Institution: University of Hull

Unit of Assessment: B15: General Engineering

a. Overview

The research activities submitted under the General Engineering UoA are focussed on two themes: ***Energy, Environment and Sustainable Engineering*** **(EESE)** and ***Medical Engineering*** **(ME)**. The activities directly support two of the University's strategic priorities – namely *Health and Wellbeing* and *Energy and the Environment*. The themes bring together researchers from the School of Engineering, Department of Physics and the Hull-York Medical School to work on collaborative projects with all other departments in the Faculty of Science and Engineering and beyond.

Maintaining energy security while mitigating and adapting to climate change is one of the key challenges of the 21st century. The **EESE Group** brings a wide range of engineering expertise to bear on understanding the changing environment and providing solutions to the efficient utilisation of energy and resources while minimising the environmental impact of human activity. For example: materials engineering, fluid dynamics and reliable fault-tolerant control contribute to enhancing the design and performance of complex energy systems, such as wind farms, tidal turbines and carbon capture technology; photonics and semiconductor devices enable more efficient solar energy; implementation of carbon dioxide capture and utilisation to produce sustainable chemical feedstocks and micro-combined heat and power for domestic use, with the latter linking in to our work on building energy efficiency. The emphasis throughout the research is on making engineering systems more energy efficient, greener in their effect on the environment, and safe, robust and sustainable in operation.

The impact of the aging population and pressure on health budgets makes the continued wellbeing of the population difficult to ensure. In parallel, there is a continuous drive to develop better medical devices to improve patients' quality of life, as well as pressures to improve the way that healthcare is provided. The **ME Group** addresses problems in musculoskeletal form, function and health, and undertakes fundamental research into the mechanobiology of bone, together with restoration and rehabilitation of speech after trauma or disease, and the development and application of telehealth and care technologies to improve patient care while improving healthcare efficiency.

b. Research strategy

Developments since RAE2008

In 2001, in support of its strategic priorities at the time, the University established the interdisciplinary Clinical Biosciences Research Institute (CBRI) and Hull Environment Research Institute (HERI) with substantial investment in infrastructure, staff and postgraduate studentships. The University has continued to strengthen and broaden these areas into ***Health and Wellbeing*** and ***Energy and the Environment*** through this REF period, with further substantial investment in existing departments as well as the establishment of new research facilities. On the health side, these include the new Allam building (£9m) to host its biomedical research activities (funded in part through the generous support of a local businessman), the Daisy Building (£8m, at Castle Hill Hospital, Hull) and the establishment of the Centre for Telehealth (CfT). The Centre for Adaptive Science and Sustainability (CASS, led by **Haywood**, EESE), a cross-faculty, business-focussed research centre for renewable energy and the low carbon economy was formed in 2009 (£1.95m). It absorbed the academic activities of HERI and also those of the Environment Technologies Centre for Industrial Collaboration (ETCIC) originally funded by Yorkshire Forward. CASS has brought in more than £8.1m collaborative research income over the past 24 months, for a variety of projects, many of which involve the School of Engineering.

Health, and Energy and the Environment have similarly been priorities within the School of Engineering. Indeed the three RAE2008 research themes (*Environment, Energy and Sensors*, *Medical Engineering and Technology*, and *Design, Materials and Process Performance*) have been focused further into two interdisciplinary themes over this current research assessment period, namely *Energy, Environment and Sustainable Engineering* (EESE) and *Medical Engineering* (ME),

with staff changes providing the opportunity to expand into carbon capture and storage, biofuels, energy efficient building services technology, and biosignal acquisition and processing for health monitoring.

Our interactions with industry have been growing significantly since RAE2008, in large part through two new University-wide industry-facing research centres: the **Centre for Adaptive Science and Sustainability** and **Centre for Telehealth** (CfT). [See the Impact statement for further details].

Vision and future strategic aims

During the next ten years, we will continue to focus on these themes, but extend our activities. In particular, our Medical Engineering activities are set to expand, with a projected doubling of staff and planned expansion into biomaterials and biofluids research (with links to cardio-, vascular- and respiratory medicine in the University and local NHS), and medical electronics, further supporting the University's Centre for Telehealth.

