Institution: The Open University

Unit of Assessment: B11

1. Unit context and structure, research and impact strategy

1.1 Context and Structure

Computing research in the B11 Unit of Assessment at the Open University (OU) is ***people-centred***. Research in this unit integrates technology into human activities, supporting human needs through technology and augmenting human capabilities to shape and influence the development of technology in our daily lives. It addresses socio-technical problems, which is particularly relevant in the current era when computing is fully integrated in society and society is an integral part of computing.

The overall environment of the OU shapes and is shaped by B11's research. Following from the social justice mission of the OU, researchers in the B11 Unit of Assessment conduct research in computing technologies for ***social good***. For example, research in digital health has contributed to the development of tools to support patients and doctors to monitor the level of pain in patients with knee issues, the development of haptic devices to help patients to recover from neurological conditions and the involvement of visually-impaired in artistic activities. Similarly, research in animal computer interaction has contributed to the training of dogs to support people with disabilities and the development of bio-sensing technology to assist with cancer detection. Other examples include the development of learning applications to improve and innovate teaching practices; methods and tools to support social interaction; applications for smart cities through the MK:Smart project including the areas of transport, energy, water, and citizen and business engagement; security, privacy-aware and forensic-ready technologies for cyber-physical systems; the use of AI technologies to support citizen scientists in pollination studies; and social media analysis through natural language processing techniques to highlight misogyny and other forms of hatred.

B11's research follows the OU's mission to use technical innovations in order to support ***openness*** to people, places, methods and ideas in a scalable way. For example, the CORE system (an impact case) is considered the world's largest open access collection of research papers; the OUAnalyse system (another impact case) supports an open dataset with learning analytics data for more than 40,000 students used by both internal and external parties; work on blockchain gives users ownership and control of their own data; and work in digital health technologies empowers patients to take control of their treatment.

Two collaborative entities contribute to B11: The *Knowledge Media Institute* (**KMi**) and the *School of Computing and Communications* (**C&C**), and both are part of the Faculty of Science, Technology, Engineering and Mathematics (**STEM**). Altogether, the unit includes 47 research-active staff with 12 Professors, 21 Senior Lecturers and Readers, three Senior Research Fellows, four Lecturers and seven Research Fellows.

The research income has increased from £11m in the REF2014 period to £19m in the REF2021 period, an increase of 30% after considering inflation and the longer REF2021 period. The unit has published 1220 outputs in peer-reviewed international venues and has enjoyed considerable international esteem (see 4.2). Table 1 compares key indicators for different assessment periods.

Table 1: Key sustainability indicators

	External Research Income				Staff	PhD Students	
	National	**International**	**Industrial**	**Total**	**Cat-A**	**Total**	**Completed**
RAE 2008	£2.9m	£3.8m	£0.3m	£7.0m	24	56	20
REF 2014	£3.5m	£7.3m	£0.2m	£11.0m	32	81	47
REF 2021	£8.5m	£9.3m	£1.2m	£19.0m	47	93	64

Building on the research described in REF 2014, we collaborate on a multidisciplinary research agenda, which spans four main research themes with international recognition, and a body of work with several years of impact:

- HCC: Human-Centred Computing
- LMT: Learning and Multimedia Technologies
- SEAD: Software Engineering and Design
- AIDA: Artificial Intelligence and Data Analysis (established since REF2014)

OU researchers in the unit work freely within and across research themes and topics, collaborating and sharing projects, and participating in a single PhD programme and joint seminar series.

Achievements of Research Goals since REF 2014

Since 2014, the OU's Unit of Assessment B11 continued to successfully:

- Address and extend our vision for people-centred computing for the social good;
- Engage in current research themes and identify new research lines, e.g., AI and Data Analysis;
- Develop inter-disciplinary and cross-boundary collaborations that reflect the complex societal contexts in which computing systems are deployed;
- Maintain and expand our well-established research infrastructure and funding sources both nationally and internationally;
- Generate impact based on a unit-wide strategy supported by a dedicated business development manager, an in-house systems and development team, and a communications manager.

1.2 Research Themes

The research themes across the unit have overlapping membership. Researchers meet periodically to discuss work in their respective fields, present seminars and discuss topics, identify funding opportunities and mentor colleagues. Themes operate in groups whose leaders meet regularly to review the overall strategy. This dynamic collaboration enables responsiveness, cross-fertilisation and consonance with our overall strategy. We use the unit's own in-house infrastructure to support online collaboration.

1.2.1 HCC: Human-centred computing

Researchers: Bowers, Gooch, M Hall, Holland, Laney, van der Linden, Mancini, Mulholland, Petre (retired), Price, Ramage, Sharp

HCC at the OU takes a bottom-up approach to designing and deploying computing technologies for real-world needs and activities – whether in homes, hospitals, museums, or cities. This allows us to empower end-users and encourages their engagement with such technologies. We specialise in novel interfaces (e.g., haptics, wearables, embedded technologies), the integration of technology into activities (e.g., music making, healthcare, working with animals), and effective design practice. Distinguishing features of our research are a methodological focus on understanding technology in context in-the-wild, and co-designing with the direct beneficiaries of the technologies, often in challenging circumstances.

Key accomplishments

We have developed Painpad as a **digital health technology**; it is a simple handheld device that enables patients to self-report about pain levels, and that provides more accurate and complete results than nurse prompting. This collaboration with clinicians at Milton Keynes University Hospital (MKUH) led to a roll out of tangible devices across several MKUH wards and two private hospitals,

and the formation of a spin-out company to explore commercial exploitation. Work on haptic wearables for co-ordinating the limb movement of drummers led to an innovative approach for improving the mobility of people with neurological conditions, including stroke. These examples exploit synergies across our research themes and groups, here software engineering and music computing informing digital health.

Our research on embodied technologies for **arts and theatre** explores how new forms of haptics and wearables can improve direct involvement for diverse people, including visually-impaired people. Flatland (Nesta, 2014-2015), the collaboration between a blind theatre director, robotics engineers and our researchers, investigated how to stage a theatre play that is not visible, but is directed through haptic technologies. Using electronic textiles, we work with visually-impaired makers and organisations, including Royal National Institute of Blind (RNIB), Tate Gallery and Whitechapel Gallery, to enable users to create art pieces based on sound and touch pushing the possibilities of accessible technologies.

We lead research on **community-based technologies** to create change in local communities. In collaboration with E.ON, we created an IoT testbed of 50 homes to enable householders to 'have conversations with their washing machines', in support of energy-demand-shifting practices with solar energy. Our HEFCE-funded MK-Smart project (2014-2017, £17M) in collaboration with Community Action MK, ran an initiative at city scale to solicit ideas for – and then develop – projects that embed 'smartness' into community concerns, from breastfeeding apps for new mothers to a community fridge.

Animal-computer interaction (ACI) seeks to advance the science of designing animal-centred interactive systems fit for a multi-species society. Canine-centred controls developed with the leading UK Charity Dogs for Good have significantly improved training efficiency for dogs that support people with disabilities nationwide. Our interfaces for Bio-sensing technology developed with the UK Charity Medical Detection Dogs, worldwide leaders of cancer detection with dogs, enables the nuanced interpretation of canine olfactory responses for earlier disease detection. This was showcased at the 2014 Royal Society Summer Science Exhibition. We have led the consolidation of the new field of ACI, and in 2014 established the ACI conference in cooperation with ACM.

