with two new facilities due to be completed in early 2014.
In Manufacturing we have created a new Automation Systems group and have strengthened the Digital Life Cycle Management group. Innovative manufacturing is a GRP and Robotics one of the 'eight great technologies'. This area has hosted an EPSRC Star Recruit (*Ceglarek*) and has received significant funding especially from the EPSRC with over £7M awarded in this area over the last twelve months.
Energy is another GRP, a 'great technology' and enabler for the UK Automotive Council's strategic technology area Energy Storage and Energy Management. It is an area that has seen a significant increase in activity focussed predominantly in the Materials Processing & Electrochemical Engineering and Energy and Electrical Systems groups. This has seen the creation of new facilities, staff recruitment and research in the Low Carbon Vehicle Technology, SCRA Energy and HVM Catapult programmes. Through this WMG has built up core capability in energy storage and energy management. In 2012, WMG was selected to create the UK Energy Storage R&D Centre, funded by BIS/TSB (£9M) and industry (£4M). This activity links with SoE's expertise in power electronics, systems and control.
Healthcare (University GRP) is a cross cutting theme in WMG with a number of research groups contributing (Experiential Engineering, Visualisation, Multifunctional Systems, Metrology, Digital Lifecycle Management). Identified in RAE2008, the most significant achievement has been creation of the IDH in 2009. Driven by the Biomedical Engineering & Medical Informatics Group (*James*, IDH Director), this is a £4M partnership between NHS Midlands and East, WMG and WMS, focusing on improving health and wellbeing through the development, evaluation and use of innovative digital technologies and services. It provides the pathway for impact for all WMG's healthcare activity and will form a key element in the newly created West Midlands Academic Health Science Network (AHSN).
Business Transformation has always been a key component of WMG's activities. In response to

the growing importance of the Digital Economy, the opportunities of Big Data, the creation of New Business Models and the impact on the Supply Chain, a number of key academic appointments have been made and the Business Transformation Group has evolved. The Group combines social science principles and technological advances to create new business models. An example of this is the £1m collaborative EPSRC project (*Ng*) recently awarded to exploit the data available from a new generation of sensors and devices to develop new economic models.

With respect to knowledge transfer and strategic partnerships the last five years has seen significant activity, including the £12.4M construction of the International Digital Laboratory in 2008 and continuing with the £8.5M International Institute for Product and Service Innovation (IIPSI programme 2012-15). Through these initiatives WMG has enabled knowledge transfer into the regional SMEs leading to over 330 new collaborations. Development of industrial collaboration continues to be a strength of WMG. In addition to the longstanding partnerships with Tata Steel and Tata Motors, WMG hosts 200 Jaguar Land Rover (JLR) research engineers creating a total of 500 industry research engineers co-located and collaborating with WMG academics. JLR is a key strategic partner investing £50M into the new 30,000 m^2 National Automotive Innovation Campus (NAIC) coupled with a 15 year commitment to provide to WMG at least £3M of revenue research funding per annum. In October 2010 the CEO of Jaguar Land Rover (JLR) stated *"In Germany all the car companies are involved with a university. We need to go more in that direction in the UK. We will do all our pre-development work at Warwick, and that will be a radical change."*

WMG's strategic plan post-REF2014

Building on the appointment to the RAEng/Tata Steel Chair (*Seetharaman* – formerly Posco Steel Chair at Carnegie Mellon University) a Sustainable Steel Technologies group will be created, supported by three new appointments (two Tata Steel funded Chairs and one Assistant Professor). Underpinning this will be significant public/private infrastructure investment. In the area of the manufacture and performance of composites two new appointments will be made supported by £2.5M equipment and infrastructure investment to create the Automotive Composites Research Centre. In early 2014 a new International Institute for Nanocomposites Manufacturing will be opened providing 1,110 m^2 of laboratory space to support the Multifunctional Systems Group. Also in early 2014 the UK Energy Storage R&D Centre will be completed to underpin the Electrochemical Engineering and Energy & Electrical Systems groups collaborating with institutions including Oxford and Imperial in the area of new battery chemistry scale-up. A JLR sponsored appointment in Advanced Propulsion will further strengthen the Energy and Electrical Systems group. The academic resource supporting IDH will be strengthened with appointments from within the NHS and the discipline of computer science to support e-health innovation, particularly in the areas of information design, policy, and technology evaluation. In Business Transformation, a junior appointment will be made in the area of service systems along with two appointments in the area of cyber security. Through the HVM Catapult we will work with our strategic aerospace partner (BAE Systems) to identify and exploit cross sector opportunities particularly in the areas of materials, manufacturing and energy storage. The development of the NAIC will create tailored collaborative research space to build upon capability in materials, propulsion, metrology, design review/validation, complex electrical systems and smart and connected vehicles. This will be supported by a recent £3.1M EPSRC Equipment Grant "Robotics and Autonomous Systems: The Smart and Connected Vehicle".

c. People, including: Staffing strategy and staff development

SoE staffing strategy and development

Staffing policy is targeted to achieve SoE's Vision 2015 strategic objectives. Since 2008 academic numbers have increased by 16 FTE and 6 replacement posts have been filled. Due to page limits the focus here is on key staffing changes, promotions and major Fellowships (in bold).

