Institution: Kingston University

Unit of Assessment: 15, General Engineering

a. Overview

This Unit covers a broad range of engineering disciplines, unified under the banner of "Engineering for Energy and Sustainability". The Unit is organised into three research centres:

- **The Sustainable Technology Research Centre (STRC)** led by **Limbachiya**
- **The Materials and Composites Research Centre (MCRC)** led by **Zhang**
- **The Centre for Fire and Explosion Studies (CFES)** led by **Dembele**

Specific measures, such as the provision of interdisciplinary PhD studentships, have been taken to promote team working and integrate the strategy with national and industrial priorities, as well as the objectives of collaborators, funders and end users. Around two thirds of the Unit are members of the research centres.

Within the research centres, Engineering has diversified into a number of themes with interdisciplinary links including biomedical and optical engineering, nanotechnology, and control systems. This has manifested in increased outputs as well as several large grants awarded since 2010: SANAD (**Wang**), FP7 €772k, MANANO, (**Zhang**) FP7, £205k, ADVANCE-FSP, (**Zhang**) FP7, £177k, BREATHE (**Pierscionek, co-applicant**) FP7 Ambient Assisted Living £233,188.

b. Research strategy

Strategic Aims

The research in this Unit addresses the strategic themes of Energy and Sustainability which are key global areas that underpin economic and social issues. This wide remit covers research from Civil Engineering and Construction to Fire and Explosion Studies. There are key underlying platform technologies associated with the broad spectrum of research with deliverable outcomes that are co-ordinated by the dedicated leaders of each Research Centre, under the direction of Pierscionek.

Whilst the overarching aim is Energy and Sustainability, discoveries which expand the strategic focus are accommodated within and supported by this framework. Examples include :

- energy efficient design and maximising recycled materials applications in construction (**Limbachiya**- STRC);
- maximising diesel engine efficiency informed by control engineering (**Deng**- STRC);
- design of implant lenses using ongoing biomaterials research (**Pierscionek/Foot** - MCRC);
- development of aerosol methodologies underpinned by computational fluid dynamics (**Dembele** - CFES).

The research strategy of the Unit is aligned to that of the University plan and includes:

1. embedding research into everyday academic life and increasing the quantity and diversity of research income through cross-fertilisation of ideas;
2. greater interaction with enterprise activities;
3. expanding industrial partnerships, collaboration with other HEIs and research organisations, staff development, and cultivating existing strengths to increase the volume and diversity of research;

4. generating impact beyond academia by creating benefit to the economy, society, culture, public policy and health.

These aims have been embodied in the following action plan.

Action Plan following RAE2008

Consolidation of Research Teams

The Unit continues to support ECRs via personal mentoring and closer working with established researchers with strong track records, in order to develop and sustain nationally and internationally excellent research in selected areas and to open up other opportunities within the broader research areas of the Unit. All staff are supported in this regard through the creation of individual research plans, with objectives linked to the Unit's strategies and objectives. Academic staff with good research track records and exhibiting excellent potential for future research growth have been recently recruited (**Pierscionek, Nixon**).

Capacity Building

A key task in sustaining and extending the Unit's research base is to encourage the development of new research themes both within and beyond the established research centres and groups. There has been a significant increase in the number of research students and outputs as well as a considerable increase in research grant income. A substantial investment has also been made to upgrade current research infrastructure (hardware and networking technology), including the purchase of specialist equipment and materials. Over 80% of the Unit is engaged in the supervision of PhD students. Seven graduate teaching assistants (GTA) were recruited (2010) to promote the emergence of new internationally competitive research niches. The Unit's research ambition is also reflected in its planned targets; the research student population nearly doubling in the next 3 years, increasing PhD completion numbers over the next 4 years.

Partnerships and Networking

Kingston University has established a PhD training relationship with Azad University, Iran and Universitas Muhammadiyah Surakarta (UMS), Indonesia. Azad is the largest private university in Iran which sought to provide its lecturing staff with an opportunity to study for a PhD at Kingston University. A contract was signed in 2008 which resulted in recruitment of nine full-time PhD students into the Unit. Seven of the students from this cohort have now completed. Similar arrangements have been established between KU and UMS and five fully funded full time PhD students have started their study.

