Institution: University of Derby

Unit of Assessment: 11- Computer Science and Informatics

1. Unit context and structure, research and impact strategy

1.1 Introduction and development since 2014
The research environment for Computer Science in the College of Engineering and Technology (CoET) builds upon the foundation of our REF 20214 submission and continues to pursue our aim of "progressively develop[ing] a sustainable, internationally excellent research environment that is highly regarded for societal impact through scholarship, interdisciplinary collaborations, income generation and knowledge contributions in the field of future computing architectures, services and technologies."

The CoET is proud of its location in a City with an historically strong industrial heritage, particularly in transport (automotive, aeronautical and rail). The College has a strong association with the expertise of the City's high-tech engineering industries that are undergoing a data revolution- a perfect alignment with the strategic direction and staff expertise of UoA11. This alignment of region and UoA expertise is evident in our Digital Data Stream Analytics Impact Case Study (ICS) (REF3, 11-1), where we highlight data science applications in the predictive maintenance of rail rolling stock as well as digital twin developments in the supply chain of Rolls Royce, for example.

A key development during this REF cycle has been the construction and commissioning of a HEFCE funded £12.5 million STEM Centre on the Markeaton Street site in September 2017; co-located with the College of Arts, Humanities and Education (AHE). This co-location leads to opportunities for emerging interdisciplinary research collaboration, on, for instance, city planning and more design-oriented aspects of data visualisation. The build gave much needed space to develop our teaching and research and significantly improved our research environment and capability. The STEM Centre hosts the Data Cave as well as specialist Cyber Security facilities and some of our Data Science infrastructure; bringing staff and students into proximity and thus enabling the development of an ecosystem for research and knowledge exchange in which greater synergies can be exploited (an example is **Stella**, an Early-Career Researcher (ECR)**,** who has worked with Undergraduate students to successfully deliver research activity for immersive reality models of disease transmission).

The establishment of the Data Science Research Centre (DSRC) in 2017 under the leadership of **Professor Anjum** until 2019 and now **Professor Meziane,** provides the overarching structure to connect the various research themes in the UoA. DSRC has provided a focal point for UoA11 research activity, focusing on interoperable, interconnected, large-scale e-infrastructures such as cloud computing or the Internet of Things (IoT), covering aspects from system and software architectures through to data analytics, applications of machine learning, data visualisation and security of such systems. The University has made an investment of £1M into the DRSC, of which c. £900k has been invested in academic posts and supporting PGR students. In addition, the DSRC was awarded £250k investment from the Garfield Weston Foundation in 2018 for the creation of a VR equipped Data Cave (Section 3.2.1).

The Rail Research Innovation Centre (RRIC) was launched in March 2019 with a capital investment of £902k from D2N2 LEP (Derby, Derbyshire, Nottingham and Nottinghamshire Local Enterprise Partnership). The RRIC has built on the close collaboration between the University's Institute for Innovation in Sustainable Engineering (IISE) and DSRC, reflecting the data revolution in engineering in the region and internationally. The RRIC, located at Lonsdale House with IISE, hosts High Performance Computing (HPC) facilities for rail related data science applications (Section 3.2).

1.2 Research objectives and strategy

UoA11 aligns to the University Research Strategy (REF5a, 2) and capitalises on the demands in almost all fields of society, industry and government to make better use of data, be able to generate, use and represent data insights and ensure that data is managed securely.

Thus, UoA11 identifies the following strategic aims:

(1) To enhance the research environment through substantial investment, increased external funding income, embedding the Research Ethics Policy and recognising scholarship and research as an integral part of the University's Developmental Performance Review (DPR) process.
(2) To increase the range, quality and quantity of research for the benefit of the taught curriculum, student learning and business engagement.
(3) To expand the capability of research in engagement with business in the City and County through knowledge transfer, training services and research consultancy.
(4) To strengthen postgraduate research provision by enhancing the sense of a postgraduate community, strengthening the programme of research training support and by adopting a risk-based approach to postgraduate student recruitment.