Electrical Power, headed by *Mawby* (**RAEng Research Chair**), holds current grants and contracts in excess of £12M. New appointments are (former institute in parentheses): *Wang* (Birmingham), power systems and control; *Ran* (Durham), electrical machines and power systems; *Shah* (Southampton), battery and fuel-cell technology. Two ECRs have recently been appointed; *Gammon* (Imperial), power devices and SiC, holds a five year **RAEng Postdoctoral Fellowship** and *Alatise* (Warwick), formerly a HEFCE funded **SCRA Research Fellow,** works in power electronics and energy conversion. Two further 'tenure track' **SCRA Fellows** are: *M. Jennings,* SiC devices and *Kiselychnyk*, power systems and control.

Thermofluids brings together existing laboratories in fluid dynamics and thermal engineering and aligns (predominantly) to the energy research theme. *Wen* (Kingston), an expert in CFD codes for combustion-related application, complements expertise in fluid dynamics and thermal engineering. *Tamainot-Telto* (Warwick), adsorption and vapour compression systems, was recruited in 2009 and recently promoted to Associate Professor; *Zhao* (Shanghai Jiao Tong (SJTU)), energy storage and phase change materials, is a joint appointment with SJTU.

Chemical Engineering was formed through the appointments of *Lapkin* (Bath), liquid-phase reactors and biocatalysis, and *Van Veen* (Technische Universität München), chemical reactors and catalytic processes, to develop catalytic reaction engineering. This activity aligns with SoE's Energy theme. A recently approved post in Sustainable Feedstocks and Industrial Biotechnology will forge links with the new University Centre in Industrial Biotechnology and Biorefining. *Lapkin* recently departed to Cambridge.

Systems, Modelling & Measurement has been significantly strengthened to align with the Warwick Engineering in Biomedicine research theme. *Bates* (Exeter) was recruited to develop activities in synthetic biology and systems medicine and is co-Director of the Warwick Integrative Synthetic Biology Centre (WISB). *Khovanov* (Lancaster), bioengineering and stochastic systems, was recruited in 2009 as an **EPSRC Advanced Fellow** and promoted to Associate Professor in 2011. *Khovanova* (Warwick), biological and stochastic systems modelling, and *Pecchia* (Nottingham), health care technology, are recently recruited Assistant Professors and *Collingwood* (Keele), neurodegenerative disease and formerly an **EPSRC LSI Fellow**, was recruited in 2009 and promoted to Associate Professor in 2013. *I Liu* (Keele), nanobiomechanics, was appointed as a Reader in 2009 and held an **RAEng/Leverhulme Senior Research Fellowship** in 2010/11**.** *Dr X. Zhao* (Oxford) is a **University of Warwick Global Research Fellow** who applies control methodologies to a wide variety of mechatronic applications.

Sensors & Devices, headed by *Gardner* (**FREng**), is organised into sensors, (predominantly chemical and ultrasonic) and semiconductor devices. This group was strengthened by the appointments of *Ashley* (QinetiQ), narrow band-gap III-V semiconductor devices; ECRs *Neophytou*, quantum scale devices and energy harvesting and *Leigh,* sensor technology and 3D printing. There is strong collaboration with the Physics Nano-Silicon Group of *Leadley* with new appointments *Myronov* (appointed 2008 for epitaxy) and *Sanchez* (**SCRA Fellow**), high-resolution electron microscopy. In Ultrasonics, *Dixon* (**Elster Industrial Chair**) is a joint appointment with Physics where *Edwards* holds a **European Research Council Starter Grant**.

Communications & Signal Processing focuses on wireless communications (optical and RF domains) and related signal and image processing techniques. These activities, which underpin all three research themes, have been strengthened by the recruitment of two Assistant Professors; *Higgins* (Warwick), optical communications & nano-communications, and *Guo* (Sheffield), networks and urban communications. Guo was appointed to link with WISC and CUSP. *Leeson,* network coding & nanocomms., held an **RAEng/Leverhulme Senior Research Fellowship** in 2010/11.

Civil research is coordinated in three areas: materials & structures, geotechnics and water engineering. *Mottram* (Head of Group), fibre reinforced polymers (FRP) and infrastructure, was promoted to a Chair in 2011. *Lewis*, structures and minimal energy surfaces, was promoted to a Chair in 2009. *Chan,* steel structures and composites, was recruited as an Assistant Professor in 2007 and promoted to Associate Professor in 2012. *Zivanovic* (Sheffield), human-structure interaction, was appointed as an Assistant Professor in 2009. *Karavasilis* (Oxford), structures and earthquake engineering, was appointed in 2010 and recently promoted to Associate Professor. *Utili* (Oxford), geotechnics and soil-structure interaction was recruited as an Associate Professor. *Ni*, a geotechnics expert developing methodologies with 'transparent soil', was awarded a **Royal Academy Industrial Secondment** in 2010 and recently promoted to Associate Professor. Very recently two further ECRs have been recruited: *Laory* (ETH Zurich), structural health monitoring, links with Sustainable Cities and WISC and *Mousavi-Nezhad* (Glasgow), advanced computational modelling in structures and materials. *Coelho* is an IEF Marie Curie Fellow (Coimbra, Portugal) investigating stress analysis of FRP structures.