Our **design studies** research addresses two key perspectives: UX design in software-based products and design dialogues among software developers. We undertake rich empirical studies in industry – informing practices, representations and tools. We produced empirically-grounded insights for designers in our pocketbook DSDM and UX Design project and book Software Design Decoded, which have in turn led to invitations for podcasts and collaborations (e.g., UX in software startups in Sao Paolo; work with Mozilla and NextGen Healthcare on design dialogues).

1.2.2 LMT: Learning and Multimedia Technologies

Researchers: Bromley, Charlton, De Liddo, Dooley, Fernandez, Jones, Knoth, Hlosta, Mikroyannidis, Kouadri Mostefaoui, Motta, Osborne, Schibelsky G Piccolo, Rosewell, Rueger, Siddharthan, Song, Smith, Wong

LMT is concerned with digital learning and social engagement technologies, which have significant infrastructural demands for reliable connectivity and rich multimedia content. The challenge is to bring demand-driven information and knowledge meaningfully to learners and consumers, and to provide contextual meaning to enrich and transform society and business.

Our research in LMT seeks to develop tangible solutions for students or members of society. We involve users of the developed technologies in co-designing solutions, by approaching problems from a broader socio-technological perspective. For example, using augmented scalable data

mining techniques with semantic technologies to improve system performance and explainability.

Key accomplishments

Our research on **technology for learning** draws on our proven track record of teaching innovation and expertise, established in online and distance learning. The work is central to current educational debates given the increasing prevalence of e-learning and social approaches to learning. Outreach and enquiry are evidenced by the iSpot project, an innovative Social Citizen Science Platform about the natural world, to help the public identify plants and animals. As of 2020 the platform has gathered 1.5m photographs yielding 850,000 biological observations of 30,000 species by 75,000 citizens. iSpot data have contributed to national and international datasets used for conservation and planning purposes, e.g., to the UK mammal atlas, iSpot partners and the State of Nature reports.

Our research into **predictive learning analytics** has also led to significant enhancements in teaching practice. Results from this work have been deployed in the OUAnalyse system, which is used in over 250 undergraduate modules by 4,500 tutors at the OU. A formal evaluation revealed that OUAnalyse tutor usage is one of the two significant predictors of whether students will complete and pass a module. OUAnalyse has been adapted to a face-to-face setting at the Czech Technical University (Prague), which after deployment in 2015, saw the average first-year student drop-out rate decrease from 33% to 19%. OUAnalyse received the 2020 DataIQ Award.

Work in **Information Retrieval** investigates state-of-the-art quantum models of human cognition of language. As well as developing the foundations of the theory, we have applied our ideas to search personalisation, question answering, multimodal and conversational sentiment analysis, and exploratory of Web and domain-specific collection.

We investigate theories, methods and tools accounting for the **centrality of social interaction** and discourse in public engagement, urban informatics, e-democracy (see also ICS1), and social innovation contexts. Our research focuses on models of dialogue and argumentation; models of crowdsourcing and participatory representation; and the design, implementation and uptake of online systems that seek to increase collective environmental awareness and capacity to make sense of complex issues, like social justice and environmental sustainability.

We also undertake research in various areas relevant to the development of **user-centric, intelligent, data-intensive solutions:** application domains include Smart Cities, Scholarly Data and Digital Humanities, while key achievements include the development of MK Data Hub, which won The Smart Cities UK Awards 2017 – 1st prize in the Data category, and an innovative approach to automatically generate scientific taxonomies, adopted by Springer Nature.

Research into *next generation* **multimedia technologies** seeks to collaboratively synthesise advanced innovative paradigms and tools for real-world applications, which are nascent from the compelling convergence of mobile communications, multimedia processing and ICT systems.
Key achievements include an UK Space Agency funded project TreeView**:** Precision Forestry to Tackle Climate Change, (NSIP, 2020-21) to develop on-board satellite ICT solutions for climate action; and award-winning multimodal medical imaging collaboration with the Deutsches Zentrum für Luft- und Raumfahrt (ABB-sponsored Postgraduate First Prize, IET Industry Awards, 2014).

1.2.3 SEAD: Software engineering and design

Researchers: Bandara, Barroca, Bennaceur, J Hall, Kennedy, Nuseibeh, Petre (retired), Price, Rapanotti, Sharp, Tun, Wermelinger, Yu, Zisman

Our research in software engineering recognises the ubiquity of 'software in the world' through investigations that challenge disciplinary boundaries in order to empower users and developers.

Through this work, we advance several interrelated software engineering areas: automated software engineering; security, privacy and digital forensics; engineering adaptive software; and empirical studies of software development. The multidisciplinary nature of our research has led to deep and sustained collaborations with researchers from other disciplines including psychology, business and law.

Key accomplishments

We have framed the agenda for research in **engineering adaptive software** that is *secure, privacy-aware* and *forensic-ready* (ERC Advanced Grant, 2013-2018). Our patented adaptive security techniques (2016, 2019, see 1.4.3) have demonstrated that a precise specification of contextual factors can support dynamic adaptation of security controls in complex cyber-physical systems. Our innovative adaptive sharing frameworks provided formally-based computational techniques for privacy trade-off management and adaptive architectures that integrate social-identity with privacy-awareness. We developed foundations, adaptive techniques, and practical methods to engineer **forensics-ready cyber-physical systems**. For example, in collaboration with Gwent Police we developed Social Lift, a tool for privacy-aware forensic evidence collection from social media platforms. Our work has received best paper awards (e.g. TrustCom 2014, SEAMS 2018) and has led to significant industry engagement (e.g., our asset-centric adaptive security technology was funded and adopted by UTC/Lenel in their OnGuard™ security software with over 20,000 global installations).

Our work on **software engineering techniques for IoT applications** has resulted in new frameworks for dynamic composition of components in cyber-physical systems and provided end-users with usable tools to program IoT applications. We have advanced the understanding of **usable privacy** through innovative empirical studies of mobile applications design in healthcare and use of wearable technologies in the wild. By combining our expertise in engineering privacy management technologies with the IoT, we patented and developed "Privacy Band", a novel tangible privacy management device that received the IET Cyber Security Innovation Award (2017).

We have advocated for and pioneered the use of ethnography **in empirical software engineering**. Most recently we used this approach to explore how professional software developers engage with security, and using our theory-building work as a starting point, we produced four NCSC-endorsed practitioner toolkits for sensitising software engineers to security concerns. Practitioner engagement is key to our empirical research activity, contributing to new understandings of technical and social factors that impact on practice. As co-founders of the Agile Research Network, since 2013 we have helped organisations reflect on and address a range of agile challenges and won the best paper award at XP 2015.

Our research on **automated software engineering** has advanced automated **traceability** techniques to enhance software development processes in general, and key activities such as bug localisation, security bug reporting**,** and refactoring. Our patented automated parsing technology is currently being developed and trialled in Huawei's global software engineering laboratory.

Our research has also substantially enhanced the performance, reliability and usability of **service-oriented systems**, in particular optimising web services composition in business processes, scalability of secure communications, and integration of **digital and human services**. We have developed innovative requirements and design methods that have led to significant advances in **systems safety**; for example in rail, naval and aerospace applications. Our distributed drone flight management architecture and simulation environment is being developed and trialled by NATS, with the support of Nesta's Flying High Challenge award and then an Engage KTN.

