REF2021

Institution: City, University of London

Unit of Assessment: 11 Computer Science and Informatics

1. Unit context and structure, research and impact strategy

1.1 CONTEXT AND STRUCTURE

City's Unit of Assessment B11 is based in the Computer Science (CS) Department, within the School of Mathematics, Computer Science, and Engineering, one of the five Schools within the University. From its origins as a mixture of loosely aligned Departments and Schools (dating back to 1990), the CS Department is now made up of five research centres that provide focal points for collaborative research, publications and funding applications. These are ACSML (Adaptive Computer Systems and Machine Learning), CitAI (Artificial Intelligence Research Centre), CSR (Centre for Software Reliability), giCentre (Data Visualisation) and HCID (Human-Computer Interaction Design).

The Department currently comprises 42 academics (up from 36 in 2014). We are returning 40 staff under B11 for REF 2021 two under D34. In addition, we depend on a research, teaching and student complement, with 13 post-doctoral research assistants (PDRAs), 48 PhD students, 3 teaching-only staff and over 1,000 taught-course students, 30% of whom are postgraduates (2020-21). Critical to the success of our research are 5 administrative staff (dedicated to research), consisting of 2 postgraduate research officers, a researcher manager to support grant applications and a research officer whose remit is to target impact.

The Department's strategic and practical planning of research is jointly managed by the Head of Department and the Centre directors. Together, they set out the longer-term research agenda and agree on initiatives such as prioritising areas of growth and staff to hire, encouraging interdisciplinary research and fostering a healthy research environment. They also provide a bridge to the broader School- and University-level strategies, the latter outlined in our REF5a statement. Staff across the Department are involved in discussion and feedback on strategic and practical planning during monthly staff meetings, and this widespread participation is further encouraged at Centre level through regular meetings.

As a Department, we pride ourselves on our welcoming and collegial research culture and the commitment of our staff, who invest considerable energy in growing and strengthening the research environment. This energy and vitality have led to a wide range of successes in this assessment period, including growth in research capacity (i.e., staff numbers and funding), the expansion of our PhD programme, enlargement in strategically targeted areas, and increased investment in partnerships across academia and industry. This exciting period of growth stems in particular from the aims we formulated four ourselves in 2014 and a strategic plan we have given shape to since then.

1.2 RESEARCH STRATEGY

In REF 2014, we set out a research strategy aiming to build expertise and extend our impact across four areas of research: cyber systems security, adaptive systems engineering, creative system design, and data analysis and visualisation. We also set out two broad goals: (i) to produce world-leading, problem-driven interdisciplinary research and, (ii) to use the outcomes of our research to benefit society, enterprise and the public sector. We pursued these goals by: aligning our research directions with new funding programmes and priorities (e.g. the EU Horizon 2020 (H2020) and Research Councils UK's Global Uncertainties, Healthcare and ICT

programmes); supporting joint research programmes and bids with user, industry and academic partners; and channelling Departmental resources to seed high-priority research. This strategy led to growth and numerous successes in this assessment period, including:

- *Growth in research staff:* The number of Category A staff members has increased from 36 to 42, representing a **17% growth in independent, research-active staff**. Reflecting growth in funded research, the number of PDRA positions has also increased, from 3 new posts in 2015 to 13 and 14 in 2018 and 2019 respectively.

- *Growth in funded research:* Since REF 2014 we have achieved a **33% growth in research income** (£6.7m for REF 2014 to £9m in this period), with funding from UK Government sources (i.e. research councils) growing by 80% (£1.5m to £2.7m).

- *Increased visibility and prominence of outputs:* We have achieved **measurable improvements in visibility and prominence of outputs** since REF 2014. Comparing our outputs from 2014 to those submitted in this period, average citations per output rose from 7 to 26 (Scopus). A normalised field citation ratio (FCR) (a normalised value accounting for subarea and year, used by Altmetric) shows that all but two of our outputs that have data available (57 out of 59) are outperforming comparable work. The average h-index score, indicating the prominence of journals and conferences in which our outputs were published, increased from 97 to 129 (using the SCImago Journal Rank (SJR) indicator).

- *Growth in areas of increasing economic and societal significance:* In 2018, we **formed the interdisciplinary Data Science Institute** (with £500k internal investment) and, in 2019, **established a research centre in AI**. Both respond to the burgeoning research and development in data science and AI, and capitalise on our interdisciplinary strengths, which are in high demand due to sector-wide growth in these areas.

- *Growth in doctoral training provision:* In 2019, the Department **launched two centres for doctoral training supported by EIT-Digital**, one in AI and one in Cyber Security, offering an approximate total of £16m for potential PhD sponsorship until 2023.

- *Increased enterprise, third-sector and public investment:* Over the period, we achieved a **balanced portfolio of public sector and industry-funded research**, with industry and charity funding growing from £0.9m to £1.1m and funding from UK Government, health and local authorities growing from £0.87m to £1.5m. This amounted to almost a third of our total income for the assessment period.

The Department's strategy for research was developed alongside the work we did to meet our aims from 2014. We now seek to be bolder in our long-term strategic planning. Thus, our strategic plan is designed to guide us in where to concentrate investment and growth and how we build connections across our five research centres. It has also been developed to respond to our strengths and to reflect the wider research and industrial landscape in the UK and globally. Specifically, it recognises and responds to the proliferation of data intensive systems across many sectors and facets of society, and the sociotechnical challenges and risks that come with these.

The plan sets out goals under three areas:

(i) *Focused research:* Our plan establishes cross-subject themes of strategic importance at the intersections of AI and machine learning (ML); reliable, safe and secure systems; and intelligible and useable interfaces. We are prioritising work across these themes in response to the rapid growth of and widespread investment in data-intensive systems.

(ii) *Interdisciplinarity:* We strongly promote interdisciplinary research. This has meant targeting investments in new interdisciplinary units and prioritising funding applications that depend on research across computing's sub-disciplinary boundaries, as well as with other departments (see below and section 4 for examples).

(iii) *Collaborations and partnerships:* Our research strategy prioritises building collaborations and partnerships within the UK and internationally. This goal targets the nurturing of networks that staff build in their areas of expertise, support for cross-institutional sharing of research, and the pursuit of impactful projects that combine expertise across institutions.

We are achieving these objectives by:

- *Targeted hiring*: We have made seven new appointments of staff who conduct research in or related to ML and AI (**Daviaud**, **Garcia-Ortiz**, **Jimenez Ruiz**, **Mondragon**, **Tarroni**, **Taylor** and **Ter-Sarkisov**). We also have a forthcoming appointment of a Professor in AI (not formally returned for this period).

- *Seed and bridge funds*: We use internal funding and resources so that research centres incubate new research as well as extend and sustain important established research areas. This, for example, includes a University-wide pump-priming fund (£80k per year) and Higher Education Innovation Fund (HEIF) targeted funding (£75k per year). Centres also use funds the University provides from grant overheads (currently the calculation is 8% of income from overhead bearing grants plus one third of principal investigator time charged against projects).