Targeting Self Funded Students

Between 2008 and 2013, the Unit has actively sought to recruit research students through:

- exploiting international research collaborators;
- promoting awareness of Kingston University as a prime location for advanced research studies.

The result has been to increase self-funded recruitment from roughly three per annum to five (in total, 25 new self-funded students).

Research Centres: Future and Vision

Within the STRC, research is split into discipline-specific key themes: concrete and sustainable materials, structural analysis, design and repair, energy efficiency and renewable energy, and geotechnical science and engineering. It has built on existing strengths in order to sustain and enhance an international reputation for research excellence in the field of sustainable construction, addressing current and future challenges. The results obtained in a recently completed collaborative practical research project have been used to develop an "Intelligent Door System"

(http://www.kingston.ac.uk/services-for-business/success-stories/documents/IDS.pd).

The MCRC provides training to PhD students, consultancy services to industry and delivers research to the international materials community. To achieve this, the research combines fundamental materials science, manufacturing processing and computer simulation for failure analysis, process control and optimization. Research in the MCRC is targeted in three areas: the development of high efficiency and low cost processes for energy applications and surface coatings; the development of new materials (polymers, composites and nano-composites) to produce new surfaces and coatings that are more robust in a range of biomedical and aerospace applications; and the development of computational models (finite element analysis, FEA, and computational fluid dynamics) in order to simulate the behaviour of materials during a range of processes and to conduct materials selection, process optimisation and equipment design.

The CFES aims to deliver research, postgraduate training and consultancy services in fire and explosion modelling as well as environmental flows. The Centre has been nationally and internationally recognised by the Office of the Deputy Prime Minister, BP and Pilkington Glass for its modelling capabilities based on computational fluid dynamics techniques. With a clear focus on model development to address the underlying physical and chemical processes, the CFES has established a niche that strikes a fine balance between fundamental research, publications in refereed journals and industrial applications related to fire and explosion safety in the built environment, transport systems, process plants and offshore platforms as well as hydrogen safety in nuclear installations.

The CFES has also developed multidisciplinary research in other strategic areas related to governmental and industrial priorities in environmental protection and sustainable energy. This has resulted in developing cutting edge modelling capabilities for the multiphase flow process during pipeline blowdown and decompression as well as heavy gas dispersion. The former has put the CFES in the forefront of research in relation to pipeline transmission in the context of carbon capture and storage (CCS). An Initial Training Network (ITN) was awarded by the EU to a value of €1.76M in 2013. For heavy gas dispersion, the CFES focuses on the physical understanding of complex multiphase flows resulting from accidental release of liquefied natural gas (LNG), carbon dioxide and other industrial gases.

Evaluating the progress of the Unit

A number of indicators can be usefully cited to illustrate the significant improvement in the position of the Unit in comparison with that in 2008.

- The total number of research students rose from 43 to 75 while the number of doctoral awards rose from 27 to 34. Just over half of the research students are supported by scholarships, one third are self-funded while the remainder are supported by collaborative partners.
- The number of research assistants has risen from 1 FTE in 2007 to 10.
- Awards since the start of the assessment period are more than double than those in the preceding 5-yr period, with 2012-13 showing more than double the next best year.

c. People, including:

i. Staffing strategy and staff development

The research centres and groups have set out strategies for staff recruitment and development.

STRC: With increasing demand for sustainability related research, the STRC has seen a steady increase in PhD students. The Centre has devised a strategy to increase its research student population within the next 3 years, while increasing its completion rate, by involving a greater proportion of staff in research supervision.

MCRC: The key strength of the MCRC is multi-disciplinary research, which enables it to collaborate with other research centres within the University and beyond. In the current

environment, the MCRC aims to maintain its staff level (8 academic staff and over 20 PhD students) and focus on improving the research capability of staff and collaborative partners. This improvement in the capability of staff in research has been achieved through enhanced internal collaboration, provision of regular research seminars and attendance at international conferences.

