Environment template (REF5)

Institution: Brunel University
Unit of Assessment: 11 Computer Science and Informatics

a. Overview

Brunel's Department of Information Systems and Computing (DISC) is an interdisciplinary centre that includes researchers with a range of backgrounds including computer science, mathematics, and psychology. We see Computer Science as being the study of complex systems that contain a computational element and aim to be a world-leading department whose focus is on Computer Science research that is applied and rigorous. We have a long tradition of applied research, in line with Brunel's history and Royal Charter. We previously submitted to the UoA Library and Information Management, achieving a 5 in 2001 and being the top ranked submission (under research power) in 2008, in which our research environment was given weightings of 50% for 4* and 40% for 3*. There has been a significant shift towards Computer Science since 2008 and this is reflected in our submitting to UoA 11. Members of DISC work on a range of related topics including software engineering, intelligent data analysis, human computer interaction, information systems, and systems biology. Our research is organised around two centres.

Centre for Software and Systems (CSS). The CSS research ranges from relatively formal, mathematical work through to the role of information systems in organisational structures. We believe that there is a need to understand systems and software in their context and this understanding can best be obtained through a mixture of analytical and empirical methods.

Professors (4): Robert Hierons; Robert Macredie; Martin Shepperd; Terry Young. Readers (5): Steve Counsell; Tracy Hall; Kate Hone; Mark Perry; Simon Taylor. Senior Lecturers (3): Laurence Brooks; Steve Love; Alessio Malizia. Lecturers (2): Andrea Capiluppi; Arthur Money.

Centre for Intelligent Data Analysis (CIDA). CIDA aims to meet the challenges in analysing, visualising and integrating a variety of high-dimensional, fast evolving, real-world noisy data. The centre champions the interdisciplinary approach to data analysis and has developed many innovative IDA methods and algorithms that have found successful applications in a range of areas, particularly in biomedicine and digital economy.

Professors (5): David Gilbert; Xiaohui Liu; Panos Louvieris; Mark Lycett; Zidong Wang. Readers (2): George Ghinea; Lampros Stergioulas. Senior Lecturers (2): Yongmin Li; Allan Tucker. Lecturers (8): Jane Coughlan; Timothy Cribbin; Crina Grosan; Stanislao Lauria; Annette Payne; Larisa Soldatova; Stephen Swift; Fang Wang.

Research projects are often carried out within smaller research groups, with these being created when there is demand. Given their temporary nature, the research groups are not outlined in this document but some are based around disciplines (for example, software engineering) and others are based around application domains (for example, healthcare).

b. Research strategy

Research strategy and achievements against this. Our vision is to be a Computer Science department that carries out rigorous world-leading applied research. We focus on high-quality research that makes a difference. We support interdisciplinary work and seek funding from diverse sources including industry, with the two centres supporting the development of large funding proposals. We have a strong PhD programme and invest heavily in the training of research students and the provision of facilities for these students. We focus on two main domains: healthcare/biomedical informatics and digital economy/business.

Our strategic plan supports Brunel's strategic research plans (2008-12; 2013-17), which aims to achieve a sustainable culture of high-quality research. The School's research committee reviews our strategic plan annually. We sustain research quality by recruiting world-leading researchers and ECRs with potential and then supporting them through the provision of a strong research environment. Our colleagues receive peer support and mentoring as well as having access to developmental opportunities. Each member of staff is in one of the two centres, with these acting as centres of excellence and providing focused research support. We ensure that our research retains focus by recruiting researchers from our core areas while paying attention to developing trends. Although the two research centres act as focused research communities, many of our

projects involve both centres and smaller research groups are formed dynamically.

We are committed to engaging with a range of user groups in order to ensure that our research is informed by domain experts and has a real public benefit and this is facilitated by contacts made through our vibrant work placement scheme. We have strong long-standing relationships with many user organisations including Microsoft, Ford, GSK, Kew Gardens, Moorfields Eye Hospital, Three, and UBS. During the period we had seven CASE awards and most of our grants included industrial partners.

The success of our research strategy is demonstrated by colleagues regularly publishing in top venues. For example, our 31 staff published over 450 journal papers since 2008. This includes over 80 papers in IEEE and ACM Transactions, with 19 colleagues published one or more such papers. We published in top journals in Biomedical Informatics (Nature Cell Biology; IEEE Transactions on Biomedical Engineering; Bioinformatics; Science), Information Systems (European Journal of Information Systems; the Journal of Information Technology), Software Engineering (IEEE Transactions on Software Engineering; ACM Transactions on Software Engineering and Methodology), Artificial Intelligence (IEEE Transactions on Neural Networks; IEEE Transactions on Evolutionary Computation), and Theoretical Computer Science (SIAM Journal on Computing; Theoretical Computer Science). A total of 113 of our 117 submitted papers were published in journals, with a mean impact factor of over 2 and mean citation count of over 20 (Google Scholar, 24/10/13), and our staff have a mean h-index of over 17 (Google Scholar, October 2013). They have been awarded over £13M in grants since 2008 (over £10M spend), including over £8M from the Research Councils, over £3M from the EU, with the rest coming from other parts of the UK government, industry, and charities. DISC is the host institution for the Multidisciplinary Assessment of Technology Centres for Healthcare (MATCH), one of only 18 EPSRC Innovative Manufacturing Research Centres. We have graduated 83 PhD students since 2008 with many having taken up senior positions in industry or lectureships/postdoctoral positions at institutions such as Cambridge, Oxford, Imperial and UCL. Our researchers have a high visibility and include editors of major journals, past and present presidents of the UK Academy for Information systems (UKAIS), and ten members of the EPSRC College. In addition, they have given keynotes at or organised many major international conferences.