Since 2008 SoE has hosted 37 visiting academics, including 13 Professors. Notable examples are Professors, James Kirtley (MIT), Blake Wilson (Duke), Chris Firth (Thales), Johan Schoukens (Vrije University), Jan Baeyens (Leuven), Philip Arundel (AstraZeneca), John Simmons (McMaster), Qi-Rui Gao (Tsinghua), Yulin Wu (Tsinghua), Roger Baker (Cranfield). SoE

academics hold 20 Visiting and Honorary Professorships including 14 international appointments. Institutes include; Harbin, Tongji, Tianjin, Shandong, Nanjing University of Technology, UTM (Malaysia), NTU (Singapore), University of Florida and IUAV (Venice).

SoE has improved staff development for all grades in accordance with Vision 2015. Line management is facilitated through three Discipline Stream Leaders (DSLs); each DSL is responsible for staff development across a number of research groups. Clear career plans and identification of training opportunities take place as part of the University's annual review process. SoE also operates a study leave policy for all academic staff (1 year sabbatical is accrued after 6 years) and 24 academic members of staff (40%) have taken advantage of this scheme since RAE2008. In addition to promoting a vibrant research environment through regular seminar programmes and the high profile 'Andrew Little' lecture series a number of additional initiatives have been introduced specifically for ECRs and mid-career staff. For example, 'top-tips' sessions are regularly arranged where senior staff share 'best practice' (e.g. on publication strategy, working with industry, EU funding, successful grant proposal writing). SoE has increased the number of Assistant Professors in the rotating membership of the internal Research Grant Review Panel – this exposes them to good grant writing practice, critical analysis, and to the breadth of research within the SoE thus promoting integration and collaboration. Additionally, Assistant Professors are: assigned a mentor who is usually independent from the formal line management of the School; required to complete Warwick's Postgraduate Certificate in Academic and Professional Practice; assigned a PhD studentship within the first twelve months of appointment; given a 50% reduction in teaching load in the first year that ramps up to a full load in their final year (usually the 5th year) of probation. Success of these initiatives is evidenced by the high number of promotions (detailed above) from Assistant to Associate Professor (the 'career' grade at Warwick) and 8 consecutive successes in winning EPSRC First Grants.

A Research Office (RO) was established in 2010 as a 'one-stop-shop' to support the research of all staff and PhD students. A wide range of services are offered, including; advice on forthcoming calls for proposals and application procedures; assistance with preparing grant applications, including peer reviewed feedback on draft proposals; arrangement of 'mock' interviews in preparation for funder's interviews; support for organising international conferences (e.g. ICTON 2012); organisation of seminars; publicising research. Support for PhD students includes: advice on preparing material for the School's evaluation and assessment process; information on scholarships and bursaries and, through Warwick's Career Services, assistance in finding employment. The RO has responsibility for implementation of *The Concordat to Support the Career Development of Researchers.* The seven principles of the concordat are promoted and delivered in conjunction with the University's Learning and Development Centre (LDC) who provide bespoke training workshops for contract research staff, such as, Academic Writing, Career Development and Technologies for Research. An LDC Advisor visits the School to promote LDC workshops and participation in Warwick's Research Staff Forum, which promotes integration of contract research staff at university level. Since 2008, a total of 12 former PhD/PDRAs have taken up academic posts in top QS ranked universities, including 4 in the UK's Russell Group.
SoE has also embedded equality and diversity in all aspects of its business and in recognition of this activity was awarded an Athena Swan Bronze Award in 2013 and plans to submit for Silver Award in 2015. The Communication and Welfare Committee, with representatives from all staff groups, has specific responsibility for ensuring embracement and compliance with Athena Swan.

WMG staffing strategy and development

Over the last five years WMG has focused on developing academic leadership in our five research areas. This has been achieved through the recruitment strategy, overseen by the WMG Board and led by the Academic Director and the Director of Operations & HR. *Dashwood* (from Imperial) and *Hughes* (ILL), were appointed in response to the increased opportunities for research into lightweighting, including through collaborations with JLR, TMETC and Tata Steel. *Seetheraman* (Carnegie Mellon) was appointed into a RAEng/Tata Steel chair to address the challenges associated with sustainable steelmaking. *McNally* (QUB), *Dancer* (Oxford), *Wan* (T.C. Dublin), *Murphy* (Oxford) were appointed in the area of Advanced Materials and Nanotechnologies creating the Multifunctional Systems group to tackle the manufacturing challenges associated with these new materials. In the area of Energy Storage there have been the appointments of *Bhagat*

(Imperial), *Low* (Southampton), *Marco* (Cranfield). *Harrison* (Loughborough) and his Automation systems group joined WMG addressing issues in Robotics. In Healthcare *James* (Southampton) and *Harte* (Technical University Denmark) have joined the IDH and *Cain* (Warwick) was appointed to the Experiential Engineering Team which she now leads. In Innovative Manufacturing, *Coles* (Warwick) joined the Sustainable Materials & Manufacturing Group and *Agyapong-Kodua* (Cranfield) joined the Digital Lifecycle Management group. In order to address the challenges of the digital economy and associated new business models the Business area has been strengthened by the appointment of *Ng* (Exeter) and *Godsell* (Cranfield).
The department operates a teaching load model that maximises the opportunity for research activities and it employs administrative staff to assist the preparation and running of research grants and contracts. It has a dedicated Business Development team, which includes an individual linked to the University's Research Support Services office. The research activities of all staff are reviewed regularly with formal appraisal/progress interviews held. Research performance is a major factor in decisions on merit pay and promotion recommendations, and good performance is recognised and shared via the weekly e-mail Bulletin to staff and research students.
WMG's Research Strategy Group supports the development of research and academic staff by providing information on a range of opportunities, including targeted support for the applications process for Fellowships and major grants. The department has a Researcher Forum to facilitate networking and to input into targeted development activities for research staff, and a Welfare and Communications Group which has a particular focus on supporting academic and ECR development. Departmental development activities include mentoring (often by suitably qualified individuals outside the University), formal induction programmes, mock panels for funding proposals, and training on writing for academic purposes.

