Institution: De Montfort University

Unit of assessment: 11

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

1.1 UNIT CONTEXT AND STRUCTURE

The UOA 11 research submission is coincident with the School of Computer Science and Informatics (SCSI), one of three Schools within the Faculty of Computing, Engineering and Media (FCEM). Combining internationally recognised expertise with the latest technology, SCSI develops cutting-edge research-based solutions to real-world scientific problems. In comparison to RAE 2008, our REF 2014 4*/3*research increased 12 points to 57% while our 1* research decreased 12 points to 3%.

To help advance both the depth and breadth of our research, in line with FCEM and DMU policy, the Unit set out a more formal and focused structure for research groupings in three intertwined research institutes (Figure 1) to enhance leadership through mentoring, to enhance performance management through goal-setting and -monitoring and to stimulate interdisciplinary research and the collaborative supervision of research students. Much of our research is focused on distinctive niches, a characteristic that we wish to maintain. Thus, our current research structure maps better our rich, long-established and world-leading three areas of research: Artificial Intelligence, Cyber Security, and Ethics of Information and Communications Technology (ICT).

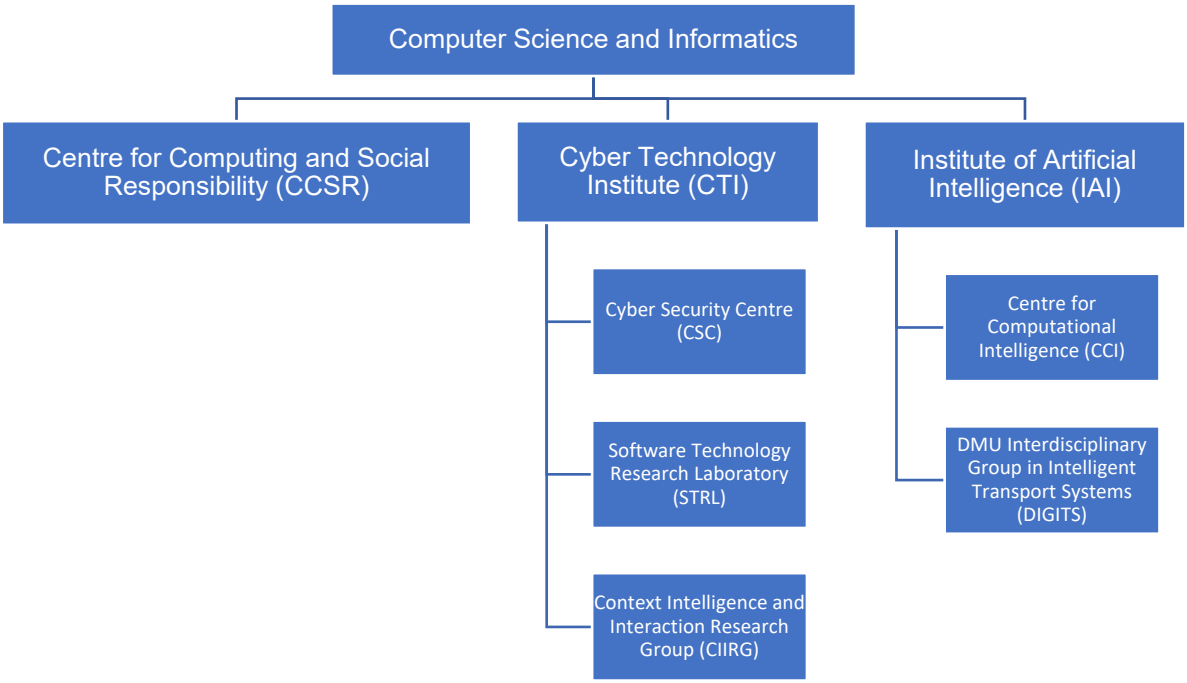

Figure 1: UOA 11 Research Structure

1.1.1 The Centre for Computing and Social Responsibility (CCSR)

CCSR aims to develop the practical and theoretical direction of research in ethical and social aspects of emerging technologies; responsible research and innovation; computer and information ethics; and ethics and culture of robots and Artificial Intelligence (AI). CCSR has gained an enviable international reputation as an international leader in research into the ethical and social implications of ICT: providing policy advice to the European Commission; leading events based in the European Parliament and the European Economic and Social Committee and UK Parliament; spin-off company ORBIT (jointly owned by DMU and the University of Oxford), as a result of an Engineering and Physical Sciences Research Council (EPSRC) contract, to provide training to EPSRC Centres for Doctoral Trainings (CDTs) across the EPSRC

portfolio; the work of its new interest research group Women Ethics Robotics and Artificial Intelligence (WE R AI) into sex robots is now part of the campaigning policies of national and international Women's Rights Groups (US: Prostitution Education and Research; Australia: Collective Shout; UK: FiLia, Campaign to End All Sexual Exploitation; France: RadicalGirlsss); while its research on ethics and professionalism in the computing field underpinned the 2016–2018 rewrite of the original 1992 Code of Ethics of the Association of Computing Machinery (ACM).

1.1.2 The Cyber Technology Institute (CTI)

CTI focuses on the development of knowledge and technologies to ensure a smart, safe and secure cyberspace. In June 2019 the National Cyber Security Centre (NCSC) and the EPSRC recognised CTI as an 'Academic Centre of Excellence in Cyber Security Research' (ACE-CSR), the first in the East Midlands and one of only two in post-1992 universities. CTI's work is supported by an Industrial Advisory Group comprising Airbus, BT, Deloitte UK and Rolls-Royce, whose regular feedback on research ensures that the CTI remains focused on providing relevant solutions that meet industry's needs. CTI is a member of two national research institutes, the Research Institute in Science of Cyber Security (RISCS) and Research Institute in Trustworthy Inter-connected Cyber-physical Systems (RITICS), and an Airbus Centre of Excellence in Supervisory Control and Data Acquisition. The CTI brings together the expertise of three specialist research centres:

- The Cyber Security Centre is a multidisciplinary group of academics and industry experts who focus on a variety of topics in cybersecurity, including Industrial Control Systems, data privacy, cyber intelligence, cybercrime and malware.
- The Software Technology Research Laboratory focuses on the study, analysis and advancement of the specification, design and engineering of computing systems.
- The Context Intelligence and Interaction Research Group focuses on building and analysing complex smart systems, comprising: sensing devices; interacting agents, including people and other organisms; embedded systems; and robots and autonomous software agents within open, pervasive environments.

1.1.3 The Institute of Artificial Intelligence (IAI)

IAI provides world leading-edge interdisciplinary research on artificial intelligence and data analytics, with strong contributions from fields such as Mathematics, Decision Sciences and Operational Research. It focuses more specifically on two areas: computational intelligence and intelligent transportation systems.

- The Centre for Computational Intelligence develops computational intelligence paradigms–based research solutions to real-world decision-making and prediction problems. Our high-quality, industrially relevant research into theoretical foundations and real-world applications of intelligent systems has four main areas of focus:
    - Evolutionary computation – evolutionary algorithms, including genetic algorithms, swarm intelligence and memetic computing.
    - Fuzzy logic – uncertainty models, including fuzzy sets, rough sets and grey systems.
    - Intelligent Data Analysis – development of innovative methods and intelligent systems for integrating and analysing a variety of real-world data and data streams; supervised and unsupervised machine learning approaches and tools in natural language processing (semantic analysis); Market Basket Analysis.
    - Intelligent mobile robots, computer vision and games – expanding the robotics portfolio and integrating AI methods with games.
- The DMU Interdisciplinary Group in Intelligent Transport Systems is dedicated to researching and developing programmes that progress the introduction of sustainable urban and regional transport policies across Europe and beyond.

1.2 RESEARCH STRATEGY

Our research strategy rests on the following research principles:

- Creating and applying knowledge: Our Unit researchers engage, when possible, on cross-university (University of Oxford, Loughborough University, Imperial College among others; and many European HE institutions; see section 3), cross-faculty (Innovation Fellowship with the School of Pharmacy) and cross-disciplinary projects and teams (Intelligent Cyber Security between IAI and CTI), but also recognise that successful research can proceed both from the activity of research groups as well as individual scholars, depending on discipline norms. In all cases, our researchers have a primary affiliation with one of our three School research institutes which, based on plans and performance, are provided with financial incentives from our Faculty to give a degree of autonomy to researchers to maximise the inputs to and outputs from their research.
- Inclusion and diversity research culture: We are committed to address diversity-related gaps wherever they manifest in our Unit. Staff with decision-making capacity have undergone Equality, Diversity and Inclusion (EDI) training along the lines promoted by Advance HE. We have actively worked during the present census to improve gender and Black or minority ethnic (BAME) balance in research (significant increases of both female and BAME staff researchers submitted in this REF compared to REF 2014; see 2.3).
- Research ethics and research integrity: Our researchers are aware of their social responsibilities, including those arising from research ethics and research integrity. This applies to all aspects of the research process. UOA 11 is at the forefront of practical and theoretical direction of research in computer ethics and responsible innovation in ICT: we were the only executive committee member from outside the US in the 2016–2018 rewrite of the original 1992 Code of Ethics of the ACM. This research was done in conjunction with leading computer ethics and industry experts in the USA and ACM members around the world.
- Open Access and Research Data Management: The SCSI, as well as DMU, recognises the need for researchers to protect their own research interests in the process of planning their research and obtaining their results. Nevertheless, the School encourages researchers to be as open as possible in disseminating their work. Researchers are aware of the Policy for Managing Open Access at DMU and the Research Data Management Policy, as well as the Institutional Publications Fund linked to the University's 'Policy on Incentivising Staff to Engage in Research and Innovation Activity' to support the costs of Gold Open Access. Our research publications are made available through the Green Open Access route via the DMU Open Research Archive (DORA) publications repository and since April 2019 our researchers and postgraduate research (PGR) students can use our new, secure and user-friendly cloud-based Research Data Management repository, DMU Figshare, to make our research data openly accessible to the wider research community both nationally and internationally.
- Undertake ambitious, innovative and rigorous research with impact on the wider society: We particularly encourage and facilitate work with international, national and regional communities to disseminate the results from our research to the wider public and to increase awareness of the effect and benefit our research has in the quality of life of society in general, as reported in our five research impact case studies (see 1.3).

