Institution: University of Leicester

Unit of Assessment: UoA12 Engineering

1. Unit context and structure, research and impact strategy

Section 1. Unit context and structure, research and impact strategy

The UoA has undergone significant change over the last seven years resulting in a more focussed identity than presented in REF2014. We have had major successes in research and impact that have enhanced our position as international leaders in engineering science. Of particular note are:

- The 2018 launch of the £2M Nanjing Iron and Steel Company (NISCO)-UK Research Centre that aims to advance impactful research in new materials and the development of advanced manufacturing techniques in materials processing. To date it has achieved considerable funding success, including: WeldGalaxy (EU, £326k); FLEXIBAT (Innovate UK, £369k); Leicester Materials Knowledge Exchange (LMKE) Regional Engagement Award (Royal Academy of Engineering, £75k); Superslab (Innovate UK, £161k); The Royal Society (£43k), and attracted £978k of in-kind support from industrial collaborators.

- Significant investment in our digital communications infrastructure resulting in our consortium leadership of a highly prestigious DSTL/EPSRC University Defence Research Collaboration project supported by QinetiQ, Thales, Selex ES, Texas Instruments, Steepest Ascent and Prism Technology, (£3.6M project).

These and other examples are detailed in what follows.

Overview and 2016 restructure

The UoA is a *General Engineering* unit with a strategic vision to address challenges facing industry and society with a particular focus on Aerospace & Computational Engineering (ACE) and Mechanics of Materials (MoM). These broadly define our two research groups: ACE and MoM (membership is listed in Table 1). Our research and impact strategies are underpinned by strong institutional, national, international, and industrial collaborations and benefit from interdisciplinary links within traditional physical science disciplines (e.g. mathematics, computer science, and chemistry) and outside (e.g. medical science). Interactions across UoL provide a vibrant environment for cross-disciplinary research and impact. Medical applications are a particular growth area and feature strongly in our future strategy in both materials and computational activities.

Aerospace & Computational Engineering (ACE) Group (19 members, 17.4 FTE)			Mechanics of Materials (MoM) Group (15 members, 15 FTE)		
Angelino*	Lefley	Su*	Azeem*	Panwisawas*	Ye*
Bagdanavicius	McEwan	Visintini	Bocian*	Pearce	
Chambers*	McMullan	Warrington	Bo Chen*	Schlindwein	
Gaojie Chen*	Morales	Eugene Zhang*	Dong	Shepherd*	
Garrett	Prempain	Yue Zhang*	Gill	Sinka	
Hussain*	Rona		Li*	Tsamis*	
Ji*	Ruiz*		Pan	Weston	

Table 1: UoA membership and group allocation. indicates a new member, not represented in REF2014 return.*

The two-group structure results from an expert external review in 2016, which recommended reorganising away from the six small research groups presented in REF2014 and consolidating critical mass in computational engineering and re-shaping the long-established MoM group (aligned with the College's research themes). This provides strategic focus to the UoA allowing us to react to and select emerging research and impact opportunities. As a relatively small unit (32.4 FTE), this focus is key to our success and frames our future expansion strategy. These changes have prompted a review of our undergraduate and postgraduate teaching profile, ensuring the integration of our teaching and research for the benefit of our students (UG and PGT) and research environment.

The restructure prompted a departure from the strategy outlined in our REF2014 return. The most significant changes being our extraction from embedded systems and analogue communication activities (replaced by digital communications within ACE); a scaling back of the electrical power and power electronics activities (now aligned to the energy activities within ACE); an extraction from forensic activity within the MoM group; and a significant refocus of the then bioengineering group (now in MoM). These changes have been necessary to ensure critical mass within materials and computational approaches. The united ACE group is the most significant change to arise from the restructure and allows coordinated research in fluids, digital communications and control to operate under shared leadership.

The reorganisation produced immediate and substantive impact and significantly improved the research culture in the School: there has been an order of magnitude increase in grant applications. It is particularly striking that £3M of new research awards FEC were secured in the financial year 2018/19, in contrast to £300k in 2016/17. The new structure has further proved successful as a vehicle for interdisciplinary interactions and international initiatives. This is evidenced by four flagship developments: 1) *NISCO-UK Research Centre* discussed above; 2) the *Materials Innovation Centre* (MatIC), a long-term strategic partnership with *The Welding Institute* (TWI); 3) as one of the founding members of the University's *Artificial Intelligence, Data Analytics & Modelling* (AIDAM) Centre, jointly with the Schools of Mathematics & Actuarial Science (SMAS) and Informatics; and 4) the space engineering component of the £13.75M UK Research Partnership Investment Fund (UKRPIF) support for the *Manufacturing, Engineering, Technology and Earth Observation Centre* (METEOR) project arising from *Space Park*

Leicester (SPL).

SPL is an important development in this REF cycle and forms a leading part of the research strategy for the School, College and University [IES 2.4, 4.4]. This ambitious new project is led by the University in partnership with the City, Council, LEP and National Space Centre (NSC) and secured an initial investment of £26M through a combination of Local Growth Fund, NERC and the University itself. Members of the UoA have been fully engaged in the development of the various activities of SPL, including: building design and associated infrastructure (**Chambers**, **Garrett**, **Gill**, **Pan**); industrial engagement (**Dong**, **Panwisawas**, Williams, Vladimirova); and training (**Dong**, **Garrett**, **McEwan**).

Research and impact strategies

The UoA's research and impact strategy consists of the following main components:

- To continue a programme of world-leading research aligned with the activities of ACE and MoM, producing discovery-led engineering science and challenge-led impact in collaboration with industry.
- Nurturing a productive and diverse research environment across the two groups to ensure our staff can conduct ground-breaking research over the next decade.
- To grow our staff base, ensuring we maintain the quality of our research and impact whilst retaining a clear focus and identity. We have an excellent team and policies which deliver staff satisfaction across all job roles (e.g. development opportunities, mentoring, flexible working, and industrial placements).
- To maintain access to and invest in the development of our research infrastructure consistent with the needs of our academics in activities aligned to our research groups. This involves a particular focus on growing biomedical capabilities and retaining cutting-edge computational facilities.
- To facilitate new links and strengthen existing relationships between the international academic and industrial sectors (particularly the medical, aerospace and space sectors), as well as the public. We engage with UoL initiatives involved in this (SPL, *Leicester Innovation Hub*, *Leicester Institute of Advanced Studies,* [IES 2.2, 2.5]) as well as engaging positively with industrial partners at all levels, from multi-nationals (e.g. Rolls Royce, Landis+Gyr, Centrica) to regional SMEs (e.g. CellCare Technologies Ltd, Red Monkey Play Ltd).
- To work alongside industry to identify areas of fundamental and applied research in which cooperative alliances/collaborations can be formed, consistent with our identity. SPL, NISCO-UK Research Centre, MaTIC, and AIDAM will be invaluable assets in attracting industrial partners to form new cooperative alliances and collaborations.

Group identities

Names in **bold** refer to members of this UoA return listed in Table 1.