CFES: The CFES has continuously benefitted from the university's strategy to strengthen key areas of research. The core team of three academic staff (**Dembele, Muppala**, and Wen (who left the institution for a post at the University of Warwick in 2013) was strengthened by the recruitment of **Volkov** and the appointment of three visiting professors with two from industry and one from a leading fire research group in Japan to add further breadth to the Centre's expertise. The CFES also continues to work with colleagues from other disciplines, e.g. Ghasemnejad from the MCRC, to develop interdisciplinary research. The Centre provides an internal mentoring and monitoring scheme for proposals and outputs, the effectiveness of which is evidenced by **Muppala's** EPSRC grant. The CFES typically has 10 PhD/post-doctoral Assistant Researchers with the majority of these being involved in externally-funded, collaborative projects and several funded by overseas governments

Visiting researchers

The reputation of the Research Centres has attracted a range of international collaborators. These have included senior professors and research fellows.

- **STRC**: Professor S B Desai OBE, (recognised expert in concrete technology and Government advisor in the Department of Environment) who has contributed to the supervision of three PhD students, acted as mentor to staff and students and was on the Industrial Advisory Board, from 2003-2012.
- **MCRC**: Professor M Khalili (Visiting Professor from Khajeh Nasir Toosi University of Technology), who collaborates with **Hadavinia** and has contributed to research outputs (REF1)
- **CFES**: Professor Vincent Tam (Senior Adviser, Fire and Explosion Safety, BP) who has contributed to research that has led to the award of an EU Industrial Doctoral Training Centre (ITN) SAFE-LNG (264710. (2011-2014) (circa 1.4M Euro)

Post-doctoral Research Associates

Success in grant applications has led to the appointment of a number of research associates such as Dr. Q. S. Wang (EU funded Incoming International Fellow 2007-09), Dr. C. J Wang (EU funded Marie Curie Fellow 2011-13), Dr O David-West (10-11) EPSRC (DT/F006829/2) DRONE, Dr Mehdi Bahrami (Fight for Sight).

ii. Research students

PhD Student Numbers

The number of PGR students has increased dramatically since 2008 from 43 FTE to around 70 FTE and is currently sustained at this steady level.

Training and Support

A new Doctoral School (DS) was formed within the Faculty in 2011, and its Director (**Augousti**) leads, monitors and manages all aspects of doctoral training across the Faculty. The DS offers both specialist as well as generic training programmes to doctoral students and supervisors

In parallel with this rapid investment in PGR student numbers, a number of national initiatives have informed the Unit's response:

1. Researcher Development Statement (RDS);

2. Concordat to Support the Career Development of Researchers;

3. QAA Code of Practice.

The activities of the Doctoral School (DS) ensure compliance with the best practice embodied in these documents. Complementary programmes for research students (and research assistants) training at the University, Unit and research centres include:

1. *subject-based* training to support research programmes and opportunities for specialist training both within and outside the university, such as Finite Element Analysis and Advanced Statistics;

2. *research method* training including literature review techniques, experimental design and scientific writing;

3. *personal development* training including secondments, teaching and laboratory demonstration experience and development of research grant applications

d. Income, infrastructure and facilities

Specialist Infrastructure and Facilities

The engineering laboratories are generously provisioned, including a number of facilities that are sparse within the UK. The latter includes two full-scale wind tunnels equipped with a Laser Doppler Anemometry system for accurate full-field measurement of wind flow patterns and an 8m microgravity drop tower facility designed to provide almost three hours of microgravity daily, a resource that is unique in the UK and one of only two in Europe. A Micromist fire suppression test rig has been developed from the Micromist Generator provided by BP. The Unit also benefits from a dedicated 16-node Linux Cluster and shared use of a 128-node Linux Faculty Cluster.