1.2.1 Review of research strategy

Over the present REF 2021 census period, we retained and developed further those research strategies that proved successful in REF 2014, while seeking to evolve, advance and support our existing research themes to increase and strengthen the amount of top-rated research in REF 2021. Key areas of development and progress against plans highlighted in REF 2014:

- Evolving and advancing our existing research themes. Progress: formation of research institutes within UOA 11, continued commitment to interdisciplinary research into the

responsible use of technology, as evidenced by the creation of the interdisciplinary Special Interest Group WE R AI (as described in 1.1).

- Developing the Unit's research capability by recruiting high-quality researchers at every stage of their career. Progress: VC2020 recruitment and appointments (2.1).
- Proactively supporting and mentoring staff in their research activities, with a specific mentoring scheme in place to support early career researchers (ECRs), improve succession planning and provide a better culture for PGR students. Progress: provided and facilitated professional development sessions for both research staff at all stages of their careers and research students: Future Research Leaders' Programme, Doctoral College PhD Scholarships Scheme, and Next Generation Researchers' Programme for emerging independent researchers (section 2).
- Increasing the research profile of the Unit both nationally and internationally. Progress: Increased the Unit's research performance and standing in world and UK rankings (described in 1.2.2); hosted international research leaders and international conferences (section 4).
- Maintaining a dynamic multi- and interdisciplinary research environment where staff undertake ambitious, innovative and rigorous research with impact on the wider society Progress: significant investment in research (3.2) that includes 'pathways to impact' (1.3); improvement of our web presence; public engagement activities via new University initiatives (DMUlocal, DMUglobal; Health, Smart cities; data analytics with Leicester City Council).

1.2.2 REF 2021 research strategy analysis

Our REF 2021 census period research strategy has led to the increases (below) in research productivity, dissemination to the research community, international research collaboration, research influence, and funding in the current REF census period with respect to the previous REF census period (Key Performance Indicators in parentheses):

Research productivity (number and type of research outputs)

During this census period we aimed at increasing both the quantity and percentage of our research outputs published in international journals (article type). Using Web of Science (WoS) data on InCites UK REF 2021 Research Area 11, Computer Science and Informatics, Table 1 shows that we published 33% more research outputs in the six-year census period [2014–2019] of REF 2021 than in the six-year census period [2008–2013] of REF 2014, while the proportion of article type documents published increased from 36% in REF 2014 to 54% in REF 2021.

Table 1: UOA 11 research productivity (InCites updated 29 January 2020; WoS content indexed up to 31 December 2019)

Period	All research output	Article type	Proceedings papers
REF 2014 [2008–2013]	466	36% (168)	60% (279)
REF 2021 [2014–2019]	621 (+33% wrt REF 2014)	54% (338)	40% (249)

Dissemination to the research community (proportion of research outputs in top quartile of journals with impact factor – Q1 JIF)

Peer-reviewed journal outputs are widely available to the scientific community. Therefore, they have the potential of being read/used by other researchers and ultimately lead to an increase of our academic impact and our standing in world universities rankings (see corresponding heading below). Table 2 indicates that our REF 2021 publications in JIF journals and the proportion of them published in the top Q1 based on citations increased significantly with respect to REF 2014.

Table 2: UOA 11 articles in JIF journals (InCites updated 29 January 2020; WoS content indexed up to 31 December 2019)

Period	Articles in JIF journals	% articles in Q1 journals
REF 2014 [2008–2013]	135	43% (58/135)
REF 2021 [2014–2019]	230 (+70% wrt REF 2014)	63% (145/230)

Internationalisation (percentage of international collaborations – IC)

We aimed during this census period to increase our international outlook. UOA 11 facilitated the research visits of our staff to international research centres as well as visits to us by international staff. This has translated into significant increases of our proportion of research with international co-authors in REF 2021 against REF 2014 (Table 3).

Table 3: UOA 11 international collaboration (InCites updated 29 January 2020; WoS content indexed up to 31 December 2019)

Period	% of all research output with IC	% article type with IC
REF 2014 [2008–2013]	39%	47%
REF 2021 [2014–2019]	66%	75%

Research influence (citation impact – category normalised citations index – CNCI)

Our IC increase also translated to a significant increase in research influence as measured by the CNCI (Table 4): a value of 1 represents performance at par with world average and values above one are considered above average.

Table 4: UOA 11 category normalised citation index (InCites updated 29 January 2020; WoS content indexed up to 31 December 2019)

Period	CNCI of all research output	CNCI of article type
REF 2014 [2008–2013]	1.2	1.51
REF 2021 [2014–2019]	2.28 (+90% wrt REF 2014)	2.78 (+84% wrt REF 2014)

Funding (percentage increase in REF 2021 against REF 2014)

During this census period, we also aimed to increase our external research funding from the levels we achieved in the REF 2014 period, which was 28% higher than in RAE 2008. The Unit increased its external research funding from £3,050,000, reported for the REF 2014 five-year period 2008–2012, to £8,880,000, for REF 2021's six-year period 2013–2019. This means the Unit's current REF period external research income incremented by 302%, which translates into an annual average increase of 243% in external research funding achieved by the Unit during the current REF with respect to the REF 2014 period.

The combined increase in our research productivity, research influence and international research collaboration translated into DMU UOA 11 being listed during the current REF period as a world top University in Computer Science in both the Shanghai Academic Ranking of World Universities (ARWU) (2015, 2017, 2018, 2019, 2020 – WoS) and the *Times Higher Education* World University Rankings (THE WUR; 2019, 2020 – Scopus).

- *THE* WUR 2020 listed 749 world universities, 54 of which are UK HEIs. DMU UOA 11 achieved a world top 201–250, placing us 24th of 54 in the UK.
- The 2020 *Shanghai ARWU* for listed 500 world CS universities, of which 39 were UK HEIs. DMU UOA 11 achieved a world top 151–200 and 13th of 39 in the UK, with our research placed world joint first based on the CNCI criterion and 32nd (5th in the UK) based on the IC criterion.

1.2.3 Our research strategy for the next five years

Our Unit research strategy for the next five years aims to:

- strengthen existing areas of excellence through investment in people, infrastructure, and impact activity;
- push the boundary of technology/AI and the human, as a distinctive feature of the Unit;
- identify and nurture new and emerging areas of excellence and research clusters;
- develop strategic partnerships with external organisations to increase the impact of our research; and
- work with the Research Services Directorate (RSD) to improve research capacity among existing staff and the quality and success rate of external grant funding applications.

1.3 IMPACT STRATEGY

The School works to actively identify and seek key local, national and international organisations that can benefit from our research. We have an Industrial Liaison Committee dedicated to creating and strengthening mutually beneficial relationships between the School and corporations worldwide, by providing advice and support to help increase levels of engagement in collaborative research and development activities. The majority of our research goes hand-in-hand with stakeholder collaboration, with many of our projects being undertaken in direct partnership with industry, or with the aim of improving and adding to industrial technology and practice through subsequent consultancy and knowledge exchange.

The Unit's approach to impact during the census period has been to encourage work in areas that demonstrate potential impact and sustainability. To achieve this, significant investment in staff and physical resources has been made available by a broad range of highly selective competitive mechanisms (research scholarships, research leave, pump-priming research and innovation funding) that include 'pathways to impact' as one of the assessment criteria (section 3).

Annual events dedicated to the promotion of Knowledge Transfer Partnerships (KTPs), our Technology Showcase and external events where we participate, like the Leicester Business Festival, provide businesses and organisations with the opportunity to explore and experience a range of cutting-edge technologies in computing, information science, sustainability and the creative fields. Our Technology Showcase has been delivering expert information and partnership opportunities to businesses since 2004 and has been responsible for a number of successful collaborations. Part-time industry-funded PhDs, especially in the CTI, provide a direct route for embedding research findings in real-world organisations. During the REF 2021 period, seven students have completed their PhDs in this way. Three of our five impact case studies result from these types of collaborations, with businesses and organisations:

- 'Cyber Incident Response and Risk in Industrial Control Systems': We have developed new methodologies for improved understanding and responding to threats and vulnerabilities within Industrial Control Systems. The methods have been adopted by users such as the UK and NATO military partners, changing their Cyber Risk and Threat Intelligence procedures. The work has led to DMU being (1) recognised as an Academic Centre of Excellence in Cyber Security Research by the National Cyber Security Centre, one of only two Academic Centres of Excellence in Supervisory Control and Data Acquisition cybersecurity in Europe by Airbus, and (2) admitted to RITICS, funded by EPSRC/NCSC.
- 'Evaluating Human Error–Related Information Security': CTI researchers have created the novel Information Security Core Human Error Causes (IS-CHEC) technique, which is an adaptation of the Human Error Assessment and Reduction Technique (HEART). The IS-CHEC tool aims to capture and analyse root causes of human errors in information security incident analysis. We are able to map information security incidents to HEART Generic Task Types (GTT) and Error Producing Conditions (EPC), which has been applied in both public sector (healthcare services provider) and private sector (IT security service provider). Our real-time 12 month (2018–2019) action research cycle within both public and private sector

organisations in parallel have positively impacted the involved organisations in terms of reducing and preventing human error–related information security incidents.