<u>The ACE Group</u>

Led by **Garrett,** also Head of School (HoS), the ACE Group focuses on fields relevant to aerospace systems, computational engineering and supporting technologies. It has 19 members of staff [17.4 FTE] and was formed in 2016 from four smaller groups to create a collaborative environment for computational and aerospace-related research. ACE's strategy has been to build critical mass in key strengths and forward-facing areas and now has two primary areas of headline activity: Computational Engineering and Control & Energy.

I. Computational Engineering. ACE consists of colleagues within the School with backgrounds from mechanical engineering, electrical engineering, physics, computer science, and applied mathematics. These diverse backgrounds generate a dynamic environment for computational approaches in engineering that reach outwards into other discipline areas of CSE. The group is well known for its fundamental work in fluid mechanics (including transition in mixing/boundary layers) and digital communications (including wireless communication in the context of 5G and beyond).

Examples of major achievements and impact in this REF period include:

- The development of digital solutions for robust space and defence systems that exploit multi-sensor data fusion techniques, fault-tolerant embedded computing, intelligent sensing and remote sensing. (Interdisciplinary work led by **Chambers** in conjunction with DSTL, QinetiQ and Thales, as partners in the University Defence Research Collaboration Phase II, £3.6M project).

- The hypothesis and subsequent discovery of an alternative instability mode within rotating boundary-layer flows for which **Garrett** was awarded a Royal Academy of Engineering Senior Research Fellowship during 2015/16 and **Hussain** an EPSRC New Investigator Award (EP/R028699/1) in 2018 (combined total £500k). Collaborative projects have subsequently been launched with Delft (Holland) and KTH (Sweden) to draw in experimental and DNS approaches. [Headline papers in journals: **Garrett**, **Hussain** et al *J. Fluid Mech.* **775**, **788**, **818**].

- **Garrett, Hussain** and **McMullan** led special interest groups in the EPSRC-funded UK Fluids Network (£800k national project led from Cambridge, EP/N032861/1), coordinating national teams with a particular focus on transition in complex rotating boundary layers and shear layers. The boundary-layer work resulted in the design and development of a UK national rotating disk facility at Warwick, and collaborative projects between Leicester and the Universities of Sydney and Macquarie, Australia.

- The design of a safer, secure, customisable, scalable and intelligent network in buildings using millimetre Wave (mmWave) and Visible Light Communications (VLC) for 5G and beyond for which Yue **Zhang** was awarded an EU Horizon 2020 5GPPP phase 2 project IoRL 2017/20, totaling £8.7M. Collaborative projects have since been established with Tsinghua University (China), Viavi Solutions and Fraunhofer IIS (Germany) to research into the Beyond 5G C-RAN network technology modelling and architecture. A further EU Horizon 2020 project 6G BRAINS (Bring Reinforcement-learning Into Radio Light Network for Massive Connections) 2021/23 was recently awarded to Yue **Zhang** (€5.7m project).

- The unique analysis of Simultaneous Wireless Information and Power Transfer (SWIPT) massive MIMO Systems with active eavesdropping, for which **Chambers** and Gaojie **Chen** were awarded an EPSRC project in 2018 (EP/R006377/1, £275k). The results of the proposed new optimization-based precoder and physical layer security design in the massive MIMO systems bring a fundamental revolution in terms of the optimization of the trade-off between the achievable secrecy rate and energy efficiency. Collaborative projects have been built with Loughborough, Queen Mary and BT. These

have the potential to bring unprecedented societal and economic benefits, including developments in smart homes, smart city, intelligent transportation, e-health and environmental monitoring.

II. Control & Energy. ACE is engaged with the fundamental theory and practice of control engineering and its application to aerospace and energy systems. It is one of the few UK control teams to combine theoretical rigour with practical applicability and has received a diverse array of funding (industrial and from government bodies).

Examples of major achievements and impact in this REF period include:

- The development of improved design and certification methods for emerging vibration reduction technologies for rotary-wing vehicles, for which **Morales** was awarded a Royal Academy of Engineering Industrial Fellowship 2014/15, allowing him to be seconded to Leonardo Helicopters Division and to perform a short research study for the Aerospace Technology Institute (ATI), funded by the ADS group. Collaborative work took place within the UK Vertical Lift Network (UKVLN), a group of UK rotorcraft specialists including Glasgow, Manchester, Bristol, Bath, Liverpool, Cranfield Universities, with Leonardo Helicopters, DSTL, ATI, Hybrid Air Vehicles, and Vertical Aerospace. The UKVLN has been awarded an EPSRC Network Grant (£145k) and the parent EPSRC grant MENtOR (EP/S009981/1, £3.5M). **Morales** led the MENtOR work package on improved control algorithms for novel rotorcraft configurations and consultancy work for the control and operation of a national rotor test rig facility with the Aircraft Research Association, of strategic importance to keep UK rotorcraft R&D competitive. Resulting publications [including **Morales** et al, *IET Control Theory and Applications* **8(6)** and *IEEE Trans on Control Systems Technology* doi:10.1109/TCST.2020.3004996] detail the development and application of advanced principles of robust control and optimisation theory to improve the reliability and performance of production active vibration suppression algorithms for helicopters when practical implementation aspects are considered. This work forms an impact case study submitted in this REF return (**Morales**, ICS1).

- The development of robust adaptive control laws for aerospace systems. This resulted from funding (totaling £320k) that began in 2014 with a two-year research grant from MoD/MBDA-UK and follow-up funding between Nov 2016 and Feb 2019 (**Prempain**, Turner, **Visintini**). Subsequent EPSRC funding (£290k) widened the research to an international collaboration with MBDA (Bristol, Stevenage and Paris) and CNRS-LAAS (Toulouse) and the National University of Colombia (Bogota). [Headline papers in journals: Turner, **Prempain**, **Visintini** et al, *Systems & Control Letters* **137**; *International Journal of Robust and Nonlinear Control* **30(2)**; *ASME Journal of Dynamic Systems, Measurement and Control* **139(1)**; *European Journal of Control*, **38**; Systems and Control Letters **102**.]

- **Visintini** is collaborating with Rolls-Royce Control Systems (Birmingham) on the development of control-oriented models and practical adaptive control algorithms for the fueldraulic actuation system of the UltraFan engines - the next generation of Rolls-Royce civil turbofan engines expected to enter operation in 2025. The work takes place in the framework of the government backed Rolls-Royce ENCASE project devoted to reaching a 25% fuel efficiency improvement over the current generation of

Trent engines. The collaboration started in 2014 with the award of an industrial PhD scholarship, which was then followed by the industrial grant 'Nonlinear modelling and control of fueldraulic systems' to **Visintini** in 2018, and the award of a Royal Academy of Engineering Industrial Fellowship in 2019. £160k in total.

The MoM Group

Following a number of years under the leadership of **Pan**, the MoM Group is now led by Bo **Chen** who joined the School in 2019 as Professor of Engineering Materials and EPSRC Early Career Research Fellow. The group was established by Prof Frederick Leckie in 1968 and currently has 15 academic staff [15 FTE]. The group has two primary and overlapping research areas: modelling-enabled materials engineering and bioengineering & biomaterials. As part of the restructure, MoM absorbed the smaller Bioengineering group in 2016.