Within this UoA, these aims are realised as follows:

- **Research themes:** The role and visibility of the research themes has been greatly increased, with a core focus on the DSRC at the spine.
- **Membership:** Active membership has increased, with more experienced members mentoring new or less established researchers, often using internal funding opportunities to support this process. Visibility has been improved by increased publications (Section 1.5) and conference presentations coupled with symposia and conference events organised and hosted at the University, or jointly organised and held elsewhere (Section 4). Section 2 details how early careers researchers (ECRs) have been recruited and developed.
- **Research funding** awarded to the UoA falls into diverse categories, with external funding for facilities (Data Cave, RRIC), specific projects aligned to expertise (KTPs and consultancy), and internal funding for enhancements of research environment (e.g. investment in DSRC), PhD/GTA students or ECR research. These income streams have created a virtuous circle positively impacting outputs, better facilities and increased growth opportunity both through this REF period and for the future direction of the Unit (Section 3).

Members of the UoA play an integral part in the College Research Ethics Committee, ensuring central policies and procedures are embedded in the UoA. Research integrity and ethics have particular relevance in the context of our data and data security focused research.

1.3 Research themes

UoA11 incorporates 4 intersecting themes, all led by professorial staff. The use of research themes as a structure for the research activity reflects both the size of UoA11 in terms of staff and, more crucially, the close collaboration between staff, to address end-to-end scenarios including networking, IoT devices, wireless components to data centers, clouds, HPC and Artificial Intelligence (AI). These end-to-end scenarios are crucial in important emerging fields such as Edge and Fog computing, Software-Defined Networking and Virtualisation and their applications. The 4 themes are as follows:

- ***AI and Data Science*** led by **Professor Meziane** engages in applied and fundamental research. The research focuses on the application of machine learning techniques to Edge Computing. Researchers within the group (**Kang**, **Yuan**), were the first to incorporate deep learning techniques in a fully decentralised Edge environment to support intelligent decision-making on the Edge. The potential contribution to the research field is significant as this research designed a novel and efficient network representation model that enables deep learning algorithms to be trained and tested in resource-constrained edge devices. The Research is engaged in explanatory artificial intelligence (AI). For example, work on explaining AI models by discretising the black-box process model of deep neural networks,

using partial differential equations (PDEs) was developed as the PDEs based deterministic models would minimise the time and computational cost of the decision-making process and reduce the chances of uncertainty that make the prediction more trustworthy. The Theme has been instrumental in attracting a number of the UoA's KTPs (Section 3.1).

- *Cyber Security* led by **Professor Kurugollu** has focused on Vehicular Adhoc Network (VANET) and IoT network security, trust management in VANET and IoT, IoT and Cloud forensics, as well as data privacy. In VANET security, the primary concern is trust management. Different methodologies underpinned by blockchain, AI and Machine Learning based techniques have been developed.

- *Data Visualisation* led by **Professor Xue** investigates methods and techniques to summarise, understand and represent data in visual ways, thus making explicit trends and patterns inherent in the data. The techniques are applied in visualising remote sensing data as well as in the creation of immersive analytics in engineering, for example employed in modelling of engineering components. The research has attracted inward investment for the Data Cave (Section 3.2).

- *Distributed Computing and IoT (Internet of Things)* led by **Professor Anjum** and, since 2020 by **Professor Reiff-Marganiec**, investigates computational and data architectures such as cloud and Edge Computing as well as the software architectures creating systems on the platforms. The ICS (REF3, 11-2) with RDS is an achievement of the results of the data processing architecture work of this theme combined with results from the data analytics theme.

Researchers disseminate results through plenary speeches, conference tutorials and workshops (Sections 1.5 and 4.3). The DSRC has increased both the University's external profile in Data Science (Section 1.4) and impact (REF3, 11-1 and REF3, 11-2), as well as research outputs and grant capture of predominantly applied research funding (Section 1.5).

1.4 Enhancing impact
The Strategy to enhance impact within the UoA has concentrated on growing Innovate UK funding, enhancing industrial and international collaboration, and improving vibrancy of the research environment. Each are introduced below, with further detail emerging in later sections:

(1) **Industrial Collaboration and Innovate UK funding**. CoET uses its Industrial Advisory Board (IAB) as an important means of communicating with industry. This has representation from all research themes and from industry, for example: Severn Trent, SNC-Lavalin, Derbyshire Rail Forum, Rolls Royce, Glenair, JCB, Bombardier (now Alstom), Davis Derby, Network Rail, Miller Construction and Toyota. The IAB helps shape the role and involvement of the College with industry. The University investment into DSRC and the opportunities in the Engineering sector for data science stimulated by the IAB discussions (Section 4.1).