To encourage collaborative research we have adopted an open plan work environment in the newer buildings (IDL & IIPSI) within which academics, researchers, doctoral students and industrial collaborators co-locate. Junior academic staff are appointed as Assistant Professors and have a probationary period of five years with a reduced teaching load. During this time they undertake a structured development programme, guided by the Academic Director. Within the department, they are assigned a Professor Responsible (line manager) as well as an academic mentor. Successful completion of probation leads directly to an Associate Professorship.
The key principles of the RCUK Research Concordat are at the core of our recruitment and development activities, and these are monitored by WMG's HR team, who provide professional advice and support at all stages of the career lifecycle. There is HR representation on all selection panels to ensure that best practice is followed. The department has strong female representation on all Committees and decision-making groups and targeted support for staff at key career transition points (e.g. maternity leave, promotion). WMG received an Athena SWAN Bronze Award in 2013 and is working towards a Silver Award application in 2015/16.
WMG has a good track record of supporting staff into Fellowships including two EPSRC Challenging Engineering Awards, two RCUK Academic Fellowships, a Royal Academy of Engineering Fellowship and two Royal Society Industrial Fellowships held by staff during the REF period.

International perspective is demonstrated through recent appointments detailed above and international appointments (e.g. *Chalmers* - Honorary President Afrigraph, *Dashwood* - Visiting Professor IIT Bhubaneswar, *James* - Europe Representative on IEEE EMBS Committee and *Ng* - Adjunct Professor National University of Singapore, Seetharaman - Top Overseas Professorship University of Science and Technology Beijing). WMG has a wide range of Visiting Professors and Fellows from universities outside the EU, including: Brazil (e.g. Federal University Uberlandia), Canada (e.g. Windsor), China (e.g. Beihang, Jilin, Nanjing Institute of Technology Tsinghua), India (e.g. IIT Kharagpur - supported by EPSRC and UKIERI), Malaysia (e.g. UT Petronas), Republic of Korea (e.g. Kangwon National University), and the USA (e.g. Purdue).

SoE research students
The number of registered PGR students has increased to 123 compared to 85 in 2008. Increasing the number and quality of research students is a primary research objective. To this end the School has introduced a bursary scheme to provide matched funds for students securing partial funding through a recognised scholarship scheme (e.g. Warwick's Chancellors Fellowships and the

Chinese Council's CSC scheme) or through industry sponsorship. The School operates the competitive Victoria Fernandes Scholarship that awards full support for an outstanding candidate and offers fee waivers to exceptionally qualified overseas students. SoE is a partner in the EPSRC sponsored DTC EngD programme run by the Research Centre in Nondestructive Evaluation led by Imperial and the recently awarded EPSRC DTC aligned with CUSP; exchange programmes operate with Tokyo Institute of Technology and Hokkaido University in Japan and a reduced tuition fees arrangement has been agreed with Zhejiang and Shanghai Jiao Tong in China as part of a strategic partnership designed to attract outstanding PGR students. Entry requirements have been raised to a 'strong merit' (65% or equivalent) for applicants entering with a Masters degree and more stringent 'progression' requirements between years of study have been introduced. Each student is assigned a bespoke Progress Panel comprising two independent members of staff that monitor and evaluate performance and offer guidance to the student (and supervisor) when necessary. The panel normally meets twice in the 1st year and once in subsequent years or more frequently when necessary. Students provide material for assessment such as a literature review and project plan (1st year) and a research paper and poster (2nd year); in the final year(s) chapters of the thesis are assessed. The panels also identify individual training needs (e.g. attendance on Masters modules) and all students are encouraged to register on Warwick's interdisciplinary science transferable skills module. An annual symposium for research students is operated as a conference at which students present and discuss their work with other students and staff. This has fostered a sense of community and improved research skills training in the dissemination of research work. This activity is over seen by the Director of Graduate Studies and the Research Office. The University operates a Post-Graduate Hub that functions as a resource centre available to all PG students with a range of support services including training, workspace and social organisation.

WMG research students

WMG currently has 102 registered PhD students and 41 registered EngD Research Engineers. This represents an approximate 3-fold increase in PGR numbers since 2008 which has been achieved through the introduction of a number of initiatives. Together with EPSRC funding for our EngD(Int.) we have increased the number of Industrial Case and Industry funded PhD students and also offer sponsored studentships, that complement University wide schemes; these are used in particular to support ECRs. To enhance the quality of our students we provide research internships for up to 20 students each summer from the UK and overseas.