1.2.4 AIDA: Artificial Intelligence and Data Analysis

Researchers: Alani, Daga, Domingue, Fernandez, Knoth, Motta, Osborne, Piwek, Rueger, Siddharthan, Third, Willis

The Artificial Intelligence (AI) and Data Analysis work at the OU tackles socially relevant phenomena such as web behaviour and data privacy, and develops technologies to help the public engage with the complex social, political and environmental debates of the time.

Key accomplishments

Our research on **social phenomena on the Web** helped uncover child grooming behaviour patterns, detect radicalisation and classify social media crisis information. This interdisciplinary research has attracted over £6m in funding in the last seven years, producing a number of key insights. Our findings on online misogynistic communities and our analysis of the spread of COVID-19 misinformation were covered by several mainstream media outlets, including BBC radio and TV, and WIRED Magazine. The latter also formed the basis for a submission to the UK Parliament's DCMS Select Committee.

Research in **natural language processing** for social media analysis has combined linguistic and data analyses of Twitter networks to understand how audiences perceive large institutions. In the context of an AHRC-funded project Russia Today (2017-2020), researchers at the OU brought new computational insights to partners in sociology and languages to challenge widely held views on the Russian broadcaster Russia Today.

We design AI technologies for engaging the public with **societally relevant issues.** Our research develops Natural Language Generation, Image Recognition, Recommender systems and Bayesian Consensus models for citizen science and outdoor learning around biodiversity, supported by the EPSRC-funded project Human Computer Collaborative Learning in Citizen Science, and funding from NERC, National Geographic and H2020. The research integrates these into school curricula using pollination as a case study and has been referenced in the UKRI public engagement strategy and was recently showcased by Defra during Bees' Needs Week 2020. The unit's work is also supported by the EPSRC-funded project Opening Up Minds: Engaging Dialogue Generated from Argument Maps (2020-2022), which builds on our expertise in modelling dialogue, including non-cooperative dialogue, to influence people's appreciation of the complexity of societal debates and attendant ability to comprehend the world from other people's point of view.

We also tackle challenging topics around **data privacy**. The unit's work on Distributed Ledger Technologies investigates how personal data can be decentralised, giving users ownership and control whilst maintaining integrity guarantees. This work has attracted over £1m in funding through a number of projects, including a cross-university platform for storing, sharing and verifying qualifications (QualiChain, 2018-2021) and the Institute of Coding (IoC, 2017-2021). The work has been highlighted in the European Commission's JRC Science for Policy Reports (2017 and 2019), and in a report from the American Council on Education (2020). We produced the world's first decentralised privacy-preserving certification system for COVID-19, an achievement that was extensively reported in the media.

We offer two large initiatives to improve information access to **scholarly publications**. Our work on CORE (multiple grants totalling £2.7m and licence income of £200k) develops new techniques in machine processing of scholarly information. As of 2020, CORE hosts 25 million open access articles (nine times bigger than the world's second-largest open access collection of research papers), has over 40 million monthly active users, and is among the top 1500 websites globally according to Alexa. CORE has been selected by Research England to support the REF 2021 audit on open access compliance. Recent adopters of CORE include arXiv, the most widely used ePrints server in the world. We have also developed a strategic partnership with Springer Nature, which has funded our research since 2014 to generate value from scholarly data. A key result is the Computer Science Ontology, a taxonomy of research areas in Computing, which is an order of

magnitude bigger than the most widely used alternative, the ACM Computing Classification. Building on this work, OU researchers developed the Smart Topic Miner system, which has been in routine use at Springer Nature since 2016. This research has also focused on the automatic generation of large-scale scholarly knowledge graphs. Outputs include the Artificial Intelligence Knowledge Graph, a knowledge base with 850k elements extracted from the most cited 330k articles in AI; and Academia Industry Dynamics, a knowledge graph that integrates information about 21m publications and 8m patents.

1.3 Research Strategy

The unit's strategy is to extend research on dependable, usable and useful software to encompass and promote responsible Computing in its four research themes. Its main goals are to:

- Excel in research for the social good;
- Empower our researchers;
- Expand multidisciplinary and cross-boundary activities;
- Innovate the nature of learning.

Excellence in research is achieved by focussing on our four research themes. Researchers in the unit participate in one or more research groups in the four research themes across the unit. Horizon scanning for funding opportunities happens at University and Faculty level for large collaborative grants, and at research groups and individual level. This informs our decisions as to which funding opportunities fit best for the research portfolio. Researchers pursue opportunities that promise impact on social good and track evidence of achievements.

We **empower our researchers** through a collegiate environment that gives everyone the opportunity to grow. Although we occasionally recruit senior positions, predominantly the unit develops researchers to more senior positions from junior intake. Within our pipeline of proposal development and execution, members in the unit share leading grant application processes, leadership of work packages and research tasks around, as appropriate, allowing colleagues to mature. This provides researchers opportunity to grow as intellectual leaders in their research areas with external profile, managers of large projects, and members of their respective research communities. Staff development, training and promotions are described in detail in Section 2.

We **expand multidisciplinary and cross-boundary activities** by fluid and soft research group membership and by a culture of actively reaching out to colleagues in Faculty, University and outside organisations. We share PhD students between C&C and KMi and across research themes. Researchers organise joint seminars and hold a regular overarching research fiesta together with other mechanisms described in Section 2. We actively pursue networking opportunities through European networks of excellence, EPSRC networks and industrial networks (see Sections 2 & 3).

Computing research leads **OU innovation**. Staff in KMi have research-only posts to act as technology catalysts enabling the introduction of radically new ways of learning. KMi acts as an innovation lab that is focused on providing a good technical and physical infrastructure to foster creativity, experimentation and prototyping of ground-breaking technologies. Key to successful innovation is the inclusion of full mirrors of the OU teaching infrastructure; highly skilled development resources to transform research prototypes into minimum viable products and scalable enterprise solutions; access to a large pilot pool of OU students and their data. We maintain and enhance our links with all OU key stakeholders, and reach out to the world of technology for education through external projects and partnerships.

Our **future strategy** centres on aligning research even more closely to the OU's social mission and the UN Strategic Development goals. The result is a discipline that engages and empowers the creation of resilient socio-technical systems that meet personal challenges and enhance collective lives. We are currently forming an alliance with the Data Science centre at VISA Europe to co-investigate bias in AI models and associated social justice issues. In a forthcoming CHIST-

ERA project, CIMPLE (2021-2024), we will bring together AI and Creative Computing to produce explanations of information manipulation. Through the EPSRC-funded Trustworthy Autonomous Systems Node in Resilience project (2020-2024), we will build on our adaptive systems research to develop automated techniques for collaborative autonomous systems for healthcare and emergency response, and through the UKRI-funded SERVICE project (2020-2022) we will continue to support vulnerable individuals in our society. Further examples of likely future engagement are:

- New digital health technologies including further spin-out companies;
- Autonomous systems for healthcare and emergency response;
- Accessible European musical heritage and entertainment performance events;
- Conservation of endangered animals and improving the welfare of farmed animals;
- Global open access of scientific work by progressing our work on CORE;
- Solutions to practitioner-identified problems with the Agile Research Network;
- Haptics for visually impaired designers;
- Accelerated convergence of mobile communications, multimedia technologies and machine learning for digital learning;
- Solutions to model news dynamic, focusing on identifying bias, blind spots and (lack of) viewpoint diversity in the media using data, NLP and AI technologies;
- Environmental monitoring methods, e.g., through the analysis of images and audio using AI.