(2) **Income streams** have been from industry as detailed in Section 3 and underpin both UoA11 ICSs (REF 3 11-1 and REF 3 11-2).

(3) **International collaboration** (see Section 4.2) has advanced our research, for example with CERN in areas of data science, in Cyber Security with partners in Turkey, and with key partner activities in China.

(4) **Vibrancy of the research environment** is enhanced through the participation of UoA staff and students in the University and regional events such as the inaugural lecture series and 3MT competition, the Researcher Development Programme run centrally by the University Research and Knowledge Exchange Office (URKEO) (REF5a, 3.4.4) and a vibrant DSRC seminar series. Research is a standing item at discipline meetings, supporting the UoA's strategic direction in realising a research-informed curriculum.

1.5 Achievements: Income generation, outputs and impact
The impact of the Research Strategy is evidenced with a dynamic network of external collaborations with industry and academia across the UK, Europe, and beyond, based on a strong core of fundamental and applied research. This has led to near £1M (excluding ERDF grants)

external research funding from a range of sources. This compares with an income of £500k reported in REF2014. Funding details are given in Section 3.

The UoA has demonstrated a successful publication record throughout this assessment period. Members in the UoA have co-authored over 511 publications since 2014, more than 240 of which are in peer-reviewed journals (based on Scopus data). As well as an increase in the volume of publications, the UoA has also increased its contribution to higher quality publications.

1.6 A View to the future
In 2020 CoET merged with the College of Life and Natural Sciences to form the College of Science and Engineering (CoSE) and Computing became part of a School of Computing and Engineering.

The synergies of the new College structure build on the expertise residing in UoA11 and already existing collaborations, for example: on climate and air quality between **Xue** and staff in Built and Natural Environment and expanding collaborations in DSRC's bioinformatics research with **Tripathi's** (UoA3) team and the Facility for Omics Research in Metabolism (FORM). UoA11 expertise in VR/AR (**Reiff-Marganiec** and **Windmill**) to transform urban planning is embedded in the University's first legacy endowment funded research project 'DUST' (Derby Urban Sustainability Transformation), £640k over 3 years led by **Bussell.**

The CoSE is playing a leading role in the development of Infinity Park, a new manufacturing centre focussed innovation and technology park adjacent to Rolls Royce headquarters. The Innovation Hub (iHub) funded by £6.2 million from the Regional Growth Fund (RGF) was the first building on site. The iHub (4700m² floor space) is a collaborative venture involving the Universities of Derby, Cranfield and Aston and offers a programme of innovation support services in alignment with regional engineering activity and has national and global reach. UoA11 is involved with many of the 30 tenants who recognise the commercial need for data science insights to improve their processes. For example, we have delivered initial work with AddQual through ERDF funded interventions and have now secured a KTP to investigate dynamic visualisation of high-performance product characteristics, allowing clearer correlation of each characteristic to inputs, features and changes, thereby offering a holistic view of the product's lifecycle capability.

Data science research with a rail and wider transport focus is a key direction for activity in DSRC. The launch of RRIC will make a significant contribution to the skills and supply chain development for the rail industry in Derby and beyond. Work in rail with Fishbone is evidenced in our ICS (REF3, 11-1).

Our future strategic direction builds upon our reputation in applied data science, with a focus on Edge Computing and data visualisation. This aligns with the Region's strength in transport and engineering and its future low carbon ambitions. This direction resonates too with three of the University's strategic interdisciplinary areas (Data Science, Clean Growth and Advanced Manufacturing).

Table 1.2: Future research strategy success indictors

Strategy 2021-2027 (With reference to REF5a, 2.3)	Indicator of Success
Invest in Talent	Retention and recruitment strategy, establish rolling Graduate Teaching Assistant (GTA) scheme, increase number of staff with SRR to 80%.
Growing Innovation and Increasing Regional Impact	Continue to grow engagement with local businesses, increase direct industry funding/ consultancy, grow data science activity in transport and other application areas.
Increase Research Income	Achieve a position where we have at least 1 funded project per 2 research active staff members at any given time by maintaining the level of success in Innovate UK funding and increase income for consultancy and from research councils.

