Institution: Kingston University
Unit of Assessment: 12 – Engineering
1. Unit context and structure, research and impact strategy

1.1 Unit Context and Structure

Kingston University's Unit of Assessment in Engineering is comprised of 42 staff (41.8 FTE), including 7 professors and 4 ECRs. Research is undertaken within the Centre for Engineering, Environment and Society Research (CEESR), led by Centre Director **Dykes** and Deputy Director **Walford**. CEESR covers a broad range of engineering and related disciplines with researchers drawn from across the Faculty of Science, Engineering and Computing's School of Engineering and the Environment (EE), the School of Life Sciences, Pharmacy and Chemistry (LSPC) and the School of Computer Science and Mathematics (CSM). The Centre is additionally supported by **Wang** (School Director of Research and Enterprise) and **Khazaeinejad** (Director for Postgraduate Research). CEESR is organised into seven themes:

Table 1. Staff research Areas (Themes), with early career researchers (ECR) and staff appointed in this cycle* indicated.

	Research Themes	Staff
CEESR (Led by Dykes)	Civil Engineering and Construction (CEC)	Donchev (Lead), Georgopoulos, Haroglu, Ofetotse*, ECR, Omer, Zafari*, Dykes
	Fire, Explosion and Fluid Dynamics (FEFD)	Dembele (Lead), Heidari, Muppala, Volkov, Elsayed (Elsayed Ali Hussin)*
	Nanomaterials and Composites (NC)	Hadavinia (Lead), Jayaseelan (Daniel)*, Esconjauregui*, Kresinski, Khazaeinejad*, ECR
	Medical Engineering (ME)	Wertheim (Lead), Barton, Singer, Thatti (formerly Ghatora), Spearman*
	Ground and Aerospace Transportation Engineering (GATE)	Wang (Lead), Benhadj-Djilali, Saleh*, Zhang X*, Duran, Zweiri*
	Kingston Energy (KE)	Gillmore (Lead), Augousti, Lin*, Mirzaii, Vienescu*, ECR, Hooda
	Earth, Environmental and Social Sciences (EESS)	Walford (Lead), Brown D*, Brown K, Coates, Dalton*, Fox*, Jarvis, Wilson*, ECR

CEESR was created in 2014 following a new strategic direction to bring together a set of smaller, highly focused research themes. This restructuring also brought together researchers previously submitted in two Units of Assessment, namely *General Engineering* and *Geography, Environmental Studies and Archaeology*. CEESR's creation was also associated with Faculty restructuring that established the School of Engineering and the Environment in order to integrate teaching, research and enterprise across a broader staff base. The formation of the new centre has led to a cross fertilisation of ideas, promoted collaborations and encouraged interdisciplinary research, supported by the generation of £3m research income in the period.

1.2 Unit Research

In line with Kingston University's (KU's) research strategy, the Unit fosters a collaborative, outward-looking research culture, developing both existing and emerging areas of excellence with

a central focus on facilitating impact within and beyond academia, enabling generation of external funds, and supporting staff development.

For REF2014 the Unit defined the following strategic objectives:

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

1.2.1 Developments and achievements since 2014

This submission comprises 42 (41.8 FTE) academic staff, which is a significant increase compared with the REF2014 submission (24 FTE) in the corresponding Units (14 FTE for UoA15, 10 for UoA17). Growth in the number of submitted staff is in part a reflection of the changed criteria for REF2021 and is also a demonstration of the fostering of a stronger research culture within the Unit throughout the assessment period. There is an emphasis on interdisciplinary research within and beyond the Unit, as well as on the co-creation of knowledge through links with individuals and organisations outside academia. This is reflected by the inclusion of staff from across the three schools of the Faculty of Science, Engineering and Computing in this submission. It also reflects the Unit's clear recruitment strategy and commitment to undertaking impactful research, strongly supporting early career researchers (ECRs), and encouraging/supporting existing staff to raise the quality of their research. These positive features are attributable to the research and impact strategy established by the Unit at the outset and refined according to emerging priorities and opportunities during the assessment period.

Since REF2014, the Unit's achievements are as follows:

- Increasing the number of outputs published in high quality journals (81% (85) of submitted outputs are published in upper-quartile (Q1) journals based on Scimago journal ranking).

- Increasing the number of doctorates awarded within the Unit by 62% since REF2014.

- Research has benefitted from the outward-looking culture through fostering national and international collaborations. The Unit has 80 (counted per university/institute) collaborations within the UK. International collaborations with the Unit extend to 25 countries and 80 collaborations (counted per institution).

- Several Unit members have received prizes or honours in recognition of the significant contributions made to their respective disciplines, including those from: the Institute of Measurement and Control, the Chartered Institute of Building International Innovation and Research Awards, National Cancer Research Institute (NCRI); and IStructE.

- Members of the Unit have served on 20 UK and international funding committees (counted per committee), such as NERC, ESRC, the European Commission (MSCA-IF), the Fonds de la Researche Scientifique (Belgium), the Innovation Fund Denmark (IFD), the Latvian Council of Science, the DAAD - Deutscher Akademischer Austauschdienst/German Academic Exchange Service Team.

- Unit members currently serve or have served as members of editorial boards/or as editor

of 25 journals during the period, including 11 Q1 journals (Section 4).

- Members of the Unit have actively participated in organising ~15 international conferences within the assessment period by joining organising committees (>10) and chairing conference sessions (>18).
- The FEFD theme, which has a long history at KU (since 1998), has earned its reputation worldwide and attracted relatively high levels of funding from several sources including the EU, Leverhulme Trust, and Softbits Consultants Ltd.
- Staff of the NC Theme have published 94% of their submitted outputs in Q1 journals based on Scimago, in journals including ACS Nano and ACS Applied Materials & Interfaces.
- Members of the GATE Theme work with major airlines (e.g. British Airways) and attract funding from the EU, EPSRC and industrial partners (such as Quanser). GATE members also work with staff in the KE theme on wind turbine anti-icing and have established a strong reputation within the industry, enabling the transfer of discoveries of aircraft anti-icing technology to the wind energy industry.
- Members from the ME theme work closely with industrial partners, for example through knowledge transfer partnerships (KTPs), establishing long term relationships, leading to impact. In addition, their interdisciplinary research facilitates collaboration with colleagues in the KE theme to further deliver impact (see 1.3.1). Research and in-house expertise in structural modelling of innovative elements in CEC have had a positive impact on the construction industry as detailed in an Impact Case Study (ICS) (ICSUoA12Donchev1).
- EESS attracts funding from Wellcome Trust, the MRC Prevention Research Partnership, British Academy, NERC, Statoil Petroleum AS (Norway), Maersk Oil (Denmark). This theme has also generated an ICS (ICSUoA12Walford4) from its interdisciplinary research.