- *New organisational initiatives*: To enable work in our focused areas of research and interdisciplinarity, we have launched an Interdisciplinary Research Centre in Data Science (spanning six departments across the University), a new Research Centre in AI, and two European Institute of Innovation & Technology (EIT)-Digital doctoral training centres (in AI and Cyber Security).

- *Cross-institutional sharing of research*: Encouraging collaboration and partnerships, we commit funding to staff travel and research centre and Department seminars. During the reporting period, £25k was committed to fund travel to other institutions and for visitors to City. Through this support, we have attracted high-profile international speakers and leaders from a range of CS areas (see Section 2.2).

- *Topically targeted funding*: Aligned with our focused research, we have targeted grant applications and had funding successes in, for example, work on explainability in AI systems (Fujitsu, £86k), risk and self-driving cars (Intel, £200k), and visual analytics in crime prevention (EU Seventh Framework Programme (FP7), £519k). We also received an EPSRC new investigator award for applying ML techniques in verification algorithms (£324k awarded in February 2020 but with the start date just outside the timeframe of this assessment).

- *Sustained research combining expertise across areas and institutions*: For example, the *Diversity and Defence in Depth for Security* project (£560k) involved collaboration with the Universities of Lisbon and Maryland to develop robust layers of defence against security attacks on diverse systems. The work led to outstanding research outputs with the collaborators (Distinguished Paper at the IEEE's European Dependable Computing Conference 2018) and subsequent involvement in a H2020 consortium project (*DiSIEM,* overall funding, €4m), which involves collaboration between two of our CSR and the giCentre.

1.3 IMPACT STRATEGY

Our impact strategy aims to take full advantage of the pathways to impact offered by industry collaboration and commercialisation, and public and policy engagement. Thinking strategically

across the lifespan of these pathways we target both short-term investments, with high impact potential, and sustaining long-term commitments.

In the short-term, we prioritise applications for internal resources (e.g. pump-priming, HEIF funding and UKRI block grants) on the basis of their potential for impact. We also target funded partnerships that emphasise knowledge co-production. The latter, through Innovate UK and knowledge-transfer partnerships (KTPs), has resulted in projects worth £720k over the assessment period.

The DMINR (Digital Mining in News and Retrieval) project provides an example of how we progressively build on industry collaborations and work towards commercialisation. The project, funded by Google (£550k), is a collaboration between staff in CS, the University's Journalism Department and Google, and involves the design of a tool to help journalists work with heterogeneous data sources to produce verifiable news. As well as research outputs, the project has produced a demonstrator tool that uses data-driven ML models to filter news and visualise the sources of information. Awarded HEIF funding (£10k), this tool is now set to trial in BBC and London Times newsrooms, and has been given access to Dow Jones's news sources.

A significant proportion of our projects for the period funded by UK Research and Innovation (UKRI) and the EU projects also involved partnerships with industry and third-sector organisations (54%). The EPSRC funded SCAMPI (Self-Care Advice, Monitoring, Planning and Intervention) project (£1.2m) offers an example of the Department's involvement in a consortium with non-academic partners, targeting real-world healthcare planning and provision in the community. The research has involved collaborations with charities, investors, practitioners and business owners in the healthcare, social care and other sectors, and is culminating in a business proposition that includes the computational modelling of quality of life.

It is through cultivating sustained engagements such as these that we seek longer-term, established industry collaborations and opportunities for commercialisation. Examples of such longer-term successes are captured in our four impact cases submitted for this assessment period. The collaboration with BetBuddy, for instance, demonstrates how over a period of 6 years our staff have sought to translate underpinning research in ML into a viable commercial product for predicting gambling addition, leading eventually to an acquisition by Playtech, the world's largest provider of online gambling software.

Similarly, the successes and international recognition of staff in CSR (detailed in 4.3) show how our longer-term commitments have built capacity for public and policy engagement. Here, staff such as **Bishop**, **Bloomfield** and **Littlewood** show how expertise, based at City for over 20 years, can be both commercialised through consultancy and operationalised in ongoing contributions to safety critical industries and governments, internationally.

Our commercial impact and public and policy engagements are more broadly aided through the support of enterprise and professional services, including a dedicated Impact Officer and academic enterprise staff (12 full-time equivalents (FTEs)), all of whom have expertise in brokering connections with commercial and non-commercial partners (see REF5a). In addition, Research Support Services (10 FTEs) and Press and Communication (5 FTEs) staff support impact-focused engagement activities, marketing, publicity and communications.

Supported by these enterprise and professional-facing services, we have, for example, pursued a number of initiatives aimed at building stronger relations with industry partners. In April 2019, we held an Industry Engagement Event with a focus on grand challenges related to AI, an ageing society, clean growth, and the future of mobility. We also held an event in May 2019 on megacities in conjunction with Design Week hosted in the local area of Clerkenwell. These activities have been closely linked to the University-funded interdisciplinary Data Science Institute. Led by **Garcez**, the Institute has built partnerships with the BBC, the British Library, Delta Capita,

the NHS, Société Generale, etc. and is targeting solutions in business, finance, health, transport and the creative industries. Annually, we also host an HCI Design Open Day to present City-based Human-Computer Interaction research to a largely industry-based audience. Through our relationships with technology- and design-based companies, particularly located around the nearby 'Silicon Roundabout', the event has attracted up to 200 attendees from SMEs and larger organisations, and also provided the opportunity for presentations from the Alzheimer's Society, BBC, BAE, Barclays, British Council, Government Digital Service, Pearson, Tesco and Thompson Reuters.

2. People

2.1 STAFFING STRATEGY AND STAFF DEVELOPMENT

The Department's staffing strategy has been shaped by our strategic plan and the University's institutional vision and Research and Enterprise Strategy 2016-2021 (see REF5a). Ongoing improvements in response to our annual staff surveys are also being planned and implemented in CS. Together these inputs set out a strategy for staffing and development that prioritises inclusive *recruitment*, a welcoming and collegial *research culture*, transparency and fairness in *workload*, and clear and transparent *appraisal and promotion* procedures.

Recruitment

During the assessment period, recruitment was designed to support incremental growth in the Department, fulfilling the need for broad-based research and teaching across CS. Accordingly, since 2014 we have hired 15 new staff and, with promotions, made a total of 27 new appointments. Accounting for staff who have left, this represents an overall increase from 36 to 42 staff members (17%).

We have sought to strengthen the quality of our research by using a well-rounded approach to recruitment, with staff hired across research areas. We have also ensured that the Department's staffing strategy is closely coupled with our strategic plan. Thus, hiring has been spread over our three priority areas, AI and ML (6), reliable, safe and secures systems (4) and intelligible and useable interfaces (5), but with an emphasis placed on research related to data intensive systems. As well significantly growing our staff working directly in AI and ML, we have sought staff with complimentary research in medical imaging (**Reyes-Aldasoro**), visual data analysis (**Jianu**) and AI ethics (**Taylor**).