1.4 Impact Strategy

1.4.1 Impact Strategy Goals

The unit develops research with **impact for the social good.** To achieve this we:

- Establish and maintain medium to long-term links with impact partners;
- Maintain a systems team and a pool of software developers and data scientists to build and run industrial systems used at scale;
- Have a business development manager who oversees relationships with legal departments, commercial entities, and funders of research translation and innovation;
- Provide advice and guidance to the researchers on all aspects of impact funding acquisition, e.g., relevant funders and calls, and consortium member suggestions;
- Manage support for running large commercial or innovation projects;
- Train academics, Research Fellows and PhD students for impact activities.

The unit's impact strategy is supported by the STEM Research, Enterprise and Scholarship team of 15 staff, which helps with funding bid development. The Faculty has a dedicated Impact Manager who helps develop pathways to impact in funding bids and supports their implementation for awarded projects including communication.

The unit's ability to run large infrastructures within commercial contexts is demonstrated by the prestigious £17m MK:Smart project (2014-2017, £3.9m for the OU), where we developed the MK Data Hub, an award-winning data infrastructure, which is a key component of the smart city infrastructure in Milton Keynes. Examples of the Hub's use include support for SME innovation in the CityLABS programme (2017-19) and the world's first International Competition of Robots in Smart Cities. It also provides a key infrastructure component for the ongoing 5G deployment in Milton Keynes (MK:5G, 2019-21). These activities derive from the unit's partnership with MK Council since 2014, which led to seven major collaborative initiatives linked to the smart city agenda in Milton Keynes.

Another example of a large-scale collaborative initiative that develops impact by influencing education is the recently awarded Institute of Coding, a collaboration between the UK Government, more than 60 universities, big players in the tech industry, SMEs, industry groups, experts in non-

traditional learning and professional bodies. The unit leads the theme on University Learning, focusing on influencing computer science teaching in universities nationally, and applying the results of our research in data analytics and blockchains to higher education.

1.4.2 Industrial and Societal Engagement

Impact is delivered via key strategic partnerships with major companies (e.g., Springer Nature, Elsevier, BT, Atos, E.ON, Samsung, Cisco, IBM, NATS, Mozilla Foundation), and collaborations with SMEs (e.g., Simply Business, DynAIkon, members of the Agile Business Consortium), governmental and not-for-profit organisations (e.g., MK Council, MK University Hospital, Thames Valley Police, Tate Gallery), charities (e.g., Dogs for Good, Age UK, Pet Plan Charitable Trust, RNIB, Learning through Landscapes) and schools.

The OU actively promotes Knowledge Transfer Partnerships and several of them have been established through Computing. The unit is a partner in the ERDF-funded ALPHAS project and in the ERDF-funded CityLabs project, both of which support over 40 SMEs from the South East and Midlands region. It also participates as partner in several EPSRC-funded networks that include companies and policy makers, e.g. Internet of Food Things NetworkPlus, 2018-2021 (Zisman); UK Manufacturing Symbiosis NetworkPlus, 2019-2022 (Zisman), Skills and Education for Robotics and Autonomous Systems, 2020-2021 (Song and Charlton). Other examples of industrial and social engagement are described in 4.3.

1.4.3 Consultancy and Patent Applications

Our researchers offer consultancy services to facilitate highly focused, typically short-term but high-value, activities. In recent years, examples have ranged from giving specialist **advice on distance learning and usability** (Ramage, 2014-2016) to **academic consultant for BBC programmes**, e.g. The Age of Image, 2019-2020 (Wong), Icons, 2019 (Smith), Secrets of Silicon Valley, 2018 (Smith), The Wonders of Dogs, 2013 (Mancini), The Secret Rules of Modern Living: Algorithms, 2015 (Wermelinger); **international programmes,** e.g. Animal Allies Season, USA, 2016 (Mancini); **companies,** e.g. Animal Wearables, Companion, USA, 2016 (Mancini); or **schools and universities,** e.g. PhD degree Programme, Kuala Lumpur, 2019-2020 (Dooley).

Patents. In the REF period two patents were awarded (Systems and methods for runtime adaptive security to protect variable assets, US9330262B2, 2013, Nuseibeh; Method and system for adaptive security in cloud-based services, US10713355B2, 2017, Nuseibeh, Bandara, Tan, Yu); and three further applications are pending.

1.4.4 Impact Case Studies

The key achievements within the description of our research themes above are a rich source of examples for the impact of our research. Our four selected impact case studies, Collective Intelligence (ICS1), Springer Nature (ICS2), CORE (ICS3), and OUAnalyse (ICS4), particularly demonstrate beneficial societal impact supporting: democratic empowering mechanisms to harness collective intelligence (ICS1), scholarly communication and open science (ICS2, ICS3), and students at risk of failing (ICS4).

Three impact cases (CORE, OUAnalyse and Springer Nature) make use of the unit's systems team and data infrastructure. For example, CORE offers unique data services for researchers, the general public, not-for-profit organisations and commercial paying customers. It enables discovery, process, and text and data mining of research literature. OUAnalyse, with its predictive learning analytics, helps tutors with early identification of struggling students, supports early intervention; while Springer Nature improves the generation of editorial metadata for all their book series covering conference proceedings in Computer Science, with demonstrable improvements in quality and increase in the number of downloads and access to scientific content. Collective Intelligence

demonstrates a mixture of problem-solving and knowledge generation approaches in which a suite of discourse-based technologies have been developed and adopted by health, higher education, public engagement, and peace building organisations (e.g. support for participation in political debates and peace building efforts in Rwanda).

The OU Computing research context defines a coherent roadmap for developing generally applicable solutions as exemplified by the submitted impact case studies. They reflect the unit's people-centred approach, with technologies for the social good, and its principle of openness; and improves quality of life with economic benefits.

1.4.5 Open Source

The unit encourages an open source (OS) philosophy. Some examples are:
- CSO Classifier - text classifier for Computer Science Ontology;
- R and Python Clique Percolation - for community extraction;
- PT Anywhere - network simulation environment;
- Open Melody - collaborative music creativity tool;
- OpenPF - requirement engineering tool;
- Cargo-Geiger - statistics of unsafe Rust code;
- Compendium - visual mapping and management of ideas, arguments and documents;
- Cohere - tool to share, create and connect people and ideas as semantic web networks;
- Evidence Hub - collaborative knowledge building tool;
- LiteMap - collaborative web annotation and visual argument mapping;
- DebateHub - online discussion and collective decision-making technology.

1.4.6 Future Impact Strategy

We aim to expand our capability to deliver impact in our core domains, including smart cities; health technologies; animal-computer interaction; scholarly data mining, learning analytics, and engineering secure, privacy-aware, and forensic-ready software. These capabilities are derived from the unit's research facilities and equipment, existing academic reputation and presence in these domains, and leading academics and professional services that ensure chosen activities to be designed, delivered and recorded. We plan to deploy emergent capabilities in new domains including, but not limited to, AI and citizen science, AI for business analytics and AI and decentralised ledgers to democratise data ownership and control.

1.5 Open Research Environment and Research Integrity

The unit follows the University's procedure for open access with outputs deposited in the Open Research Online repository and data deposited in the Open Research Data Online repository. This is evidenced by less than 2% of the unit's submitted papers not being deposited on time. Staff and PGR students receive regular support and reminders about the open access policy for outputs and data. Similarly, the unit follows the robust institutional provision for research integrity (see Institutional Environment), including the principles of the Concordat to Support Research Integrity, briefings and trainings of researchers; and analysis in research work, outputs, grant proposals, and PGR work.