Delivering Assurance	Optimise use of existing and new systems (CRIS, PhD Manager, UDORA) to allow early management insights and hence better operational and strategic planning.

2. People

2.1 Staffing strategy and staff development
Our staffing strategy is based on strategic recruitment combined with ensuring targeted support and development opportunities for staff and students at all stages of their career. We are focussed on recruiting ECRs with excellent developing research profiles as well as bringing in experienced research leaders. Each staff member is supported to understand the opportunities available to them, and the personal development needed to achieve the next step in their career. This is supported by the central mentoring schemes (REF5a,3.4.2) and our annual appraisal process. The UoA11 staff submission represents a breadth of academic experience, including 4 Professors (**Kurugollu**, **Manning, Reiff-Marganiec**, **Xue**), 2 Associate Professors (**Bagdasar**, **Barnby**) 4 Senior Lecturers (**Farid**, **Hardy**, **Korpelainen**, **Windmill**), 2 Lecturers (**Azad**, **Ali Khan**), and 6 ECRs (**Atlam, Azad, Hardy, Saravi**, **Stella**, **Yuan**).

2.2 Academic staff
The UoA has made substantial investment in research leadership since REF2014. Three Professors with international reputation (**Xue**, **Kurugollu**, **Reiff-Marganiec**) have been appointed, with specialisms in cyber security, IoT, data science, and embedded systems with applications to future smart cities, smart transport and medical applications of data science. Two Associate Professors (**Bagdasar** and **Barnby**) have also been appointed through the internal professorial promotions process (REF5a, 3.4.1). Other staff have moved to more senior roles away from Derby (**Professor Antonopoulos** to Vice Principal at Napier University, **Professor Liu** to Head of School at University of Leicester).

While every staff member in Computing and Maths is allocated a minimum of 10% of their time for research, enterprise and scholarship, a growing percentage (49%) of academic staff in UoA11 have significant responsibility for research (SRR) and thus have a minimum of 20% FTE for research activities. For example, DSRC flexes teaching responsibilities to ensure research commitments are fulfilled (**Kang** and **Yuan**).

All staff in this UoA are engaged in PGR supervision and are required to complete the supervisor training programme before they can join a supervisory team. Additionally, there are PGR Supervision Good Practice seminars hosted by the University's Research and Knowledge Exchange Office to build a community of practice.

2.3 Early-Career Researchers (ECRs)
The development of a more prominent research culture within the University has meant that there has been increased internal support to develop new researchers. These fall broadly into two categories. Some staff are well established but due to a particular career trajectory may not have engaged with research, and now wish to become research active. **Hardy** is an example in the UoA, who has been supported by the University to successfully complete a PhD which has provided the focus to more actively engage with and contribute new dimensions to the research agenda. Others are ECRs. **Yuan** completed his PhD at the University and has since moved to a permanent staff role with SRR. Each ECR is linked with an experienced mentor. For example, from the submitting group for this UoA, **Atlam** is mentored by **Kurugollu**, and **Stella** is mentored by **Reiff-Marganiec**. Development activities for ECRs include masterclasses on key research skills such as publication and bid writing, networking opportunities through seminars and Research Cafes, key skills in research-related areas such as bibliometrics and information technology, as well as developing research impact in wider society (REF5a, 3.4.3).

The University has also provided funding for ECRs in a competitive scheme and **Stella** has acquired support for research using VR for modelling and representing disease spread in the

context of COVID-19, which has led to a publication (Mason, Stella & Bauso, 2020) and the submission of a Leverhulme ECR Application (outcome pending).

2.4 Research Students

The University has invested significantly in the recruitment of PGR students. Seventeen Graduate Teaching Associates (GTAs) have been funded in the UoA since 2014 all of whom are registered PhD students, who also carry adjusted teaching duties.

The number of PGR students has grown throughout the reporting period. Recruitment is through a combination of attraction through reputation (of both the CoET as a whole and individual researchers) and progression from undergraduate and PGT. As of the census date there were 17 PGR students in the UoA encouraging growth in recent years. The number of PhD completions is shown in Table 2.1.