- 'Support for Operations and Security for the Global Air Transport Industry: Modelling, Forecasting and Optimisation': Applicability of our Computational Intelligence algorithms has led to major impact in the management of processes and operations, especially in the air transport industry. The research led by **Gongora** resulted in a spin-off company, as well as the participation of the lead academic in international advisory activities. Gongora has actively participated in the development of the Smart Security programme Guidelines disseminated to all the airports around the world by the International Air Transport Association and Airports Council International, in turn steering the industry to develop suitable solutions to implement them.

Our approach also includes seeking opportunities to engage with the public in order to demonstrate the relevance of our internationally acclaimed research, to disseminate our work to the wider public and to increase awareness of the effect and benefit our research has for the quality of life of society in general. Two of our five impact case studies result from these types of opportunities:

- 'Rewriting the ACM's Code of Ethics': Research conducted at CCSR underpinned the 2016–2018 rewrite of the original 1992 Code of Ethics of the ACM. This research was done in conjunction with leading computer ethics and industry experts in the USA and ACM members around the world. The modernisation of the Code is globally shaping the discourse around ethics and professionalism in the computing field. Beneficiaries include the 100,000+ members of the ACM, who are required to abide by it; society, benefiting from implementation; industry and academia, benefiting from its framework; and educators at all levels, for use in ICT teaching and training.
- 'The Ethics of Sex Robots and Harms to Women and Girls': **Richardson**'s research has been following the making of anthropomorphic robots since 2001, which are promoted as relational others, and engineered and sold as 'lovers', 'therapists', 'sexual partners' or 'friends'. Richardson has identified the development of these robots as socially problematic, urging caution for some and the banning of others (sex robots in the form of women and girls). In 2015, she founded the Campaign Against Sex Robots (CASR) which has had over 350,000 views on topics relating to the ethics of sex robots. This has led to a global ethical discussion about the normalising of sex robots in the form of women and girls and led to the development of legislation in the US: the Curbing Realistic Exploitative Electronic Pedophilic Robots (CREEPER) Act. Richardson's work is underpinned by a humanistic ethics and has led to her being invited to events to speak on her robots research, including SWSW (Frankfurt), SIBOS (world's largest banking conference), and Web Summit (international technology conference).

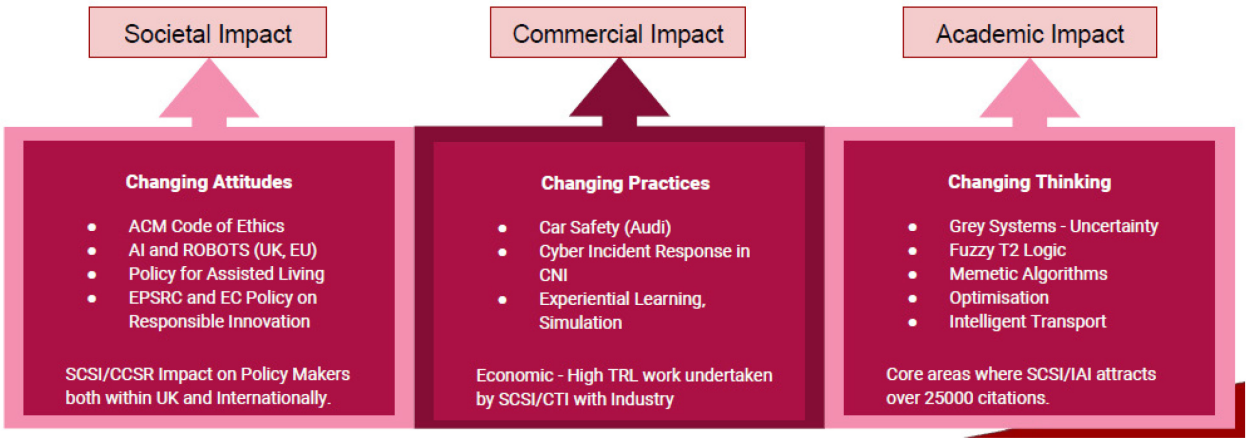

Figure 2: UOA 11 research impact by Institutes

The ultimate aim of our approach to impact is to encourage high-quality applied research that impacts (Figure 2) both academics (IAI research work on uncertainty, fuzzy logic, optimisation and intelligent transport) and society (CCSR research work on the ethical and social implications of ICT) while identifying projects with potential for impact at an early stage to facilitate the realisation of this future impact with industry (CTI research work on car safety, cyber incident response in CNI and experiential learning and simulation).

The Unit's goals for supporting and enabling impact from its research in the future include:

- To maintain a dynamic and pervasive research environment supported by a robust research infrastructure, and to encourage a scholarly culture where staff undertake ambitious, innovative and rigorous research with impact on the wider society.
- To ensure, through the allocation of resources and appropriate staffing, that our world-leading and internationally excellent research is disseminated to as broad an audience as possible.
- To work with our stakeholder community (through knowledge exchange, collaboration and partnership) as well as with national and international partners, to promote research, technology and education and to increase our research profile and the level of impact of our research on the wider society.
- To ensure that internal research funding is made available for projects that aim to establish links for the purpose of maximising impact. Public engagement activities will also be encouraged by placing more emphasis on the implementation of outreach activities in the criteria for the award of internal funding.
- To communicate effectively and equally to both academic and non-academic audiences through the continual improvement of our web presence and the strategic targeting of events that engage with stakeholders.
- To ensure that there is a pipeline of information from the School to the press office at DMU so that opportunities to enhance the research profile and successes of the School in national, international and sector media are exploited.

Section 2. People

2.1 STAFFING STRATEGY AND STAFF DEVELOPMENT

DMU is committed to recruiting and appointing academic staff with demonstrable or emergent research excellence with a strategic focus on fostering and supporting early career staff. The research strategy for the School has its researchers at its heart, and delivers its vision and mission through strong leadership, meaningful engagement and the development of a high-performance culture where researchers are supported to deliver excellence in research with confidence. To be able to respond to the changing demands of the marketplace, our staffing strategy has been addressed using the following headings:

2.1.1 Staffing and recruitment policy

DMU's aspiration to be a more research-intensive university requires having a more diverse and more highly qualified research community and maintaining our ethos of social and ethical values. Motivated, high-achieving staff members are essential to research excellence. We aimed during this census period to recruit the best and retain them through training and mentorship while also offering rewards for their contribution to research excellence (described next). Research track record/potential was a key element in all our recruitment opportunities during this census period. We aimed to build a sustainable research environment by maintaining a sensible balance between recruiting acknowledged research leaders, and potential research leaders (see Tables 5a–b and Figure 3 in section 2.3). We will continue to monitor the recruitment of new researchers to ensure we build capability and capacity. The School has recruited a significant body of excellent researchers through our Vice-Chancellor's 2020 (VC2020) lectureship programme, amounting to 36% (20 out of 56) of our submitted staff, some

of whom have already moved to more senior career positions since their joining our School. VC2020s are given a light teaching load in their first academic year with at least 50% of their time given for research and PhD supervision and £2,000 start-up (replaced in 2017 by internal bid for up to £5,000; see 2.1.2) for their personal development to enable progress along a teaching and research trajectory. The time and money support we provide our ECRs aims to ensure we harness their excellence and enthusiasm to the full. Many of our recruited VC2020s have already established themselves as strong research leaders and we will continue to support existing appointees and recruit new ones. New staff members are appointed with a probation period, which feeds into their first annual appraisal process, where relevant discussions around research leads, where appropriate, to dedicated quality research time articulated in individual workloads as elaborated next. The Unit has also recruited recent PhD graduates through our Early Career Academic Fellows (ECAF) programme, who are appointed to a one-year post that can lead to a full VC2020 lectureship. Up to 73% of our submitted staff to the REF 2021 are appointments made since January 2014: 4 professors/senior staff; 5 readers/associate professors; 32 senior lecturers/lecturers/ECAFs. To facilitate the integration of each new member of staff, we offer them a Faculty staff induction session on research and innovation covering the Faculty research vision, research aims and strategy, including our research and enterprise key performance targets and the indicators to measure success as well as their link to the United Nations' Sustainable Development Goals (UNSDGs); our Faculty Policy and Guidance, as well as where and how to get Research and Innovation (Enterprise) support from our Faculty's Research and Innovation Office and University's RSD; from our Faculty Associate Dean of Research and Innovation regarding processes for submitting research bids, applying for research allowances and appointing research students; as well as information on mandatory/ recommended training and development; and effective use of MyAppraisal. We also have in place a Faculty VC2020/ECAF champion, and poster events to disseminate the new knowledge and experience of our VC2020/ECAF colleagues.