2. People

2.1 Academics and Researchers

The profile of 44.7 FTE staff submitted to this REF is: Professor (11.5), Reader (1), Senior Lecturer (19), Senior Research Fellow (3), Lecturer (3.2), and Research Fellow (7). The unit's research strategy prioritises appointments of academics who build research excellence within our key themes, expand our research into related emerging areas, and complement existing expertise. Around one quarter of the staff are on research-only contracts.

Since REF 2014, the unit has maintained both leadership and critical mass in each of its previous REF 2014 key areas and developed a new research area (AIDA). We have developed and promoted tenured staff: five to Professorship and six to Senior Lectureship. Three Postdoc researchers have been promoted to Lecturers and, subsequently, two of them to Senior Lecturers. Eight contract researchers have been promoted to Research Fellows to develop independent research. Four professors and one senior researcher retired, two professors moved abroad to other academic institutions and two senior researchers left. One new academic (a research leader in AIDA) and five early career researchers (ECRs) have been recruited.

Individual researchers may move across disciplines, sometimes focusing on aspects of computing technology, sometimes on integrating that technology into other disciplines. As a result, some of our researchers are submitted under the disciplines to which we contribute (e.g. Collins' research on Field-Studies is submitted under Education).

A substantial investment in research is made annually in studentships; flexible support for research activity including seed money for new projects and collaborations; development for early-career staff; equipment and infrastructure. The unit's robust implementation of the OU's Concordat was recognised in 2013 with the European Commission HR Excellence in Research Award, which was retained at the six-year review point in 2019.

Staff Development and Training. Transferring the experience of senior staff to career-young academics is regarded as critical. Every new member of staff is allocated a **probation supervisor** who supports the staff with career development. Academics are also allocated a **mentor** who will support them throughout the probationary time, which can be extended beyond probation on request. Contract researchers are moved into permanent positions through mentoring and internal development processes. As far as possible, new academics have **reduced teaching loads for the first two years** of their appointments and are entitled to **travel funds** from the unit to attend any activity useful to the role, and bid for **PhD student scholarships** offered by the university.

The unit has a substantial budget to be used for external training. Members of B11 have taken up these opportunities to increase their technical knowledge and skills, and for other professional development, e.g. leadership courses. There are also many opportunities for internal training, both face-to-face and online. These courses are on offer for both academics and researchers. The OU offers an *Academic and Professional Development* programme of courses that can be booked online. Examples of training packages run by the OU are Academic Leadership Development Programme; Academic Career Development and Staff Appraisal; Mental Health and Wellbeing; Awareness of Implicit Bias; and Equality, Diversity and Inclusion Practices.

The Faculty also offers its own Academic Professional Development programme, led by Faculty members who have the corresponding expertise, e.g., workshops by a BBC-trained presenter on engaging content for online audiences. These sessions are popular, highly valued, and annually updated. Most seminars, workshops and other staff development sessions across the university are accessible online and often recorded. The OU offers staff fee waivers for its own modules, and many staff take up these opportunities for personal and career development.

All staff members engage in on-going career development and appraisal, coupled with tailored

workload planning that tracks career goals and performance against objectives. Preliminary workload plans are completed in April-June for the following year, and projected days allocated to different tasks are recorded in the University Academic Workload Management system.

In addition to allocated research time, staff can take up to **two months of study leave annually** for research and scholarship. Study leave **corresponds to a sabbatical system** elsewhere. With line manager agreement, study leave can be accrued to give someone up to 12 months of continuous study leave. Staff in senior leadership roles (e.g. Associate Deans) have an additional month of study leave per year of service, in recognition of the need for additional time to re-engage with their research activities. The unit also facilitates colleagues who wish to take **secondments in industry** or other external organisations. Recent examples included periods to support writing- up research or developing bids; external visiting positions (e.g. Malmö University; University of California Irvine); and industrial secondments (e.g. Huawei).

Parental leave is supported through workload planning. Flexible working is supported and encouraged. Dedicated contingency leave supports our diverse workforce. The Faculty has adopted a policy of core hours for meetings in order not to exclude those with childcare or other caring responsibilities.

2.2 Promotion

In 2015, the OU adopted a set of four **academic promotion profiles:** Teaching; Knowledge Exchange; Research; Research and Teaching. The corresponding criteria make explicit the range of activities that are recognised and valued for each profile and seniority level, including criteria related to academic leadership. The promotion criteria adapt expectations for staff who have taken periods of parental leave, part-time working, or where other special circumstances apply.

Within B11, there is a Senior Lecturer Promotions Panel: all staff at Lecturer level are considered by the panel to see whether they are ready to go forward to the Faculty for promotion in the current year or in following years. Candidates for promotion prepare a draft promotion case, supported by their **career development appraiser.** Potential candidates for subsequent years provide a mapping, which demonstrates their progress towards meeting the criteria. The promotion case documents are developed by the candidate, with support and feedback from a **mentor from the panel** and the candidate's appraiser. This support continues throughout several stages of drafting and feedback, with final submission of suitable cases to the Faculty. The Faculty's Promotions Group reviews all submitted cases and makes the final judgement. There is **no limit on the number of promotions** in a given year.

Promotion to Professor is supported by a Chairs Promotions Panel, which considers mappings, draft cases and CVs of candidates. Appropriate cases are submitted to the Faculty Chairs Working Group for consideration and feedback. Each candidate is allocated a mentor from this group, and given considerable support from the mentor and other senior colleagues. After a period of **review, support and feedback** from the group, appropriate cases are submitted to the University Promotions Committee, which makes the final judgements. There is **no limit on the number of promotions** to Professor in a given year. There are three professorial bands, and movement between the bands is supported in the same way.

Promotion from Research Assistant to Research Associate and Research Fellow requires evidence of achievement in research, and assessment of satisfactory progress. Line managers present the case for approval by the Faculty.

Up to 20% of staff can be put forward to the Faculty each year for **merit awards and increments;** the majority of applicants are successful. This enables staff to receive increments on the pay-scale, or a one-off financial award. The unit encourages staff to recommend their colleagues for awards and increments, which adds an element of **community support** to the process. Staff can also put themselves forward.

2.3 PGR students

The University infrastructure for PhD research **exceeds the requirements** of both UKRI and the Quality Assurance Agency. Our programme is supported by a university-wide **Graduate School** that provides consistent administration and training in research methods and skills; structured annual progress reporting; and a university-wide **Graduate School Network** which provides access in one place to a range of skills, news, careers, supervision, library, social media and administrative resources. It ensures **comparability of experience** to all OU research students regardless of their physical location or part- or full-time status. All students have **at least two supervisors and a third-party monitor** who takes a pastoral role. The faculty invests in mental health support, and Mental Health First Aid training has been completed by all staff with responsibility for PGR student welfare.

The unit has 93 PG students, an increase from 81 students in REF 2014. Since August 2013, 64 PhD students completed their degrees successfully – see Table 1. All our students publish in refereed outlets before submission, with eleven best-paper awards and five Honourable Mentions in journal and conferences (a marked increase from four best-paper awards in REF 2014). Furthermore, our students won eight awards from respected organisations, e.g. IET Cyber Security Innovation Award 2017, European Women in Games Hall of Fame by Women in Games 2019, and Distinguished Dissertation Award from the Semantic Web Science Association 2016.

The success of this vibrant PhD programme is owing to a comprehensive PhD support infrastructure and training programme that operates throughout their studies, including a strong focus on community building and peer-to-peer learning; weekly research skills seminars; regular on-line seminars for part-time students; annual student conference attended by the whole research community; funding to attend conferences, external courses and summer schools; and dedicated on-line resources. All full-time PhD students receive an annual bursary of £1,000 for travel and research expenses.