Table 2.1: PhD Completions (HESA)

Ac. Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Completions	1	2	1	1	5	3	1

The University has a strong commitment to assuring the quality of its PGR provision overseen by strong governance structures and, in 2018, introduced PhD Manager which has enhanced the UoAs ability to monitor PGR progression and support. The University provides a researcher development programme (RDP) for PGR students, encompassing key research skills, such as thesis writing, presentation techniques and understanding intellectual property rights (REF5a, 3.4.4). In addition to the RDP the University also provides training support for GTAs.

The Markeaton Lodge situated next to the STEM annex hosts dedicated PGR student offices, with specialist high-performance computing desktop machines to meet data science project needs. This is supported by working alongside academic researchers at all points in their careers, and the use of dedicated specialist equipment.

Since 2017 PGR students have been invited to a University-wide conference as well as encouraged to participate in opportunities, such as the 3MT competition, which gives them a chance to practice presentation skills in a supportive environment. It has also enabled a stronger sense of community to develop between students in different Colleges. Several students from this UoA have presented to these fora.

The University holds an Annual Research and KE Conference, which offers opportunities to network, keep up to date with changes and developments within research as well as hear external experts speak. This is replicated at School level which has seen an increased participation, reflective of the growing influence of research. These events are where researchers hold AGMs and discuss and develop future-focussed plans.

2.5 Visiting Professors and Industrial Advisers

The College benefits from a number of Visiting Professors with expertise aligned to any of the diverse branches of its activities. Current and recent individuals aligned with UoA11 include Dr Andreas Koop (Visiting Professor of Medical Informatics), Patrick Richardson (Visiting Professor of Personalised Medicine) and Professor Alan Sill (Visiting Professor of Distributed Computing).

2.6 Equality and Diversity

The University's commitment to diversity and inclusion is encapsulated in its Equality, Diversity and Inclusion Policy. UoA11 has a wide international staff base with Pakistan, China, Korea, Romania and Turkey among the nationalities represented. Over the last two years among new appointees, around one third identify as female. This is redressing the gender balance, which is skewed towards male, in common with other UoA11 submissions in the sector. At PGR level there is a more even overall representation with ~32% female PhD students.

Statistical data on staff submitted for REF is reported in Table 2.3. The School of Computing and Engineering recognises that it needs to make further progress in increasing female representation in its research staff team.

Table 2.3: UoA11 REF submitted staff by protected characteristics and contract information (%)

Ethnicity Group	
Arab	6
Asian	24
Black	0
Chinese	12
Other/ mixed	6
White	47
Not Known/Refused	6
Gender	
Female	6
Male	94
Disability Group	
Disabled	0
Not Disabled	100

Age Group	
25-34	25
35-44	35
45-54	24
55-64	12
>65	6
Contract Level	
B0	6
E1	6
F1	24
IO	6
JO	59
Contract Type	
Permanent	100

3. Income, infrastructure and facilities

3.1 Research Income

UoA members take considerable pride in the wide-ranging interaction they have had with a variety of industries and funding bodies and the income they have been able to generate from these. Our focus has been on very clear engagement with industry through the vibrant suite of KTPs (Knowledge Transfer Partnerships), other Innovate UK (IUK) projects as well as consultancy income and industrial funding for PhD students.

Income breakdown by year and HESA category is shown in Tables 3.1a and 3.1b, which report on drawn down contributions from grants in the REF period. Discussion of individual projects below describe the income awarded, with figures for KTPs as shown on the KTP portal, which does not reflect the additional industry partner contribution. Some KTPs explore results from a single theme in DSRC, such as a KTP with XAD Communications Limited (£86k, completed 2014) which investigated improved architectures for video processing, in alignment with areas of development in the Distributed Computing and IoT theme; a KTP with Solutions for Retail Brands Limited (£97k, completed 2019) explored applications of data analytics in retail; other KTPs have highlighted the strength of combining themes in the DSRC as they are building on integrating developments. KTPs with Bloc Graphics Limited (£260k running to June 2022 and £133k running to January 2022) investigate applications of research at the intersection of data visualisation/ immersive environments and data analytics.

A KTP with Financial Performance Solutions Limited (£145k running to March 2022; income was £45,000 for FY2019/20) and KTP with RDS Global Limited (£288k running to April 2022; income for 19/20 was £91,000) explores Edge data analytics and computing solutions integrating research insights from three of our research themes (data science, cyber security and IoT) and have led to an ICS (REF3, 11-2) in this REF period already.