Research culture

We aim to support an inclusive research culture, paying attention to this in our strategic plans and our support for early career researchers (ECRs) and research students (see Sections 2.2 and 2.3).

With respect to staff development, an inclusive culture is built through both University and School inductions, a mandated *equality and diversity general awareness training*, and a range of courses and training programmes targeting inclusion and inclusive leadership and management practices (see Sections 2.2 to 2.4).

The University-wide annual staff survey provides a valuable resource for assessing levels of satisfaction. The results are used to run workshops on issues that have been given a high priority and identified as challenging by staff. Crucial for the Department is that issues are addressed transparently and through a participatory process (see workload and promotion examples below). This process has worked particularly well around issues of diversity and inclusion in the current REF period, enabling a broad base for consultation, strategic planning and achieving milestones

(such as the Athena SWAN Bronze award; see Section 2.4) and planning ongoing events and activities led by our Diversity and Inclusion committee.

Workload

Our staff survey in 2018 showed CS staff wanted greater recognition of workload and more transparency in the allocation of tasks around teaching, administration, research and attracting funding. In response, a workload model was instituted in 2019 that now offers a uniform and transparent measure of staff contribution, while being flexible enough to adapt to the demands of different sub-fields and individual circumstances. The model contains a weighting scheme for three types of activity: teaching, research and administration. An annual allocation exercise ensures work is fairly distributed across staff and allows staff to declare preferences for weightings across the three activity types.

In addition to managing day-to-day workloads, staff have a number of different options for managing their time and taking leave, including long-term leave, parental and adoption leave, flexible working and sabbaticals. Very few staff have taken up any option for extended leave in this assessment period (11 staff, School-wide, took maternity, paternity or shared parental leave in the period). Staff can take sabbaticals after six years of service on request to the Head of Department and if approved by the School's Board of Studies.

In CS, 11 staff took year-long sabbaticals in the assessment period. This proved effective in supporting our research achievements, outputs, and networks with other research institutions. For example, **Child** was awarded two Innovate UK KTPs (£652k); Howe held a visiting research fellow position at the University of St Andrews; **Spanoudakis** applied for and won two H2020 grants (€818k for City); **Stumpf** established three separate industry partnerships with Microsoft, Microsoft Research Cambridge and Fujitsu Labs (total £276k); and **Wood** released *Elm-Vega*, a software tool that produces declarative visualisations using *Elm*.

Appraisals

Appraisals occur annually. These are held with the Head of Department for staff at a professorial grade and with research centre directors or departmental professors for those at lower grades. The appraisals take into account research achievements over the year set against agreed targets.

Staff outputs are incorporated into appraisals through an Annual Research Quality Monitoring (ARQM) review. Each year, staff are asked to nominate up to four publications from the past four years, which are then assessed using the same scoring system as REF (i.e. 1* to 4*). The number of outputs required is reduced for staff who are part-time or early career, or who have had maternity leave or other extended periods of absence. The ARQM review is managed by the research centres, with some solely using external referees and others using internal assessment and external referees for calibration of the results.

Training needs are also considered in appraisals. A new mechanism for mappings between career paths and training is being developed to support this. This will help to identify which training activities are of most use to staff at various stages of their career and what training is required to undertake certain roles.

Promotions

There were 12 promotions in the Department during the assessment period (around 30% of the total staff count), 8 from lecturer to senior lecturer, 3 from senior lecturer to reader, and 1 from senior lecturer to professor.

From 2019/20, the promotions process for the Department has been refined to improve transparency and set clearer criteria. Applications for promotion are initiated by staff and a panel considers staff achievements, contributions to research, education, professional practice, and

service and/or leadership. In assessing promotion cases, the panel also takes into account the internal ARQM review. Promotions from lecturer to senior lecturer are determined at School level. Promotions to reader, associate professor and professor, as well as advancements within professorial banding, are first considered at School level, but ultimately determined at University level by the Academic Promotions Committee chaired by the President.

2.2 SUPPORT FOR RESEARCHERS AND EARLY CAREER RESEARCHERS

As indicated in our REF5a statement, the University is signed up to the Concordat to Support the Career Researcher Development of Researchers. Relatedly, our aim is to excel at the supporting and managing researchers, and to prioritise their active control in career-related decision making. This has meant, for example, that researchers' contracts now have parity with academic staff contracts at the University, and research staff are now automatically promoted to a higher salary grade (5B to 6) upon successful completion of a PhD or equivalent doctoral award.

As a Department, we make use of the full range of internal funding opportunities to support our staff and especially our ECRs. ECR-specific successes in funding include two awards in 2017 under the EPSRC's "First Grant" scheme (**Kalyvianaki**, £100k; **Turkay**, £134k). To offer a current example of how we support researchers, **Neate,** a grant-funded PDRA (hired in 2017) in HCID, was awarded pump-priming funds (£5k) to conduct research into mid-air haptic technology and its potential for gesture-based systems. Neate subsequently submitted an EPSRC Future Leaders application (£1.43m), which has reached the final stage and is currently awaiting a decision. This application has been supported by a commitment to fund a complementary PhD student and to promote Neate to lecturer at the end of the project.

Support and scholarly development are encouraged in and across the centres. Numerous seminar series (both centre-based and across the Department) provide opportunities for City staff to share their work and for external academics to visit from national and international institutions. Internal talks are seen as especially important for sharing expertise and serve as a catalyst for collaboration. We have found our monthly short-talk seminars, that group staff presentations, are especially effective in sharing the background to specific research areas and projects, and providing a basis for collaboration. World leading in areas of computing, we are also proud to attract internationally recognised speakers to present as part our seminars and departmental events. Highlights include, Dr Carpendale (University of Calgary), Prof. Fitzpatrick (Vienna University of Technology), Prof. Gaver (Goldsmiths), Prof. Hook (KTH, Sweden), Dr Fekete (Inria), Dr Munzner (University of British Columbia), Dr Rosner (University of Washington), Prof. Shneiderman (University of Maryland) and Dr Viegas (Google).

Complementing these seminars, the centres run a range of research activities. For example, HCID holds weekly research groups, a biweekly reading group, and regular research-planning and strategy meetings that include all staff and postgraduate research students. ECRs and researchers routinely participate in all these activities to the extent that they have become core contributors to the intellectual vibrancy of the Centre and have chosen to build on this collective ethos by establishing a weekly writing group and, among the PhDs, daily commits (borrowing from the Agile software development tradition).

2.3 POSTGRADUATE RESEARCH

Postgraduate research (PGR) students are core to the energy and vitality of our Department. Two significant achievements over the current REF period are especially noteworthy under PGR. During the period, our department joined the EU's European digital innovation and entrepreneurial education organisation, EIT Digital. Through EIT Digital, we have received support for two doctorial training centres (DTCs), one in AI and the other in Cyber Security. Both permit the intake of ten PhD students per year over four years (2019/20-2020/23). With a commitment to promoting

industry impact, students must match their EIT Digital funding with funding from an industry partner. In each DTC, the maximum award ceiling is £8m, yielding a total of £16m for potential PhD sponsorship between 2019 and 2023.