I. Modelling-enabled materials engineering. The group consists of colleagues with both material science and computational mechanics backgrounds. This has proved a unique strength and the group is internationally leading in its research on material processing and material behaviours. It is underpinned by computational materials science, AI technologies (providing a link to computational expertise in ACE and AIDAM) and micro-mechanics.

Examples of major achievements and impact in this REF period include:

- Developing new processing routes to characterise and improve properties of brittle surrogate radioisotope ceramics and thermoelectric intermetallic materials (Williams, **Weston**). This represents a major advance in powering deep-space exploration (where solar power is unavailable) and enables the exploration of previously inaccessible regions of space. It has led to substantial economic impact by creating new international export markets and job creation; policy and practice changes; and environmental impact by developing energy-harvesting technologies and reducing the environmental cost of nuclear power. This work forms an impact case study submitted in this REF return (Williams, ICS3).

- The development of material selection procedures subsequently used across the energy sector to avoid pipeline failures and minimise environmental impact. For example, by the National Grid for the asset management of underground power transmission cables (**Pan**, **Weston,** £370k project); the oil & gas sector for joining dissimilar metals in subsea oil and gas pipelines (MINTWELD, supported by the European Commission via FP7, **Dong**, €5m project) and in improving materials for flexible systems that give longer lifetimes in ultrathin printed batteries (FLEXIBAT, supported by Innovate UK, **Weston**, £1.2M project). This work forms an impact case study submitted in this REF return (**Weston**, ICS2).

- The development of a multi-scale modelling strategy for powder-based processing of advanced materials. This includes ceramics (for which **Pan** was awarded the 2018 Verulam Medal and Prize by IoM3) and pharmaceutical materials (for which **Sinka** led an EPSRC funded consortium with Imperial, Leeds, Surrey and Greenwich, £1.7M project, EP/N025261/1). **Pan** is currently a partner on the UKRI Strength in Places Fund (SIPF) Stage 2 bid 'Midlands Advanced Ceramics for Industry 4.0' (total £1.9M).

- The development of a multiscale and multi-physics modelling strategy for casting and welding for which **Dong** was appointed a Research Chair by the Royal Academy of Engineering and the School received £2M funding from NISCO to establish the NISCO-UK research centre. Bo **Chen** is co-director of the centre and holds a £1.2M EPSRC Fellowship (EP/R043973/1). The group hosts an EPSRC Centre for Doctoral Training 'IMPaCT' in this area (Innovative Metal Processing) led by **Dong** and **Gill** (EP/L016206/1, total £3.1M). **Azeem** was recently recruited to further support the growing momentum in this area.

- The development of coatings using nano-technologies for materials working within extreme environments. This is led by **Ye** and **Weston** in collaboration with the School of Chemistry, and has led to the formation of the *Materials Innovation Centre* jointly with TWI, one of the world's foremost independent research and technology organisations with expertise in materials joining and engineering processes. Following this, **Ye** is leading an EU-funded international consortium 'D-SPA' (€1.05m) with partners from UK, Spain, Ireland, and USA to develop diamond coatings for electronic and photonic applications. He is also a key partner of an Innovate UK funded industrial challenge project to develop antimicrobial coatings for aerospace application. The invention has been patented and will be adopted by Teer Coatings Ltd into their future products.

II. Bioengineering & biomaterials. MoM is engaged with the development of engineering technologies and materials to improve quality of life through better physical health. This consists of activities linked to international networks and also via membership of the College's *Life Science Interface* theme that links to *Leicester Microbial Sciences and Infectious Disease Network* (LeMID).

Examples of major achievements and impact in this REF period include:

- The development of methods and technologies that have improved the cure rate for cardiac arrhythmias (both atrial fibrillation and ventricular arrhythmias causing sudden cardiac death and ventricular arrhythmia). Working with the NHS, **Schlindwein** has minimized false positives and false negatives from implantable cardiac defibrillators. The project won the European Heart Rhythm Association Inventors Award in 2016. R2I2 patent (WO2011117608) has been granted in USA (13/3/2018), Australia (9/4/2018), China (2015) and Japan (2015) and is under review in Canada, Europe, and India. PERS patent (WO2015150831), was granted in Australia (9/4/2019), USA (4/6/2019) and Japan (30/3/2020) and is in the national phase in four other countries. The technology is being improved for non-invasive use backed by a £1M project funded by the MRC (**Schlindwein**).

- The development of biologically inspired computational algorithms for chemical processing and brain modelling/signal processing strategies for neuroscience (**Pearce**) developed together with a consortium of scientists and engineers including Max Planck Institute for Chemical Ecology (Germany), KTH (Sweden) and NCBS (India - originally funded through two EU Future and Emerging Technologies projects - Neurochem and iChem). This laid the foundations for collaborative grants with Sussex and Luebeck (Germany) to investigate fast neuromorphic hardware for chemical sensing and 'big data' approaches to cracking the olfactory code, the relationships between molecular structure and neural representation of odours (EPSRC eFutures programme and

Volkswagen Foundation). The work is acknowledged as the world's first neuromorphic implementation of the first (main olfactory bulb/antennal lobe) and second (piriform cortex/mushroom bodies) stages of olfactory processing in mammals/invertebrates, integrated with a large-scale biomimetic chemical sensor array for odour classification, learning and segmentation. [Headline papers in journals: **Pearce** et al *Bioinspiration & Biomimetics*, **10(4)** and *Microsystem Technologies*, **20(4-5)**, FWCI 7.84].

Future strategy

The School has developed a robust and sustainable identity that sets its future direction. This identity will serve as a platform for growth beyond the current REF cycle and provide the ability to react to (and select) future research challenges from the opportunities provided by the rapidly changing world.

The School has grown significantly since REF2014 (from 30 to 47 academic staff members, including teaching focused staff within the *Engineering Learning and Professional Practice* (ELPP) group not returned here) and intends to grow further. The staffing strategy for the School aims to further improve the research environment by growing critical mass in key areas and better aligning our research and impact portfolios:

- ACE will continue to evolve towards a clear focus on activities within computational engineering – particularly in fluids and digital communications – and the group intends to invest in talent to bring these areas in line with its aerospace ambitions, for example, the recent appointment of **Angelino** and **Hussain**.

- MoM will continue to grow under the modelling-enabled materials and bioengineering themes, but with a priority focus on bioengineering. The appointments of **Bocian**, **Shepherd** and **Tsamis** demonstrate this commitment and others are expected to follow. This includes hosting Kaul's RAEng Research Fellowship (£500k) from January 2021-2026, entitled *the Lung Pharmacome,* to develop an in-silico lung to be used by pharmaceutical companies as a drug design/discovery tool and by clinicians as a disease management pipeline.

The School's strategic aims include pursuing a policy of continuous improvement by uplifting the quality and volume of research, including outputs and improved success rates for funding applications through sustaining a dynamic and supportive research environment. We will continue to grow our national and international collaborations and be ambitious in our outlook. We will exploit and contribute to the unique research environment at Leicester that is entirely consistent with our new identity (including SPL and AIDAM), and also those external to it. This will allow us to support growth in research and knowledge transfer and to improve our equipment infrastructure. This wider institutional environment provides an ideal context and mechanisms to engage in interdisciplinary science and industrial collaborations; these unique local opportunities have motivated our particular strategic choices. Furthermore, these flagship programmes complement our UoA's world-class reputation in providing a significant draw for talented PGR students.