1.2.2 Future research plans and mechanisms

Building upon these successes, the Unit has reviewed its objectives in order to maintain consistency and to further develop its research base during the next six years. Our three primary objectives will seek to:

i) Increase the number of research-active staff by an enhanced mentoring scheme and Research Time Allocation model (Section 2);

ii) Ensure a sustainable balance of senior, mid- and early career researchers through strategic appointments and career development;

iii) Expand interdisciplinary research by implementing integrative activities and exchanges across the Unit.

Collectively these three strategic goals will allow us to exploit new opportunities; further enhance outreach activities and public engagement; and increase external funding and PhD awards.

Restructuring, as already outlined, has established a coherent organisation to foster interdisciplinary working and enable an agile response to opportunities for research funding and impact. Research and enterprise in the Unit has benefitted from these changes in the current review period and has created a launchpad for the next six years.

The current recruitment and staff replacement policy, as described above, has strengthened the Unit, especially in terms of the quantity and quality of research outputs (refer to Section 1.1)

and in the potential commercialisation of research through appointment of staff with industrial experience (**Zweiri**, Shaw, Dansoh, Haritos). Therefore, the current policy will be maintained to further improve research capability and strength within the Unit.

Support mechanisms, such as staff development funding, PhD studentships/bursaries, research capital funding, flexible teaching loads, and a practical mentoring scheme have been deployed. Unit funding and teaching relief have been targeted strategically. For example, sabbatical leave funding has been provided to support researchers to strengthen proposal development, to write high quality journal papers and engage in outreach or public engagement, which will be developed as further support mechanisms. In addition, the Unit offers leadership and support to facilitate the efforts of experienced, returning, and new researchers in initiating or extending their research activities in the interests of career development and achievement.

Networking and building collaborations have been exploited to gain international esteem in addition to growth in internal partnerships to obtain the critical mass and cross-disciplinary perspectives. Under the auspices of CEESR and assisted by the School's Research Focus Group, research themes have been established to support ECRs and other staff to develop more high-quality research funding proposals and outputs.

Collaborations internally, nationally and internationally remain a key element to the success of the Unit. Internal links are well established and will be strengthened through the internal networking activities, such as CEESR or theme meetings, research away days, research seminars organised by research themes and pump-priming funding targeted for interactions. Furthermore, collaboration across Units has been and will continue to be enhanced through the following mechanisms:

i) When allocating QR funds, consideration is given to multidisciplinary/interdisciplinary research and studentships;

ii) Cross-School research activities will be integrated into Faculty events, and School research events will invite staff from different schools;

iii) Continued support for PhD student conferences to provide training opportunities;

iv) Utilising and integrating Faculty-managed facilities to encourage interdisciplinary collaborations. National and international collaboration is supported and encouraged within the Unit on an ongoing basis.

1.2.3 Open research and ethics

The Unit complies with the University Open Access policy, which commits to ensuring that the Unit's outputs are freely accessible in line with HEFCE and REF requirements unless there are special requirements from the sponsors. QR funding is available together with a library fund to cover Gold Open Access costs.

The University is committed to the highest standard of ethical conduct in carrying out all of its activities. To support staff, the University has adopted online ethics training provided by Epigeum, part of Oxford University Press. Following University requirements, the Unit and Faculty encourages and monitors research ethics training attendance of all research active staff. The Unit works with the Faculty to prepare and organise activities, such as seminars, thematic discussion fora, information events, online public lectures, etc. to discipline specific issues relating to research ethics.

1.3 Unit Impact Strategy

Researchers in the Unit, while undertaking research in their disciplines, including interdisciplinary research, concurrently adopt a proactive approach to generating impact beyond academia mainly

through collaboration with third-stream partners.

Our strategy, focusses on:

1) developing long-term relationships with commercial organisations to generate impact through knowledge transfer leading to product development/enhancement,

2) collaboration with local and central government to improve policy, and

3) enhancing public understanding and engagement in STEM subjects.

The Faculty Impact Champion coordinates – along with support from Impact and Business Development Managers from KU's Research Business and Innovation (RBI) office – regular workshops involving established external experts to assist in developing and realising the impact of the Unit's research. Commercialisation and Knowledge Transfer are supported by KTP Champions in each academic department, who work with the University's Business Development Team to facilitate productive engagement with businesses. The University has a Contracts Manager and retains the services of IP consultants.

Researchers participate in Research Circle meetings with staff and external organisations including, for example, the National Physical Laboratory (**Gillmore**, **Hadavinia** and **Wertheim**), the Radon Council (**Gillmore**), Natural England (**Hooda**), English Heritage (**Coates**), and Local Councils (**Walford**). In addition to impact arising from specific research projects, a programme of enhancing public understanding and engagement in STEM subjects has been enhanced by a £6.8 million project (including a £1.9 million investment by HEFCE) for 'Labs in a Lorry' with a dedicated outreach centre. These endeavours raise public understanding and involvement in STEM subjects. Additional outreach activities include the Primary Engineer program (the Faculty is the London partner) and the Saturday Engineering Club in partnership with the Sorrel Foundation (the Faculty is the founder and lead institution) engaging with young students. These outreach initiatives are continuously refined and contribute to our overall impact strategy.

During the next REF cycle, impact will continue to be driven by sector needs. Current collaborations and research partnerships will be extended to enhance impact. Researchers with clear pathways to impact include: **Barton**, **Brown D**, **Brown K**, **Georgopoulos**, **Haroglu**, **Hooda**, and **Thatti** (formerly **Ghatora**), who recently have been or are currently in receipt of external funding, thus ensuring a healthy pipeline of future impact initiatives is in place. Future outreach and public engagement activities will include research outcomes, demonstrations and animations, such as: showcasing development of robotic control methods and AI systems (**Zweiri** and **Duran**); rocket propulsion laboratory/test bed, wind turbine anti-icing research (**Wang** and **Lin**); and intelligent manufacturing and cloud manufacturing including 3-D printing (**Zhang X**). Outreach and public engagement are important ways in which the Unit fosters research with far-reaching social impact and works with its economic, industrial, governmental and policy networks.

1.3.1 Relationship between the Unit's approach to impact and the submitted case studies

The Unit's four impact case studies demonstrate the breadth of interdisciplinarity as well as discipline-specific research carried within the Unit. These case studies also exemplify the longevity of researchers' connections and collaborations that have in some cases endured more than two decades. The submitted case studies are:

1) A case study in the ME theme (**Thatti**, **Barton** and Foot, ICSUoA12Thatti3), grew from doctoral research completed in 2010 in collaboration with Rayner Intraocular Lenses Ltd and other manufacturers to help them to understand better their materials' capabilities enabling them to develop new or improved products.