Students participate alongside academic staff in research groups and seminars, reading groups, our annual Research Fiesta (a forum for intellectual debate and for refining research goals), and engage with research visitors. In person or online seminars are open to all staff and research students.

B11's doctoral programme is at the forefront of quality and innovation, as reflected by our collaboration with Vitae to realise the potential of our researchers, and by leading doctoral activities within European networks of excellence and major international conferences (e.g. European and International Conferences on Computer-Supported Cooperative Work, International Semantic Web Conference, International Learning Analytics and Knowledge Conference).

Members of the unit have applied the OU's leadership in innovative educational models to international PhD Summer Schools. These include the ESWC summer schools in the Semantic Web area and the JTELSS in Technology-Enhanced Learning. PhD students regularly go on to take-up positions in academia (e.g. Queen Mary University, Warwick University, Glasgow University, Dundee University; VUA Amsterdam, University of Lappeenranta); private companies (e.g. Google, IBM, Siemens, HSBC, Nokia, Palantir, Adarga AI, Elastic Path Software); and global non-profit organisations (e.g. EdTech Hub).

Students are recruited through normal channels, including advertising and professional networks. Staff members use conferences, summer schools, collaborations and internships to identify and form relationships with potential candidates. Between August 2013 and July 2020, the unit hosted 75 visiting PhD students from 14 countries (e.g. Brazil, China, Russia, Switzerland and EU countries), including 38 students for a period of 3-6 months each as part of their studies abroad; nine of them joined the OU's PhD programme after their visits.

2.4 Equality, Diversity and Inclusivity (EDI)

Table 2 details the proportion of female, BAME and disabled staff within the 47 submitted staff and within different seniority levels, and contrasts that to the proportion of the outputs attributed to them. Female and BAME staff proportions **compare favourably** with the sector, while the proportion of disabled staff is in line with the academic sector. Female and BAME staff are over-represented in outputs and well represented in higher academic roles, **demonstrating equal opportunity** in the unit.

Table 2: Proportion of female, BAME and disabled for staff categories & attributed outputs

	Sector	B11 Staff	Professor	Reader, Senior Lecturer and Senior Research Fellow	Lecturer and Research Fellow	Attributed Outputs
Female	22.3%	27.7%	25.0%	33.3%	18.2%	29.1%
BAME	14.2%	21.3%	41.7%	16.7%	9.1%	28.2%
Disabled	4.6%	4.3%	n/a	n/a	n/a	2.7%

The OU holds an **Athena SWAN** Bronze Award for promoting gender equality, *"demonstrating a clear commitment to change and a solid foundation for eliminating gender bias"*. Both C&C and KMi have obtained Athena SWAN bronze status and will pursue silver status in April 2021 (C&C) and November 2021 (KMi). Female members of staff are supported to attend the Aurora Leadership program, which encourages women to become leaders in HE institutions. Female PhD students are offered a female third party monitor if their supervision team is all male. Monitoring of the gender distribution of workload, especially the balance between teaching and research, is carried out annually at Faculty level.

Our strong and supportive research culture attracts researchers from around the world. The Computing community comes from 14 different countries from North and South America, Asia, and Europe, bringing global research links and cultural understanding.

The unit encourages women applicants during recruitment; e.g. promoting posts via women's professional networks such as WISE (Women in Science and Engineering) and sharing widely via social media. The wording of advertisements, job descriptions and person specifications is carefully considered for inclusivity. Diversity statements are promoted on our websites to highlight our commitment to equality and diversity. We have also ensured that our **websites feature positive images in terms of gender, ethnicity, disability, and other protected characteristics,** and present a good balance across groups. The University's **Dean of EDI** has the responsibility to support representation of staff and to improve recruitment, management, and development of diverse groups of people.

Social activities to increase the visibility of the research conducted by minority groups, to promote a collegiate culture and to raise awareness about the importance of diversity, are frequently organised, e.g. Wikipedia editathons to increase its representation of women; posters displaying the achievements of female researchers; games to learn about female and black role models; or knowledge makers forums to incentivise creativity across diverse groups. A specific summer internship program has been deployed to attract, support and mentor BAME students. Staff members need to complete our *Equality Essentials* and *Unconscious Bias* courses before they are involved in any recruitment process, including PGR recruitment.

The unit is committed to equal opportunities for all staff in pursuing their research. All academic staff are guaranteed research time and encouraged to apply for external and internal funding. Support for external engagement and development of grant applications is available at University, Faculty, and unit levels: in particular, academic staff members are encouraged to apply for externally funded **research fellowships**; when applicable, these fellowships allow researchers to be released from teaching and administrative duties. Success in externally-funded fellowships

include Royal Society-Wolfson Merit Awards (Nuseibeh, 2013-2018); ERC Advanced Grants (Nuseibeh, 2012-2017); David Parnas Fellowship, Lero, Ireland (Zisman, since 2018). We foster international research through collaboration and welcome **research visitors** each year (see 4.1).

3. Income, infrastructure and facilities

3.1 Income

The unit continues its successful external funding strategy, with a focus on diversification and sustainability. For example, the SEAD research theme has been ranked in fifth place in the EPSRC ranking in terms of values of grants held by organisations. Table 1 shows the growth of research income from RAE 2008, REF 2014 and REF 2021.

The unit's strategy for funding is to:

- **Engage with national and international research councils.** For example, EPSRC ICT Strategy Advisory Team (Nuseibeh, 2012-2017); EPSRC Strategy Advisory Network (Sharp, 2016 to present); BBSRC research portfolio scoping exercise (Mancini, 2020); ERC Computer Science and Informatics Panels (Advanced Grants, 2017-, Nuseibeh; Consolidator Grants, 2011-2017, Rueger; and Starting Grants; 2019-, Motta).

- **Maintain and build relationships with key funders and partners.** For example, running a workshop on behalf of the Head of the Future Internet Research and Experimentation on Skills and the Future Internet (Domingue); MK Council in relation to MK:Smart (Motta); Cisco (Bennaceur, Mikroyannidis, Third); and JISC (Knoth).

- **Build leadership roles to aid in enhancing partnership networks.** For example, membership of networks in the Semantics and Data Analysis areas with key European and Global research groups fostered through: Presidency of the Semantic Technology Institute (Domingue); leadership positions within the Semantic Web Association (Motta); and co-partnership in the EPSRC-funded Internet of Food Things (Zisman) and the UK Manufacturing Symbiosis NetworkPlus (Zisman).

- **Coordinate external research relationships** (academic and industrial) with research staff and a Business Development Manager as appropriate. On the industrial side our main partners include: Agile Business Consortium Ltd, BT, CISCO, Springer International Publishing, IBM, Medical Detection Dogs, Microsoft, Milton Keynes University Hospital, and NATS.

- **Diversify funding sources** including research councils, national and local government bodies, industry, and charities. Examples are UKRI (EPSRC), HEFCE, European Commission, Royal Society, Leverhulme Trust, British Council, Innovate UK, GCHQ, Milton Keynes Council, Agile Business Consortium Ltd, JISC, Dogs Trust, and Sir Halley Stuart Trust.