In addition to these funds, the School makes EPSRC and block grant funds available for PhD studentships across its three departments; CS received funds for 16 PhDs between 2014 and 2020, and individual centres funded a smaller number of students (currently 9). We also continue to apply and receive awards for individual student funding (this period having won 3 AHRC doctoral training partnership awards and a Microsoft Research PhD scholarship).

Altogether, the significant increase in PhD funding over this period has set the stage for considerable growth in postgraduate research in CS. Through the EIT Digital model, we are also closely aligned with the University-wide strategic plan to extend international and enterprise partnerships (as outlined in our REF 5a).

Recruitment and completions

Over this assessment period, we have maintained healthy enrolment and completion numbers and diversity in our PGR programme (see 2.4). The annual intake of PGR students remained stable between 2014 and 2018/19 (9-14 students) and began to grow with the inauguration of the EIT Digital DTCs. In 2020 we had an intake of 16, and we expect this to increase significantly with the potential for an additional 20 part-funded positions each year across AI and Cyber Security. With respect to completions, we awarded 57 PhDs in the six years between August 2013 and 2019/20 (approximately 9 per year), representing a 19% increase on the previous assessment period.

To provide a snapshot of our PhD cohort, in July 2020 there were 43 PGR students, of whom 21 were studying full time and 22 part time. Most students were part of the ACSML (47%), CSR (16%) or HCID (16%). Of these, 16 were 'home' students, 18 from the EU and 9 'overseas'. About half were funded through University or Department funds and half through self-funding or external grants.

Support and training

Research student supervision and progression monitoring are undertaken through a supervisory procedure with all students having a primary and a secondary supervisor, and in some cases – particularly industry collaborations—additional external supervisors.

Wider support for research students is provided by postgraduate student representatives (three in CS), two research degree administrators and three departmental senior tutors for research (STRs), all with oversight from the School's Associate Dean for Research and Enterprise. Quarterly Research Degree Committee meetings are held with student representatives and staff representing academic, administrative, and research management and strategy roles. Outputs from the Committee have included regular updates to the Department's *Guide to Research Studies* document, improvements to graduate teaching assistant contracts, and the design and provision of our Postgraduate Research Experience Survey (PRES) and Survey of Research Culture.

An inclusive culture is core to investing in our students and recognising their contribution to the Department. The School holds an annual summer symposium to enable PGR students to present their work through posters and papers and compete for prizes. The School also provides students with a conference travel fund (£1k/student) and the Department's centres supplement this with fixed sums per year and responses to specific requests. This allows, for example, students to attend top-ranked conferences in their area and to present their work to an international audience.

Across all areas of postgraduate training and support, we pride ourselves on enthusiastically encouraging and promoting students' contributions. Our PhD students have many impressive

achievements, including: **Booth** being awarded a National Science Foundation grant to attend IEEE Symposium on Visual Languages and Human-Centric Computing 2015 (one of only two awards to non-US students) and presenting a full-paper at the top-ranked ACM SIGCHI 2016 (USA); **Koulman's** paper presentation at CogSci 2019 (Montreal); **Liem's** Best Poster Award at IEEE VIS 2018 (Berlin); **Mereani's** two consecutive papers at the International Joint Conference on Computational Intelligence (2018-2019, Bangladesh); and **Reljan-Delaney** winning the Equality and Diversity Scholarship to fund attendance to IEEE VIS 2018 (Berlin) as well as acting as Student Ambassador at IEEE VIS 2019 (Vancouver).

Under training, the University's Doctoral College oversees a Researcher Development Programme for PGRs (see REF5a statement). This provides training in qualitative and quantitative methods, research ethics, thesis writing, and viva preparation. In CS, training for PGR students begins with twice-yearly departmental inductions that cover library services, our *Research Manager* software tool and *FigShare* (the latter, an institutional repository and publishing platform for digital research outputs). In their first year, students also attend seminars on writing literature reviews; research ethics; institutional procedures for data management, research integrity and good practice; and thesis submissions and vivas. Like ECRs (see Section 2.2), PGR students have access to much of the University's professional development and research training, with courses ranging from presentation skills and project management to integrity and ethics in publishing and creating impact.

Progress monitoring

The Department's PGR programme is evaluated each year. This is undertaken by the STR team and submitted to the School's Board of Studies for approval. It draws on the outcomes of Research Degree Committee meetings, survey data, direct student and supervisor feedback, and progression data. In addition to our annual evaluations, in 2018, we undertook a programme periodic review (PPR) of postgraduate research degrees. The review was undertaken by a cross-School committee of academic and management staff, and an external reviewer, Professor Helen Petrie (York). One specific outcome from the PPR has been the formation of a *Framework for Doctoral Training* for autumn 2019, which put in place a training programme for PGR students.

2.4 EQUALITY AND DIVERSITY

Our strategic vision for the Department is led by a commitment to building and enriching a collective and inclusive culture (see Section 1.2), and core to this is recognising the significance of equality and diversity. At an institutional level, support for this area comes from City's numerous programmes and courses developed to promote and instil the values of equality and diversity, as specified in our REF5a statement.

In 2018 the School received the Athena SWAN bronze award. A self-assessment team of academics cutting across the Departments that make up MCSE (including two staff from CS) and professional services staff assessed our teaching provision and academic staffing against the principles of the Athena SWAN Charter. This resulted in a series of action items: supporting students, academic staff recruitment, staff induction, promotion of academic staff, staff training, appraisal, flexible working, support for staff and culture.

In accordance with the Athena SWAN Charter, we have been monitoring the gender diversity across the CS Department's total headcount. We currently meet Athena SWAN's Equality Challenge Unit 2017 CS benchmarks (78% men, 22% women). However, we recognise the challenges of ensuring an inclusive culture; achieving fairness in assessment and promotion; promoting flexible working and support for parental leave; and eliminating discrimination, harassment, and bullying.

With issues such as these foremost in our minds, we are pursuing (alongside the School) a set of initiatives to further improve equality and diversity. Our priority areas are:

- *Improving gender diversity and representation*: In hiring over the assessment period, we have done better in gender distribution than national metrics. Five (31%) of our newly hired staff members are women, 8% higher than the average reported by HESA for "IT, systems sciences & computer software engineering" (23% for 2018/19). Of the department's 12 promotions, 3 were women, representing greater than the proportional number of women to men in the unit (20%-80%). We have been especially strong in achieving a gender balance in postgraduate research students. In 2019/20, 24 of our PhD students were male and 20 female.

- *Supporting staff through a fair and transparent promotions process*: By increasing the transparency of promotion criteria for both full-time and part-time staff and tailoring support for particular needs, the School targeted 75% satisfaction in assessing 'fairness and transparency of the promotion process' by 2020 (yet to be assessed), and for women to make up 20% of professors by 2022.