2) Similarly, another case study (**Wertheim** and **Gillmore**, ICSUoA12Wertheim2) based on research carried out during the previous assessment period achieved new impact as a result of Olympus, the manufacturer of the confocal microscope, making their improved

software add-on commercially available. The new technology has been incorporated into the main microscope software in the latest version, with IP shared between the University and Olympus.

3) The CEC case study (**Donchev**, Limbachiya, **Wertheim** and **Hadavinia,** ICSUoA12Donchev1), demonstrates the value of using lightweight concrete and thin-layer mortar in wall systems for offsite housing construction, and illustrates how our research benefits the economy, society, and public policy by reducing the time and cost of housing construction.

4) The fourth case study (**Walford**, Samarasundera and Pratt, ICSUoA12Walford4) exemplifies our interdisciplinary research collaboration with researchers in other UK universities that has achieved national and international impact by focusing on the design of built environments as places which are potentially unfriendly, unfamiliar and inaccessible to older people.

2. People

The Unit aims to integrate the research of its staff with the research and training of its postgraduate research students, adopting a research-led approach to teaching and research development.

2.1 Staffing Strategy and Staff Development

The overall staffing strategy of the Unit follows the University strategic plan of developing an inclusive and supportive environment to nurture and foster current and future research leaders, to ensure a vibrant research culture, and to sustain strong international research teams. Therefore, the Unit has established the strategic objectives to:

1) Ensure a supportive research environment through active engagement with the University's equality and diversity strategy, and corresponding activities such as the Athena Swan and Race Charter awards;

2) Optimise recruitment opportunities to strengthen research leadership and develop ECRs;

3) Support the development of researchers through the University's academic career framework and its training programmes, the staff mentoring system and the faculty sabbatical policy.

2.1.1 Equality, Diversity and Inclusion

The staffing strategy of the Unit is guided by its commitment to Equality, Diversity, and Inclusion (ED&I). Kingston was one of the first 8 UK institutions to be awarded a Bronze Race Equality Charter in 2015 (renewed in 2019). Its ED&I work on academic career progression was recognised by The Guardian Award for Diversity Initiative in 2014. Within the Unit, there exists a sustainable critical mass of research active staff with a good balance of senior, intermediate and junior researchers (7 Professors, 10 Associate Professors, 18 Senior Lecturers, and 7 Lecturers, including 4 ECRs). The appointment of research students and staff aligns with best practice for equality and diversity and adheres to Athena SWAN principles. This is overseen by the Faculty Director of Postgraduate Research Programmes in the case of research students, and by the HR department in the case of staff. The University was awarded Athena SWAN Bronze accreditation in 2017. All three Schools in the Faculty have been awarded the departmental Athena Swan Bronze Award. The Unit's EDI ambassador is **Thatti**, who has been involved in the KU Race Equality Charter submission as well as the development of Athena Swan at faculty and institution levels. **Thatti** has also completed the Stellar HE strategy executive leadership programme for diverse leaders. Four Unit members have undertaken the Aurora leadership development

programme for women with Advance HE.

Of the 42 (41.8 FTE) staff within this submission, nine are female (8.8 FTE) (21%) and 33 are male (79%). These proportions remain the same as REF 2014 in which 24 FTE were submitted, 5 were female (21%) and 19 male (79%). The proportion of BAME staff within the submitted Unit (45%) has increased slightly since 2014 (~42% in REF2014 for combined units 15 and 17).

2.1.2 Career Framework for Staff

Kingston's Domains framework (see Institutional Environment Statement) facilitates and supports the career development and advancement of academic staff, giving clear guidance and criteria for research expectations. Clarity around requirements of academic domains and roles have enhanced the Unit's ability to organise research by providing flexible working load for research active staff, who can apply for up to 40% research time and sabbaticals when necessary.

2.1.3 Recognition through promotion

Through the annual promotion process, four staff have been promoted to Professor (**Georgopoulos, Gillmore, Wang** and **Wertheim**) in this cycle. Five staff have been promoted to Associate Professor (**Dembele, Donchev, Dykes, Thatti** and **Zweiri**) and seven to Senior Lecturer (**Brown D, Coates, Heidari, Saleh, Wilson, Zafari** and **Zhang**) within the period.

2.1.4 Strategic recruitment

New academic staff are appointed based on existing capability and potential for high-quality internationally recognised research, evidence of attracting external funding, industrial connectivity, and fit to Unit strategic research directions. New staff across the range of academic roles have been appointed during the assessment period. They are aligned with one of the Unit's research themes and are mentored, given a reduced teaching load and provided with funding for consumables, research travel and small equipment items. New staff within the Unit (since REF2014) are: **Ofetotse** and **Zafari** (CEC theme); **Elsayed** (FEFD theme); **Jayaseelan**, **Esconjauregui** and **Khazaeinejad** (NC theme); **Spearman** (ME theme); **Saleh**, **Zhang X** and **Zweiri** (GATE theme); **Lin** and **Vienescu** (KE theme); **Brown D**, **Dalton**, **Fox** and **Wilson** (EESS theme). Our aim is to maintain a critical mass of SRR researchers in each theme thereby promoting sustainability and developing potential, which has already delivered an increase in number of outputs (~230) eligible for inclusion in the submission.

2.1.5 Faculty/School Support

All new staff, irrespective of seniority, are mentored by an experienced colleague in a cognate field, who assists with writing grant applications, publishing and building their research profile. All staff have unrestricted access to research equipment, facilities and technical support aligned with their research interests. Researchers in the Unit have contributed to and benefited from central and faculty level research support mechanisms, which have been strengthened during the assessment period. The University has established a Peer Review College for research funding applications (Unit members include **Jarvis**, **Walford**, **Gillmore**, **Dembele**, **Wang, Wertheim** and **Augousti**) and a Research Mentorship scheme for ECRs. For example, **Wang** has mentored new staff, **Lin**, **Saleh** and **Jayaseelan** in the Department of Space and Aircraft Engineering, **Augousti** has mentored new staff, **Esconjauregui** and **Zhang X**, in the Department of Mechanical Engineering, and **Walford** mentored two new staff (**Brown D** and **Wilson**) in the Department of Geography, Geology and the Environment. The University deployed Quality Research funding strategically during the assessment period through a First Grant Scheme and two researchers in the Unit (**Brown D** and **Wilson**) were successful in open competition in 2016 and 2019 respectively (Section 3). These and similar faculty level initiatives have the combined aim of

enabling academic staff to maximise their research potential and contribute to the institutional research strategy.