- **Increase in the number of large grants.** Examples include the £1.3m EPSRC-funded Platform Grant on SAUSE: Secure, Adaptive, and Usable Software Engineering; £1.0m EPSRC-funded STRETCH: Socio-Technical Resilience for Enhancing Targeted Community Healthcare; £1.0m EPSRC-funded Citizen Forensics; £1.4m Home Office-funded Policing Research and Learning Centre; £1.0m Innovate UK-funded project Happie Audience of the Future – Creative Touch, Design Prototyping; £3.9m HEFCE-funded MK:Smart project; and €3.0m EU Horizon 2020-funded project Polifonia to start in 2021.

- **Increase share of interdisciplinary grants.** Examples include our EPSRC and NCSC grants on social factors that impact writing secure software; and EPSRC grants on citizen-

police collaboration; development of smart homes technologies to enhance independent living for older adults; use of automation to improve technical resilience; and pollinators - a biodiversity citizen science project embedded in primary schools.

- **Exploit synergies with teaching and outreach.** Examples include the Institute of Coding with funding from the OfS and industry and Smart cities MOOC with funding from Department for Business, Energy & Industrial Strategy.

The unit plans to carry this strategy forward, responding to the changing funding landscape and the unit's development by increasing the emphasis on major collaborations, on larger grants, and on industry collaborations leading to funding and in-kind contributions.

3.2 Infrastructure and Facilities

Computing excellence underpins the mission of the OU to exploit the latest technology for open education. This strategic alignment coupled with the unit's objective to study and build systems for concrete user populations in authentic contexts has led to the provision of a well-endowed computing infrastructure supporting impactful engaged research. The unit provides a flexible and adaptive platform to help initiate, develop and sustain dynamic and evolving computing research and innovation requirements including:

- Flexible hosting environment with five on-campus data centres and external cloud providers
- Scalable server hosting for 250 servers and 500 web services using Software Defined Storage
- Load Sharing Facility Cluster with £400k of investment and over 1,000,000 CPU hours per year
- Big Data Cluster
- High-bandwidth 10GBE network

The unit's hardware and software infrastructure is architected, configured, managed and maintained by a unit-specific Technical Services Team that support infrastructure resources as required. This team works with researchers and external partners to understand research needs; develop requirements and specifications for systems; manage the unit's technology backbone, data centres and network resources; and provide specialist technology assistance. Other responsibilities are to liaise with researchers at bid development stage and during the lifetime of large projects to ensure that research, funder and stakeholder needs are met including organisational, national, and international requirements, e.g. GDPR, accessibility and security.

The University's commitment to computing research is also evident in the purpose-built modern buildings that house KMi and C&C. The unit has five state-of-the-art labs in addition to web-cast facilities, available to host appropriate projects: **Software Engineering and Design Lab** that supports experimentation with software engineering methods; **Music Computing Lab** that offers specialised musical, haptic, gesture-sensing, and sound processing systems, with an anechoic chamber for acoustics, and a recording studio; **Animal-Computer Interaction Lab** that provides a growing repertoire of monitoring and interactive equipment to test prototypes with animals in an animal- and human-friendly settings; **Pervasive interaction Lab,** with its focus on augmenting and extending everyday learning and work activities, with electronic textiles, haptic technologies and other interaction technologies, and a **Maker Space Lab** with advanced equipment to support prototyping and development work across C&C.

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

4.1 Collaboration

The Unit of Assessment B11 at the OU has a rich history of collaboration with external partners from academic, business, not-for-profit and government/policy domains. We have engaged in more than 100 collaborative research projects since 2014, ranging from short engagements with a single partner to projects of over five years duration with up to 20 partners. Researchers in the unit carefully select collaborators from an extensive network and consider how resulting consortia can best address the challenges posed by research funding bodies in the context of economy and society in multidisciplinary domains.

Since 2014, B11 has proactively invested in staff, wider network engagement, and technology infrastructure to develop capability and applications in the Smart Cities multi-disciplinary domain. Such investment has resulted in leadership and participation in projects, including: HEFCE-funded MK:Smart (2014-2017), CityLabs (2017-2019), SEMLEP-funded MK:5G (2019-2021), UK Autodrive (2018, consultancy), EU-funded SciRoc (2018-2022) and Gatekeeper (2019-2023). Similarly, the unit has invested resources in software engineering and design resulting in the leadership of the EPSRC-funded SAUSE platform grant (2018-2022), STRETCH (2017-2020), Citizen Forensics (2018-2021), STRIDE (2020-2023), JENNY (2017-2019), and JOHNNY (2017-2020) projects.

The profile of consortium partners includes highly respected universities (e.g. Imperial College London, Lancaster University, University of California Irvine, University of Limerick Ireland), national research institutes (e.g. NASA), government bodies (e.g. SEMLEP, NHS Trusts, Milton Keynes Council), corporations and SMEs (e.g. Atos, BAe Systems, BT, Simply Business, IBM, E.ON, Cisco, Samsung, BT, Huawei), and charities or community organisations (e.g. Age UK, RNIB, Community Action MK).

The OU has a Memorandum of Understanding with Japan's National Institute of Informatics (NII), which has resulted in mutual visits, regular joint workshops, 3-month research internships by our PhD students at NII, and co-authored papers. Our staff have held **visiting professorial and research fellow posts** in 20 institutions around the world, e.g. University of Bergen (Motta, since 2019); University of California, Irvine (Petre, since 2018); University of Cambridge (Siddharthan, 2018–2019); Malmö University, Sweden (van der Linden, 2018); NII, Japan (Nuseibeh, since 2007); and University of Waikato, New Zealand (Rueger, 2009–2021).

Researchers in the unit promote international collaboration with **research visitors** each year. Some visitors spend a short time giving seminars and engaging with our colleagues. Others stay longer (e.g. the academics from Tianjin University in China visiting Song and Yu as part of an EU Marie Curie project). Our influential community of long-term visitors includes Visiting Professors David Bainbridge (University of Waikato, NZ); Carole Beal (University of Massachusetts, USA); Paul Cohen (also UMass), Clayton Lewis (University of Colorado, USA), Henry Lieberman (MIT, USA), Cory Doctorow (tech activist and science fiction author), Mark Levine (University of Lancaster, UK), Bjornar Tessem (University of Bergen, Norway); visiting Research Fellows David Bush (NATS), Ryan Kelly (University of Melbourne, Australia); and independent consultant Michael Jackson (London). All the long-term visitors play strategic roles as research collaborators, advisors and domain specialists.

4.2 Academic Leadership and Esteem

The unit's **leadership in the academic community** is evident through:

(1) Coordination of **international collaborations** such as EU projects (e.g. ERC ASAP advanced grant (2012-2018), Gatekeeper (2019-2023), SCiRoc (2018-2022), Polifonia (2021- 2024)); Qatar National Research Fund (2013-2016)); and **community building** (Animal Computer Interaction).

(2) **Advisory roles** in 24 different occasions, including the Software Carpentry Foundation (Petre, 2015-16); with research funders as exemplified in Section 3.1. Other roles include evaluator for internal REF2021 B11 UoA submissions: Swansea University (van der Linden) and University of Essex (Piwek); and representing the EU at EU-US Future Internet Workshop in 2017 (Domingue).

(3) Chairing over 18 of the **leading conferences** in our research themes. Examples include PC Co-Chair of the ACM SIGSOFT ESEC FSE conference (Zisman, 2017); IEEE RE conference (Zisman, 2020); ACM International Conference on Multimedia Retrieval (Rueger, 2014); ICSE, Software Engineering in Practice (Sharp, 2019); Conference on Computer Simulation of Musical Creativity, (Laney, 2017); International Conference XP 2016 (Sharp, 2016); and general chair of International Conference on Animal Computer Interaction (Mancini, 2016, 2017, 2020).