2.1.2 Staff development and support

Our commitment to the Concordat to Support the Career Development of Researchers informed our Concordat Action Plans (2018–2020) and secured us the HR Excellence in Research Award in 2018. Over the census period, the implementation of consistent support and mentoring for staff in research and capacity-building activities has been an effective mechanism to successfully build upon research excellence. The School's plans at the institute level include development funding to attend high-quality conferences. The School has in place a mentoring process that enables established researchers to take advantage of more effective opportunities to engage in research while also being able to assist our VC2020 ECRs. A key element implemented during the current census to help staff develop and plan their research career is the annual 'Research and Innovation Allocation' (RIA) scheme, which is peer reviewed and assessed by a School-based panel. In addition to a 10% scholarship allocation, staff are able to apply for 320–640 hours per annum (amounting to between 1–2 days per week). RIAs are submitted yearly, describing developmental and research activities to be undertaken. All our researchers are required to complete the University's Equality and Diversity training; the Certificate in Research Supervision course is also compulsory to act as supervisor for research degree students. Researchers are also invited to give lectures / deliver training courses to PGR students in the Unit's Doctoral Training Programmes (DTPs).

Support is given to our individual researchers and research institutes in raising the profile of their research, the work of their Institute, and the University as a whole, using a variety of competitive schemes with the support of the RSD (see 3.2):

- A DMU-wide Research Leave Scheme offering a term of research leave to staff: **Ahmadi**, **McBride** and **Picinali** (worth approximately £21,000);
- Higher Education Innovation Funding (HEIF) to support and develop a broad range of knowledge exchange activities between universities and the wider world, which result in economic and social benefits to the UK (since 2011);
- Research Investment Fund (RIF) to support new initiatives to build our research capacity, performance and reputation (since 2010);

- Research Capital Investment Fund (RCIF) to sustain and develop DMU's research equipment base (since 2010);
- Annual ring-fenced funds to support pump-priming and funding for new talent through the FCEM VC2020s additional funds (up to £5,000 per project), with special attention to ECRs, to ensure a smooth transition into academic life so that they are ready to make a major contribution to the REF, and that they are supported in developing outstanding research profiles (since 2017);
- DMU Doctoral College PhD Scholarships (full bursary; fee waiver) for projects aligned with the University–Faculty–Unit strategy and relevant to one or more of the 17 SDGs and a supervisory team combining early career (e.g. VC2020) with more senior academics (since 2010); awarded 31 PhD scholarships – 16 fees-only that included 5 overseas studentships; 15 fees and stipend and 1 EPSRC scholarship;
- The Future Research Leaders Programme (since 2012) offers monthly developmental sessions over a year-long course to develop researchers' leadership skills (**Yevseyeva**, **He**). Those unsuccessful in getting a place on the programme may be selected for the Leading Research Mentoring programme;
- An ECR network (since 2012) with training programmes (including writing retreats and workshops) and mentoring from senior staff;
- Regular CEM Research Away Days (since 2012) to allow staff to meet colleagues in the School to encourage internal new research collaboration activities and links.

Specific support is also provided to the Unit's researchers for knowledge exchange through the RSD's activities including:

- hands-on training for developing scientific and transferable skills for R&D careers in both industry and academia (entrepreneurship, research integrity, proposal preparation, patent applications, IPR management, take up and exploitation of research results etc.);
- workshops on Commercialisation of Research, IPR, Open Access, KTPs and related schemes;
- active training on research and financial management of the research projects; organisation of scientific/training/dissemination events; communication, outreach activities and horizontal skills; and training dedicated to gender issues.

2.1.3 Staff recognition and rewards

In order for the School to become a location of choice for staff at all career stages it is important that research talent is nurtured, recognised and rewarded. The School encourages and supports researchers committed to achieving a high level of distinction in research and scholarly activity to seek recognition by the University. In alignment with the University, our strategy makes clear that a career-stage approach to research development, where success in research is one aspect of career progression and where readers / associate professors and professors have more robust research expectations placed upon them, is appropriate and productive for the individual and the School. The Faculty has in place a central competitive leave scheme to allow a research-active academic to focus on a research activity beyond what can be achieved through the annual RIA process. Research staff were provided with a focused period of one term for research to contribute to the Unit's research strategy and REF submissions, including the building of research capacity either for the applicant or the institution. Our Future Research Leaders (FRL) programme has identified and mentored our rising research stars (**Yevseyeva**, **He**) and developed their research leadership skills, thereby setting out a path to senior positions which several have already achieved (details below). DMU has invested during this census period in computer-based systems to achieve better developmental support and stronger performance monitoring (new DORA system; online MAX/MyAppraisal; grants management system; progression monitoring system and skills training records system for PGRs). In addition, since 2018, our researchers' achievements are celebrated annually in our Faculty-based Research OSCARs. Our ongoing commitment to achieving a high level of distinction in research and scholarly activity has been recognised by DMU in the promotion of the following staff within the present census period: **Chen**, **Deka**, **Kiraz**, **Shell** and **Yerima** were promoted from lecturers

to senior lecturers; **Al-Bayati**, **Anastassi**, **Caraffini**, **Coupland**, **Flick**, **Gongora**, **Siewe**, **Smith**, **Wagner**, **Wakunuma** and **Yevseyeva** have been awarded readerships / associate professorships, while **Ayesh**, **Elizondo** and **Richardson** were awarded professorial chairs. These promotions have enabled us to also achieve a better balance of gender and race in our Unit.

2.2 POSTGRADUATE RESEARCH STUDENTS

PRG students make a crucial contribution to our Unit's research capacity, culture and outputs, and act as ambassadors for the University externally. Built on the foundations of computer science and Information Systems or Informatics, our research environment lets PGRs draw on academic expertise and high-quality research to develop a deep understanding of their subject area. DMU has a long history of fostering new technologies and we always encourage PGRs to challenge convention and to innovate. Our programmes also encourage creative freedom and experimentation, allowing research students to explore ideas and to learn in an organic way.

We aim to balance recruitment so as to maintain our reputation across our areas of excellence and to ensure that our PGRs receive effective supervision, outstanding career development (including opportunities to teach), and avenues to publish their work while in training. This assists us in retaining the best of our PGRs as ECRs (**Ayres**, **Caraffini**, **Fahy**, **Khuman**). We recruit a number of PGRs from our master's programmes and advertise potential ideas for doctoral study via our website, attracting interest from a diverse range of people. The recruitment of PGRs within the School benefits from the creation in 2013 of the DMU Scholarships Scheme that aims to encourage the retention of our highest-quality students to study for their PhD; the offering of both full and fees-only bursaries; and our proactive work with research councils in relation to their competitive schemes. Recently, in partnership with the University of Nottingham, the Unit has been awarded the EPSRC Centre for Doctoral Training in Horizon: Creating Our Lives in Data (funded value: £5,800,578, 5 PhD students at DMU; funded period: 2019–2028). PhD applicants are interviewed and aligned to a research institute working in the area of interest. To ensure academic standards are maintained and that sufficient supervisory resources are available, applications are accepted after scrutiny from the School/ Faculty Head of Research Students and the Faculty Associate Dean of Research if needed. All PGRs are subject to the oversight and monitoring of the University's Doctoral College.

At School level, based on the area of research and the agreed supervisory team, PGRs are associated to the most relevant of our three DTPs: in Intelligent Systems, in Information Society or in Cyber Security. All three DTPs provide PGRs with high-quality accommodation in dedicated research laboratories as well as bursaries from endowment funds for travel to and attendance at conferences (Doctoral College Conference and Travel Award Scheme, with PGRs allowed to bid for up to £500). PGRs are offered a DMU Researcher Development Programme that aligns with the national Researcher Development Framework, curriculum and infrastructure (including an online PGR management system); and School-specific research training through DTPs. There are a number of rigorous procedures to maintain and improve quality, including: regular progress meetings between PGRs and supervisors – an online monthly progress report must be completed by the student and signed off by a member of the supervisory team; the School/Faculty Head of Research Students reviews the progress of PGRs and checks that regular discussions between supervisors and their students have been taking place; progress is subject to a positive formal annual review by the supervisory team and an experienced researcher who is independent of the supervisory team. The Doctoral College promotes the achievements of PGRs and offers opportunities for them to enhance their employability. Additionally, the Doctoral College runs a regular Doctoral College Lecture Series, an annual poster competition and the DMU PhD Society via Facebook as a way of connecting up research students at DMU to learn from others and make a few friends, particularly being championed since the lockdown in March 2020.

Between 1 August 2013 and 31 July 2020, 117 students were awarded a PhD with a mix of self-funding, DMU bursaries and grant funding, an18% increase compared to REF 2014. Our last PhD alumni destinations survey (summer 2019 covering period January 2016—June 2019)

shows that approximately 51% of our Faculty alumni were in HE (some in managerial posts: Vice Dean of IT—Saudi Arabia; Head of Information Technology and Computing Department—Jordan); while 18% were in industrial / commercial sectors (e.g. Microsoft Game Studios, Deloitte).

2.3 EQUALITY AND DIVERSITY

DMU has been recognised for our work in equality and diversity. We have been listed in the last five years (2015–2020) in the prestigious Stonewall Top 100 Employers league table (DMU was placed 40th on the 2020 list); were commended by the Quality Assurance Agency in our 2015 Higher Education Review; and became one of the first UK universities to receive the Race Equality Charter Bronze Award (REF5a).