We have also developed a more integrated teaching and research environment through the provision of regular research seminars to which undergraduate/postgraduate students are invited. These policies have led, for example, to a marked broadening of research capacity and experience in the area of Aircraft Engineering, along with concomitant growth in the other disciplines that make up the Unit.

2.1.6 Training for staff development

The University and Faculty/Unit provides comprehensive training for all the staff, covering for example, research supervision, introduction to the programmes/projects from the funding bodies (such as EU, Innovate UK, EPSRC, Leverhulme, etc.), how to improve grant bidding quality and peer review, and contracts and negotiation. More than 30 training programmes are provided, including: research ethics and good practice in research, management of research funds, impact development, mandatory training in PhD supervision, KTP and IP training, Academic Mentoring – Sharing Best Practice, and Publication Masterclasses. Postdoctoral research associates (PDRAs) within the Unit, funded through external awards are integrated into the relevant research theme and enrich the research environment and culture overall. Past investment in research students and their training has led to some of them becoming PDRAs in the Unit and continuing their research with former supervisors (e.g. **Wang**, **Augousti**, **Dembele**, **Hadavinia** and **Zweiri**). These ongoing relationships with their supervisory teams help to transition these PDRAs towards becoming independent researchers. They, like other researchers in the Unit, are required to develop and maintain individual research plans.

2.2 Research Students: Support Mechanisms, Training and Supervision

2.2.1 Recruitment

We have made considerable efforts to increase research student numbers by providing Faculty Graduate School studentships and starter bursaries for self-funded PhD students. The Unit has aimed to grow the postgraduate research (PGR) population and also the pool of academic supervisors. The Faculty purchases 100 project credits per year on the FindAPhD.com online platform to allow all SEC academics, without any restriction on their previous track record, to advertise their project ideas nationally and internationally. Since 2014, 22 start-up bursaries (£10k for Fulltime students) were awarded to recruit high-quality self-funded students into the Unit.

The number of PGR students within the Unit has been maintained at a sustainable level since REF2014, and currently stands at 53 (52 PhD, 1 MPhil), with total completions numbering 74 (plus 7 wholly overseas), representing 1.8 per FTE staff in the submission, and an increase from 50 completions in REF2014. Research students show a similar degree of ethnic diversity and gender balance to the staff researchers. The overall number of research students supervised by staff in the Unit shows a similar profile, with some 55% of research students being BAME, and 15% female (faculty data).

2.2.2 Support Mechanisms

The recruitment, training and development of students is managed centrally by the Faculty, under the academic leadership of the Faculty Director of Postgraduate Programmes. The School Director for Postgraduate Research (DPR; **Khazaeinejad**), ensures that the development of the PGR student portfolio follows best practice and is compliant with the Researcher Development Framework, the Concordat to Support the Career Development of Researchers, and the QAA Code of Practice. The DPR liaises with and manages postgraduate study and contributes to the

Faculty Research Degrees Committee (FRDC) which oversees student progression and the faculty strategy for developing and enhancing PGR programmes. PGR representatives from all disciplines and stages are members of the FRDC, at which they provide formal feedback which is recorded and actioned.

A student society for SEC PGRs, supported financially by the Kingston University Student Union and the Faculty, organises social events to bring our PGR population together and also hosts a series of "Research Stories" that provides a platform for PGR students to discuss their experiences. PGRs within the Unit help to organise events. Students are also encouraged to take part in Vitae's 'Three Minute Thesis' (3MT) competition. The Faculty operates a competitive bidding system to enable research students to apply for funding to actively engage in conferences through attendance and paper/poster presentation with most students receiving support to attend at least one national/international conference per year of study.

2.2.3 Training and Supervision

The University Graduate Research School acts as a focus for research student life and activity and has a physical presence in the form of ICT facilities, meeting rooms and social space. Graduate Schools at the University and Faculty levels together provide a structure for research student support and require students to undertake a programme of training to build key researcher skills. The training is organised in three layers:

i) The first layer is provided by the GRS and aims to cover training needs that are common to all University PGR students, e.g. research ethics, academic writing, information management, research impact, IPR. The programme is based on Vitae's Researcher Development Framework.

ii) The second layer is organised by the Faculty for all SEC students and covers training needs that are more closely aligned to the research needs of students in SEC. Examples include specific training sessions for existing and new facilities and for new students including safety and specialist software.

iii) The third layer of training is discipline and project-specific, and is mainly overseen by the supervisory team. Such specialist training is delivered both within and outside the university, and includes training in finite element analysis, computational fluid dynamics, and advanced statistics.

Part-time and overseas-based research students are also required to participate in this training. Customised training, for example in the use of specialist equipment or analytical techniques is provided on a case-by-case basis according to research requirements making use of in-house technical support or external courses if necessary. The systems of research student recruitment, involving interview and preparation of project proposal and initial and annual monitoring, provide robust mechanisms for ensuring suitable students are enrolled and for tracking progress. These measures have helped to raise our retention and completion rates.

During the assessment period KU became a founder member of the University Alliance's Doctoral Training Alliance (DTA) for Energy, and **Gillmore**, based in the Unit, leads the DTA Energy Specialist Training Group, which resulted in the recruitment of four fully-funded research students. As a member of the University Alliance DTA Management Committee, he helped to organise and run the Energy Spring and Summer Schools (the first DTA Energy Summer School was held at KU) and two DTA Energy Electives. Other self-funded students have been attracted to the Unit as a result of the DTA Energy initiative, which has also increased the range of staff with supervisory experience and contributed to our aim of heightening interdisciplinarity.

Publication of research outputs before completion of research programmes in the form of conference papers/posters and journal articles is encouraged and forms part of the strategy aimed at developing excellent practice in dissemination of research. As part of the process of fostering development as independent researchers, research students on completion of their

doctorates and Research Associates (RAs) during their contracted research invariably lead in the publication of co-authored journal articles. All research students and RAs engage with the wider academic community through participation in conferences, workshops and similar meetings and working as postgraduate representatives on committees. These actions demonstrate our commitment to and implementation of the Concordat to Support the Career Development of Researchers.

Apart from tutorials and assisting laboratory sessions, Unit PhD students are given opportunities to develop teaching skills by completing the Introduction to Learning and Teaching course, providing Associate Fellowship of the HEA.