- *Tackling bullying and harassment*: By making dignity at work, unconscious bias, and active bystander training compulsory, and by improving communication of procedures for reporting bullying and harassment, the School targeted a marked reduction in the reporting of bullying and harassment by 2020 (yet to be assessed).

- *Ensuring equitable treatment of staff through a workload model*: In 2019, we instituted a fair workload model with a transparent responsibility allowance (which includes outreach and engagement activities) (see Section 2.1).

The most recent data on ethnic identities for all staff (research and teaching) in the CS Department are from 2017/18. The breakdown is as follows: Black, Asian or minority ethic: 9; White: 48; Refused or not known: 1. With 15.5% of staff in CS identifying as Black, Asian or minority ethic, we have a greater representation than the national measure for higher education (13.7%) (HESA, 2018/19). The Department also has academic staff and research students representing a broad range of nationalities, with 50% of staff from EU countries and 17% from non-EU countries, representing 34 nationalities overall. Among research students who graduated during the assessment period, 21% came from EU countries and 54% from non-EU countries, representing 20 nationalities.

The Athena SWAN principles act as a key mechanism for shaping and promoting an inclusive culture across the Department, and we have worked hard to arrange thought-provoking events and discussions around diversity and inclusivity. For example, in April 2018 we organised our first Athena SWAN lecture – 'Bringing about Change' given by Carolyn Griffiths, President of the Institute of Mechanical Engineers – with 100 attendees. In December 2018, there was an Athena SWAN and Ada Lovelace Celebration in which CS Department staff contributed to a School-wide panel discussion, 'Career Progression of Women in STEM: Challenges and Opportunities' (approximately 60 attendees). In mid to late 2020, CS staff also contributed widely to a series of talks and discussions on diversity and inclusion in response to the race protests in the US and worldwide and the Black Lives Matter movement.

3. Income, infrastructure and facilities

3.1 INCOME

The Department's aim to foster a culture of generating grant applications and initiatives to attract funding from diverse sources has seen an overall growth in our applications since REF 2014 (see Figure 4). As an example, in 2013/14 we submitted 10 proposals (to EU government bodies and

UK research councils). In 2019/20 we submitted a total of 43 applications for external funding, with an outstanding success rate of 44%.

The diversity of our research portfolio has been important to balance the risk to our income, as well as ensure wider engagements with both the users of technology and related areas of research and industry. In this period, we have achieved a greater diversity of income across UK research councils, UK/international industry, charities, and EU government bodies. In REF 2014, 22% of our income came from national public bodies, 50% from EU government bodies, and 10% from industry and commerce. For this assessment period, the respective figures are 30%, 40% and 29%.

Overall, the strategy to strengthen our research portfolio and diversify funding has resulted in significant growth in income, rising from a total of £6.7m (REF 2014) to £9m for the current period. This represents a 34% growth in funding. The growth in funding from Research Councils UK funding and from other public sources has been marked, almost doubling from £1.5m (REF 2014) to £2.7m. Funding from national and international industry sources and charities has also risen, from £0.9m for REF 2014 to £1.1m for this period, indicative of our increased commitment to non-academic as well as academic partnerships (see Section 4). We have also seen growth in EU Government funding, from £3.4m in REF 2014 to £3.6m in REF 2021 (with a general trend of fewer EU applications, possibly associated with Brexit).
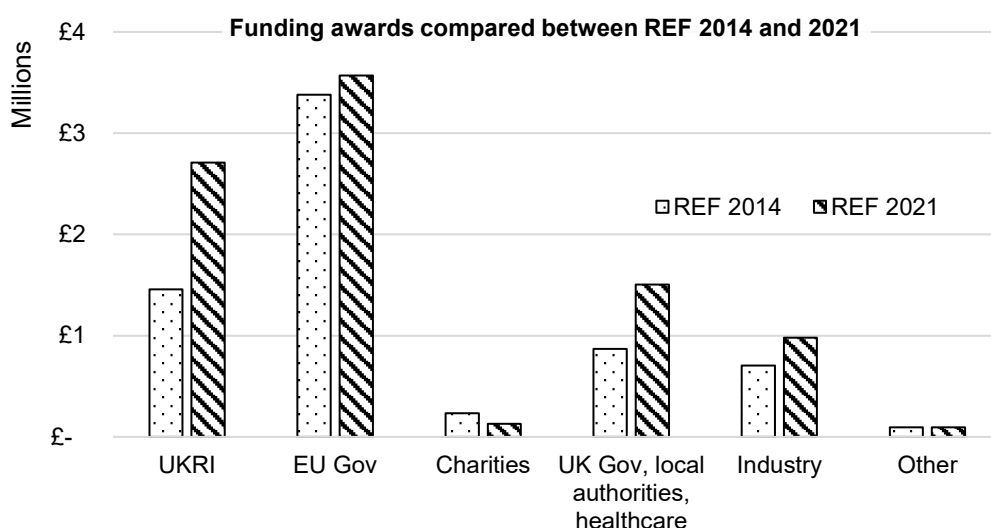
Figure 1. Funding awards compared between REF 2014 and this assessment period.

Funding highlights include significant EU and EPSRC grants:

- *AQUAS (Aggregated Quality Assurance for Systems)* (2017-2020): EU H2020 grant, €15,512,787 with City awarded **£670k**. Academic, public sector, and industry consortium.

- *Communicating and Evaluating Cyber Risk and Dependencies* (2014-2017): EPSRC grant, City awarded **£503k**. Academic lead.

- *CyberSure (CYBER Security InSURancE – A Framework for Liability Based Trust)* (2017-2020): EU H2020 grant, €1,647,000 with City awarded **£250k**. Academic and industry consortium.

- *D3S* (*Diversity and Defence in Depth for Security – A Probabilistic Approach*) (2015-2018): EPSRC grant, City awarded **£704k**. Academic lead.

- *DiSIEM* (*Diversity Enhancements for Security Information and Event Management systems*) (2016-2019): EU H2020 grant, €4,020,018 with City awarded **£0.9m**. Academic, non-profit and industry consortium.

- *EVOTION (Big Data Supporting Public Hearing Health Policies)* (2016-2019): EU H2020 grant, €4,963,776 with City awarded **£482k**. Healthcare, academic and industry consortium.

- *INCA (Inclusive Digital Content for People with Aphasia)* (2017-2020): EPSRC grant, City awarded **£620k**. City academic lead.

- *Learning, Approximating and Minimising Streaming Automata for Large-scale Optimisation* (2020-2023): EPSRC grant. **£250k** awarded to City's new CS AI Centre. City academic lead.

- *TOREADOR (TrustwOrthy model-awaRE Analytics Data platfORm)* (2016-2018): EU H2020 grant, €6,311,218 with City awarded **£468k**. Academic and industry consortium.

- *VALCRI (Visual AnaLytics for sense-making in CRiminal Intelligence)* (2014-2018): EU FP7 grant, €16,569,525 with City awarded **£519k**. Academic and industry partners including Antwerp Federal Police, Linköping University, Middlesex University, West Midlands Police Force, and University of Konstanz.