We have two Engineering Doctorate programmes. The original programme has run since 1992 and covers all aspects of Manufacturing and is aimed primarily at those who are employed in a company. The EngD(Int.) has financial support from EPSRC as well as from industry and has an embedded MSc in Innovation and Entrepreneurship. There are also seminars, masterclasses and structured debates as well as a three week placement overseas.

All research students attend a tailored induction followed three months later by a Progress Review Workshop where all students present their project to their peers and supervisors. This encourages a cohort approach and cross-fertilisation of ideas. All participants attend a three-day Research Methods module early in year one and then study detailed modules on specific techniques as appropriate. All students attend annual doctoral conferences; those in year two give a poster presentation, those in years three and four give an oral presentation. Written feedback is provided. All programmes are overseen by the Research Degrees Committee chaired by the Research Degrees Director. The EngD (Int.) has a dedicated executive overseen by the Centre's Strategic Director. Students have two academic supervisors and where appropriate (Industry Sponsored PhD, Case, EngD) an industrial mentor. They meet with their supervisors at least once per month and records of the meetings are held centrally. There is a formal annual progress review comprising a report and interview by two independent members of staff. Any issues are followed up with a subsequent report and/or interview as appropriate. Candidates for the PhD enter onto an MPhil/PhD route. At the end of year 1 candidates write a report including research objectives, literature review, findings to date and future plans and present to an independent panel of senior academic staff. Candidates may be invited to continue onto the PhD or to resubmit within 3 months for a final decision. Unsuccessful candidates will be invited to complete an MPhil.

d. Income, infrastructure and facilities

Combined annual income per academic FTE between 2008-2013 averaged £215k which rises to an average of £248k over the period 2010-2013. Recently, the value of research awards has grown rapidly; in 2012-13 new awards amounted to £49M.

Infrastructure and Facilities SoE: Major enhancements to SoE's infrastructure since 2008 include provisions for the development of several new specialist research facilities. These include:
Science City Research Alliance (SCRA): A £6M investment in the Energy Efficiency initiative through the regional development agency Advantage West Midlands (AWM). Funds were used to; install a class 1000 silicon carbide clean room facility for the development of high power MOSFETS, procure fuel diagnostics and optical diagnostic equipment, establish a power systems control laboratory and develop a state-of-the-art solar and thermal testing facility including a large scale environmental chamber and a solar simulator. The SCRA Advanced Materials theme provided £11M of materials analytical tools, including the advanced electron microscopy facility now housed in a bespoke environmentally controlled, vibration free building. Additional funds of £200k were obtained through SCRA's Translational Medicine programme to establish a gait laboratory that provides state-of-the-art motion tracking facilities for biomechanical modelling.
£3M HEFCE CIF investment: Used to create approximately 400 m^2 of new laboratory space including; new labs in Chemical Engineering, Biomedical sensors, Nanobiomechanics and Trace Metals in Medicine. Additionally a modern open plan PhD work room was created.
£1.4M HEFCE CIF2: Expansion of the SiC 1000 clean room facility to establish the Mesoscopic Electronic Engineering Centre. Nano-imprint lithography and high vacuum metal deposition system, as well as several smaller process and characterisation tools, have been procured. A Process Engineer and a Process Technician recruited from QinetiQ are funded through HEIF5 monies to support this industry facing facility.
£2.5M EPSRC SiC epitaxy reactor facility is currently being commissioned in collaboration with Physics to complement the existing Si-based epitaxy facility that has supplied over 1000 wafers to 11 UK and 14 EU groups since 2008. This will provide a unique national centre for the fabrication of SiC wafers and forms part of the BIS *Underpinning Power Electronics* initiative.

Infrastructure and Facilities WMG: Major enhancements to WMG's research infrastructure since the RAE 2008 include:
International Digital Laboratory: £12.4M, 5,133 m^2 high specification building opened July 2008 with an additional £2.5M research equipment funded by AWM. It provides state-of-the-art facilities and hosts the IDH and novel facilities including the world's only High Dynamic Range video system for capturing and displaying real world lighting.
International Institute for Product and Service Innovation: £8.4M, 2,377 m^2 high specification building occupied in September 2012. Facilities focus on experience-led innovation, digitally enabled eco-systems and multi-functional polymers including the UK's first University based conductive ink printing system.
Vehicle Energy Facility (VEF): £2.3M initial investment (SCRA) enabling integration of real and virtual powertrain components, opened in July 2010. It links two new dynamometers (for micro gas turbines, petrol and diesel engines), battery packs (electric and hybrid powertrain) and control strategies. Further investments of £317k (ERDF) and £2.7M (TSB/BIS) have created unrivalled facilities to enable research on battery packs, control modules and battery abuse performance.
Metrology: AWM/ERDF and TSB funding (£1.4M) has created dedicated facilities for exploring product quality and customer interfaces including: micro CT scanner, 3D visualisation wall, and whole vehicle coordinate measuring machine.
Structural Materials and Manufacturing: ERDF/AWM/TSB funding (£2.4M) facilities to enhance materials and manufacturing research including, polymer extrusion, ultrasonic and cryogenic milling, drop tower, metallographic preparation along with Analytical FEGSEM, XRD, DSC/TGA, & hot stage confocal microscope.
Facilities are accessible to researchers in academia and industry. An Equipment and Capability Directory is published and available on-line from websites including WMG, University, M5 Consortium, Rail Supply Strategy Board and the SMMT. A dedicated contact in the Development team works with users to plan and cost activities, which include full technical support.
The following activities are funded and will be completed between 2014 and 2016:
UK Energy Storage R&D Centre: Co-funded by BIS (£9M) and industry (£4M), the Centre will accelerate research into future battery cells for the next generation of ultra-low carbon vehicles,