We have gained three further KTPs; with AddQual (£119k), Aquis (£152k) and Premtech (£113k) in 2020, which are recruiting associates at the time of submission. The first two are aligned with the data analytics research theme, the third with the data visualisation theme.

Through our collaboration with IISE, the data visualisation theme £16k of direct industrial consultancy projects have been awarded from Amey to explore the use of VR technology in

applications of infrastructure inspection and training. Additional contributions by group members have been made to further projects awarded to IISE from Amey.

The DSRC has been awarded industrial funding for 4 PhD students, 3 in the medical data integration and analytics area from Roche, and 1 in the mechanical engineering area from Rolls Royce to a combined value of £215k.

Table 3.1a: Research income by year in the REF period

Year	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Amount (GBP)	102,000	103,000	42,000	97,000	51,000	122,000	316,000

Table 3.1b: Research income by HESA category

Category	Amount (GBP)
Research Councils	4,000
UK-based charities (competitive process)	53,000
UK central government bodies/local, health and hospital authorities	273,000
UK Industry, Commerce and public corporations	353,000
UK Other sources	23,000
EU Government bodies	3,000
EU Industry, Commerce and public corporations	120,000
Non-EU based charities (open competitive process)	4,000
Non-EU Industry, Commerce and public corporations	137,000
Totals	970,000

3.2 Infrastructure and facilities

3.2.1 Specialist Facilities

In 2018 the Data Visualisation Laboratory, comprising a VR-equipped Data Cave and laboratory with VR headsets was opened. It is funded by a £250,000 grant from the Garfield Weston Foundation. The Data Cave is used in both teaching and research. These facilities have been instrumental in consultancy work undertaken with Amey in 2018 and 2019.

The University has also invested in a data centre, primarily focussed on the rail sector with opportunities for wider use. It was partly funded by a D2N2 grant of approx. £300,000 as part of the RRIC investment. Equipment in this facility includes a £280k Nutanix Supercomputer, digitisation and VR equipment as well as suitable software for data visualisation and immersive environment creation. Early results for the usage of these systems are described in the Distributed Data Analytics ICS (REF3, 11-1), especially the work undertaken with Bloc Digital and Fishbone.

A UoA11 team, working with the University's IT Services department, were key in launching a 'node' of the Worldwide LHC Computing Grid (WLCG) which has been operating since June 2018, processing simulation jobs for the A Large Ion Collider Experiment (ALICE). This has given the UoA valuable experience in the technologies and in the operation of a trusted distributed system. It has involved collaboration with members of the GRIDPP consortium from the Rutherford Appleton Laboratory to bootstrap the node and the WLCG members from the European Council for Nuclear Research (CERN) for operations. The Grid operates with a system of securely issued electronic certificates to allow use of resources by all members of the ALICE Collaboration.

Currently it is a proof-of-principle system which has made a modest contribution of around 0.03% of the computing resources used by ALICE.

Aside from the facilities discussed, UoA members are also responsible for the operation of Virtual Reality and 3D printing labs in the iHub (Infinity Park).

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

4.1 Industrial collaboration
Research in the CoET is often collaborative, with researchers from industrial partners and much of the grant income detailed earlier shows our close interaction with industry and is evidenced by our Impact Case Studies (REF3).

DSRC and IISE have been a successful partnership in creating links to industrial partners, for example Fishbone worked with RRIC/IISE before moving quickly to also work with DSRC on a data science project in relation to predictive maintenance (**Anjum**, supported by a PhD student). Another example of this collaboration between researchers in CoET is a consultancy project funded directly by Amey in 2019-20 investigating opportunities for Data Visualisation capabilities relating to rail infrastructure upgrades. This Project used the DSRC data visualisation capabilities and was managed collaboratively between IISE and DSRC with delivery driven by **Windmill**, **Davies** (then UG, now PhD student) and **Merrit** (PhD student).

Our distributed data analytics ICS (REF3, 11-1) evidences a range of work with local SMEs through a structured approach of small investigative projects, often supported by students. These initial collaborations have grown into more stable partnerships leading to ERDF funded interventions and have been accelerated to KTP or larger consultancy interactions. Our KTPs with Bloc Digital involve **Yuan**, **Stella**, **Anjum**, **Manning** and **Reiff-Marganiec**; whilst for RDS/FPS **Kurugollu**, **Saravi** and **Yuan** have provided the academic knowledge.