Governance and integrity

The review, development, and implementation of our research and impact strategy is the responsibility of the School Research Committee. The Committee is also primarily responsible for promoting a culture of research integrity, ensuring that researchers (particularly students

and ECRs) understand the expected standards and obligations, as outlined in the Concordat to Support Research Integrity. We adhere to institutional requirements (IES 2.7) and expect researchers to observe these standards, promote an ethos of professionalism, and embed good practice in all aspects of their work.

Open research

We aim to embed a culture of open science to increase the global visibility of, and engagement with, our research. We do this by: (1) complying with REF open access (OA) requirements and institutional policy and procedures (IES, 2.6), and (2) utilising local, national, and international open scholarly infrastructures to disseminate outputs and data. In Leicester's first Open Research Survey, 100% of Engineering staff who responded agreed that they believed there is value in anyone being able to access their research and 67% agreed that they had actively made more of their research freely available and accessible since 2014. Researchers in the UoA also regularly ensure outputs such as conference contributions, reports, book chapters, preprints, and codes are made openly accessible via open research platforms such as Figshare, Github, and arXiv. Many of our researchers are editors and/or on the editorial board of fully open-access peer-reviewed journals, including *Frontiers in Physiology: Computational Physiology and Medicine* (**Li**) and *Crystals* (**Ye**).

2. People

Staffing strategy

New academic staff are appointed on proven research merit (strategic fit, publication record, and prior funding success unless ECR) whilst ensuring that all aspects of the curriculum are delivered to a high standard. Consideration is also given to the EDI profile of the school. The HoS in conjunction with the School Management Group (SMG) is responsible for consulting and recommending to the College where and at what level new appointments should be made. Our newly articulated direction will continue to influence new appointments to ensure the maintenance of critical mass in our key areas. Highly specialised technical staff (seven) and experimental officers (two) provide support to the research.

Since REF14 the School's academic head count has grown from 30 to 47 reflecting a strategy of growth in the research groups. In terms of the UoA, seventeen new appointments were made at all career levels (ACE: 9, MoM: 8). ACE recruited two Professors (**Chambers,** Eugene **Zhang**) and seven Lecturers (**Angelino**, Gaojie **Chen**, **Hussain**, **Ji**, **Ruiz**, **Su**, Yue **Zhang**) all to permanent contracts, with Yue **Zhang** being recently promoted to Associate Professor. MoM recruited two Professors (Bo **Chen**, **Ye**), one Associate Professor (**Panwisawas**), and five Lecturers (**Azeem**, **Bocian**, **Li**, **Shepherd**, **Tsamis**). The Professorial appointments in MoM (Bo **Chen**, **Ye**) followed the departure of Atkinson and Hainsworth to replace energy and intellectual leadership in materials engineering. **Chambers** and Eugene **Zhang**'s appointments in ACE were to bolster intellectual leadership in computational engineering, and the appointments have facilitated interdisciplinary collaborations with researchers specialising in informatics and computer science. **Garrett**'s appointment as HoS in 2019 saw him return from SMAS and provide stability and long-term vision to the School following the restructure. His intellectual leadership within the fluids area is a key feature of the School's future ambitions, along with improved interdisciplinary interactions with the AIDAM initiative that he was instrumental in launching from SMAS.

Of the thirteen non-professorial appointments made, three (**Azeem**, **Shepherd**, **Su**) were an active expansion funded by the School's involvement in the Dalian-Leicester Institute (DLI). This is a joint educational partnership led by **Pan,** as Dean of DLI, and encompassing Engineering, Chemistry and Mathematics programmes in collaboration with Dalian University of Technology, China. Other early career staff were brought in to replace a natural turnover of more senior staff members. Replacement of senior members at the lecturer level has been a conscious decision to rejuvenate the research base and reshape the unified ACE group. This has resulted in the UoA having a younger age profile than in 2014, with more than 54% of our staff now younger than 45 (including 38% of our Professors). This represents an opportunity to grow our own future leaders. Of the staff also present in REF14, there have been three promotions to Professor (**Garrett**, **Gill, Sinka**) and three promotions to Associate Professor (**McEwan, Morales, Rona**).

Our recent appointments and promotions have been extremely successful as evidenced by the increased success in securing research income and uplift in research performance across the UoA. The planned growth of DLI, the anticipated increase in our UG cohorts and PGT offer, and some very recent staff departures provide further opportunities for new appointments in the near future. These will be actioned once the uncertainties of COVID have been navigated.

EDI

The School is committed to providing a good working environment for its staff and has a dedicated committee overseeing our EDI action plan. The committee aims to promote equality and diversity in the workplace, to continually assess and improve working practices, and to provide a culture of participation and inclusivity. EDI is embedded across all management committees (with EDI as a standing agenda item) and the EDI committee is represented on the SMG and the newly formed staffing committee where promotion cases are discussed and staff supported. The diversity of the School (in terms of gender, ethnicity, job role, and family situation) is represented within the committee to ensure all perspectives are considered. It is leading the School's application for an Athena SWAN award in 2021.

The UoA has an exemplary 91% completion of our Equality and Diversity Training (Jan 2021), compared to an 80% University average. This training encompasses all protected characteristics, with gender awareness comprising the first section.

In the interests of inclusion, School activities are kept as far as possible to core hours 10am-4pm. Research meetings and committees are often flexible by nature and arranged at the mutual convenience of members. We are promoting inclusivity through better communication and shared common spaces. Staff in all roles, and PGR students, can request part-time or formal flexible-working arrangements. These are agreed so that teaching duties can be organised around them as necessary. Currently, several staff have formal flexible working arrangements and/or reduced FTE.

All academic appointments are advertised internationally, and academic staff represent more than eight different nationalities spanning South America, Europe and Asia. New staff appointments over the REF period have been from British, European, Chinese, Thai and Indian backgrounds resulting in a sustained and diverse community. We are proud of our ethnic diversity with more than 30% BAME staff (38% of our Professors), which is on the higher side of sector norms.

The gender distribution within the School has however been historically heavily imbalanced

and, despite three female appointments during this REF cycle, the departure of Atkinson, Hainsworth (who took up PVC level positions at Cranfield and Aston, respectively, following UoL career support and successful tenures as HoS) and Vladimirova (being returned under UoA11) means that female engineers still represent only 10% of our UoA return. Moving towards a more balanced distribution in line with sector norms (c20% female) will be a key priority in our recruitment activities throughout the coming REF period by, for example, ensuring representation on shortlists and advertising flexible appointments at negotiable FTE. The School promotes female role models at all levels, and successful female graduates are heavily promoted within undergraduate literature and at open day events; Vladimirova is Director of Enterprise and more junior female academic staff are provided with significant support and mentoring. The post-graduate tutor (**Shepherd**) is female and plays a key role in post-graduate recruitment. She is ideally placed to promote the role of women in academia. Female PGRs represent about one third of those enrolled within the UoA and the most recent Postgraduate Research Experience Survey (PRES) indicates our female PGR students are particularly satisfied with their experience, with 100% satisfaction in nearly all areas. The support and careers advice given to our female PGRs is intended to encourage onwards academic careers, improving the through-flow of female talent into staff recruitment.