We will continue to develop the EESE theme, and grow our activities further, for example, by incorporating energy storage technologies into power station/grid modelling through further collaboration with the Centre for Low Carbon Futures (CLCF). The recently awarded £6m EPSRC project between the University of Birmingham and **Wang** to set up a Centre for Cryogenic Energy Storage at Birmingham (www.epsrc.ac.uk/newsevents/news/2013/Pages/85million.aspx) amply demonstrates the opportunities. Through new appointments in Chemical Engineering (*e.g.* **Skoulou**), we are developing expertise in energy from waste and from biofuels. An RAEng Industry Secondment with Spencer Group (**Haywood**) will develop industrially relevant projects in this area. Some of these will be funded through Spencer's Energy Works Academy (www.energyworkshull.co.uk/benefits.htm) which will house an R&D centre and support postgraduate studentships (www.thespencergroup.co.uk/news-energy-works-awarded-grant.htm).

c. People

i. Staffing strategy and staff development

Academic staffing changes, strategy and development

There have been significant changes in staffing since RAE2008. As a result the General Engineering submission is reduced in size, with 6 professoriate-level staff *less* than in 2008, and key members of Computer Science now included in a separate submission. However we have taken this opportunity to increase the coherence of our EESE and ME research activities, while also expanding the scope of EESE to include chemical engineering expertise. Four key members of staff have been lost from the EESE theme (Attenborough and Swift, retirement; Neighbour (now Head of Department, Oxford Brookes University) and Postema (now Professor of Acoustics, University of Bergen)), but replaced with 4 new appointees (**Mi**, **Rybchenko**, **Wang**, **Zhao**). In addition, we have lost two key members of the 2008 ME Group (Langton from Medical Physics (now Professor of Medical Physics, Queensland University of Technology) and Professor Phillips (now deceased) from Computer Science). Those colleagues were not replaced directly; however 3 new members of Engineering staff (**Curtis**, **Langley**, **Zein**) and a new appointee in Hull-York Medical School (**Cox**) have joined the ME Group. Three more members of staff have been appointed recently and will be joining the School shortly; they will contribute to the EESE theme in the next REF submission.

Succession planning, recruitment and retention issues are dealt with through the annual budget round to which departments and research institutes submit plans. For academic staff, workload allocation is used to ensure that a balance is achieved between the demands of teaching, administration and research. Staff complete annual workload forms and research time is allocated dependent on the numbers of postgraduates supervised, research grants awarded, research output and the potential for strategic development of new activities. During annual staff appraisals, research targets are established and subsequently monitored. The University provides a comprehensive staff development programme including seminars on key funding providers and special funding initiatives, managing research, and postgraduate supervision (compulsory for new academic staff). New staff are assigned a research mentor whose remit is to brief them on procedures relating to grant applications, support the process of postgraduate supervision and

examination, encourage participation in University research activities and give general advice on research development.

The University also recognises the need to enhance the career development of post-doctoral research scientists and has established a steering group (comprising representatives from all faculties) to oversee the implementation of an action plan developed in consultation with staff and the post-doctoral researcher community, following the release of the Concordat to Support the Career Development of Researchers. The plan highlights the achievements to date (www2.hull.ac.uk/theuniversity/research/theconcordat.aspx) and details future actions with the monitoring timeframe.

Research fellowships

Four staff have benefited from personal research fellowships (won in open competition) between 2008-2013, namely:

- **Two Royal Society Industry Fellowships:** Awarded to **Fagan** to work with Smith and Nephew Research Centre (York) on bone mechanobiology, and **Mi** to work with Doncasters Group Ltd (Burton-upon-Trent) on solidification technology for Ni superalloys.
- **Leverhulme Fellowship:** Awarded to **Curtis** to work on the development of advanced methods for the simulation of mastication.
- **Royal Academy of Engineering Fellowship:** Awarded to **Moazen** to work on the development of models to simulate growth of the mammalian skull and clinical conditions that affect that growth, along with development of new treatment therapies.

In addition, the School has benefitted from **two Marie Curie International Incoming Fellowships** (awarded to Qiu and He) to work with **Zhao** on solar thermal and solar photovoltaic/phase-change-fluid systems; and one **Royal Society KC Wong Postdoctoral Fellowship** (awarded to Huang) to work with **Mi** on metallic glasses and composites.