4.2 International collaboration
UoA members are themselves an international community; they enjoy extensive international connections, leading to numerous opportunities for collaboration. Individual contributions are varied, with examples summarised below.

From his arrival in 2016, **Xue** collaborated internationally with EAS Aerosol and the EU Marco Polo projects as a data validation expert. In each case, along with other UoD staff, **Bi** (Research Assistant) and **Windmill** worked to produce independently validated high quality algorithms for the processing of long-term records of global aerosol properties from satellite instruments. This work has fed into the NERC U-ALERT project (NE/N020677/1) investigating the impact of Climate Change in Africa.

In July 2015 UoD signed an agreement to join the ALICE Collaboration, as an Associate member, joining over 150 Institutes worldwide. The agreement focuses on collaboration with the software framework and applications of the *O2* project. This is concerned with upgrades to ensure successful data-taking, with rate increases of up to a factor 100, with the upgraded ALICE detector after the Large Hadron Collider (LHC) shutdown period. At the time, the shutdown was planned to last until early 2021 but this has now been extended to 2022.

Staff, including **Anjum** (up to 2019) and **Barnby** (from 2016), have collaborated, along with their PhD students on areas of the *O2* project including AI-assisted data monitoring, smart job scheduling and algorithmic improvements to reconstructing the signals of interest. In addition, **Barnby** currently co-leads a specialist data analysis group of around 20 regular contributors and has attracted current (ST/P005047/1, £18k) and future (ST/V001094/1, £96k) grant funding from the Science and Technology Facilities Council (STFC) for this work.

Reiff-Marganiec has long-standing collaborations with ICMC (USP) and UNIFEI (Itajuba) in Brazil, which he has brought to UoD and which are investigating Cloud and Web Services as software architectures for IoT; he hosted a visiting scholar from USP in Spring/Summer 2020. Several publications have recently resulted from these collaborations and further visits are being planned.

The joint project "Computational Models for the reproduction of ceramic colours" between the University of Alba Iulia, University of Derby and IPEC Alba Iulia (leading ceramics suppliers for IKEA, concluded in December 2018). The Project aimed to optimise the reproduction and correction of ceramic colours and was financed by a grant of 103K Euro (PN-III-P2-2.1-PED-2016-1835). Three UoD Mathematics students supported by Erasmus traineeships worked on the statistical modelling and the design of a graphical user interface in the Summer of 2018 under the leadership of **Bagdasar**. Two of them, Manzal and Chandni Mohammad, were also sponsored by the University's Undergraduate Research Student Scholarship scheme (URSS), in line with our strategy of investing in talent. The results have been presented at the URSS conference in October 2018 and the Jiangsu 20-20 workshop in China in December 2019.

Our involvement in the Jiangsu 20-20 collaboration creates a significant link to China, with leadership by **Paneerselvam** and **Yuan**, but also now involving further colleagues such as **Reiff-Marganiec** who presented at the Jiangsu 20-20 AGM in 2020. **Yuan** is using the consortium to explore opportunities for his work in Data Science in Agriculture and food security.

4.3 Contributions to the scientific community
UoA members have played a wide range of leading roles in the scientific community, for example as conference organisers, session chairs, journal editors, keynote speakers, chairs or members of professional panels, or advisers to professional bodies. Expertise exercised in this way is brought back to benefit the overall academic community of the College. Example individual contributions are given below.

Visiting Roles: Some of our more senior staff have been invited for research visits funded by grants offered or secured by the inviting organisations, such as **Kurugollu**'s 4 week visit to Tubitak Marmara Research Centre, Turkey (2019), **Reiff-Marganiec** visit to China University of Petroleum (2014, 2019) and Harbin University (2019) as well UNIFEI (Brazil, 2018, 2019). **Xue** holds Visiting Professorships at the Chinese Academy of Sciences, the Chinese Meteorological Administration, China and at Chongqing University, China.

Ali Khan has been nominated ACM Distinguished Speaker in July 2020, with presentations focusing on data analytics and software engineering for medical informatics.