Staff development

The annual Performance Development Discussion (PDD) provides an opportunity for academic staff to reflect on their career progress and discuss with a senior colleague their career aspirations. Individual performance targets for the next year are set with individuals' and School priorities in mind. The annual process includes a mid-year follow-up meeting to ensure all targets remain stretching yet feasible, and the environment in which staff operate remains supportive and appropriate.

All new academics are given reduced teaching loads and academic staff who teach on programmes in China are primarily engaged in research when they are based at Leicester. Early career researchers have mentors and receive support organised by their research group head. This is focussed on writing papers, writing research applications, and developing knowledge transfer opportunities, as well as teaching skills and any specific support deemed necessary for the individual. A robust and institution-wide probation process is adopted within the School to ensure all mentoring support is focussed and aligned with the School and institutional ambitions. Broad research support (including commercial support) is provided by UoL's Research and Enterprise Division (RED) and training is organised centrally by the University on these and related areas, such as the supervision of PhD students.

Academics (outside of probation) may apply for study leave for one semester in eight. The application process requires a statement of their research strategy and how this will be developed by the leave. In every year throughout this REF period at least one member of staff has been granted study leave to refresh their research activities (**Garrett**, Hainsworth, **McMullan**, **Pan**, **Schlindwein, Sinka, Visintini**). This is a key component of our research culture and provides academics with dedicated research time away from all teaching and administrative duties. Many of the achievements presented in Section 1 can be traced back to periods of study leave and the practice will continue.

UoL is a signatory to the Concordat to Support the Career Development of Researchers and many practical measures are implemented at the School level. Engagement in career development is mandatory and all staff are mentored via the PDD process. In addition to this, particular attention is given to early career staff, those close to promotion, and those with

particular leadership aspirations. At the root of this support is a robust mentoring scheme in which all researchers are paired with a senior member of staff. This is typically the group head (but sometimes delegated to ensure the advice is relevant to a sub-discipline), and all professors are paired with the HoS who is, in turn, mentored at the PVC level. The mentoring mechanisms are continuous and typically informal, but with particular fixed-point formal meeting points within the PDD cycle. Here staff ambitions (and School needs) are compared with existing skills to identify development needs. Specific development needs are accommodated via internal training programmes delivered by the central *Leicester Learning Institute*, and external professional bodies and learned societies. Development needs are fed into the workload allocations so that practical leadership skills, for example, can be developed within the School's operations and succession planning of the key roles accommodated. A particular example of this is **Garrett**, who has moved from Group Head, to Research Director and Deputy Dean of Research for CSE, and now HoS within this REF cycle. This was made possible from the mentoring from previous Heads, College leaders, and engagement with central leadership training programmes and the provision of wider College opportunities to aid his development. Similarly, **Gill** is now Director of Research and Deputy HoS, and Bo **Chen** now leads the MoM Group. Both have demonstrated excellent leadership potential and have been given the opportunity to develop in appropriate roles under the close mentorship of the HoS and wider College community.

Development of researchers at Leicester builds on Vitae's Researcher Development Framework to develop the skills and capabilities required of researchers from PhD to academic and as leaders of large research programmes. The programmes are highly focused and aim to add value to individuals' professional development, as well as institutional performance. Examples of ECR development include **Morales** who has been supported since joining the UoA as a PDRA in 2008 and moved to a permanent lectureship just prior to the REF2014 submission. During this REF cycle he has been mentored via his research group head, RED, and the wider national rotor-lift community. He is now a key member of the ACE group, with significant and impactful achievements as detailed in Section 1. **Morales** was promoted to Associate Professor in 2020. **Ruiz** is on a similar track and has been supported by his group head and the EPSRC Funder Group (via RED) leading to a successful EPSRC New Investigator Grant application £243k, EP/S025707/1.

The interdisciplinary nature of much of the UoA's work offers additional opportunities for career development. For example, **McEwan** and **Schlindwein** play a leading role in AIDAM, working closely with SMAS and Informatics; and **Bocian, Pearce**, **Schlindwein, Shepherd** and **Tsamis** work closely with the College of Life Sciences. Industry placements are further opportunities for development and these have been embraced by **Dong**, **Morales** and **Visintini** via the placements discussed elsewhere in this document. Engagement with this wide portfolio of development opportunities is accounted for within the annual workload allocations to ensure time is made available. Sufficient funds are also made available within the School's financial planning.

Research Students

The UoA has increased the number of annual PhD completions compared to the REF2014 cycle. It has a current steady-state population of c70 students and typically graduates around 20 doctoral students per annum, compared to around 10 in 2014. Students are typically funded by research grants and contracts, industrial fellowships, DTP income, and through funding from the University, College and School. Approximately 60% of our PhD students are full fee-paying students, generally from overseas. Around 10 research studentships are built into the College

financial plans each year and the UoA has been successful in competing for these, averaging two or three studentships per year from this source. The University also committed over £1M to the *Doctoral Training Centre in Innovative Metal Processing* (IMPaCT) led by the UoA throughout the REF period. This collaboration with Nottingham and Birmingham has graduated c80 PhD students with c40 from Leicester. IMPaCT draws on cross-College expertise, including from within Chemistry, Physics & Astronomy, and SMAS. The UoA is also a partner in the PhD student-focussed *National Structural Integrity Centre* led by TWI to address the shortage of qualified structural integrity specialists.

All PGR students are matched to their supervisory team (first and second supervisors) at application. The online *myPGR* system provides a management tool for monitoring student progress throughout their registration and ensures that the institutional requirements for progression are adhered to, in line with the University's policy as determined by the *Doctoral College* (IES, 3.2). The progression hurdles consist of year-end assessments at the end of the first and second years that simulate the thesis submission and viva experience. These are conducted by two members of academic staff outside of the supervisory team.
PhD students, like ECRs, are integrated into a research group. The School runs a seminar series on alternate weeks with each group chairing on a rotating basis; the students also organise and host an annual research showcase event within the School. This complements other institutional showcasing events organised by the Doctoral College; for example, annual poster competitions and the Doctoral Inaugural Lecture series that celebrates and shares PGR success across the institution.

The UoA provides a nurturing and robust programme of research skills training delivered through the School, College, and the Doctoral College, building up postgraduate research students as effective and confident researchers, whilst also enhancing their transferable skills and future employability. The initial training needs of individual students are determined at the induction stage and through discussion with the supervisory team and the PGR Tutor. In addition to the specialist training that happens within the supervision, academic knowledge and skill development is delivered through attendance of relevant graduate level modules (across CSE) and training programmes (delivered by the Doctoral College). These include: *Managing your Research* – small group activities and support directly related to their thesis, their project and their time management, and highlighting the important milestones on the journey; *Communicating your Research* – a comprehensive programme of transferable skills training; *Employability and Career Management* – a range of events/activities, training, and advice and guidance sessions to help researchers enhance their employability. Various computing modules are also available. Once needs are identified, attendance of relevant training courses is mandatory and confirmation of a student's engagement is part of the probation hurdles for the end of their first year. At the most recent PRES, more than 90% of PGR students in the UoA agreed that their research skills had been sufficiently developed during their programme.