creating a new generation of high performance batteries with higher energy density levels.
National Automotive Innovation Campus (NAIC): NAIC is funded through HEFCE's UK Research Partnership Fund (£15M government investment, supplemented by £79M industry cash capital funding) to create 30,000 m^2 of research facilities. The funds have been awarded and completion of the new buildings is scheduled for March 2016. The NAIC will act as the national focus for research to address the challenges in the long-term strategy of the UK Automotive Council.
Automotive Composites Centre: £2.3M 380 m^2 centre to enable the West Midlands' automotive supply chain to exploit the opportunities offered by lightweight vehicle technologies. Part funded by the Coventry and Warwickshire Local Enterprise Partnership, it will open Q2 2014.
International Institute for Nanocomposites Manufacturing: 1,110 m^2 laboratory and office space to support the activity of the Multifunctional Materials group. It will include pilot scale manufacturing together with microstructural characterisation facilities to facilitate the industrial take up of this new class of material.

e. Collaboration and contribution to the discipline or research base.

SoE collaborations

Electrical Power has a research portfolio in excess of £12M and collaborations with over 30 international companies including National Grid, Toyota, Mott Macdonald, Western Power Distribution, Dynex Semiconductors, Prodrive and Raytheon UK. Global companies include GE Energy, GE Aerospace, JLR, Tata Motors, Ricardo and Axeon. Academic collaborations include the Universities of Toronto and Utah, the Instituto Politecnico Nacional (Mexico), MIT, and 13 UK universities. Current major projects led by *Mawby* include; the £3M EPSRC 'Vehicle Electrical Systems Integration' collaborating with 9 UK Universities and 21 industrial partners and the £2M Underpinning Power Electronics (Devices Theme) involving the universities of Cambridge, Bristol and Newcastle. *Wang* leads the £3M EPSRC 'IMAGES' programme in collaboration with Loughborough, Nottingham, the NERC British Geological Survey and nine industrial partners.
Thermofluids collaborates with over 45 industrial partners. *Critoph* leads i-STUTE which is a £5.2M EPSRC funded programme with 26 industrial and government partners including; Hewlett Packard, Asda, J Sainsbury PLC, CSIRO, National Grid, and academic partners; Loughborough, Ulster, London South Bank. *Wen* holds in excess of £1.5M funding from the EC, EPSRC and industry with significant collaboration with National Grid, BP, DNV GL and GexCon and over 30 international academic partners include Berkley, Tokyo University of Science, Universitat Politècnica de Catalunya, Barcelona, Zhejiang University. *Lockerby* is the Warwick PI in a £2.5M EPSRC Programme Grant with Strathclyde and STFC–Laboratories involving 8 industrial partners including EDF, JLR, EADS UK Ltd and UK Sport. Other significant academic collaborations exist with the Weisman Institute, Tokyo University, Rutgers University, Hokkaido University, Shanghai Jiao Tong University, Xi'an Jiaotong and Curtin University of Technology, as well as many UK institutions including Cambridge, Imperial and Manchester.
Chemical Engineering collaborates with over 30 academic and industrial partners. *VanVeen* initiated BIOGO-for-Production, a £7.6M EC project with 15 partners including Institut für Mikrotechnik Mainz (Fraunhofer Society), Teer Coatings Limited, TOTAL S.A., C-TECH Innovation, SPIKE Renewables, MICROINNOVA Engineering GmbH, Technische Universiteit Eindhoven and Boreskov Institute of Catalysis. He is the Bochum (DE) PI in OCMOL, a £6.4M EC project with 20 partners including Bayer Technology Services GmbH, Johnson Matthey plc, LINDE AG - Engineering Division, Haldor Topsoe A/S and the University of Cambridge.
Systems, Modelling & Measurement has industrial collaborations including JLR, AstraZeneca, Gambro, Waitrose, New Generation Biogas and Veola. Academic collaborators include the universities of Boston, Birmingham, Leicester, Manchester, Shanghai Jiao Tong, Tianjin, Jilin, Harbin Institute of Technology and the Liverpool School of Tropical Medicine. Medical links include University Hospitals Coventry and Warwickshire, Birmingham NHS Blood & transport, and renal units in Coventry, Birmingham and New Zealand. WISB, co-directed by *Bates*, is formally linked to 'CoSBi' the synthetic biology centre at Boston University directed by Jim Collins who is the William Fairfield Warren Distinguished Professor at Boston University and a founding faculty member of the Wyss Institute for Biologically Inspired Engineering at Harvard University. *Bates* is also co-I on a £3.08M five-year BBSRC LoLa grant involving Imperial, Newcastle and Exeter and the BBSRC Genome Analysis Centre and several industry partners. *Chappell* is lead on a £1.0M Marie Curie European Industrial Doctorate (EID) ITN which is part of a well-established collaboration with AstraZeneca and also involves the Fraunhofer-Chalmers Centre and Uppsala University.