Additional facilities include a full-scale environmental chamber which provides a temperature range between -24°C to 24°C, for phase flow testing of elements; a specially designed rig for shear testing of composites and concrete; a high resolution thermal imaging camera for non-destructive testing of materials; a range of large-scale specialised ovens for curing concrete, a CNC machine, two 3-D printers (one powder-, one liquid-based), a clean room, metrology laboratory, automotive engineering laboratories, a range of programmable load-testing machines, specialised lasers, an X-ray diffractometer, a spin coater, as well as the use of NMR and TEM microscopes more broadly within the Faculty.

Research Funding

Since RAE2008, the Unit has generated over £2.39M of research income (see Table REF4b). Of this total, £645k is from EPSRC funded projects and scholarships, while over £1M derives from EU Framework Programme projects. A total of £458k funding was obtained from industrial sources, of which £144k originated from non-UK industry. In addition, the Unit has been very successful in engaging with industry through the KTP scheme, generating around £190k with companies such as Lerch Bates, Chess Dynamics and Rayners.

e. Collaboration or contribution to the discipline or research base

All researchers submitted in this Unit collaborate with a number of research institutions and industries, have chaired and organized conferences, have been invited to speak at international conferences and have served as members of editorial boards and editors of international journals (details given below).

Collaboration

STRC: **Limbachiya** completed an industrially funded project and developed a case study, and this work was jointly funded by London ReMade and Day Group Ltd. His work has included highly

practical outcomes, such as research on the operation of automatic doors, in collaboration with Intelligent Door Solutions (IDS) Ltd. **Ordys** collaborated with Strathclyde on an EPSRC grant, and MAN (Germany) have funded PhD project research. He has also collaborated with Jaguar Land Rover on fuel consumption control, and Chess Dynamics Ltd on high precision fast tracking devices. The Caterpillar company has collaborated with **Deng** on vehicle energy recovery and emissions modelling.

MCRC: **Zhang** has collaborated with over 30 EU academic and industrial collaborators, including UK Universities and industry, on a range of EU-funded research projects in the area of nanotechnology and material research & development. Continuing the theme of materials, **Foot** has had a long-standing collaboration with the Space Physics Institute in the area of electronic materials, and with the Università degli Studi di Milano Bicocca, Italy on opto-electronic applications. **Hadavinia's** collaborations include Loughborough University on Blast and the Impact of FRP materials, Imperial College on adhesive bonding, Oxford Brookes University on bonded structures and FRP materials, Brunel University on solar energy, and Zotefoams plc on the impact properties of polymer foams. **Ghasemnejad's** research is supported by Composite Evolution and Composites UK, who are funding a PhD project. **Augousti** collaborated with Wroclaw University of Technology, Poland, in the development of advanced algorithms to model charge distributions and currents in cellular pores, and with Carlow Institute of Technology, Ireland, the Laboratory of the Government Chemist (LGC) and Tianjin University (China) to develop analytical systems for characterisation and fingerprinting of liquids. **Pierscionek** has national collaborations with Warwick University on optoelectronic applications in medicine and with Cardiff University on designs for intraocular implant lenses (funded by Fight for Sight); she is also working with beam line scientists at the Spring8 synchrotron in Japan conducting interferometric measurements on the eye lens, and with Wroclaw University of Technology on finite element applications to the measurement of biomechanical properties of the eyeball. **Wang** has cooperated with several companies including Bombardier Aerospace, FG Wilson (Drone EPSRC (DT/F006829/2)), and British Airways, and is one of the investigators on a project funded by the Chinese Government investigating the mechanical behaviour and optimum design of advanced aircraft structures in complex environments. He has also worked with North-western Polytechnic University China supervising PhD students and bidding for projects. He was awarded an FP7 grant (SANAD) to look at novel nanomaterials for coating aircraft wings to prevent icing and to decrease drag.

CFES: The Centre, working with BP/HSL on Health and Safety, successfully completed the 'HYFIRE' project, training 10 young researchers during this project. **Dembele** and **Muppala** have collaborated widely with over 20 partners in the European Hydrogen Safety Network, including Southampton University (PhD project), FM Global (CFD model development), University College London and Leeds University (National Grid funded COOLTRANS project). **Volkov's** collaborators include Rolls Royce and the Universities of Surrey and Sussex on the development and exploitation of advanced CFD models, as well as the University of Central Lancashire, the Daresbury Laboratory and the Russian Scientific Centre, in the areas of internal air systems for turbomachinery and pulse radiation.