Since 2014, our PGR graduates have progressed onto a wide range of highly competitive academic, industry, and related professional roles. Around 40% have gone on to secure Postdoctoral positions in the UK (including Cambridge, Nottingham, Oxford, Southampton, and UCL) and internationally in Australia, Brazil, and China. Furthermore, a number of Lectureships have been secured at universities across the UK, China, Europe, Iraq, Saudi Arabia and Turkey. Around 50% have progressed to posts across an array of international industries including R&D roles in, for example, British Steel, HORIBA, and Sandvik.

3. Income, infrastructure and facilities

Research Income

During the REF period, the UoA has received external grant income of £7.6M and the University has invested more than £1.5M into the research environment specific to the School. This includes £1M to the IMPaCt CDT and various infrastructure items detailed below. The annual external grant income is shown in the figure and reflects year on year growth since the restructure in 2016. HESA data for 'general engineering' schools suggests we are currently ranked around 18th (from 41) in terms of income/FTE/year and it is our aspiration to move upwards towards 14th over the next 5 years. This necessitates an ambitious increase in awards from around £80k/FTE/year in 2019/20 to £110k/FTE/year by 2024/25.

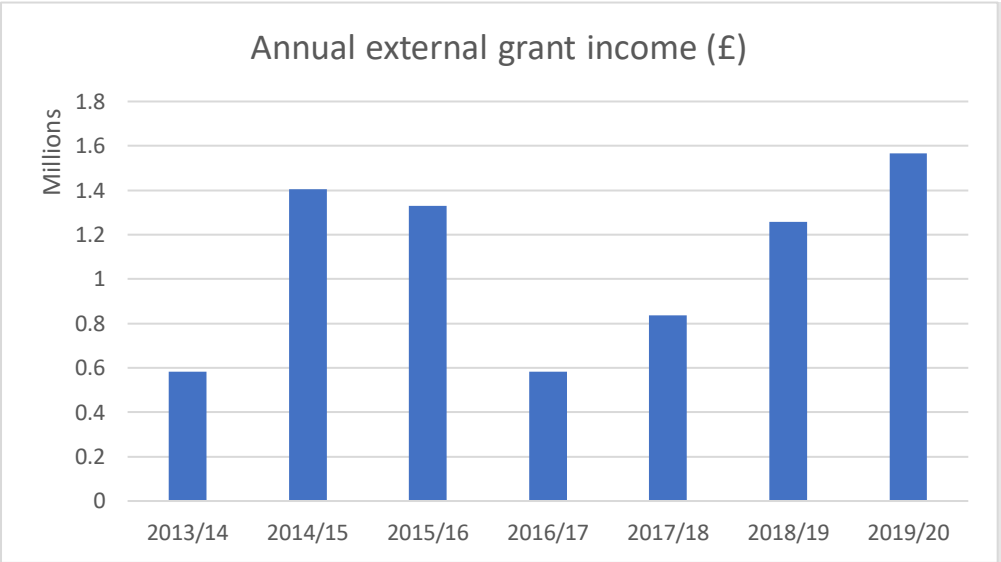

Figure 1: annual external grant income (£)

Grant income has been won by staff at all career stages within the UoA and is from a diverse range of sources; for example, EPSRC, the EU, the Royal Society, NERC, RICS Research Trust, Innovate UK, the British Heart Foundation, and multiple private sector partners.
In some cases the salaries of staff are part- or fully-funded by industrial research partners: in MoM, 33% of **Dong**'s salary is provided by RAEng via his Research Chair, and he receives tailored career development support from TWI. **Panwisawas** and Bo **Chen** are currently funded by EPSRC through their Innovation and UKRI Early Career Research Fellowships. In ACE, **Visintini**'s RAEng Industrial Fellowship covered 70% of his salary for the 2019/20 academic year, while he was seconded to Rolls Royce. Similarly for **Garrett**, **Gill**, **McMullan** and **Morales** during their fellowship buy-outs.

Consultancies and professional services

The UoA has undertaken a number of consultancy contracts totaling £1.8M during the assessment period. Our broad portfolio of consultancy contracts has provided a mechanism for the application of our research and routes to impact. Full details are not included here owing to confidentiality agreements, but work has been undertaken for a number of industrial concerns and government agencies including Rolls-Royce Plc (**Visintini, Bagdanavicius**), European

Space Agency (**Warrington**), AstraZeneca UK Limited (**Sinka**), EURAMET e.V. (**Gill**), National Grid (**Pan**, **Weston**), Aero Engine Controls (**Visintini**), ADS Group Ltd (**Morales**), NISCO Ltd (**Dong**), and the Aircraft Research Association **(Morales**). Represented in the headline figure is £1M of income from Innovate UK via KTP projects (**Lefley**) with local SMEs and larger concerns including Centrica plc. This growing KTP activity falls within the Energy activities of ACE and showcases applied research in home energy usage and metering.

Infrastructure and facilities

The School has a range of laboratories and specialist equipment supporting its research programmes. These have been expanded over the REF period to reflect our new focus, including, for example, a massive MIMO lab for 5G and beyond (£250k) and a directional solidification furnace (£115k). These arose from successful engagement with the University's competitive mechanism for funding prioritised strategic and interdisciplinary initiatives. In addition, UoL has invested in a new *Biomechanics and Immersive Technology Laboratory* (£100k), which features interactive virtual/extended reality equipment to allow researchers to study human interaction and gait within our emerging Bioengineering activities (**Bocian**, **Pearce**). Furthermore, UoL contributed £200k for high temperature fatigue equipment to support Bo **Chen**'s EPSRC Fellowship. Further investment in bioengineering and digital comms is a key future priority via competitive internal and external funding mechanisms and lobbying for strategic UoL investment.

College-wide facilities are an important aspect of our research infrastructure within our interdisciplinary environment. The Advanced Microscopy Facility (AMF) was developed under Engineering leadership funded through SRIF 2. The AMF (housed in Engineering) supports major experimental and analytical research activities in Engineering, Chemistry, Physics & Astronomy, and Geology, Geography & the Environment; it advances multidisciplinary research activities across the Physical and Biological Sciences. It comprises: a FEGSEM with EBSD and EDX, an Environmental SEM, a TEM with EDX and the associated specimen preparation equipment. The TEM, FEGSEM and AF are hosted within Engineering. UoL investment in the AMF during this REF cycle exceeds £1M.