International staff appointments

Over the REF period, Postema has moved to the University of Bergen (as Professor of Acoustics), but we have gained **Mi**, **Wang**, **Zein** and **Zhao** as new academics in Engineering. We also welcome Professor Witzel (Honorary Professor of Biomechanics) as an annual visitor to the ME Group to work on bone biomechanics. In addition, the following have spent extended periods working with the EESE Group: Professor Yingde Cui (President, Zhongkai University), Dr Peng Li (Tongji University), Dr Liang Zheng (Royal Academy of Engineering Senior Visiting Researcher, Beijing Institute of Aeronautical Materials) and Professor Daoliang Tan (Department of Jet Propulsion, Beijing University of Aeronautics and Astronautics).

Diversity and equality

The University of Hull and School of Engineering is committed to equality of opportunity and respecting diversity for both staff and students. To support this and raise awareness about equality and diversity, different training opportunities ranging from online modules to bespoke training packages are offered by the University's Staff Development team. Training participation is recorded and reported regularly to all Deans. Participation rates vary across the University but overall stands at 85.6%, including 91% of the established staff in this Engineering return. All those involved in staff appointments must have undertaken equality and diversity training. In addition, the University has submitted an application for the Athena SWAN Bronze award. The working party, led by Professor Gillian Greenway (Head of Department, Chemistry), includes **Gilbert** (Head of School, Engineering) and is tasked with further work towards higher level awards.

ii. Research students

PGR recruitment

PGR student applications and scholarships are directed towards the School's priority themes wherever possible. All PGR vacancies, whether funded externally or by the University or School, are always advertised externally to ensure we attract the best applicants, who are always interviewed before being accepted for a postgraduate position. These advertisements are placed on academic recruitment websites, such as *www.jobs.ac.uk*, but in addition on subject specific distribution lists and websites, *e.g.* Biomech-L for the ME positions. Unsolicited applications to

study for a self-funded PhD are also scrutinized carefully with an interview, in person where possible, or alternatively by Skype.

Our PGR students have gone on to take up key positions in the UK and around the world, for example, Dr Omar Altuwaijri (ME, 2012) is now an Assistant Professor at King Saud University, while Dr Gik Hong Yeap (EESE, 2009) is the newly appointed Head of Engineering at KDU College, Malaysia (www.kdupg.edu.my/campus-life/past-events/271-past-events/939-kdu-college-penang-kdu-penangs-engineering-students-shine-at-comiic-2013.html). Dr Supat Klinkhieo (EESE, 2010) is Director of the Technical and Engineering Division at the Thailand Synchrotron Light Research Institute (SLRI).

PGR training and support mechanisms

The Graduate School at Hull is an on-campus purpose-built facility (1996) with 24-hour access for research students and their supervisors. Both an administrative centre and a resource, with its own IT and common rooms, it liaises with all University faculties and departments on matters concerning research students. It also delivers continuing professional development for supervisors, and coordinates an established and fully-comprehensive Postgraduate Training Scheme which enables students to graduate with certificated evidence of their research and employability skills at Master's level. Interdisciplinary modules offered by the Graduate School cover (for example) project management, career development, and enterprise and entrepreneurship skills. Credits are also awarded for publication of research papers by PhD students, and an annual 'PhD Experience' conference (www2.hull.ac.uk/student/graduateschool/phdexperience.aspx), organised by students, is hosted by the Graduate School.

An innovative online Graduate Virtual Research Environment (www2.hull.ac.uk/student/graduateschool/researchstudents/thegvre.aspx) has assembled the collective stories of researchers and research students across the University, enabling students to access over 200 short videos illustrating individual research achievements and advice on all aspects of the research degree journey. The University also promotes the use of the **Researcher Development Framework** (RDF), developed by Vitae, for both research students and staff – to plan, promote and support their personal, professional and career development – with the Staff Development Unit available to run focussed briefing sessions and more extensive workshops on using the framework.

PGR progress monitoring

Each research student is supported by at least two supervisors and progress is formally reviewed every six months. The School uses a TAP (Thesis Advisory Panel) system, which not only monitors progress and training, but also formally encourages writing of the thesis and journal papers. Typically we would expect the submission of one draft chapter (or part) every TAP meeting. In parallel, the Graduate School also requires a regular progress report on each student.

d. Income, infrastructure and facilities

Infrastructure and facilities

The School is currently well equipped through £4.5m SRIF, HEFCE and University support over the past 10 years, with the establishment of bespoke Medical Engineering Labs, Materials and Nanotechnology Labs, a refurbished Acoustics Lab, Energy Harvesting Lab and Fluid Dynamics Facility. More recently the School has established a new Energy Technology Lab to support its growing activities in energy research and two anechoic chambers for its acoustics and speech-based research. Underpinning engineering support services have also been supported over the period with the purchase of a new CNC machining centre, two new rapid prototyping machines and a bioethanol production facility as part of chemical engineering investment.