DMUfreedom, the University's Equality and Diversity charter, commits DMU and our School to addressing diversity-related gaps wherever they manifest. A comprehensive range of policies spanning from flexible working through to Dignity at Work enact these commitments. The most relevant to this code is our Equality of Opportunity in Employment Policy. This sets out how we uphold the requirements of the Equality Act 2010, including the duty to advance equality of opportunity. In 2018, DMU introduced a positive action development programme for women, disabled staff and staff of BAME heritage. In meeting the commitments set out in our Athena SWAN and Race Equality Charter action plans, through our communications and line management structures, women, BAME and other under-represented groups are encouraged to apply for opportunities in relation to promotion and development. We have ensured that all staff within the Unit are supported with flexible working arrangements in line with University guidelines and policies. Family-friendly policies such as parental leave have also been supported throughout the census period, ensuring arrangements are put in place to cover tasks of staff on leave schemes. This includes making provision not just for their teaching but also supporting PhD students under their supervision, and do so fairly, without any bias.

As per the University REF Code of Practice, all staff in any REF decision-making capacity have undergone EDI training along the lines promoted by Advance HE, with a special focus on REF-related decision-making (selection of staff/outputs for the REF). This includes those on the REF Steering Committee, as well as the REF Working Group. The application of the University's Code of Practice identified a percentage of the School of Computing and Informatics (UOA 11) as 'Staff with Significant Responsibility for Research' (SSRR) of 67% (56/84), well above the target 60% set in DMU's strategic plan for the period 2018–2023. The School of Computing and Informatics (UOA 11) SSRR percentage increases to 76% when staff employed on 'research only' contracts as per the REF 2021 Guidance on Submissions (paras 130–132) are not considered.

The Unit has actively worked during the present census to improve gender and BAME balance in research (see Table 5a). We have increased significantly both the number of female researchers submitted in REF 2021 (13 of 56 staff submitted: 23%) in comparison with REF 2014 (2 of 29 staff submitted: 7%) and the proportion of BAME staff submitted in REF 2021 (45%) in comparison with REF 2014 (17%).

Table 5a: EDI data for UOA 11 in REF 2021 vs REF 2014

REF	2014 (24 staff)	2021 (56 A staff)
Male	27 (93%)	43 (77%)
Female	2 (7%)	13 (23%)
White	23 (79%)	30 (54%)
BAME	5 (17%)	25 (45%)
Not disclosed	1 (3%)	1 (2%)
Profs / senior staff	6 (21%) (1F)	10 (18%) (1F)

Readers/AP/PL	9 (31%)	11 (20%) (4F)
ECAF/L/SL	4 (14%)	35 (62%) (7F)
RF/SRF	8 (28%) (1F)	
Other	2 (7%)	

Note: 'F' indicates number of women in the population. In the submitted population are 1 ECAF, 12 VC2020 Lecturers and 6 VC2020 Senior Lecturers.

It is worth noting that 36% of our submitted staff in REF 2021 in the readers / associate professors and principal lecturers group are women (0% in REF 2014), creating a pipeline for women to enter senior positions. In the last three years the School has provided mentoring for two female staff as part of the University FRL programme. Table 5b provides the Unit career-stage distribution by gender of the submitted staff. There is a notable healthy growth within the ECR category (ECAFs, lecturers and senior lecturers) (62% in REF 2011 vs 14% in REF 2014), which indicates that our Unit is in a very good position in terms of building research-capacity.

Table 5b: Career-stage staff distribution by gender

	Prof.	Reader	Asst Prof.	Senior L	Lecturer/ECAF
Male	90%	67%	62%	73%	84%
Female	10%	33%	38%	27%	16%

Figure 3 shows the distributions of Unit's outputs and (category A) staff with respect to career-stage categories (there are 7 outputs by category B as part of our submission):

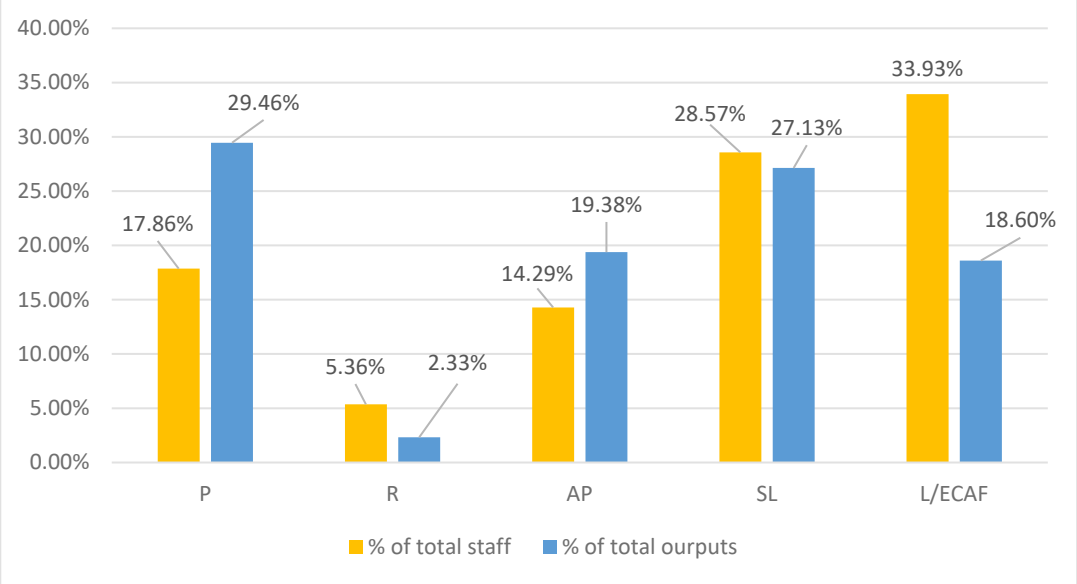

Figure 3: UOA 11 distribution of research outputs by career-stage

Figure 4 shows the Unit's average outputs submitted by (category A) staff career-stage categories:

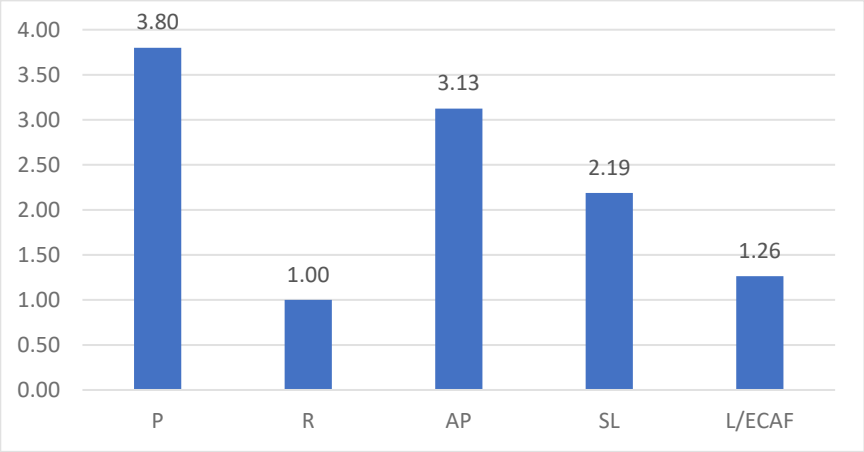

Figure 4: UOA 11 average outputs by career-stage

With regard to the Unit distribution of outputs by gender of submitted Category A staff, our female researchers contributed 28 outputs (average 2.2 outputs) while our male researchers contributed 97 outputs (2.3 outputs average), with no significant average difference noticed.

Section 3. Income, infrastructure and facilities

3.1 RESEARCH INCOME

During the census period, members of the School have received major funding from:

- Economic and Social Research Council (ESRC)
- EPSRC (Research, Training, Tender)
- EU (Tender)
- EU FET Flagship
- EU FP7 (Research, MSCA-IIF)
- EU H2020 (FET, IC, MSCA-IF, MSCA-ITN, SwafS)
- Home Office / RISCS
- Innovate UK (Knowledge Transfer Partnership, Feasibility Studies)
- Leverhulme Trust
- NCSC/RITICS
- NERC (Research)
- The Royal Society (International exchange programme, Short Industry Fellowship)
- TSC (Transport Systems Catapult)-UPP scheme

Commercial clients include Guidance Marine Ltd, Airbus, Geospatial Insight Ltd and Surbana Jurong Consultants Pte Ltd.

External research income to the Unit in this REF census period represents an increase of 302% with respect to the previous REF census period, which translates into an annual average increase of 243% in research funding achieved by the Unit during the current REF in comparison to the REF 2014 period. Key research projects awarded to UOA 11 (our contribution in brackets when in consortium) within the current census period are:

3.1.1 EPSRC

- ‘Observatory for Responsible Research and Innovation in ICT’. CCSR and University of Oxford. Funded value: £450,000 (£250,000 DMU); funded period: 2016–2021.

- ‘EconoMical, PsycHologicAl and Societal Impact of RanSomware’. CTI (Lead Research Organisation). Funded value: £751,635 (£444,858 DMU); funded period: 2017–2019.
- ‘PryMe, a Universal Framework to Measure the Strength of Privacy-Enhancing Technologies’. CTI. Funded value: £88,642; funded period: 2017–2018.

3.1.2 ESRC

- ‘Digital Wildfires’. The University of Oxford (Lead Research Organisation); CCSR (Project Partner). Funded value: £198,000 (£5,481 DMU); funded period: 2014–2016.