A range of initiatives are in place to sustain our strategy for attracting income and offering all staff the resources to develop their research. We run a departmental pump-priming scheme and provide significant funding for seminars and events (totalling £30k/year). These initiatives have seen embryonic projects grow into funded research programmes and have successfully seeded external partnerships. For example, work with Microsoft Research funded through pump-priming in 2018 studied the role of AI in front-end systems. This work created the opportunity for a Microsoft sponsored PhD scholarship focused on AI in team-based tools (£72k) and a two-year Microsoft-funded project, ORBIT, to develop a dataset for AI-based assistive technologies (£91k).

Research centres also supplement departmental resources to encourage research in their respective areas. Three of the five Centres pool their income from grant awards to provide investment for all levels of FTE and research staff, and PhD students. For instance, the centres have used these funds to provide bridge funding for PhDs transitioning to grant-funded research or writing fellowship grants, or to cover minor research costs. To offer an example, the HCID maintains a relatively healthy centrally pooled fund from grants (between £60K and £90K per year). During this assessment period, this has allowed one of our PhD students to receive bridge funding while preparing postdoctoral grant proposals; supplemented the pump-priming funds that one of our PDRAs received from the School (£5k); funded two small projects in preparation for larger grant applications (£10k); and provided conference fees and travel costs including for all staff and students (with accepted papers or workshop papers) attending ACM SIGCHI 2019.

Overall, we will continue the strategy of prioritising interdisciplinary and collaborative initiatives and placing an emphasis on building non-academic partnerships that have significant and far-reaching impact (see Section 1.2). In Section 4, we capture how our efforts and successes with collaborations and wider economic and social impact are targeting this strategy.

3.2 INFRASTRUCTURE AND FACILITIES

Much of the Department's support infrastructure and facilities are delivered through the School of MCSE's investment in world class buildings and labs, equipment and service provision, as well as maintenance and repair. In total, this amounted to £19.4m over the assessment period.

The infrastructure and facilities provided to support the CS Department's staff and students range from equipment for research, to tools for the management, sharing and distribution of research data and outputs.

Research

CS staff and research students receive support for computationally intensive research through the provision of computing equipment and services, such as data storage, dedicated hardware, software, networking and cloud computing. During the assessment period, almost £950k was spent on new computing equipment for our labs. Notable is the new CitAI *Robin Milner Lab,* which contains state-of-the-art high-performance GPU computers and software tools, and the computational power needed for artificial general intelligence and deep learning. The Department is also home to the Interaction Lab, which provides a dedicated space and professional-grade facilities for user-testing, expert reviews and accessibility audits. The lab supports in-house research by staff and postgraduate students, as well as offering a successful commercial user experience consultancy (with an income of approximately £200k per year) run by a dedicated, full-time lab manager.

Supporting research and research impact

To support research and research impact, the University offers a range of events and training programmes. All Department staff receive support from the University's *Research and Enterprise* team on relevant grant initiatives and calls, developing grant proposals, costing grants, and managing their administrative duties while they are running projects. In addition, all staff have access to training on grant-related activities, including grant writing, interdisciplinary research, research leadership, ethics and integrity, project management, inclusive hiring and assessment, and creating impact. The University also regularly holds events hosting funders such as the UKRI councils, the Leverhulme Trust and the Royal Academy of Engineering.

To facilitate impact and in particular expand the reach of their work, all staff are encouraged to make use of third-party licensed tools and services. This includes provision for project management (*Worktribe*), research management (Haplo's *Research Manager*), data management and sharing (*FigShare*), research profiles, publication management and sharing (*Symplectic Elements* and *ORCID* – with all staff having ORCIDs).

To ensure best and ethical practices in data collection, and storage, the University offers training on the EU's *General Data Protection Regulation (GDPR)*. We adhere to the GDPR in our *Framework for Good Practice in Research* and our *Research Ethics Framework*.

Library Services

The University's Library Services plays a central role in supporting the Department's research. Our staff have access to an extensive portfolio of 300 University-wide and specialist databases including Scopus, Web of Science and ScienceDirect. These collections are maintained by a current annual budget of approximately £254k for specialist resources and a £1.6m annual spend on cross-School and cross-Department content. A dedicated Research Librarian and a Subject Librarian serve the Department, offering staff and PhD students support and workshops on literature searching, citing and referencing, and specialist database access.

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

4.1 ACADEMIC COLLABORATIONS

Staff in our five research centres have strong ties with their respective communities. Indicative of our diverse geographic and institutional collaborations are the number of cross-institutional outputs (73% of total) submitted for this assessment period (with institutions in the UK, Asia, Australia, Europe, and North America). Of these collaborations, over a quarter (29%) were with institutions ranked in the top 100 of the Times Higher Education World University Rankings for 2020 (e.g. the universities of Cambridge, Oxford, Southern California and Stanford, and Imperial College London and LMU Munich).

To offer an example of our academic collaborations, **Reyes-Aldasoro**, from our giCentre, has worked with life scientists from the Francis Crick Institute, King's College London, the University of Sheffield and Monash University to aid in the analysis of cells in in vivo environments and better understand the characteristics of the immune system. This work has resulted in numerous conference papers, 14 articles in top-ranked journals (e.g. *Nature Methods*, REF2_ID:241422*,* and *PLoS Medicine,* REF2_ID:255870) and two grants from the Australian Research Council. The work's importance for cancer cell analysis has been covered in the press, including at Phys.org ('Academics develop algorithm to analyse HeLa cancer cells', 2020).

4.2 CONTRIBUTIONS TO THE RESEARCH BASE

The visibility and prominence of our outputs show we are having a marked impact on the research base. Although we recognise their limitations in reflecting research quality, metrics suggest we have achieved measurable improvements. Comparing this period's output to REF 2014, the average citations per output has risen from 9 to 26 (Scopus). Available normalised data indicate the significance of this achievement. For the 59 publications submitted for this assessment period that have data available, all but two have a field citation ratio (FCR, a normalised value accounting for subarea and year) greater than 1, indicating a higher-than-average rank relative to comparable articles (data from Altmetrics). The FCR is greater than 10 for 25 of this 59. For the 61 outputs where journal ranks are available, 58 are in the top quartile of journals in their subareas, with the remaining 3 in the second-to-top quartile (data from SJR). We have also seen a greater proportion of our publications scoring higher in the SJR field-normalised rank (a measure of a journal's prestige derived from citations and the source of citations). On average, the SJR value rose from 1.013 in 2014 to 1.974 for our outputs in REF 2021.

The strength and recognition of our outputs has been captured in numerous accolades, including prestigious individual awards, high-profile research achievements, and recognition from external agencies and organisations. These include:

- First Prize, European Institute of Innovation and Technology, ICT Labs Idea Challenge on Smart Energy Systems (2014): €40k awarded to **Alonso** for the project 'Neural Networks for the Smart Grid'.