3. Income, infrastructure and facilities

This section focuses on funding received by the Unit during the assessment period in respect of awards for specific projects and for infrastructure and facilities. However, the connections between internal and external funding should also be emphasised as **Brown D**, **Brown K**, and **Zweiri** succeeded in gaining external funding as a result of their success in securing internal research studentships and seed corn grants.

3.1 External Funding

Since REF2014, the combined income to the Unit (£3m) has originated from a diverse range of national and international sources with ~60% from EU projects.

Table 2. Analysis of Income and new awards during the census period.

Category	% of income	% New award headline value	Example funders
Civil Engineering and Construction (CEC)	1%	9%	Innovate UK
Fire, Explosion and Fluid Dynamics (FEFD)	54%	24%	EU Marie Curie Schemes, FM Global, National Grid, Leverhulme Trust, Royal Academy of Engineering, Softbits Consultants
Nanomaterials and Composites (NC)	6%		EU Framework Scheme, University of Birmingham
Medical Engineering (ME)	12%	13%	British Heart Foundation, Fight for Sight, NIHR, MoD, KTP, Essilor international
Ground and Aerospace Transportation Engineering (GATE)	13%	8%	EU Framework Schemes, including Marie Curie, Jaguar Land Rover Ltd, Royal Academy of Engineering, EPSRC, National Space Technology Programme, KTP
Kingston Energy (KE)	1%	9%	British Council, DEFRA, UNESCO, Sellafield UK
Earth, Environmental and Social Sciences (EESS)	13%	36%	NERC, Randgold Resources, Statoil Petroleum, European Goldfields, Surrey Fire & Rescue Centre, Royal Society, Wellcome Trust

Activity has focussed on supporting staff to increase the breadth, scope and quality of their research. The increased maturity developed is demonstrated by the direction of bids to significant funding streams. Successful new external funding awards were distributed across the Unit's research themes with successes in each theme and the majority ~36% awarded to EESS, closely followed by FEFD with 24%. 13% of the total award values have been for the collaborative and cross-disciplinary area of Medical Engineering (Table 2). However, other areas also cross disciplinary boundaries. For example, **Brown K** has built upon his internal first grant funding to secure further funding from the Wellcome Trust to study Morbidity, Mortality and Occupational Health in the Victorian and Edwardian Post Office (£288k awarded).
Other significant competitively-won awards include:

- **Dembele** has won funding from both EU-MSCA (€147k), for efficient methods for radiative heat transfer analysis in fires and water sprays for fire suppression to, and the Leverhulme Trust - Distinguished Visiting Fellowship Scheme (£98k) to investigate new engineering solutions to improve fire protection by water mist curtains. These have helped to support a collaboration with Professor Leonid Dombrovskiy from Russia and enabled him to work within the Unit. **Dembele** has also received industry funding for work with Softbits to develop water spray screening methods.

- **Ofetotse**, an ECR, has won (£254k) funding from Innovate UK (SwanaSmartStore, £83k to KU) to lead a project with companies EmPowered, OneSunSolar and SolaForm to research Intelligent solar and storage for reliable and affordable household energy access and sustainable support for stressed electricity grids in Zimbabwe & Botswana. The project is a collaboration with the companies, colleagues within our computing unit and Ulster University.

- We have been awarded £151k (**Augousti**, **Gillmore**, **Lin**) from several British Council schemes, including their IKIERI and Newton Schemes.

- £83k has been awarded by other UK charities, including the British Heart Foundation, Analytical Chemistry Trust Fund and the Royal Academy of Engineering.

- GATE has been awarded £51k across several space-themed projects by the National Space Technology Programme and the UK Space Agency.

University and Faculty funding for developing research profile, attracting external funds

University and Faculty research funding has been competitively targeted towards key areas of development and to fostering a vibrant research community by supporting ECRs through an annual First Grant Scheme. **Brown D** was successful in securing one of these awards in the first round, which has assisted with the development of his research profile and with providing a foundation for a successful funding application to the Welcome Trust with co-investigators from King's College London, University College London and the University of Derby. This ongoing project entitled 'Addressing Health: Morbidity, Mortality and Occupational Health in the Victorian and Edwardian Post Office' has brought a PDRA and PhD student in the Unit. The Unit has in place procedures to encourage and support researchers and one member of the unit (**Wilson**) transitioned from PhD completion to full-time staff member during the period under review. **Zweiri** received a Research Transformation Fund award from the University (£65k) for the OptiTrack system housed in the Learjet lab that contributed to him securing three external awards from the Royal Academy of Engineering (IAPP1R2\100174), Quanser Canada (in-kind support - a gifted autonomous self-driving car) and AOUK (with St George's Hospital). University funding for the Rocket laboratory led to a rocket Engine test of A 'self-eating' rocket engine for University of Glasgow, and also the data acquisition system for the Rocket laboratory will be used for data acquisition for a recent funded project by UK Space Agency through NSTP – Pathfinder Grant.

3.2 Internal Funding

The Unit has benefitted from over £2m investment by Kingston University through various initiatives, such as: i) 30 fully or partially funded PhD studentships; ii) Staff development funding (travel funds for conferences and networking); iii) Pump priming funds for innovative research projects, especially for newly recruited staff; iv) Research transformation funding; v) Research Capital funding for improved research facilities; vi) Funding for outreach and public engagement to equip and maintain the outreach initiative 'Lab in lorries'; vii) PhD starting (typically £10k) and completion bursaries to attract self-funded students and to help self-funded students to complete their studies; and, viii) University-funded sabbaticals.

3.3 Infrastructure and Facilities

Faculty-facing Research, Business and Impact Development Managers from within the University Research, Business and Innovation (RBI) Directorate assist staff in identifying opportunities for external funding, developing grant applications, identifying external partners, designing pathways to impact, as well as evidencing and evaluating impact. RBI coordinates a structured process of internal peer review of applications. Internal support ranges from research group and departmental mentoring, peer review and faculty-level training, such as grant-writing workshops which enable staff to devote concentrated effort toward completing funding applications. There is specialist RBI support at Faculty level in preparing research funding application budgets, and Research Operations Managers and a Finance post-award team dedicated to Research/Enterprise support post-award.

The University has invested in its research support infrastructure and the improvement of the facilities where Unit research is located. The John Galsworthy Building (2008/09, £20m) provides 65 lecture/seminar/conference rooms. In the subsequent period, other spaces have been reconfigured as specialist research facilities to benefit the Unit including Palynology and GIS/Remote Sensing laboratories. Funding from HEFCE/University initiatives totalling over £8m in the past decade have permitted continued enhancement and refurbishment of research facilities in the SEC Faculty, which have increased laboratory space and computational equipment and are helping to enable further interdisciplinary working. The University's flagship building project (~£55m), known as the Town House, was opened in January 2020, which is close to the Unit's present buildings and provides world class library and seminar space for researchers to work and collaborate.