3.1.3 Innovate UK

- ‘De Montfort University and Airbus Group Limited’. CTI (Lead Participant). KTP. Project cost £213,008; project grant: £106,504; funded period: 2015–2020.
- ‘De Montfort University and Geospatial Insight Limited’. IAI (Lead Participant). KTP. Project cost: £138,310; funded value: £92,668; funded period: 2018–2019.
- ‘Adaptive Cyber Threat Intelligence for Cyber Security InVEstment Optimisation’. CTI (Lead Participant). Feasibility Study. Funded value: £69,730; funded period: 2018–2019.
- ‘Water Advisory Demand Evaluation & Resource Toolkit’. Mfatech Limited (Lead Participant), IAI (Participant); Feasibility Study. Funded value: £137,406 (£80,804 DMU); funded period: 2015–2016.

3.1.4 NERC

- ‘Fruit Ripening Overlay SysTem Sensing TIming Communication’. IAI (Lead Participant). Funded value: £44,044; funded period: 2016–2018.

3.1.5 Leverhulme Trust

- ‘International Network on Grey Systems and its Applications’. IAI (Lead Participant). Funded value: £124,997; funded period: 2015–2019.

3.1.6 NCSC/RITICS

- ‘Agile Incident Response for Industrial Control Systems’. CTI (Lead Participant). Feasibility Study. Funded value: £250,000 plus £160,000 in kind from industrial partners; funded period: 2019–2020.

3.1.7 TSC–UPP

- ‘The Intelligent Mobility Partnership – Midlands Competence Centre of Excellence’. Loughborough University, IAI, Nottingham Trent University and Coventry University. Funded value: £600,000 (£97,500 DMU); funded period: 2015–2019.

3.1.8 EU

- H2020 ICT: ‘Responsible Ethical Learning With Robotics’. CCSR (Partner) [Coordinator – Aarhus University, Denmark]. Funded value: €2,000,000 (€500,000 DMU); funded period: 2017–2019.
- H2020: ‘Living Innovation’. CCSR (Partner) [Coordinator – Vienna University of Business and Economics]. Funded value: €3,550,000 (€267,000 DMU); funded period: 2018–2021.
- H2020 ICT: ‘3D-games for TUNing and lEarnINg about hearing aids’. CCSR (Partner) [Coordinator – Imperial College]. Funded value: €2,896,175 (€100,000 DMU); funded period: 2015–2018.
- H2020 SC1: ‘Progressive Standards Around ICT for Active and Healthy Ageing’. CCSR (Coordinator). Funded value: € 905,781 (€255,000 DMU); funded period: 2016–2019.
- FET Flagship: ‘Human Brain Project (Grant Agreement 1)’. CCSR (Ethics Director). Funded value: €89,000,000 (€760,000 DMU); funded period: 2016–2018.

- FET Flagship: 'Human Brain Project (Grant Agreement 2)'. CCSR (Ethics Director). Funded value: €89,000,000 (€750,000 DMU); funded period: 2018–2020.
- FET Flagship: 'Human Brain Project (Grant Agreement 3)'. CCSR (Ethics Director). Funded value €150,000,000 (€2,000,000 DMU); funded period: 2020–2023.
- FP7: 'Civil Society Organisations in Designing Research Governance' CCSR (coordinator). Funded value €1,500,000 (€250,062 DMU); funded period: 2012–2015.
- H2020 SwafS: 'Shaping the Ethical Dimensions of Smart Information Systems: A European Perspective'. CCSR (Coordinator). Funded value: €2,850,000 (€419,000 DMU); funded period: 2018–2021.
- FP7: 'Development of Robot-Enhanced Therapy for Children with AutisM Spectrum Disorders'. CCSR (Partner) [coordinator – HOGSKOLAN I SKOVDE, Sweden]. Funded value: €6,690,000 (€500,000 DMU); funded period: 2014–2018.
- FP7: 'Responsible Research and Innovation in Business and Industry in the Domain of ICT for Health, Demographic Change and Wellbeing'. CCSR (Coordinator). Funded value: €1,496,992 (€182,827 DMU); funded period: 2014–2017.
- FP7: 'Stakeholders Acting Together on the Ethical Impact Assessment of Research and Innovation'. CCSR (Coordinator). Funded value: €3,600,000 (€234,000 DMU); funded period: 2014–2017.
- H2020-GARRI: 'COMPASS – Evidence and opportunities for responsible innovation in SMEs'. CCSR (Partner) [Coordinator – WIRTSCHAFTSUNIVERSITAT WIEN, Austria]. Funded value: €1,499,945 (€246,875 DMU); funded period: 2016–2019.
- EU (tender): 'Network Analysis of CSO Participation in Research Framework Programmes'. Sub-contractor (PI A. Martinuzzi, WU Wien) CCSR. Funded value: €756,650 (€160,000 DMU); funded period: 2016–2019.
- H2020-MSCA-ITN: 'Advanced Technologies and Platform for Smarter Assisted Living'. CTI (Coordinator). Funded value: €3,860,209 (€819,863 DMU); funded period: 2016–2019.
- FP7-PEOPLE-2013-IIF: 'Grey Systems and Its Application to Data Mining and Decision Support'. IAI (Coordinator). Funded value: €309,235; funded period: 2015–2016.
- H2020-MSCA-IF: 'Evolutionary Computation for Dynamic Constrained Optimization Problems'. IAI (Coordinator). Funded value: €195,455; funded period: 2015–2017.
- H2020-MSCA-IF: 'Trust Based Decision Support System for Social Networks with Uncertain Knowledge'. IAI (Coordinator). Funded value: €183,454.80; funded period: 2017–2020.

Additionally, the Royal Society awarded two International Exchanges Cost Share (2017, 2018) China (NSFC) to researchers from the IAI and CTI, respectively.

3.2 UNIVERSITY INVESTMENT AND POLICIES TO SUPPORT THE RESEARCH ENVIRONMENT

Over the census period, DMU has invested heavily in central support for research. The University RSD office brings together research support in the form of specialist help with grant applications from expert advisers for research council, EU and knowledge transfer funding opportunities, and post-bid support with grant management (see 2.1.2). The RSD also has a major role in monitoring the institution's research activity and helping research groups promote themselves externally, such as through web pages and events.

Our own Faculty Research and Innovation Office (RIO) supplements this DMU provision. A team of research administrators works closely with the Associate Dean of Research and have a major role in developing industry contacts into opportunities for research and commercial income, preparing costings for research bids, and organising research events and other administrative tasks. The RSD administers several annual research support funds from which the School

researchers have benefited: RIF, HEIF and RCIF; this typically supports new initiatives to build our research capacity, performance and reputation such as:

- the £25,000 of RCIF funding provided to an interdisciplinary team of researchers in the School 'to create an Immersive Vehicle Virtual Reality Testbed by means of 6 degree-of-freedom (DOF) motion system, and enhance DMU's research capacity in new areas of research such as autonomous vehicles and gaming';
- the £15,000 of HEIF funding awarded to researchers in the CCSR 'for the development of a commercial grade course crucial in building the reputation of ORBIT and in increasing DMU impact and leverage prior research investments, with a target audience of approximately 2,500 doctoral students, an equal or greater number of industry-based researchers over the next 5 years, and revenue associated with the course to be approximately £800,000'; or
- the £12,000 of RIF provided to a team of researchers from CTI and IAI 'to collaborate with Atos UK and Prof. James A. Hendler to develop an Intelligent Cyber Security Knowledge Sharing System to generate cybersecurity knowledge from social media (e.g. global media feeds)'.

Our research staff also benefit from the RSD's comprehensive staff development programme aimed particularly at ECRs. This covers, for example, training on writing grant applications, writing for journals, and impact (see 2.1.2).

Over the census period, doctoral support has been rationalised through the DMU Doctoral College (set up in 2009) and its strategic role in the development of the DTPs across the University in 2013, whilst also managing administrative responsibilities for research students (see 2.2).

The School recognises that the balance between scholarly, organisational and operational elements of the research infrastructure is dynamic, depending on the requirements of the Unit within the census period. During the census period, the organisational element has taken priority, with resources focused on the appointment of new staff and investment in research funding to support our Unit, including: an external grant-writing consultancy company; a specific scheme in our Faculty providing additional funding of up to £5,000 per year for our VC2020 academics; the Impact/Acceleration fund focused on the development of impact from our research during this REF cycle; and MATLAB licences for research (see 2.1.2). The significant investment by the School in operational elements during the previous REF period (a state-of-the-art Game Development Studios; Cyber Security Research Labs) has also been complemented during this census period with investment to enhance/update them, such as the development of the country's first cyber risk training Research Security Operations Centre in CTI, costing £150,000, that allows the threat gauged by a cyber-attack to be assessed. We have a state-of-the-art Game Development Studios that 'brings together the latest technology for playing and developing games on a range of platforms', dedicated Cyber Security Research Labs, developed with industry partners, which are among the best equipped facilities of this type. The relationship between these three elements is kept under constant review through School- and Faculty-level Research Committees, and responds to initiatives such as the University's Strategic Research Plan, designed to ensure that areas of research excellence continue to receive investment and funding.

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

4.1 COLLABORATION WITH NATIONAL AND INTERNATIONAL ACADEMIC, INDUSTRY AND OTHER BODIES

This is a key element in the School research strategy as part of our aim to promote research, technology and education and increase our research profile and the level of impact of our research on the wider society.