Many UoA research projects require significant computing resources for modelling, simulation, data processing and analysis that are satisfied by the University's High-Performance Computing systems. ALICE (£2.2M, >3k cores) primarily provides a batch service, and SPECTRE (>2,600 cores) an interactive environment. ACE is Leicester's dominant user of ALICE (**Angelino**, **Garrett**, **Hussain**, **McMullan**, **Rona**). Leicester is also a partner in the Tier 2 regional services HPC Midlands+ Athena (£1M, 15k cores) (**Dong**, **Rona** CIs, EP/K000063/1) and Sulis (£3.2M, 15k cores, 180 GPUs ensemble computing) (**Rona** CI, EP/P020232/1). The College invests significantly (£100k pa) in providing research software support services (ReSET) that is functional to the upscaling of codes on the national supercomputing facility.

AIDAM unites researchers with shared interests in advanced modelling and simulation methods. Cutting across traditional disciplinary boundaries, AIDAM facilitates active, funded collaborations between Engineering, SMAS and Informatics (e.g. **Chambers** with Vladimorova; **McEwan** with Tyukin (UKRI Turing AI Fellow) and Gorban; **Dong, Pan** and **Sinka** with Davidchack; **Garrett**, **Hussain**, **McMullan** and **Rona** with Georgoulis, Paganini and Lescke).

Organisational infrastructure

The SMG within Engineering is chaired by HoS (**Garrett**) and consists of five other key members of staff. SMG operates in an advisory capacity to the HoS and determines School

strategy; members of direct relevance to the research structure are the Research Director and Operations Manager. The Research Director (**Gill**) chairs the Research Committee which consists of the Enterprise Director (Vladimirova), Post Graduate Tutor (**Sheppard**) and Research Group Heads who line manage staff within the two research groups. The Operations Manager advises on budgetary matters and also line manages technical staff within the research laboratories. Performance management is contained within the groups and follows principles determined by SMG to ensure consistency. In addition to monthly SMG meetings, the HoS meets the Research Director in fortnightly meetings and the Operations Manager on a weekly basis. Research strategy within the School is determined by the HoS and Research Director in consultation with the Research Committee. Links to the College are provided by the College Research Committee which meets bi-monthly. It is chaired by the Dean of Research and consists of the Research Directors of all constituent schools. Furthermore, the HoS sits on the College Leadership Team that is chaired by the PVC & Head of College and consists of other heads, the College Operations Director, and the Dean of Research. College level strategy is determined through these channels and the research themes mentioned in this statement. The College Research Committee encourages cross-disciplinary activities within the College. Institutional strategy is influenced by the School through the College Research Committee and College Leadership Team, as well as via more specialist interdisciplinary research centres including AIDAM.

Research in the UoA is supported by our award-winning Library (IES, 4.2) and IT services, both of which provide excellent services. The library provides a dedicated space for researchers to study and network, with 156 study spaces, a group study room, and a one-to-one consultation area where researchers can access support from Library Research Consultants and Doctoral College Researcher Developers. Since 2014, UoL has invested £830k in growing its primary source collections, databases, and e-journals.

We are also actively supported by staff from RED that provides support for all funder groups, research committees, and individual researchers from planning and writing proposals, through to the submission process. Our Finance Office is also actively engaged throughout this process.

Future income and investment plans

A specific aim is to generate research income at the level of £110k/FTE/annum, consistent with other leading national schools (as determined from HESA data). Note that our annual grant income/FTE/year has increased some 250% since the 2016 restructure which is a direct result of our new focus in areas where we have critical mass. We intend to maintain and grow this momentum within the context of the two research groups. This will be achieved through the cultivation of a culture of improved productivity in grant income and engagement with institutional initiatives such as the funder groups and collaborative ventures.

Funder groups at UoL represent each of the main UKRI funders and provide a mechanism for strategic engagement with the funders and inter-school interactions around, for example, peer review, ECR mentoring (e.g. **Ruiz**'s EPSRC New Investigator Grant £243k, EP/S025707/1), and interdisciplinary projects. Funder groups complement the numerous interdisciplinary research interactions evident at Leicester (e.g. AIDAM, MaTIC, bioengineering interactions) by providing support that facilitates funding.

SPL is an important institutional initiative with significant opportunities for the UoA that will prompt investment in many areas of direct benefit. Following the initial investment in SPL,

further investment has been secured through UKRPIF Round 6 funding for the new *Manufacturing, Engineering, Technology and Earth Observation Research Centre* (METEOR) that the UoA feeds into (Bo **Chen**, **Dong**, **Pan**, **Warrington**). This new Centre will form the basis of Phase 2 of SPL and will drive the research excellence that underpins industry growth in the space sector. This research translates into and supports Phase 3, focused on supporting growth of the UK space sector by providing facilities to businesses for the manufacture of small to mid-range (30kg–200kg) satellites through the Low-Cost Access to Space Facility (LOCAS). All the main areas of activity within METEOR have direct relevance to Engineering: *The Advanced Manufacturing Research Laboratory*; *Next Generation Intelligent Systems Facility*; *Services and Solutions Laboratory*; and *Building Research Capacity*. Importantly these activities underpin our strategy for research, impact and training developments. Planning for Phase 3 continues in conjunction with local government and national/international industrial partners. To further support industrial collaboration an ERDF grant (matching UoL funds) to a total of £4.7M has been secured to provide state of the art manufacturing equipment including additive manufacturing (3D printing) and 5-axis CNC to work with regional SMEs on prototyping new products and providing equipment for use within SPL work. This is of direct relevance to the ambitions of the MoM group.

Outside of SPL, Engineering is a strategic priority for the University. In addition to increasing the staff base over the next REF period, UoL is intending to invest in specialist lab facilities to nurture the growing bioengineering and digital communications activities. This will be, in part, funded by growing student numbers through the launch of new UG/PGT programmes in computational engineering (that reflect our changed research focus) and the coming demographic uplift.

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

1. Research Collaboration, Networks and Partnerships

The UoA is actively engaged in a variety of projects taking advantage of the facilities and expertise in the School, College and University, and our staff engage proactively with the interdisciplinary research centres in Leicester. Cross disciplinary links are promoted within CSE, the University and beyond through research themes.

An interdisciplinary collaboration of particular note is **Schlindwein**'s work with the Department of Cardiovascular Sciences, mentioned in Section 1. Furthermore, **Tsamis** and **Gill**, and **Hussain**, **Angelino** and **McMullan** are engaged with projects in collaboration with the Department of Respiratory Science. These intend to bring modelling expertise to problems associated with the collapse of small airways in the human lung and its effect on asthma, and ventilation design in Covid testing environments, respectively. Clinical collaborators are providing the interpretation of computational simulation results and opening routes to impact.

The UoA has a number of collaborations with national and international HEIs. Each project is consistent with our new strategic aims and identity. As discussed elsewhere, this is true across both ACE and MoM and involves staff at all levels. A number of Leicester researchers are the overall leads for significant multi-partner projects, including, for example the following. Successful outcomes of many of these partnerships are detailed in Section 1.

- Bo **Chen**, **Dong**, **Pan**, **Warrington**: Involvement in the £13.75M UKRPIF funding for SPL under the METEOR project in collaboration with Surrey, Open University, Aston,

MTC, Thales Alenia Space, Lockheed Martin, Spherea, Tyvak, Open Cosmos, ATM, ETL and Omnidea. The project intends to revolutionise how satellites are conceived, designed, operated and produced, as well as how data derived from them is interpreted and used to solve real world problems.