Sensors & Devices collaborate with over 50 educational institutions world-wide including EPFL, ETH Zurich, KTH Sweden, NTU Singapore, 12 Russell Group, with UK hospitals and NHS trusts. Industrial links include Airbus, BP, Corus, Honeywell, Hyundai, IQE, Philips, Rolls-Royce Aerospace and Marine, BNFL, Shell, STMicroelectronics, Owlstone Ltd and pre-industrial research institutes IMEC, LETI & VTT, as well as DSTL, the Home Office and US organisations (US Army Research Labs, ONR, DARPA and others). *Cole* directed the FP6 iCHEM project valued at €2.3M collaborating with the Max Plank Inst. of Chemical Ecology, CSIC Spain and Twente (NL). *Leadley* has led international consortia: £2.7M Basic Technology on electronic cooling, with UK & Finnish partners; £2.1M EPSRC on spintronics with Cambridge & Southampton; £2.3M EPSRC "Renaissance Ge" with IMEC & Glasgow; and holds a £1.7M EPSRC Platform Grant. CIU are partners in the £3M EPSRC RCNDE with 13 industrial partners and *Dixon* coordinates the £1.2M EU Marie Curie "SACUT" IAPP.

Communications & Signal Processing has strong global links with over 20 universities in Italy, Romania, China, Australia, Spain and Iran. Industrial collaborators include Vodafone, Fujitsu Laboratories Europe, Thales and BTS Holdings Ltd. Other collaborative organisations include the Potato Council and the Agriculture & Horticulture Development Board. Green leads WP4 of the ICT COST Action IC1101 on Optical Wireless Communications which involves educational institutes from 23 countries.

Civil have projects with 17 industrial partners (examples include, Mott MacDonald, ARUP, Unilever, Courtaulds, NASA Langley, Lonza, Seven Trent Water, TATA steel, Geotechnics Ltd) and over 20 academic partners including; Princeton, Oxford, Tongji, Tsinghua, Western Sydney, Patras, University of Hong Kong, Oxford, Sheffield and Edinburgh. *Guymer* is the University of Warwick's co-lead for the CUSP initiative that partners with NYU and NYU-poly, Carnegie Melon, Toronto and IIT Bombay and nine industrial partners including; IBM, Microsoft, Xerox, Cisco, National Grid, Siemens, ARUP. *Mottram* directs the £1.4M EPSRC DURACOMP project with Bath, Bristol, Glasgow and Newcastle. *Utili* is coordinator on an EC IRSES project on Geohazards and Geomechanics in collaboration with three EU, and Indian and two Chinese universities.

WMG Collaborations

WMG links its core research activities with an integrative capability to address 'systems level' industry challenges with support from major industrial partners. EPSRC-funded projects initiated in 2013 include: *Kirwan's* £2.5M "Cleaning Land for Wealth" where he is leading a team from the Universities of Birmingham, Cranfield, Newcastle, and Edinburgh; *Ceglarek's* £2M "Self-Resilient Reconfigurable Assembly Systems with In-process Quality Improvement" involving companies such as BAE Systems, Jaguar Land Rover, EnginSoft, Hexagon Metrology and Georgia Tech; *Harrison's* £2M "Knowledge Driven Configurable Manufacturing" bringing together Ford, GE, Schneider, Thysen Krupp and University of Loughborough; *Williams'* and *Gibbons'* £0.5M "Statistical methods for Computed Tomography Validation of Complex Structures in Additive Layer Manufacturing" a joint project with the Mathematics department; and *Ng's* £1M "Home Hub-of-all-Things (HAT) as Platform for Multi-sided Market Powered by Internet-of-Things: Opportunities for New Economic & Business Model" with Universities of Nottingham, Edinburgh, Cambridge, Exeter and the West of England.

The Warwick Innovative Manufacturing Research Centre completed a £7.2M 10 year research programme in 2011 involving 7 departments across the university and 38 companies. Its legacy has continued in the WMG-led Warwick GRPs in Innovative Manufacturing (*Kirwan*) and the Innovative Manufacturing strand in the Warwick-Monash Alliance (*Dashwood*). International collaboration includes formal agreements with Chulalongkorn University, Confederation of Indian Industry, IIT Kharagpur, Hong Kong Polytechnic University, A*STAR research institute SIMTECH, University of Science and Technology Beijing and Purdue, together with activities with Warwick's partner universities including Boston, Monash and Seoul National University. Chalmers chairs EU COST Action 1005 HDR involving participants from 23 countries. WMG hosts numerous events for BCS, IET, IMechE etc., hosts conferences (e.g. *Chalmers* – EG UK Theory and Practice of Computer Graphics, Warwick, 2011) and provides input to standards development (e.g. IEC Dependability Techniques). A WMG Project Manager coordinates the £10.8M EPSRC/JLR Programme for Simulation Innovation (including *Chalmers'* £840k visualisation project). Industry-funded research facilities include PTC – £35M long-term software licences and direct support to PhDs; Siemens - £25M long-term software licences; DMG – machine tools provision and JLR/other