In August 2019, our Unit led and organised at DMU the 5th IEEE Smart World Congress and five co-located conferences: the 6th IEEE International Conference on Ubiquitous Intelligence

and Computing; the 16th IEEE International Conference on Advanced and Trusted Computing; the 19th IEEE International Conference on Scalable Computing and Communications; 5th IEEE International Conference on Internet of People; and the 3rd IEEE International Conference on Smart City Innovations.

The School's research institutes have maintained strong and lasting external research collaborations during the REF census period (with joint research grants and research publications), as well as developing new links with key influential research organisations.

We have established international and national partnerships beyond DMU. CTI has established relationships with world-leading businesses, including Airbus and Rolls-Royce, CCSR has a joint spin-off company with the University of Oxford to train CDTs across the EPSRC portfolio, while the Centre for Artificial Intelligence also provides consultancy work to industry (Rail Safety and Standards Board, Network Rail, Birmingham and the East Midlands Airports in UK, Northrop Grumman International, Frankfurt airport in Germany and the Air Transport Association).

CCSR has extensive and fruitful relations, both with other research institutes in DMU (with IAI, which has led to several publications; with CTI, shared PhD supervision; and with IESD in Engineering several collaborative funding bids) as well as with institutions and research groups outside DMU.

- National links include: University of Oxford; University of Southampton; University College London; King's College London; Middlesex University; Sussex University; Manchester Metropolitan University; University of Exeter; Leeds Beckett University; Liverpool John Moores University; University of Brighton; Open University; University of York.
- International links include: Karlsruhe Institute of Technology; Technical University of Berlin; Technical University of Munich; University of Nuremberg; University of Twente; University of Namur; Technical University of Delft; University of Lille; University of Greifswald; Linkoping University; Jonkoping University; University of Hradec Kralove; VTT, Finland; Tecnalia, Spain; Fraunhofer, Germany; Politecnico Turin, Italy; Vienna University of Business and Economics; Campinas University, São Paulo, Brazil; University of Malta; University of Malaysia, Sarawak; University of Santiago, Chile; University of Illinois; Charles Sturt University, Australia; University of Limoges; University College Cork, Ireland.

An Industrial Advisory Group ensures that CTI's work provides relevant solutions that meet industry's needs. CTI is a member of the RISCS and RITICS national research institutes and an Airbus Centre of Excellence in SCADA. National and international universities produce research in collaboration with CTI:

- National links include: Cardiff University; Ulster University; Newcastle University; University of Surrey; Loughborough University; University of Leeds; University of Kent; University of Warwick; University of Surrey; and Huddersfield University.
- International links include: Edith Cowan University, Australia; Technical University of Munich; Universidade de Vigo, Spain; Saint Francis Xavier University, Canada; Embry-Riddle Aeronautical University, USA; University of Piraeus, Greece; University of Guelma, Algeria; Prince Sultan University and King Saud University, Saudi Arabia.

IAI's industrial research partners include UK and international rail and airport organisations as already mentioned. Internally, IAI conduct interdisciplinary research work with other DMU institutes (mainly with CCSR, CTI and IOCT) and with institutions and research groups outside DMU which resulted in research outputs, joint PhD supervisions, a Midlands4Cities CDA and research visits.

- National links include: University of Nottingham; Brunel University; Newcastle University; University of Surrey; Heriot Watt University; University of Leicester; Bournemouth University; University of Birmingham; University of Huddersfield; Lancaster University; Liverpool John Moores University; University of Nottingham.

- International links include: Sichuan University; Nanjing University of Aeronautics & Astronautics; Southwest Jiaotong University; Shanghai Maritime University; University of Salerno; Universität Siegen, Germany; University of Granada; University of Salamanca; Complutense University of Madrid; University of Tampere; Iwate Prefectural University; University of Sydney; University of Alberta; Iona College; Vietnam National University Hanoi; EIA University, Colombia; Zigzag University, Egypt.

4.2 CONTRIBUTION TO THE RESEARCH BASE

4.2.1 Research awards:

- **Amira:** Best Presentation at SCORed 2019 conference, Malaysia; Best Paper at IEEE GPECOM 2020 conference, Turkey.
- **Ayesh:** The 2019 ICT Express Best Paper Award.
- **Chiclana:** paper doi: 10.1016/j.knosys.2014.01.017, recipient of the Emerald Citations of Excellence for 2017; Best Paper at the International Fuzzy Systems Association and the European Society for Fuzzy Logic and Technology 2015; and Best Paper at the IEEE International Conference on System Science and Engineering 2015.
- **Maglaras:** Best Paper – 1st International Workshop on Security and Reliability of IoT Systems 2019 in conjunction with DCOSS 2019; Best Paper – IEEE International Conference of Smart Systems and Emerging Technologies (SMARTTECH 2020).
- **SYang:** Best Paper at 2014 IEEE Congress on Evolutionary Computation.
- **Yerima:** 2017 IET Information Security Premium Award.

4.2.2 Membership of disciplinary and professional bodies and networks, journal editorships:

Editors-in-Chief

- **Ayesh:** *International Journal of Computational Complexity and Intelligent Algorithms* (Inderscience: 2016–2020).
- **Chiclana:** Fuzzy Systems section of *Frontiers in Artificial Intelligence*; Fuzzy Set Theory section of *Mathematics* (MDPI).
- **Maglaras:** *Transactions on Security and Safety* (EAI).
- **Stahl:** *ORBIT* journal.

Associate Editors

- **Amira:** *EURASIP Journal on Image and Video Processing*.
- **Chiclana:** *Information Fusion*; *Group Decision and Negotiation*; *IEEE Transactions on Systems, Man, and Cybernetics: Systems*; *International Journal of Fuzzy Systems*; *Information Sciences*; *Journal of Intelligent and Fuzzy Systems*; *International Journal of Intelligent Systems*; *Soft Computing*.
- **Elizondo:** *IEEE Transactions on Neural Networks and Learning Systems*.
- **Fisk:** *European Conference on Information Systems*.
- **Greenfield:** *Journal of Intelligent and Fuzzy Systems*; *Information Sciences*.
- **Maglaras:** *Access* (IEEE); *ICT Express* (Elsevier); *Array* (Elsevier).
- **SYang:** *IEEE Transactions on Evolutionary Computation*; *Information Sciences*; *Enterprise Information Systems*; *IEEE Transactions on Cybernetics*; *Journal of Information and Computing Science*; *Neurocomputing* (2016–2017).

- **YYang:** *IEEE Transaction on Cybernetics*; *Scientific World Journal*; *Journal of Intelligent and Fuzzy Systems*; *Journal of Grey*; *Grey Systems: Theory and Applications*.

Board/steering committee

- **Anastassi:** *Mathematics* (MDPI, 2020–); *The Scientific World Journal* (Hindawi, 2013–2016); *Journal of Theoretical Chemistry* (Hindawi, 2012–2017).
- **Ayesh:** *IEEE Transactions on Affective Computing*.
- **Boiten:** *Formal Aspects of Computing* journal; FOSAD summer school.
- **Caraffini:** *Preprints* (MDPI).
- **Chiclana:** *Knowledge-Based Systems*; *Applied Soft Computing* (2014–2018).
- **Fisk:** *Informatica Medica Slovenica*; *Journal of Enabling Technologies*; *International Journal of Integrated Care* (2014–2015).
- **Flick:** *ETHICOMP* (steering committee chair).
- **Wagner:** *Computer Networks*.
- **Wakunuma:** *Regional Journal of Information and Knowledge Management*.
- **SYang:** *CAAI Transactions on Intelligence Technology*; *International Journal of Bio-Inspired Computation*; *Soft Computing*; *Evolutionary Computation*.

Fellowships/honorary appointments

- **Boiten:** honorary professorship at the University of Kent.
- **Chiclana:** honorary professor in the Department of Mathematics (University of Leicester), 2015–2018; visiting scholar at Department of Computer Science and AI (University of Granada, Spain), 2018–2021.
- **SYang:** visiting professor at Northeastern University, Shenyang, China (2010–); Beijing University of Technology (2017–2019); China University of Geosciences, Wuhan (2017–2019); Xiangtan University, China (2012–2018); Nanjing University of Information Science and Technology, China (2011–2017).
- **YYang:** visiting professor at Nanjing University of Aeronautics and Astronautics.

Invited keynotes, lectures or conference chair

- **Amira:** 2019, invited talk at CompBioMed2019 Conference; Keynote speech at the IEEE I&M Chapter/GDR SoC2 Workshop; 2018, Tutorial at The IEEE ICECS.
- **Aparicio Navarro:** 2019, programme chair, Third Symposium on Software Engineering for Smart Systems.
- **Ayesh:** 2018, co-chair of Big Data AI and Robotics: Digital Futures; 2017, invited talk at the National Assembly for Wales; 2015, co-chair of The European Simulation and Modelling Conference.
- **Boiten:** 2018, invited keynote, SAI Computing conference; 2015, chair, Refinement Workshop at FM.
- **Caraffini:** 2014, organiser and chair of the IEEE Workshop on Memetic Computing at Symposium Series on Computational Intelligence.
- **Chiclana:** 2019, conference organising committee for ITQM; 2016, co-chair of International Conference of Computational Intelligence and Intelligent Systems; 2015, programme co-chair of IEEE International Conference on System Science and Engineering.