In addition, the University has established the Allam building (adjacent to Engineering) to support biomedical research, which includes a radiochemistry unit comprising a bench-top cyclotron and bespoke laboratories, Philips Bioscan, PET/SPECT and PET/CT scanners. As part of this initiative there has also been significant investment in complementary biological facilities: *i.e.* BiaCore T200 unit and state-of-the-art mass spectrometry. The ME Group has already applied for research council funding to take advantage of these facilities, with this new facility now offering the potential to acquire *in vivo* validation of its bone modelling simulations.

Research funding portfolio

During the REF period, the ME and EESE Groups have secured many 'blue chip' and industry supported grants from a wide variety of sources, reflecting the diversity and broad impact of the research. Because of the change in the number and balance of staff during the REF period, the level of funding has inevitably dipped, although the number of research council and other blue chip grants has actually increased compared to RAE2008. However there is already evidence of renewed growth, with the value of grants awarded in 2012/13 having increased by 27% compared to 2011/12.

Over the assessment period, the bone biomechanics research within the **ME** Group has been supported by BBSRC(x4), EPSRC(x3) and NERC(x1) grants (total value £1.9m, spend £1.3m), reflecting the true multidisciplinary nature of the work, plus funding provided by the Royal Society(x1), Royal Academy of Engineering(x1), Leverhulme Trust(x1), EU(x1), Action Medical Research(x2), OSPREY Charity(x2) and other small charities (total value £0.9m, spend £0.4m). In addition, the speech restoration and rehabilitation research has been funded by the Dept of Health NEAT (x1) and NIHR i4i(x1), Action Medical Research(x1) and Yorkshire Forward (ex RDF x2) (total value £0.7m, spend £0.5m). [ME total spend £2.2m].

Meanwhile the **EESE** activities have been supported by a similarly wide range of funders, including EPSRC(x7), NERC, Royal Society(x3), Royal Academy of Engineering(x2), EU(x7), ERDF(x3), Office of Naval Research(x2), plus industrial sponsors and collaborators including AB Graphic, AEA Technology, Baosteel (Shanghai), Biomass and Fossil Fuel Research Alliance (BF2RA), British Energy, GB Solo, GrafTech, Jaguar Landrover, the Ministry of Science and Technology of China, RD Group, Siemens(x5), Suzhou Building Energy Research Institute, Uniscan and Yorkshire Forward, and facility-specific funding including HECToR, Diamond Light Source and Advanced Photon Source (USA). [EESE total spend £2.3m].

We aim to increase the level of funding from the research councils and other blue chip funding bodies, in particular through the pursuit of more collaborative, larger projects with other institutions. This strategy has worked well for the ME Group and newer members of the EESE Group. For the ME activities we will also continue to apply to medical charities, in particular to initiate new research activities but also to apply more of the research to clinical practice, with follow-on funding from MRC and NIHR.

Consultancy and professional services

Engineering offers consultancy and professional services through its business unit – the Engineering Innovation Institute (EII). In the past 5 years, the EII has worked with over 300 companies and organisations in the region, many of which included input from academic staff. The EII also acts as a key route for exploitation of the unit's research (see Impact Statement).

e. Collaboration or contribution to the discipline or research base

The School of Engineering recognises the many benefits of collaborative research and the great majority of on-going projects involve collaboration with one or more academic, industry and/or healthcare partners. The wide diversity of our funding sources (see above) confirms the wide relevance and reach of our research. The following exemplars illustrate that commitment to collaboration and highlight some of the contributions to this discipline (and others):