- Best Paper Award, European Conference on Mathematical and Theoretical Biology (2014): Teichmann, Broom and **Alonso**, 'The Application of Temporal Difference Learning in Optimal Diet Models' (in best 4 of 800 papers).

- Best Paper Session, Quantitative Evaluation of Systems (2015): **Salako**, **Stankovic** and **Popov**, 'Stochastic Model for Performance Evaluation of Database Replication Protocols' (in best 4 of 42 papers).

- Best Paper Session, European Dependable Computing Conference (2016): **Gashi**, **Povyakalo** and **Strigini**, 'Diversity, Safety and Security in Embedded Systems: modelling adversary effort and supply chain risks' (in best 3 of 59 papers).

- Best Paper, EuroVis (2017): Buchmüller, Janetzko, **Andrienko**, **Andrienko**, Fuchs and Keim, 'Visual Analytics for Exploring Local Impact of Air Traffic'.

- 10-Year Impact Award in Ubiquitous Computing (2017): Brown, **Taylor**, Izadi, Sellen and Kaye, 'Locating Family Values: A Field Trial of the Whereabouts Clock' (awarded every ten years to papers deemed most impactful in Pervasive and Ubiquitous Computing).

- Test of Time Award, IEEE VIS (2018): **Andrienko** and **Andrienko**, 'Spatio-temporal Aggregation for Visual Analysis of Movements' (recognises major impact and influence within and beyond the visualisation community).

- Contribution to House of Lords committee report, *Regulating in the Digital World* (2018): contribution invited to materials on internet regulation to the Lords Select Communications and Digital Committee ('The Internet: To Regulate or Not to Regulate?').

- Best Paper, ACM SIGCHI (2018): Schlesinger, O'Hara and **Taylor**, 'Let's Talk About Race: Identity, Chatbots, and AI', REF2_ID:243935 (top 1% of accepted papers).

- Best Paper Honorable Mention, IEEE VIS (2018): **Wood**, Kachkaev and **Dykes,** 'Design Exposition with Literate Visualization', REF2_ID:246961 (in top 3 of 165 papers).

- Three Best Paper Honorable Mentions, ACM SIGCHI (2019): **Heitlinger**, Bryan-Kinns and Comber, 'The Right to the Sustainable Smart City', REF2_ID:255941; Neate, Bourazeri, Roper, **Stumpf** and **Wilson**, 'Co-Created Personas: Engaging and Empowering Users with Diverse Needs Within the Design Process', REF2_ID:255038; Neate, Roper, **Wilson** and Marshall, 'Empowering Expression for Users with Aphasia through Constrained Creativity', REF2_ID:255039 (top 4% of accepted papers).

- Best Paper Session, IEEE Symposium on Software Reliability Engineering (2019): Zhao, Robu, Flynn, **Salako** and **Strigini**, 'Assessing the Safety and Reliability of Autonomous Vehicles from Road Testing' (best 3 of 134 papers).

- Advisor on Ethereum Foundation: **Krol** invited advisor on service discovery protocol to be implemented in Ethereum 2.0.

Our staff are frequently asked, through numerous service duties, to set research benchmarks and contribute to their subareas. Such contributions include reviewing for and serving on UKRI panels, membership of the EPSRC College, journal and conference reviewing, and examining PhDs.

Our Department has been represented on many conference committees (including ACM SIGCHI, CSCW, IEEE VAST, IEEE VIS and IJCAI) and top-tier journal boards (including *ACM Interactions*, *IEEE Transactions on Dependable and Secure Computing*, *IEEE Transactions on Neural Networks and Learning Systems*, *IEEE Security & Privacy* and *IEEE Transactions on Visualization and Computer Graphics*).

The research expertise we bring to these activities, and the regularity with which staff are asked to undertake them, reflects core strengths embedded within the Department, which in turn feed back into the research base internationally. External recognition of our contributions includes conferred fellowships such as FBCS (**Garcez**), FREng (**Bloomfield**), FRSA (**Taylor**), and Fellow of the Royal Statistical Society (**Littlewood**).

We are especially excited to see ECRs making significant contributions to their subareas and attracting high-profile recognition. **Denisova** has had novel work on the 'placebo effect in games' (Denisova and Cairns, CHIPlay, 2015) promoted through outlets including the New Scientist and tech-media outlet Gizmodo. In 2019, **Turkay** received the EuroVIS Young Researcher Award; the committee recognising his highly innovative and influential contributions in the visual analysis of high-dimensional data. **Jimenez-Ruiz** was ranked in the top three knowledge engineering scholars the AI 2000 Most Influential Scholars annual list (2,000 of world's top-cited research scholars in AI). **Tarroni** was awarded a Marie Skłodowska-Curie European Fellowship (€183k, H2020) and also led on work contributing to the UK Biobank Dataset (Tarroni et al., IEEE Trans. on Medical Imaging, 2019).

Our giCentre presents an outstanding case of contributing to the research base in longer-lasting, structural terms. Over 15 years, giCentre has become an influential leader in Visualisation by publishing a body of high-quality research at IEEE VIS, the premiere visualisation conference. This has amounted to more than 60 papers in the associated journal, *IEEE Transactions on Visualization and Computer Graphics* (39 published in current REF period). Of these highly collaborative papers, many with leading international colleagues, 4 have received honourable

mentions at IEEE VIS. This influence has been sustained through an equal commitment to service. **Dykes** (2012/13), **Wood** (2018/19) and **Gennady Andrienko** (2015/16) have served as Papers Chairs at IEEE VIS and IEEE VAST. Between 2014 and 2019, **Dykes** served on the InfoVis Steering Committee, during which time he contributed to the reVISe process, which has consolidated the conference, extended its formats, improved governance and increased transparency. He now serves as Vice-Chair of the conference's Executive Committee. In addition, he and **Natalia Andrienko** have acted as Associate Editors of *IEEE Transactions on Visualization and Computer Graphics*. The quality of the giCentre's academic contributions and staff members' sustained work and commitment to visualisation represent a long-lasting and transformative effect on a significant area of CS.

4.3 CONTRIBUTIONS TO THE ECONOMY AND SOCIETY

The Department aims to build partnerships that translate into wider impact. Our income data show how we have succeeded in strengthening such partnerships, with combined industry and charity funding totalling £1.2m and funding from government agencies (such as healthcare and local authorities, GHCQ, Innovate UK and the National Cyber Security Centre) totalling £1.6m. Together, this represents a 33% increase in income from non-research dedicated sources (industry, charities, local health authorities, etc.) since REF 2014.

Our outputs also reflect the substantial number of industry and commercial collaborations we are involved in. Over a quarter of our outputs were co-authored with non-academic partners including AT&T Labs, BT, CSIRO, the Fraunhofer Institute, Google, IBM, Inria, the Max Planck Institute and Microsoft Research. We have successfully developed such partnerships into funded research projects. Funding for small- to mid-scale projects have come directly from industry such as Telefonica Alpha (£20k), the Tavistock Trust for Aphasia (£50k), Intel (£200k), Microsoft Research (£250k), the Stroke Association (£250k) and Google (£550k).