Staff in the Unit are currently accommodated on the Penrhyn Road and Roehampton Vale campuses. Staff in the Department of Civil Engineering and Construction and the Department of Geography, Geology and the Environment are located in the Main Building at Kingston University's Penrhyn Road Campus with administrative and technical support staff in neighbouring offices or the adjacent John Galsworthy or Sopwith Buildings. The Department of Aerospace and Aircraft Engineering and the Department of Mechanical Engineering are together at the Roehampton Vale Campus.

The engineering laboratories are generously provisioned, and include 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. A Micromist fire suppression test rig has been developed from the Micromist Generator provided by BP. The Unit also benefitted from a dedicated 16-node Linux Cluster and shared use of a 128-node Linux Faculty Cluster before 2018. Since then, the University has invested £340k on a new High-Performance Computing facility, which is a 768 core with 6144GB RAM, which nearly doubles the number of cores of the old HPC. The storage comprises 2 x SuperMicro servers with attached IBM Storage and GPFS file system, total storage is 85 TB. The interconnect is a Mellanox SN2100B, providing 10gb connectivity between devices. The software stack uses Adaptive HPC Suite, which provides a web front end for managing and submitting jobs, making access easier and accessible for all.

The Unit's indoor Rocket Laboratory is a unique, European-leading facility for teaching and research on small to medium sized rocket propulsion engine development work. Nearly £200k from the University has been invested in this laboratory. Specifically designed for rigorous "hot-fire" testing, this facility allows students and academics to build, fire and evaluate novel and unique experimental rocket engines. With its integration with the High-Performance Computing Cluster, new advances in machine learning to develop new engines and diagnostic equipment for the UK Launch and Space Propulsion industry can be developed.

In addition, there are several Faculty-owned facilities which are freely accessible to all academic staff in the Unit. These include the Olympus LEXT OLS4100 laser scanning digital microscope, which can be used to conduct non-contact 3D observations and measurements of surface features easily at 10 nanometer resolution. The OLS4100 industrial microscope has distinctive features for fast image acquisition and high-resolution microscope images over a wider area. One ICS (ICSUoA12Wertheim2) is based on work using the Olympus LEXT OLS4100. Furthermore, the Faculty strategically invests to maintain and/or acquire additional new facilities, for example, upgrading the LEXT400 to 5000 series, and investing £103k to replace a Renishaw Laser Raman.

Additional facilities include: a full-scale environmental chamber which provides a temperature range between -24 ^{O}C to 24 ^{O}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; a 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. Most recently, a portable Geovisionary 3D geo-visualisation system (£30k) (**Walford**) has been purchased as a research facility and as part of the development of the STEM Outreach Centre at the Penrhyn Road Campus which can accommodate up to 30 people for interactive activities.

Research students are located in open-plan offices with their own desk space and computers, which are renewed on a four-year cycle. Research students have access to specialist laboratory and ICT facilities in accordance with the needs of their research and benefit from full access to the University's library and learning resource services. Technical support is provided at Faculty level, but with discipline-specific assistance provided to researchers in the Unit for example in respect of thin section cutting and geographical information systems.

4. Collaboration and contribution to the research base, economy and society

4.1 External Collaborations within the Unit

Members of the Unit collaborate on both disciplinary and interdisciplinary fronts with academic colleagues nationally and internationally. A high proportion, ~80% of submitted outputs include at least one co-author from outside KU and ~49% of these include at least one non-UK co-author. Collaborations demonstrate reach in respect of the range of external organisations, breadth through the involvement of all researchers, and depth in relation to endurance of links over many years.

These academic collaborations with UK-based researchers are particularly strong with universities and research institutes in London and South-East England, although there is also geographical spread from the University of Plymouth in the South-West to the University of Stirling in Scotland. The submitted outputs include 80 institutional UK collaborations across 35 universities and research institutes, such as the National Physical Laboratory and the Natural History Museum (Table 3).

Table 3. Co-authorships within the total pool of submitted outputs highlighting collaboration with **UK universities and other research institutes** (excluding companies) by UoA staff. The number of collaborations shown is at the level of the organisation and not with individual researchers (authors).

Total number of separate UK collaborations (counted per university/institute): 80			
University	**No.**	**University**	**No.**
University of Warwick	12	University of Bristol	2
Imperial College London	5	Anglia Ruskin University	1
Queen Mary University of London	4	Birmingham University Botanic Gardens	1
University of Bath	4	Coventry University	1
University of Cambridge	4	London School of Medicine and Dentistry	1
British Geological Survey	3	Middlesex University	1
Cranfield University	3	Nottingham Trent University	1
Durham University	3	The Natural History Museum	1
King's College London	3	University College London	1
National Physical Laboratory	3	University of Derby	1
University of Edinburgh	3	University of East London	1
University of Leicester	3	University of Leeds	1
University of Southampton	3	University of Manchester	1
Heriot-Watt University	2	University of Plymouth	1
Lancaster University	2	University of Stirling	1
University of Birmingham	2	University of Surrey	1
University of Oxford	2	University of Wolverhampton	1
University of Reading	2		

The submitted research outputs also demonstrate wide-ranging international collaborations across 25 countries, with notably high levels in China, Russia and the Middle East, to some extent reflecting the cultural diversity of staff in the Unit (Table 4). The full spectrum of UK and international collaboration with researchers in universities and research institutes extends beyond those summarized in Tables 3 and 4.

Table 4. Co-authorships identified within the total pool of submitted outputs highlighting **international collaboration** by Unit staff. The number of collaborations shown is at the level of country and not research organisation.