Bone and skull modelling: The core expertise of the ME Group (led by **Fagan**) lies in modelling and simulation applied to musculoskeletal biomechanics, and the modelling of skulls in particular, and they now lead the world in the complexity and biofidelity of their skull models. It is true interdisciplinary research, with collaborators in Human Anatomy (Dundee, Liverpool, Hull-York Medical School, University of Western Australia), Evolutionary Anatomy (UCL), Human and Animal Biology (Chicago, Paris, York), Human Evolution/Anthropology (Albany USA, Max-Planck Institute), Palaeobiology (Bristol), Bioengineering (Shinshu Univ, Japan), Computing (Edinburgh, Imperial College, Leeds, Oxford) and Maths (Manchester). Originally focussed on the modelling of animal skulls, this research is now being applied to clinical applications, including novel research into dental biomechanics, and the management of conditions such as craniosynostosis through a five year Royal Academy of Engineering Fellowship in collaboration with the University of Oxford and the John Radcliffe Hospital, Oxford. Other projects, such as the design and optimization of

new cellular-based cranial implants with collaborators in Imperial College, Seattle and Washington are also under development, and demonstrate a dynamic and very promising future for this skull research work.

In parallel, other bone modelling work is (for example) researching the growth, development and ageing of the human femur. Projects include an investigation into the biomechanical causes and potential prevention of Legg-Calvé-Perthes' disease in young children (with the Universities of Bochum Germany and Southampton), and the role of altered biomechanics and gait in osteoporosis through the development of a fundamentally new concept of the way in which the musculoskeletal system functions (in collaboration with colleagues at the local Castle Hill Hospital and supported by a local osteoporosis charity).

Optoelectronic nanotechnology: The expertise of the Optoelectronic Nanotechnology Group (led by **Haywood**) is in modelling, fabrication, characterisation and testing of a wide variety of semiconductor devices, including photovoltaic cells, photodetectors and laser active regions - in particular narrow gap materials for the mid-IR (2-5µm) region based on GaAs and InP substrates. A Framework VI programme was funded with the University of Montpellier 2; NNL, Italy; III-V Lab, Alcatel; the Ioffe Institute Russia and the Paul Drude Institute in Germany to study antimonide-based quantum dots for both laser and detector applications. The University of Hull's role in this programme was device modelling and we successfully designed and fabricated an antimonide dot-based laser for the 3-4µm region where there were previously no solid state devices. Subsequently this work was extended to modelling quantum dot-in-well structures (which have advantages over both well and dot systems) through a collaboration with Sheffield University, funded via a Defence Technology Strategy scheme.

Recently we began work with Leeds, Sheffield and York Universities supported by White Rose funding to develop a photo-electrochemical cell for the reduction of CO_2 to methanol using solar energy. This is inter-disciplinary research involving chemists, physicists, electronic and chemical engineers. Hull's role is in designing and testing the III-V semiconductor-based photo-electrode for solar-harvesting grown by our collaborators at UCL. Photovoltaic structures analogous to these electrodes are also being studied as thermo-photovoltaic devices for micro CHP i.e. co-generation of electricity by domestic boilers, in collaboration with an SME, Enertek International Ltd.

Fault detection, diagnosis and fault-tolerant control. The Control and Intelligent Systems Engineering group (C&ISE, led by **Patton**) has extensive expertise in the development of new theory and application studies using mathematical techniques for diagnosing faults in uncertain and non-linear process systems. New tools (e.g. using linear parameter-varying system theory) are used to ensure that fault effects can be estimated robustly in the presence of modelling uncertainty and bounded disturbance, and compensated in active fault tolerant control (FTC) systems. An EU FP7 study ADDSAFE [2009-2012], involving C&ISE with (Deimos Space, Airbus, DLR, Leicester, Delft, STAKI Budapest, and IMS Bordeaux has focused on new research into advanced methods for fault diagnosis aimed at stimulating future methods of overall design optimization to achieve more affordable, safer, cleaner, 'greener' or environmentally-friendlier aircraft. The fault diagnosis/FTC methods have been adapted to an innovative new research study: Sustainable control of offshore wind turbines. C&ISE collaborated with Dr Peter Odgaard of kk-Electronic (Denmark) and a robust design by C&ISE for an offshore wind turbine (OWT) was tested at kk-electronic. The design won second prize presented at IFAC Safeprocess 2012, Mexico in an international competition on "FTC designs for application to wind turbines". Odgaard and Patton also organised an InstMC sponsored workshop with CASS on this subject in September 2012 at Hull, with industry and academic speakers from University of Colorado, kk-Electronic, University of Aalborg, Technical University of Berlin, Siemens, UK Crown Estate, SmartWind and Garrad-Hassan (Bristol).