- **Elizondo:** 2019, invited speaker to the Simposio en Inteligencia Artificial Aplicada a Imágenes Medicas, Costa Rica.
- **Flick:** 2020, Australian Institute for Computer Ethics conference keynote; 2019, Ingenuity19 keynote; QCon 2019, invited speaker; 2017, invited speaker at World Economic Forum Workshop.
- **Khan:** 2015, organising committee of ICET-2015.
- **Kiraz:** 2017, invited talks at NATO Emerging Security Challenges, Science for Peace and Security Programme in the Field of Cyber Defense, NATO HQ, Brussels, Belgium; 2016, invited talk at 20th Workshop on Elliptic Curve Cryptography.
- **Smith:** 2015, invited talk, Tackling Cyber-Enabled Crime: Delivering an Effective and Efficient Response, Westminster Briefing.
- **Stahl:** 2019, keynote at Equitable AI in Public Health; 2019, keynote at European Computer Science Summit; 2019, presentation to the EPSRC CDT directors' meeting; 2019, contribution to panel on 'Towards a Human-Centred Ethical AI' as part of the Global Conference on 'Principles for AI: Towards a Humanistic Approach?' UNESCO; 2018, keynote at #RespAct ThinkTank: Responsible Innovation 4.0 & Artificial Intelligence; 'Privacy Protection and Data Ownership' panel chair at the conference on Healthcare in the Era of Big Data: Opportunities and Challenges, The New York Academy of Sciences; keynote at the UKAIS; keynote at meeting of the National Ethics Councils Forum and the European Group on Ethics in Science and New Technologies.
- **Wagner:** 2018, invited tutorial for ACM AsiaCCS; 2017, co-chair of Privacy and Security track, IEEE International Smart Cities Conference; 2016, web chair and publicity co-chair of Internet of Vehicles and Vehicles of Internet at ACM MobiHoc; 2016, invited tutorial for IEEE International Smart Cities Conference.
- **Wakunuma:** 2018, opening address at the Digitalisation in Africa: Interdisciplinary Perspectives on Technology Development and Justice Conference; 2015, Convenor and Lead on evaluation workshop on stakeholder engagement at UNESCO.
- **SYang:** 2019, keynote at International Academic Forum on Dynamic Evolutionary Optimization Theory and Applications; keynote at 3rd Asian Conference on Artificial Intelligence Technology; 2018, keynote at International Academic Forum on Dynamic Evolutionary Optimization Theory and Applications; keynote at 9th International Conference on Swarm Intelligence; 2017, keynote at International Academic Forum on Dynamic Evolutionary Optimization Problems; keynote at 23rd International Conference on Soft Computing – MENDEL; 2015, keynote at UK–China Forum on the Design and Creative Industry in Big Data Era; 2014, keynote at 10th Symposium on Logistics Systems Engineering.
- **YYang:** 2015, 2017, 2019, keynote at IEEE International Conference on Grey Systems and Intelligent Services; 2016, 2018, keynote at International Conference on Grey Systems and Uncertainty Analysis; 2015, keynote at International Joint Conference on Rough Sets; 2015, keynote at Leverhulme Trust Network Asia Workshop on Grey Systems; 2015, keynote at Leverhulme Trust International Network European Workshop on Grey Systems; 2015, 2017, 2019, chair programme committee for IEEE International Conference on Grey Systems and Intelligent Services; 2016, 2018, chair programme committee for International Conference on Grey Systems and Uncertainty Analysis; 2015, chair programme committee for International Conference on Advanced Computational Intelligence; 2015, chair of Leverhulme Trust Network Asia Workshop on Grey Systems; 2015, chair of Leverhulme Trust International Network European Workshop on Grey Systems; 2014, 2016, 2017, co-chair of the special session on grey systems at the IEEE International Conferences on Systems, Man and Cybernetics.

- **Yevseyeva:** 2014–2016, chair, Multicriteria Decision Making in Enterprise Information Systems workshop in CENTERIS2016, CENTERIS2015, CENTERIS2014.

Grants committees

- **Boiten:** panel member for EAPLS best PhD thesis award.
- **Fisk:** La Caixa Foundation (second-largest foundation in Europe after the Wellcome Trust, appointed 2018).

Membership of research council or national/international committees

- **Amira:** IEEE Biomedical Circuits and Systems (BIOCAS) Technical Committee.
- **Ayesh:** IEEE Technical Committee on Brain-inspired Cognitive Systems (2018–); IEEE P7010: Wellbeing Metrics Standard for Ethical Artificial Intelligence and Autonomous Systems Working Group (2017–); IEEE SMC technical committee on Robotics and Intelligent Sensing (2002–).
- **Boiten:** EPSRC college member; Academy Finland panel member.
- **Chiclana:** Research Foundation Flanders Expert panel in the Informatics and Knowledge Technology (October 2019–).
- **Fisk:** appointed to Roster of Experts for the World Health Organization Digital Health Technical Committee (2019–); chair of the Board of Trustees of Age Cymru (for Wales, within the Age UK Group) for one year 2018–2019; NICE (National Institute for Health and Care Excellence) Quality Standards Committee 3 (2011–); expert for ANEC (European Consumer Voice in Standardisation), representing their interest on CEN Technical Committees (Quality of Care for Older People) (2016–).
- **Gongora:** AI adviser to the Latin American community of industries managing risk and safety/security as external experts leading advice and policies in AI matters relating to this industry for a community of over 2,000 companies and governments in 15 countries (February 2019–).
- **Maglaras:** member of NIS experts group, ENISA; director of the National Cyber Security Authority of Greece; member of IEEE Standards Development Working Group.
- **Stahl:** EPSRC Peer Review College.
- **SYang:** EPSRC Peer Review College; founding chair, Task Force on Intelligent Network Systems, Intelligent Systems Applications Technical Committee (IEEE CIS), 2012–2017; chair, Task Force on Evolutionary Computation in Dynamic and Uncertain Environments, Evolutionary Computation Technical Committee (IEEE CIS), 2011–2017.
- **Wakunuma:** member of the UK's ESRC Global Challenges Research Fund Peer Review Group.
- **YYang:** EPSRC Associate Peer Review College; executive president of International Association of Grey Systems and Uncertainty Analysis, 2016–; co-chair of Technical Committee on Grey Systems of IEEE Systems, Man, and Cybernetics Society, 2012–; vice-chair of Task Force on Competitions for Fuzzy Systems Technical Committee of IEEE Computational Intelligence Society 2011–2017; deputy director of Institute of Grey System Studies at Nanjing University of Aeronautics and Astronautics, 2010–.

Refereeing research proposals

- ESRC: **Orun**, **Stahl**, **YYang**.
- EPSRC: **Amira**, **Ayesh**, **Chiclana**, **Fisk**, **Kiraz**, **Maglaras**, **Stahl**, **Wagner**, **SYang**, **YYang**.
- MRC: **Amira**, **Stahl**, **YYang**.

- The Royal Society: **Chiclana.**
- UKIERI: **Boiten**.
- European and international research proposals:
    - **Amira:** Australian Research Council, Qatar National Research Fund, Czech Science Foundation, Canadian Funding Agency, the Dutch Research Council.
    - **Boiten:** EU H2020.
    - **Chiclana:** The Research Foundation – Flanders (Belgium); The Romanian National Council for Development and Innovation; Portuguese Foundation for Science and Technology; Austrian Science Fund; Italian Ministry for Education, University and Research MIUR-PRIN 2017; Netherlands Organisation for Scientific Research, Division of Social Sciences; Kazakhstan, National Center of Science and Technology Evaluation; Singapore's 2020 AME IRG & YIRG Grant Calls.
    - **Fisk:** Horizon2020 Programme; Echord++ Programme; European Research Council; European Science Foundation; La Caixa Foundation; National Institute for Health Research; Networks of Centres of Excellence and Mitacs, Canada.
    - **Flick:** Austrian Research Promotion Agency (FFG), 2020.
    - **Khan:** Irish Research Council's Advanced Laureate Awards in 2018.
    - **Kiraz:** NATO Emerging Security Challenges Division, Science for Peace and Security.
    - **Wagner:** EU H2020; ANR (French RC); SNF (Swiss RC).
    - **Wakunuma:** EU H2020-Marie Skłodowska-Curie COFUND Leading Fellows Postdoc Programme for Netherlands; Ethics Expert on European Commission's flagship Future and Emerging Technologies research projects; European Commission monitoring and evaluation expert on funded EU research projects; European Commission Evaluation Expert on Intra-Africa Academic Mobility Scheme research proposals managed by the Education, Audio-visual and Culture Executive Agency; UNESCO's External Reviewer on UNESCO publication on Co-designing science in Africa: 'First Steps in Assessing Sustainability Science from the Ground' (2019).
    - **SYang:** The Netherlands Organisation for Scientific Research, Netherlands; The Portuguese Foundation for Science and Technology, Portugal; The Research Programme 'Archimedes III', Greece; The National Council for Development and Innovation, Romania; The Chilean National Science and Technology Commission, Chile.
    - **YYang:** National Research Foundation (South African); National Science Centre (Poland).

In addition to the above: **Chiclana** is a Highly Cited Scientist in Computer Science in 2018, 2019 and 2020; Prof. Hiroki Idota from Kindai University in Japan was a Honorary Research Fellow at the CCSR Institute during the period September 2018–August 2019; and **Amira** had the Patent 'Using Thermochromic Ink for Blood Simulation in Medical Training' (US Patent Application No. 16/271,651. US20190251869A1, August 2019).