Stumpf's involvement in the FREEDOM (Flexible Residential Energy Efficiency Demand Optimisation and Management) project offers an exemplary case of industry collaborations and our commitment to wider impact. The research aims to understand the effects of smart metering technology in consumers' homes and, specifically, what can be done to improve the presentation and use of the data the meters produce. The project is conducted in collaboration with the home energy service and device manufacturer Passiv Systems Ltd and funded by Western Power Distribution and Wales & West Utilities (£94k).

Slingsby leads another project that will have long-term impact. The work stems from funding from the Rail Safety and Standards Board (£118k), the rail industry's applied research funder, which only funds research that is likely to have impact. Thus far, the work has led to the design and implementation of interactive visualisation tools that will help to interpret the modelling of delays and alternative timelines. Currently, the project is undertaking case studies with Great Western Railway, Greater Anglia and Railtrack. The target is for the work to become part of a commercial service offered to train operating companies.

CSR's longstanding and significant contribution to safety and risk control in computer-based systems deserves special mention (see REF3 impact case 'Risk Framework'). Notable is CSR's research on assurance methods for critical systems in nuclear power plants. CSR worked between 1997 and 2018 for the Control and Instrumentation Nuclear Industry Forum, that represents the industry and regulators. With overall funding above £1m, this research delivered advice on diversity and defence-in-depth (work central to a REF 2014 impact case, judged especially noteworthy by the panel), and probabilistic assessment of safety. Much of this research has been published in well-respected peer-reviewed forums such as IEEE TSE and TDSC, Reliability Engineering and System Safety, and the ISSRE and DSN conferences. Published

research by **Bishop** and **Povyakalo** (REF2_ID:142285; REF2_ID:273212) is being used for a multi-million-pound test programme that will be used for regulatory approval of a nuclear plant protection system.

Dealing with the wider implications of sociotechnical systems, several members from CSR have been involved in efforts to overturn the miscarriages of justice in the Post Office Horizon case. **Bishop** contributed to a review that challenged the statistical basis of a key defence submission made by the Post Office. **Littlewood** and Newby (Engineering) co-authored a paper used to support the recent overturning of convictions of 39 sub postmasters at the Court of Appeal. The same authors were invited by the Under-Secretary of State at the Ministry of Justice to provide a case to support a referral to the Law Commission to replace the presumption in English Law of the infallibility of computer systems. More recently, these authors have briefed the Shadow Minister for Science, Research and Digital on legal and technical issues likely to arise as a result of emerging technologies, such as ML and AI.

Our impact cases (REF3) present four examples of where we have achieved sustained impact. All our impact cases are directed at the welfare of populations in the UK and internationally; they target issues including gambling ('BetBuddy'), equality and inclusion ('GenderMag'), and forensic analysis and criminal investigation ('familial DNA searching'). A fourth impact case ('Risk Framework'), improves the safety and security of high-risk industries and the communities they affect, internationally. The BetBuddy, GenderMag and the Risk Framework cases demonstrate how wider social benefits can yield economic benefits for the stakeholders. These cases include testimonials or evidence showing impact on and benefits to products and services from major companies in the respective gambling (Playtech), software design and development (Bloomberg and Microsoft), and safety critical industries (Intel and Radiy).

The wider societal relevance of the Department's contributions is captured in press coverage and plaudits we receive. Highlights include:

- 'Which Bits of London Are Most Photographed?' (*Londonist*, 2104) – coverage of work by **Wood**;

- 'Royal Institution Christmas Lecture' (*BBC*, 2014) – contribution from Weyde's Music Informatics Research Group;

- 'Early Warning System to Assist Gamblers' (*Bloomberg Businessweek*, 2015) – coverage of work by **Garcez**;

- 'EVA Park: a Virtual World to Help With Speech Recovery' (*Huffington Post*, 2015), 'Tech4Good People's Award' (2015), and 'Braille smartwatches, bespoke wheelchairs... technology that matters' (*The Guardian*, 2016) – coverage of the Tech for Aphasia work, led by **Wilson**;

- 'How science can help us make AI less creepy and more trustworthy' (*The Conversation* and *Daily Mail*, 2016) – authored by **Stumpf**;

- 'Musical Influence in Jazz Investigated with 'Big Data'' (myscience.org, 2017) – coverage of research from **Weyde**;

- 'Microsoft Accessibility Grants Go Out to Companies Aiming to Improve Tech for People with Disabilities' (*TechCrunch*, *HuffingtonGlobal* and *Wiredfocus*, 2019; *Techregister*, *Scienmag* and *Finance.yahoo.com*, 2020) – coverage of City's lead in the AI and disability project ORBIT, led by **Stumpf**;

- 'Record Number of People Ride 'Boris Bikes' after Lockdown Rental Slump' (*Evening Standard*, 2020) – coverage of data science and visualisation work by **Wood**;

- 'Five Ways Artificial Intelligence Can Change Online Gambling' (*Newswatch*, 2020) – coverage of BetBuddy work from **Weyde** and **Garcez**;
- 'Professors Bev Littlewood and Martin Newby to Improve Software for COVID-19 Models' (*ScienMag*, 2020) – coverage of awarded funding from the Royal Academy of Engineering.

At home, we have leveraged our central London location and excellent facilities for the benefit of the surrounding community. Situated alongside design and technology firms as well as long-time residential neighbourhoods in London's Clerkenwell, we are invested in building and sustaining local relations, with both businesses and the community. Aiming to support the local economy, the CS Department has been working with the Digital Catapult and the Connected Places Catapult to establish mechanisms to transfer STEM knowledge to SMEs and start-ups; the HCID's annual Open Day attracts representation from local firms.; the Centre also supports and hosts activities and events run by the UK chapter of the, not-for-profit, User Experience Professionals' Association.

In surrounding communities, we engage with local schools. For example, as part of City's "Widening Participation" programme, **Makri** delivered a "masterclass" titled 'Designing for serendipity: An oxymoron?' to sixth form and college students from the local area. Separately, six research students and ECRs from the Department ran four- to six-week coding clubs for primary schools in Central and East London. Key goals in designing and undertaking this project were to introduce the concepts of coding to children with diverse ethnic backgrounds and to appeal to a balance of boys and girls.

Our investment in the local community is also represented in our research portfolio. Building on the EPSRC-funded Connected Seeds project (with an associated publication receiving an Honourable Mention award at CHI 2019), Heitlinger is continuing to engage with the charity Spitalfields City Farm. This research has had the objective of exploring inclusive technology design with and for sustainable urban communities, cutting across the usual divisions of social class and ethnicity. As part of this work, Heitlinger established the City Farm Lab, an academic–community partnership building on her long-term collaboration with the Farm. This has meant operating a user-centred, open-innovation Living Lab, which integrates research, teaching and innovation processes. The engagement started with nine master's students' dissertation projects, run in collaboration with the Farm. In recognition of her support and commitment to the Farm, Heitlinger now holds a position on its Board of Trustees.