Interdisciplinary Research

STRC: Limbachiya's work on intelligent door systems brings together researchers with expertise in scientific visualisation, image analysis and civil engineering. The fields of image processing and pattern recognition (with applications to automotive and tracking systems) are brought together in **Ordys'** work, along with the application of thermodynamics to engine combustion applications, and control algorithms are employed in the analysis of the dynamic properties of materials, with particular relevance to the analysis of crashes.

MCRC: **Zhang** was a driver of an EU project (ADVANCE-FSP), working at the boundaries of chemistry, fluid mechanics, heat and mass transfer, nanomaterials and computer simulation. He is also a partner in another FP7 project (MANANO) that synthesises research in nanomaterials, mechanics and manufacturing processing. **Foot's** work in the area of smart polypyrrole nanoparticles for targeted delivery of anti-cancer drugs bridges materials science, nanomaterials and pharmacology, and along with **Barton** he is investigating materials for intraocular implant

lenses. A KTP with Rayners was recently awarded in this area. **Pierscionek** leads projects in optical and biomedical engineering funded by Fight for Sight, MOD, Essilor International and as co-applicant in a grant on Ambient Assisted Living (BREATHE) with colleagues in Units of Assessment 3 and 11.

Role of research users in shaping Activity and Strategy

STRC: Limbachiya collaborates with Day Group Ltd on different types of recycled aggregates. This led to 2 PhD research projects, and a patent application was submitted by the IDS which resulted in further product development. **Ordys** collaborated with MAN on the modelling of vehicle power trains. This also helped to establish contact with Jaguar Land Rover, where concepts of driving economy are transferred to passenger vehicles

MCRC: Zhang's group has direct industrial collaborators e.g. the Advanced-FSP project has 6 industry partners (2 in the UK) and the MANANO project has 9 industry partners. **Hadavinia** researches in the renewable energy sector, directs projects on composite, wind energy and solar energy and works with Zotefoams plc on polymer foam materials. **Wang** is an Associate Fellow of AIAA, closely working with the Institution, and collaborating with Bombardier Aerospace Belfast (on Nacelle technology), FG Wilson, LMS, Masters Choice Ltd, Houchin Aerospace; Queen's University Belfast; Caterpillar Wimborne Marine Power Centre and British Airways.

CFES: Dembele's major industrial sponsors include international companies including BP, FM Global and National Grid. Collaboration with BP and HSL has been instrumental in shaping the strategy to expand the modelling activities of CFES into explosion modelling.

Leadership and achievement in the Academic Community

Several members of the Unit operate as journal Editors or Editors-in-Chief (**Foot, Ordys, Hadavinia, Pierscionek**), as well as acting as assessors for grant applications and report submissions. These include organisations such as the EPSRC (**Foot, Zhang, Pierscionek, Augousti**) the EC (**Ordys**), the British Council and the Royal Academy of Engineering (**Augousti**), the Slovak Research Agency, the Republic of Cyprus and the DESMI Research Programme (**Foot**).

Prizes and awards received by members of this submission include the 2011 Honeywell International Medal of the Institute of Measurement and Control and the 2011 President's Award of Tianjin University (**Augousti**), the 2010 Kenneth Harris James Prize and the 2010 George Stephenson Research Prize, both of the Institute of Mechanical Engineers (**Wang**).

Service to the Engineering community over the assessment period includes membership of the Council of the Institute of Measurement and Control (**Augousti**), Chair of the Instrument Science and Technology Group of the Institute of Physics (**Augousti**), member of the Advisory Group of the Electronic, Sensors and Photonics Knowledge Transfer Network (**Augousti**). **Augousti** also chaired the 15th conference in the international series on Sensors and their Applications, held in Edinburgh in 2009. Several members are Fellows of Learned Societies, including the Institution of Engineering and Technology, the Institute of Measurement and Control, the Institution of Mechanical Engineers and the Institute of Physics.