(4) Leading or participating in over 19 **steering committees**. Examples include Chair of the BCS Information Retrieval SG Committee that coordinates the European Conference on Information Retrieval Research (Rueger, 2016-2019); European Semantic Web Conference (Domingue, 2008-2019); SIGSOFT ESEC FSE Conference (Zisman, 2016-2020); IEEE Requirements Engineering Conference (Zisman, since 2020).

(5) Seven **Editor-in-Chief** roles, including International Journal of Human-Computer Studies, (Motta, 2004-2018); ACM Transactions on Autonomous & Adaptive System, 2017-2020 (Nuseibeh, 2017-2020); Journal of Creative Music Systems (Laney, since 2017).

(6) 36 memberships of **editorial boards,** including IEEE Transactions on Software Engineering; Elsevier Journal of Systems and Software; Elsevier Science of Computer Programming Journal; Springer International Journal of Multimedia Information Retrieval; ACM Transactions on Information Systems; Empirical Software Engineering Journal; IEEE Software; ACM Transactions on Software Engineering & Methodology; Elsevier Journal of Web Semantics; ACM Journal on Interactive, Mobile, Wearable and Ubiquitous Technologies

(7) Membership of **standards and working groups**. Examples include vice-chair of the IFIP Working Group 2.9, Requirements Engineering (Zisman, since 2016); co-chair of the DARIAH AIM Artificial Intelligence in Music working group (Daga, since 2019); Data and Analytics Task Group of the Government Office for Science (Motta, 2014-2015); Knowledge Graph Construction W3C Community Group (Osborne, 2020); W3C Credentials Community Group (Mikroyannidis, 2020); IFIP Technical Committee on HCI - TC13 (Schibelsky G Piccolo, 2020).

(8) OU B11 members have received **29 best-paper awards** (e.g. van der Linden/Mancini, CHI 2014; Siddharthan NLDB 2017; Tun, SEAMS 2018; Fernandez/Alani, WebSci 2018; Song, ICTIT 2019; Wermelinger, VMV 2020). Other awards include Smart City UK 2017 Award in categories Housing and Communications (van der Linden, 2017).

(9) Researchers in the unit delivered **76 keynotes** at international conferences (e.g. ICSOFT, Domingue, 2015; ACM ItiCSE, Petre, 2019; ESEC FSE, Nuseibeh, 2015; IEEE ICSC, Rueger, 2016; Green Data Conference, Siddharthan, 2019; SEMLA, Bennaceur, 2019; eLmL, Mikroyannidis, 2020).

(10) Researchers have engaged in **international summer schools** either as organisers (e.g. ESWC Summer School, 2011-2016, Domingue) or as speakers (e.g. International Semantic Web Summer School, 2018, Motta; Computational Social Science Summer School, 2018, Fernandez; Natural Language Generation, Summarisation, and Dialogue Systems Summer School, 2015, Piwek).

(11) Members of the unit held 20 **Visiting Chairs** at other universities as exemplified in Section 4.1.

(12) Examples of other distinguished positions include **fellowships** such as the ACM Distinguished Scientist (Petre, 2016); the Irish Computer Society Fellow (Nuseibeh, 2017); Royal Society of Arts (Laney, since 2019), the Office of Naval Research, Department of Defence, US (De Liddo, 2019-2022); and seven fellowships of BCS (some by invitation), five of CEng and eight of HEA.

(13) Members of the unit have taken Government and policy **advisory roles**, For example: Government Office for Science, Data Analytics Task Group (Motta, 2014-2015); Her Majesty's Treasury, Unlocking Digital Competition (Nuseibeh, 2019) and industrial Chair of the Digital Policy Alliance (J Hall).

4.3 Contribution to Economy and Society

The research in the unit embraces **users** in a multidisciplinary way: *technical stakeholders,* e.g. the software developers who informed our empirical studies of design, or who informed the development of secure software – EPSRC Johnny's project; and *domain specialists*, e.g., NATS, in the Drone Identity project; Milton Keynes University Hospital and Age UK in the EPSRC-funded STRETCH project. Researchers in the unit work actively with users during the formulation of research questions, through research and development, and subsequently in the deployment of technologies into real contexts. For example, our long-term relationship with Agile Business Consortium Ltd allows researchers to work with practitioners to understand their challenges. Similarly, the work with policing organisations around the UK through projects supported by the OU Centre for Policing Research and Learning since 2015; the work with World Wide Fund Switzerland and Earth Hour on user studies around climate change issues; deployment of blockchain badges; work with older adults around digital health technologies and privacy management in ubiquitous environments; and work with yachtsmen, sailing instructors and other users to scope issues and challenges for augmented reality navigation interfaces.

Researchers in the unit **collaborate with industry** through research projects, knowledge and technology transfer, and consultancy. The industrial collaborators act both as research partners in several projects and as informants. The unit's collaboration with industry includes companies like BAe Systems, IBM, APPII, Cambridge Research Lab of Toshiba Europe, Cisco, Daiwa Capital Markets, Huawei.

B11 unit research at the OU has also informed the **research agenda of industry and public bodies**. Examples are Advisory Board of the Software Carpentry Foundation (Petre, 2015-2016); Iceland Ministry of Education, input to COVID-19 plan for schools (Petre and Richards, 2020); Digital Policy Alliance Industry Chair (J Hall, since 2019); Thames Valley Police (Bandara, Price, Nuseibeh, 2019-2020); MK-AI, Science Advice to Policy (Piwek, 2021-2023).

The unit's wide scope of impact activities is supported by a communication and dissemination strategy, which covers a wide **array of channels**, such as:
- Industry workshops, e.g. a series of AI workshops with communities and SMEs, 2019 (Charlton), Tate Gallery workshops, 2014-2015 (Charlton);
- Public engagement events, e.g. 'Women in IT', Credit Suisse, 2016 (Petre), 'STEMettes', Women in STEM careers, 2019 (Bandara), Edinburgh Science Festival, 2019 (Mancini); Royal Society Summer Science Exhibition – 2014 (Mancini);
- Public lectures, e.g. Oxford Café Scientifique, 2019 (Mancini);
- UK Government's Digital Skills Toolkit, 2020 (Mikroyannidis);
- Social and broadcast media; in particular, our strategic relationship with the BBC and Radio 4 has been instrumental in generating wider impact from OU Computing research, e.g. Inside Science, 2016 (Mancini), 2020 (Jones); Computing Britain; 2015 (Jones); Today Programme, 2013 (Price), 2014 (Yu); as well as international media, e.g., Canadian Public Radio 2014 (Mancini). Members of the unit have published 18 articles in The Conversation; for example Bandara, Mancini, Price and Yu.

Summary. Research in the OU's B11 unit constitutes a coherent, sustainable core of expertise with international recognition, and a body of work with many years of impact. It reflects the OU's mission and contributes to the development of technologies that are people-centred, open and for the social good and society at large. The four research themes in our unit are overlapping areas with applications in Learning and Education; Health and Wellbeing; Citizen Empowerment; Politics and Government; Security and Policing, Forensics & Privacy; Environment & Sustainability; Science & Scholarly Communication; Urban and Smart living; New Media and Society; Accessibility, Inclusion, Ethics, Social Justice and Diversity; Arts, Entertainment and Culture; and Professional Practice.