Evidence of contribution to the discipline, leadership and esteem

Editorial board membership*:* **Patton** currently serves as a subject editor for *International Journal of Applied Mathematics & Computer Science*, and subject editor of *International Journal of Adaptive Control & Signal Processing*. **Wang** is an associate editor of *Journal of Process Mechanical Engineering*. **Zein** is on the editorial board of 7 journals including *Natural Science*,

Journal of Applied Sciences, *Trends in Applied Sciences Research*, *Research Journal of Nanoscience and Nanotechnology*, *Current Research in Chemistry*, and *International Journal of Chemical Technology*, and is associate editor of the *Malaysian Journal of Fundamental and Applied Sciences*. **Langley** is on the editorial board of the *Scientific World Journal*. **Mi** is on the editorial board of review of *Metallurgical and Materials Transactions*. **Zhao** is on the editorial board of three journals *Sustainable Cities and Society*, *Energy Science and Technology*, and *Heating, Ventilation and Air Conditioning*.

Keynote and invited lectures: Staff have given many keynote and invited lectures around the world, and organized a wide variety of sessions and symposia. For example, **Lukaschuk** gave three keynote lectures in France, Israel and Russia; **Patton** gave a keynote address entitled *New perspectives for research in fault tolerant control* in Italy in 2010; and **Zhao** gave two keynote lectures in China in 2012. **Zhao** was also an invited speaker at the *Low Carbon Earth Summit* in Dalian China the year before. **Cox** (ECR) organised a symposium at the*10th ICVM Congress in* Barcelona 2013, where **Curtis** (ECR) also presented an invited paper. Meanwhile, **Dyson** gave an invited lecture at the *Material Research Symposium (MRS)* in Boston (2010) and **Zein** was invited to present his work in Malaysia. **Mi** gave four invited papers in China, Las Vegas and the UK; **Fagan** gave invited lectures in Bonn, Paris and Uruguay.

National/international advisory panel and academic group membership*:* **Fagan** was a Member of the Hull and Humber Healthcare Technologies Group (2008 - 2011). **Haywood** is a Trustee of Humberside Engineering Training Agency (HETA) (2007 to present). **Paulson** is a member of two OFCOM committees (Fixed Service Task Group, and Fixed Wireless Industry Liaison Forum), and a member of ITU-R UK SG3 (International Telecommunications Union UK Study Group 3), one of only 12 people who define the UK's position on radio regulation in international negotiations. **Zhao** was the chair of the *UK-China Forum in Sustainable Energy and Environmental Technologies for Buildings* in Beijing (2009); he was also an external advisor to the *EU FP7 Programme on Energy Efficient Buildings.* **Patton** is also an external advisor to the *EU FP7 ICT Programme on Control in Embedded Systems*.

In addition, **Haywood** is a member of the *REF2014 General Engineering sub-panel*, and was Chair of the *Professors and Heads of Electrical Engineering* (PHEE) National Committee (2008 - 2012), a member of the *Membership & Professional Development Board* of IET (2010 to present), and a member of the *Engineering Professors Council Committee* (2009 to present).

Grant review and funding*:* Staff review for a large range of national and international grant awarding bodies on a regular basis. In addition to these activities, **Langley**, **Haywood**, **Wang** and **Zhao** are all members of the *EPSRC Peer Review College*. **Haywood** was also a member of the *Challenging Engineering panel* (2010) and chair of the final interview panel, plus she was a member of the *UK-India Solar Cells panel* (2009 - 2010). **Fagan** also served as an invited member of the *ERC LS7 Advanced Research Grants panel* (2007 - present).

Institutional fellowships and senior memberships and other external recognition*:* Most members of the School of Engineering are members of one or more professional bodies and hold chartered engineering status. In addition: **Patton** was nominated to a Fellowship of the *Institute of Electronic & Electrical Engineers* (IEEE) for research contributions to fault diagnosis and fault tolerant control in 2010, is a Senior Member of the *American Institute of Aeronautics and Astronautics*, and is a Fellow of the *Institute of Measurement and Control*. **Haywood** is a Fellow of the *Institute of Physics*, Fellow of the *Institution of Engineering and Technology*, and Senior Member of the *IEEE*. Also **Zhao** was recognised with an Honorary Professorship in Harbin Institute of Technology (2010 to 2013), Guangdong University of Technology (2011 to 2015), Beijing University of Civil Engineering and Architecture (2010 to 2013) and holds an honorary Senior Research Fellow in China Academy of Building Research (2012 to 2015).