Our researchers are further recognised and shaping research agendas nationally and internationally through invited contributions to funding review panels. For example, staff are expert reviewers for: Austrian Research Promotion Agency (FFG) funding programme **"**R&D Infrastructure Funding" **(Reiff-Marganiec)** (2016-present); UKRI Science and Technology Facilities Council "Projects Peer Review Panel" (**Barnby**) (2019); NOW (Dutch Research Council) Open Competition Domain Science (**Xue**, 2019) and Member of Associate College of Engineering and Physical Sciences Research Council (EPSRC) (**Kurugollu**).

Editorial positions and esteem factors. Staff members hold editorial positions for journals, contribute to conferences with invited presentations as well as holding roles as Technical Programme Committee or Conference chairs. Staff also contribute as session chairs, programme committee members and frequently present work at conferences, however we see this as a baseline expectation so do not report here. The following list highlights, organised by staff members, some of their involvement in these activities:

- **Anjum**: Keynote Talk, 13th International Symposium on 'Smart Micro Grids for Sustainable Energy Sources enabled by Photonics and IoT Sensors' (Cyprus 2016), Programme Chair 12th International Conference on Utility and Cloud Computing (UCC 2019) combined with long standing service to UCC (General Chair in 2017 (Texas) and 2015 (Cyprus) and Organising Chair in 2014 (London)), General Chair IEEE/ACM International conference on Fog and Edge Computing (FEC 2017, Madrid) and Programme Chair, 3rd International Symposium on Big Data Computing, Applications and Technologies (BDCAT 2016, Shanghai, China).
- **Bagdasar**: Chair of "The Knowledge Triangle: Mathematics Applied to Industry", within the Exploratory Workshop on "Internationalisation of Higher Education: Challenges and Rewards" (2015, Alba Iulia, Romania) and co-Chair and local host of 2nd IMA Conference on Theoretical and Computational Discrete Mathematics (2018, Derby).

- **Farid** has contributed to the standards roadmap white paper for the IEEE 2957 Big Data Governance and Metadata Management standard in the areas of healthcare and mental health.
- **Kurugollu**: Technical Program Chair of 5th International Conference on Cloud and Big Data Computing (ICCBDC 2021), Programme chair of 3rd International Conference on Cloud and Big Data Computing (ICCBDC 2019), General chair of 2nd International Symposium on EmeRging Technologies in the Era of 5G-based Internet of Things, 2020, General co-chair, 2nd International Workshop on Vehicular Networks over Future Internet Architecture, 2019, Guest Editor for Special Issue in Sensors Journal, 2020.
- **Paneerselvam**: Programme Chair for IEEE RTDPCC 2019, Programme Chair for IEEE DMTS 2019, Reviewer for IEEE Transactions on Parallel and Distributed Systems, IEEE Transactions on Sustainable Computing, IEEE Transactions on Cloud Computing and IEEE Access Journal,
- **Reiff-Marganiec** (since joining Derby in 2019): PC co-Chair of SOSE 2020 (IEEE Service Oriented Software Engineering) and elected as General co-Chair of SOSE 2021, General Workshop Chair for the IEEE Services Congress 2020 (overall decision making on all 9 workshops associated with the conference to ensure suitable alignment, relevance as well as quality control), Invited panellist at IEEE Big Data Service 2020 panel on "Big Data and AI for Tomorrow", Guest Editor (Special Issue "Recent Advances in Web Services Research, IEEE Transactions on Service Computing, 2019) and reviewer for IEEE Access Journal, International Journal of Distributed Sensor Networks, IEEE Transactions on Service Computing.
- **Xue**: Associate Editor for the International Journal of Remote Sensing published by Taylor and Francis Group and Associate Editor for the International Journal of Digital Earth published by Taylor and Francis Group.
- **Yuan**: Reviewer of IEEE Transactions on Industrial Informatics, Peer-to-Peer Networking and Applications, IEEE Access, IEEE Internet of Things Journal, ACM Transactions on Intelligent Systems and Technology, Information Sciences – Journal, Chair for MLHI2020 (at UCC2020), Workshop co-chair of ScalCom 2019.

Overall, we presented an environment that is vibrant and enabling our applied research as well as ECRs to flourish. The Environment has significantly evolved from our REF2014 submission in terms of internal investment, but also in terms of external funding, outputs and activity profiles, and we consider direction of travel over the last 7 years as one to continue and grow.