- **Chambers** and Gaojie **Chen**: £1M EPSRC M3NETs project working with Loughborough, Queen Mary and Kings College London to tackle the critical challenges of massive Machine to Machine communications in 5G (EP/R006377/1).
- **Yue**: €5.7m EU Horizon 2020 grant as the consortium Scientific and Technical Project Manager for 6G BRAINS (Bring Reinforcement-learning Into Radio Light Network for Massive Connections).
- Bo **Chen:** £1.2M EPSRC Fellowship working with Oxford and EDF Energy UK as well as several international research partners in Europe and China on advanced sodium-cooled fast nuclear reactors (EP/R043973/1).
- **Dong**: £2M NISCO project on the development and application of new casting technology for extra-thick steel products and of high-performance steels for marine application.
- **Sinka**: £1.7M EPSRC project working with Imperial College, Leeds and Greenwich to build a Virtual Formulation Laboratory for the prediction and optimisation of the manufacturability of advanced solid-based formulations.
- **Ye**: €1.1M EU H2020 D-SPA project to investigate diamond-based nanomaterials and nanostructures for advanced electronic and photonic applications.
- **Dong** and **Gill**: £3.2M EPSRC funded CDT IMPaCT. UoL is the lead partner with Birmingham and Nottingham. An additional £1M cash support from industry plus £1.4M matched funding from universities; a total of £5.6M (EP/L016206/1).

2. Relationships with key research users, beneficiaries or audiences

The growing international reach of the UoA is evidenced, for example, by its research interaction with the Dalian University of Technology, a top 20 Chinese university, as part of the Dalian-Leicester Institute opened at DUT's Panjin Campus in March 2017. Further evidence is provided by the establishment of the NISCO-UK Research Centre in July 2018 with more than £2M financial support provided by NISCO. The strengthening of the Materials Innovation Centre (MatIC) in January 2018 through a new partnership with TWI is an example of national and industrial collaboration which has already secured more than £1M in new research projects including Geo-Coat: Development of novel and cost effective corrosion resistant coatings for high temperature geothermal applications (EU H2020-LCE-2017-RES-RIA, TWI €922k); Acorn: Advanced coatings for offshore renewable energy (EU FP7 SME, TWI €400k); FlexiBat: Graphene-enhanced flexible battery (I-UK, UoL £294k).

3. Exemplars of wider activities and contributions to the research base

Fellowships and prizes

Chambers is a Fellow of the Royal Academy of Engineering, FREng, and FIEEE, FIET and FIMA. Other elected Fellowships of professional institutions include: FRAeS (**Garrett**), FIMMM (**Sinka**), and FInstP (**Panwisawas**). The School has been successful throughout the REF cycle in securing Senior Research and Industrial Fellowship funding from the Royal Academy of Engineering (**Garrett**, **McMullan**, **Morales, Visitini)**. Furthermore, **Gill** was awarded an APEX fellowship from the Royal Society. **Dong** is a RAEng Research Chair. High-profile EPSRC/UKRI Fellowships have been won by Bo **Chen** and **Panwisawas** who are currently an Early Career Research Fellow and Innovation Fellow, respectively. In 2018, **Pan** was awarded

the Verulam Medal and Prize by IoM3. **Bocian** won a four-year fellowship funded by the Polish National Agency for Academic Exchange (NAWA).

Conference Chair Roles and Invited Keynote Lectures

We play a major role in leading and contributing to the scientific and local organisation of many national/international conferences, symposia, and workshops and do not detail these here. Around 20 plenary and keynote lectures have been given by members of the UoA. Select examples include: *Chinese Underwater Conference 2017* (**Chambers**); *Sintering 2014* (**Pan**); *2020 International Symposium on Structural Integrity* (Bo **Chen**); *SIAM conference on Mathematical Aspects of Materials Science* (**Gill**); *CHoPS18 - 9th International Conference for Conveying and Handling of Particulate Solids 2018* (**Sinka**); and the *International Conference on Information and Communications Technology Convergence* (Yue **Zhang**).

Journal Editorship

Our staff play active roles in Journal Editorship and as members of Journal Editorial Boards. These include, but are not limited to, the following Q1 journals: *IEEE Communications Letters* (Gaojie **Chen**); *Frontiers in Neuroscience (Neuromorphic Engineering)* (**Pearce**); *International Journal of Adaptive Control and Signal Processing* (**Visintini**); *International Journal of Control* (**Lecchini-Visintini)**; *IET Power Electronics* (**Ji**); *IEEE Transactions on Broadcasting* (Yue **Zhang**); and *IEEE Access* (Yue **Zhang**).

Refereeing Academic Publications or Research proposals

All research staff contribute to the peer review process for both refereed journals and for grant proposals. This is expected of all our staff including ECRs and is the norm for the discipline.

Co-operative/Collaborative arrangements for PGR Training

The IMPaCT CDT hosted within the UoA has trained c40 PhD students over the last 7 years. They have all undertaken a one-year training course of 120 credits of technical modules provided in collaboration across the three partner institutions (Leicester, Birmingham and Nottingham). Every year the partners have also organised a bespoke annual 2-week summer school in professional and personal skills training, e.g. future leaders, research ethics, and public engagement activities. This has included career workshops with visits to industry (Doncasters and MPI) and large facilities (Diamond Light). The CDT received an NPIF award from the EPSRC for innovative placements, which has been used to support PGR students to travel abroad for 3-6-month placements (e.g. to Brazil, Australia, France). Annual research days are organised where students present and discuss their research. The students are registered at all three partner institutions and have access to experimental facilities and software across all.

Honorary Positions Elsewhere

Chambers is in the 1000 Talents Scheme Academician run by the Chinese Government and is *International Honorary Dean* at Harbin Engineering University, China. He also holds visiting professorships at Kings College London, Newcastle, and Loughborough. **Garrett** held a visiting professorship at the University of Sydney and was a Distinguished Honorary Fellow at Macquarie University, Sydney. Visiting researcher positions have been held at various institutions Sydney (**Hussain**), KTH (**Garrett**, **Hussain**). Honorary positions at Sydney and Macquarie are reciprocated with positions for female Australian researchers (Stephen [Hon. Prof], Calabretto [Hon. A/Prof]). These close links facilitate increased mobility for shared PhD students and access to complementary techniques in fluid mechanics not currently represented in ACE. **Bocian** is a visiting professor at Wroclaw University of Science and Technology,

Poland.

Final Words

Our UoA has made substantial enhancements to every aspect of our activity in this REF cycle: grant capture, PGR completions, industrial impact, and discipline leadership. We have achieved beyond our size through pursuing extensive interdisciplinary and cross-institutional collaborations. Our global reputation has been extended through discipline-leading publications and an active pursuit of partnerships. Our successes have been enabled through a substantial overhaul of our identity and reshaping of our activities. Our forwards vision is to continue our upward trajectory through the pursuit of a core strategy based on this new identity to achieve meaningful internationally-reaching research and impact in our rapidly changing world.