automotive companies - numerous items (e.g. dynamometer). WMG engages industry based research and development groups as partners, leading to major provision of research infrastructure funded by Government programme and to direct and quantified take up of research outputs. Industry direct funded WMG academic posts and fellowships include: JLR Chair in Advanced Propulsion Systems (£1.25M – *TBA*); Royal Academy of Engineering / Tata Steel Research Chair in Low Carbon Materials (£370k – *Seetheraman*), Royal Society Industrial Fellows (*Chalmers* and *Debattista*) and IBM Faculty Awards (*Chalmers* and *Creese* [now at Oxford]). Several Honorary Fellowships have been created, enabling industry leaders to participate in WMG's research strategy and major programme steering groups e.g. the EPSRC EngD(Int) Steering Group includes Ralf Speth as Chair (CEO, JLR and a WMG EngD alumni), Don Newton (Johnson Matthey Axeon) and Cliff Robson (Director Combat Air, BAE Systems).

SoE/WMG leadership in the academic community with exemplars.
International advisory board membership (23); *Critoph* - DECC appointed UK member of International Energy Agency Annex; *Gardner* – President of International Society for Olfaction (2009-2011); *Ran* - International Council on Large Electrical Systems, CIGRE working group; *Mottram* – sole UK member of WG4 Eurocode committee CEN TC250; *Leadley* - Director of the SiNANO Institute for European Academic Research in Nanoelectronics; *Chalmers* - Chair of the EU COST Action IC1005; *Ceglarek* - UK representative in the Implementation Support Group of ManuFUTURE, European Technology Platform.
National advisory board membership (16): *Mawby* – BIS Power Electronics Strategy Group; *Dixon* - Chair, Technical Committee of British Institute of Non-Destructive Testing; *Guymer* - UK Chair of International Association for Hydro-Environment Engineering and Research; *Dashwood* - Member of the UK Automotive Council Lightweight Vehicle Group; *Godsell* - Cabinet member of the Council of Supply Chain Professionals (CSCMP), UK Roundtable
Research council panel membership (37): *Mawby* - TSB Enterprise Ireland Technology Assessor; *Green* and *Chalmers* - Reviewers for Agence Nationale de la Recherché; *Green* - Australian ARC; *Dashwood* – Austrian Research Promotion Agency (FFG); *McNally* - Italian MUIR assessor; *Kirwan* - EU FP7 expert reviewer and 19 members of the EPSRC Peer Review College Members.
Conference Chairs (13): *Green* - IEEE ICTON (Warwick, 2012); *Mawby* - European Electronics Conference (Birmingham, 2011); *Whitehouse* - Ultra precision Engineering (Royal Society, London 2011); *Leadley* - Ultimate Integration in Silicon (Warwick, 2013); *Marco* – Chair, Low Carbon Vehicles, (IMechE, London, 2009); *Murphy* - GADEST Conference, (Oxford, 2013).
Fellows of Learned Societies (36) including; 1 Fellow of APS, 3 FREng, 4 FInstP, 8 FIET, 2 FIStrucE, 3 FICE and 3 CIRP Fellows, 2 FRSM, 3 FIMMM, 2 FIoN, 1 FRSC, 1 FIMechE.
Invited plenary/keynote lectures (27): *Karavasilis* - Plenary, STESSA 2009 USA; *Liu X* - Plenary, International Conference on Mechatronic Systems & Measurement Technology 2012; *Chetwynd* - Keynotes ISIST 2008, ISPEMI 2010; *Lockerby* - Keynote ASME ICNMM 2013; *James* - The IET Wheatstone Lecture: Chennai, 2012; *McNally* - Keynote 6th Int. Conf. on Carbon Nanoparticle Based Composites, 2013. Bhattacharyya – Keynote Confederation of Indian Industry 4th National Leadership Conference.
Editor-in-Chief (EiC) and Editorships (46): *Dixon* (EiC) Nondestructive Testing and Evaluation; *Hutchins* (EiC) Nondestructive testing; *Chetwynd* (EiC) Precision Engineering; *Mawby* (EiC) Int. J. Num. Modelling, Elec. Networks, Fields and Devices; *James* (EiC) The Open Medical Informatics Journal; *Mallick* (EiC) Bioinspired, Biomimetic and Nanobiomaterials.
Awarded Fellowships and Prizes (33): *Whitehouse* - CIRP General Pierre Nicolau Award (the most prestigious international award in production engineering); *Dixon* – British Institute of NDT Grimwade Medal; *Gardner* - IET JJ Thomson Medal; *Ni, Guymer* - ICE Thomas Telford Premium Award; *Burton* – EPSRC Dream Fellowship; *Mawby* - RAEng Res. Chair; *Leeson, Liu KK* - RAEng/Leverhulme Trust Senior Research Fellowship; *Debattista, Chalmers* – Roy. Soc. Industrial Fellowship; *Kirwan* - Thornton Gold Medal from IOMMM and the IK Brunel award from BSA; *McNally* - Composite Award 2009 Institute of Materials, Minerals and Mining; *Seetharaman* – AIST, Elliott Lectureship Award 2011; *Nicholls* – the Wiley Young Investigator award; *Bhattacharyya* - Honorary Member of American Society of Manufacturing Engineers, Lifetime Contribution to Midlands' Business Award, Honorary Doctorate of Sciences IIT Kharagpur Honorary Doctorate of Sciences from IIT Bhubaneswar.