Total number of separate non-UK collaborations (counted per Institution): 80 in 25 countries		
Country	No.	**Example Institutions**
China	14	Beijing Research Institute of Chemical Industry; Northwestern Polytechnical University; Shandong University; Southwest Jiaotong University; Wuhan University of Technology.
Russia	10	Baltic State Technical University; ITMO University; Moscow Radiotechnical Institute of Russian Academy of Sciences; St Petersburg State University
USA	9	Johns Hopkins University; Northwestern University; South Dakota State University; St. Louis University; University at Albany (SUNY); University of Minnesota
Abu Dhabi	7	Khalifa University of Science and Technology; Robotics Institute
Spain	5	Public University of Navarre; Universidad de Las Palmas de Gran Canaria; University of Vigo
Italy	4	National Nanotechnology Laboratory (NNL); Università degli Studi di Milano Bicocca; Università del Salento; University of Insubria
Poland	4	Wrocław University of Science and Technology

Greece	3	Piraeus University of Applied Sciences; School of Pedagogical and Technological Education
Canada	2	University of British Columbia; University of Calgary
France	2	Université Paris-Sud; Université Paul Sabatier
Germany	2	Goethe-University Frankfurt
India	2	Bombay College of Pharmacy; NMIMS University
Madagascar	2	Université d'Antananarivo; Université de Fianarantsoa
The Netherlands	2	Utrecht University; Vrije Universiteit
Vietnam	2	Nha Trang University; Vietnam National University
Others (10 countries)	1	Australian National University (Australia); Institute of Geophysics (Czech Republic); University of Copenhagen (Denmark); Kyoto University (Japan); Universität Basel (Switzerland); American University of Sharjah (United Arab Emirates); National Technical University of Ukraine (Ukraine); Seoul National University (South Korea); Universitas Muhammadiyah Surakarta (Indonesia); Jordan University of Science & Technology Jordan).

4.2 Relationship with Industry, the Public Sector, Economy and Society

Researchers in each of the research themes in the Unit are also engaged in networks and partnerships with industry, the public and charitable sectors. Several of these transcend the research themes and help to integrate researchers across the disciplines contributing to the Unit. These partnerships and relationships are at different stages of maturity, some have already contributed to the submitted outputs, with others expected to lead to outputs suitable for future REF assessments.

Table 5. Examples of networks and partnerships with industry, the public and charitable sectors across the research themes in the Unit.

Theme	Example Partners
Civil Engineering and Construction (CEC)	BP/HSL on Health and Safety; Institution of Construction Engineers; Barratt Homes Construction; H+H Celcon; SIG Roofspace; Willmott Dixon
Fire, Explosion and Fluid Dynamics (FEFD)	BP/HSL on Health and Safety; European Hydrogen Safety Network; FM Global; National Grid (COOLTRANS project); Daresbury Laboratory; the Russian Scientific Centre; London ReMade, Day Group Ltd.; Intelligent Door Solutions (IDS) Ltd.
Nanomaterials and Composites (NC)	National Physical Laboratory; Zotefoams plc; SCG Chemicals in Thailand, Ansaldoenergia in Switzerland, Westinghouse USA, DLR Germany, Tokyo Institute of Technology Japan, Dunlop Oil and Marine Limited Lincolnshire UK
Medical Engineering (ME)	Central Glass and Ceramics Research Institute in Kolkata, India; Carlow Institute of Technology, Ireland; the Laboratory of the Government Chemist (LGC)
Ground and Aerospace Transportation Engineering (GATE)	Bombardier Aerospace; Chess Dynamics Ltd.; FG Wilson through Drone EPSRC (DT/F006829/2); Chinese Government; British Airways; Bionanovate; Glanotech; DEMOKRITOS; Rolls-Royce
Kingston Energy (KE)	China Aerodynamics Research and Development Centre (CARDC)
Earth, Environmental and Social Sciences (EESS)	Colchester Borough Council; Maersk Oil Denmark; Equinor; Evolution Applied Ltd.; National Physical Laboratory; Natural England; Olympus Corporation; Petroleos de Venezuela SA (PDVSA) Venezuela; Soils Ltd.; Statoil Norway

The networks and partnerships in the Unit, including some noted in Table 5, have operated in a variety of ways. Some have focused on specific research questions such as investigating the mechanical behaviour and optimum design of advanced aircraft structures in complex environments, and novel nanomaterials for coating aircraft to prevent icing and to decrease drag. Some concentrate on highly specific topics including adhesive bonding, nanomaterials, bonded structures and FRP materials, polymer foams, high and ultra-high temperature materials and slippery surface coating. Some of the networks and partnerships have resulted in externally funded research studentships with co-supervision from the industry partner. The non-academic links also help our research to be impactful in relation to the economy and society.

4.3 Interdisciplinary Research

Interdisciplinary research within the Unit by members from different disciplines and with external collaborators is commonplace. The submitted outputs (36% flagged as interdisciplinary) and examples below serve to illustrate such interdisciplinarity.

Brown D works with demographers, historians and human geographers to investigate health in relation to people's occupation, focusing on postal workers and other selected categories in the nineteenth and early twentieth century.

Hooda collaborates with chemists and environmental managers to undertake environmental assessment especially in relation to soil and water.

Walford works with urban designers, gerontologists, planners and demographers in respect of older people's navigation and mobility through urban spaces. He also works with 3D modellers to create and visualise contemporary and archaeologically significant buildings and environments for heritage experience purposes.

Wang is working on synthesis of advanced top nanocoatings with improved aerodynamic and de-icing behaviour, which involves research on new nanomaterials and its application on the aircraft. The products have been applied on British Airways aircraft.

Wang and other colleagues have supervised a university funded PhD student researching "Finite Element Modelling of Human Eye Lens", which led Zeiss-Meditec, a major manufacturer of implant lenses post-cataract surgery, to provide funding for developing novel implant lenses (£70k). Eventually, Dr Kehao Wang (then PhD student) is employed by Beihang University as Associate Professor, who secured a grant from National Natural Science Foundation of China (240k Yuan) to continue this research.

Barton and **Thatti** have built up a good relationship with Rayner investigating materials for intraocular implant lenses. An ICS (ICSUoA12Thatti3) is submitted in this area.

4.4 Leadership and Achievement in the Academic Community

Members of the Unit are embedded in their respective disciplines and support these in a number of different ways including editing journals and serving on editorial boards, organising and participating in international conferences and symposia, working with and advising national and international public sector organisations and private corporations, and supporting the work of the learned societies of which they are members (fellows) through various forms of committee work and other research-related activities. The following examples demonstrate this engagement with the wider academic community and disciplinary bases of the Unit's members.

Journal Editorships and Editorial Boards

Unit members currently serve or have served on the editorial boards of ~25 journals during the period. These journals include 11 Q1 journals, i.e. *Bulletin of Geography, Frontiers in Environmental Science, Geomorphology, International Nano Letters, Journal of Environmental Management, Journal of Intelligent and Robotic Systems, The Journal of Maps, Journal of Sensors* (*Measurement*), *MDPI Applied Science, Population, Place and Space* and *Science of the Total Environment*.

International conference organisation and participation

Members of the Unit have individually or in conjunction with others organised ~15 international conferences in the review period and have been invited to speak/act as session Chairs/give plenary talks at over 30 meetings internationally. Unit members have delivered keynote presentations at conferences in China, France, Italy, Jordan, Lebanon, Norway and Switzerland. Unit researchers have supported over 80 international conferences through delivery of papers and more especially by joining organising committees (10) and chairing sessions (18). The global reach of our organising and chairing participation has included Aerodynamics CARDC, Mianyang, China (2016); Multi-Scale Self-Healing Nanocomposite Shielding Materials conference Turkey (2018); 6th Structural Engineers World Congress (Mexico 2017); 10th International Symposium on the Cretaceous, Austria (2017) and Drilled Shafts of the Deep Foundations Institute, USA (2018).

Funding Committees

Unit members serve on UK and international funding committees, including NERC, ESRC, the European Commission (MSCA-IF), the Fonds de la Researche Scientifique, Belgium, the Innovation Fund Denmark (IFD), the Latvian Council of Science, the DAAD - Deutscher Akademischer Austauschdienst/German Academic Exchange Service Team, the Cypriot Government Research Promotion Foundation, the British Council, the Royal Academy of Engineering.

Learned Society Engagement

Members of the Unit are fellows of a range of learned societies as befits the disciplinary breadth and interdisciplinary research carried out by its researchers. Examples include: Association for Geographic Information, British Ecological Society, British Institute of Soil Science, Geological Society, Institution of Civil Engineers, Institution of Structural Engineers, Institute of Electrical and Electronics Engineers, Institute of Engineering and Technology, Institute of Measurement and Control, Institute of Physics, Mineralogical Society, Royal Geographical Society with IBG and Royal Society of Chemistry. A number of Unit members support their disciplinary bases by holding leading roles on committees in a range of these organisations making significant contributions to the academic community. These include work for learned and professional societies, notably the British Ecological Society (**Brown K** review college member and Meetings Officer 2014-16); the European Geosciences Union (**Jarvis** Deputy President, Stratigraphy, Sedimentology and Palaeontology Division 2009-18); the International Union of Geological Sciences (**Jarvis** appointed voting member International Subcommittee on Cretaceous Stratigraphy 2016-20); the Royal Geographical Society (RGS-IBG) and its research groups, among them Population (**Walford** Treasurer 2009-18), Rural Geography (**Walford** Chair 2013-19), Council for British Geography (**Walford** Treasurer 2008-), Commonwealth Geographical Bureau (**Walford** Treasurer 2012-20); Expert Panel Member of the Institution of Civil Engineers (**Georgopoulos** 2013-); Geological Society of London Science Committee (**Gillmore** elected member); and Research Panel of the Institution of Structural Engineers (**Georgopoulos** 2007-16). UK Research Councils include Unit members in their Peer Review Colleges, including the EPSRC (**Augousti**, **Jayaseelan**, **Khazaeinejad)**, ESRC (**Walford**), and NERC (**Hooda**). Our contribution to research in the discipline also includes external PhD examinations, roles on national advisory bodies

including University Alliance Doctoral Training Alliance Energy, Specialist Training Group (**Gillmore** is Chair), UK Radon Council (**Gillmore** is elected Chair and Director), where he leads Radon regulation and training workshops (with the Health and Safety Executive and the Royal Society for Public Health) to educate builders, engineering companies, lawyers, environmental health and building control officers on radon issues, reviewer for Royal Academy of Engineering Fellowships (**Jayaseelan**) and membership of Research Panel of the Institution of Structural Engineers (**Georgopoulos**).

Service to the Engineering community over the assessment period includes membership of the Council of the Institute of Measurement and Control, as well as its Accreditation Committee (**Augousti**), **Dembele** is a member of the Scientific Council International Water Mist Association. **Wang** is a Member of the Design Engineering Technical Committee and the Value Driven Design Programme Committee of AIAA. A number of Unit members have received prizes or honours in recognition of the significant contributions made to their respective disciplines. These include **Augousti**'s receipt of the Callendar Medal for "Outstanding Contribution to the Art of Instruments or Measurement" by the Institute of Measurement and Control in 2020; **Haroglu**'s Merit Award in the Research Paper Category by the Chartered Institute of Building International Innovation and Research Awards in 2014; **Wertheim**'s National Cancer Research Institute (NCRI) Prize Award in 2015; and **Zafari**'s Research Prize - Midland from IStructE in 2015.

4.5 Ongoing contribution to research base, economy and society for REF2021 and beyond

Contribution to Economy and Society

As detailed in Section 1, our research and its impact are articulated through collaborative and reciprocal links with industry and the public sector at national and international levels and through acting in an advisory capacity. Notable examples from across the spectrum of research include knowledge exchange and training with petroleum companies (e.g. Statoil) which has led to industry support for doctoral students, development of scientific instrumentation with NPL facilitating access to its LEXT OLS4000 confocal microscope series allowing subsequent commercialisation of new software on this equipment by the Olympus Corporation (see 1.3.1, ICSUoA12Wertheim2), and influencing local government (Colchester Borough Council) in respect of urban design and directional signage (see 1.3.1, ICSUoA12Walford4). Unit members have worked in an advisory capacity with a range of organisations including the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES), the Department of Agriculture, Food and Rural Affairs (Northern Ireland Assembly (landslide advice)), All-Party Parliamentary Group on Energy Studies, and the joint European Federation of Foundation Contractors and Deep Foundations Institute (USA) working group in relation to the Chennai Metro Rail Project (India).

The Unit's researchers also engage with and inform the public through a range of activities including participating as an academic expert on BBC1's flagship genealogy programme "Who Do You Think You Are?", contributing to the work of the KU Outreach centre (Section 1), and talking at meetings of local/regional scientific societies including branches of the Geographical Association and the Royal Geographical Society.

The Unit achieves impact as a natural outcome of its engineering research and through members of the themes in CEESR working with partners across government, industry and commercial organisations. Much of the supported activity occurs in collaboration with industry, where the outcome of the research is directly translated into societal and economic benefit.

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.

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.

Zweiri works closely Jaguar Land Rover on fuel consumption control. **Wang** collaborates with partners in Greece and UK including British Airways towards anti-icing and improving aerodynamic performance of aircraft.

Georgopoulos was commissioned by Wiley-Blackwell to author a book on the sustainable use of concrete in modern construction. The book - 'Sustainable Concrete Solutions' has been distributed in more than 40 countries.

The range of disciplines represented in the Unit coming from both core engineering fields as well as the environmental and social sciences constitutes fertile ground for the gestation of blue-skies interdisciplinary research and serendipitous interaction. It also strengthens the Unit's ability to work with industrial, public and charitable sector partners to deliver real impact. The synergies created through these interchanges result in research of significant importance to the Economy and Society. This has been achieved through careful and sustained nurturing of early career researchers on their journey towards senior research status and the recruitment of staff with established research leadership capability.