Our RAE 2008 submission highlighted healthcare and biomedical informatics as areas to grow. As a result, we recruited Professor David Gilbert, Dr Larisa Soldatova, and Dr Crina Grosan. We have been awarded over £5M in external funding for these areas. In addition, Brunel recruited Professor Nigel Saunders to a new Interdisciplinary Chair of Systems Biology – Biosciences. The recruitment of Professor Saunders (submitted under 3-Allied Health Professions and 0.5FTE in the school) added biological expertise that supports our systems biology research. These appointments have led to a major research group in systems and synthetic biology with top quality publications including papers in Nature Cell Biology and Science. The achievements against our research strategy include a number of significant contributions and we now briefly describe some of these.

CSS focuses on the development, analysis and use of software and systems. This includes work on simulation, which we use to analyse organisational processes but also the evolution of software [Counsell:2]. We led the development of the international SISO-STD-006-2010 Standard to promote interoperability of simulation packages [Taylor:4]. We also explored usability issues, with a particular focus on mobile devices where we have shown how real user and organisational requirements can be incorporated [Love:2].

Within software engineering we explored the effect of design patterns and refactoring on how fault-prone systems are [Case Study: Software Engineering]. We devised prediction techniques that work with small, noisy datasets and that dynamically update predictions [Shepperd:4]. We showed that open-source projects require new prediction models and identified classes of prediction model that perform well. Within software testing we showed that the nature of the interaction of a system with testers has a significant impact if this is asynchronous or distributed, making (normally tractable) standard problems NP-hard or undecidable [Hierons:2,4]. We developed methods for analysing (slicing) programs and models to make them simpler [Hierons:1] and used evolutionary algorithms to drive test automation [Swift:3].

CIDA staff developed Intelligent Data Analysis methods for challenging real-world applications,

particularly in biomedicine and digital economy. This includes work on visualisation, where we have shown that a 3-dimensional view of the human body can be manipulated so that patients can indicate the location, type, and intensity of back pain [Ghinea:3]. This provides a non-verbal way of identifying location and type of pain, facilitating remote monitoring and management.

Novel algorithms have been developed for several key IDA methods, including complex networks [Wang:3], pattern recognition [Li:1] and evolutionary algorithms [Liu:2]. This includes algorithms to support the evaluation of gold immunochromomatographic assays based on image processing techniques, which have been used in medical devices to test for pregnancy and Downs syndrome [Case Study: Diagnosis]. We also used a novel ontology engineering approach to improve the semantic foundations and interoperability of data held in IT systems, addressing organisational issues around consistency of meaning within and across systems [Case Study: Ontologies].

Future strategic aims. Our research will continue to be focused around the two centres and two main domains (healthcare/biomedical informatics; digital economy/business). We will build on our strengths in these areas by appointing world-leading researchers in fields that complement our current expertise, facilitated by our strong profile in these areas and our links with other centres of excellence. We will use our relationships with user groups to identify long-term developments to which we can contribute and will recruit staff that can support the areas identified. We see our research students and research assistants as being junior colleagues and will further enhance their roles in our centres and projects by enabling them to play to their strengths and collaborate closely if appropriate, and through mentoring and training. We will maintain the population of research students, will continue to provide bursaries and will seek external funding to support this.

We will seek to ensure that our work has as strong and broad a public benefit as possible. For example, we are currently in the process of rolling out results from the Multidisciplinary Assessment of Technology Centres for Healthcare (MATCH) project and more generally will use external PR consultancy to complement our current dissemination methods. Since our strategy is to focus on relatively applied research, we will continue to ensure that the range of user groups with whom we engage reflects our research focus, with the School's research committee reviewing the membership of our Industry Advisory Board on an annual basis and comments from this board feeding into our research strategy. We will use other mechanisms, such as our work-placement programme, the annual Made in Brunel exhibitions, and our involvement in industrial/user bodies to engage with a wide range of user/industrial interests.

Over the next 5-10 years we will develop our key areas further but one area/technology underlying the two main domains is Big Data: the ability to manage, integrate and analyse large-scale, heterogeneous, noisy real-world data. We plan to take a coordinated approach to the Big Data challenges and become an international leader in the area. We will do so by having outstanding staff and students join us, by combining research efforts from CIDA and CSS as well as other schools at Brunel, and by collaborating with leading experts in the area. External collaboration will be facilitated through our current high-profile, internal funding to support visits and visitors, and involving international experts in projects. CSS and CIDA will continue to act as centres of excellence and we will encourage interdisciplinary research through seed funding and workshops to explore opportunities, with the workshops being promoted to experts outside of the department. Large funding applications will target priority areas and will typically have a significant Big Data element and we will use these to increase the number of research assistants.

c. People, including:

i. Staffing strategy and staff development

Overview. Our strategy is to recruit researchers who have shown that they have the potential to carry out world-leading research and provide a research culture that helps them achieve their potential. We strategically appoint in areas that complement and strengthen our two centres and that contribute to the two application domains. We look to appoint staff with the potential to develop strong funding bids related to Big Data, with the aim that the grants obtained will further develop our strengths in this area but also extend the facilities we have to support Big Data research.

We place a strong emphasis on research when appointing academic staff, recruiting internationally leading researchers that can contribute to our two themes. All staff appointed since 2008 have

been returned. In 2010 the Graduate School and Staff Development assessed Brunel's implementation of the Concordat to Support the Career Development of Researchers through a gap analysis, preceded by a survey and focus group. This informed an action plan that coordinates effort from a range of stakeholders within Brunel. The effectiveness of the action plan is monitored and reviewed through the university's Staff Development Strategy Group and the Research and Knowledge-Transfer Committee (the seventh key principle of the Concordat). Brunel was awarded the European Commission's 'HR Excellence in Research' badging in 2011, recognising its commitment to the Concordat.

Since 2010 the annual appraisal and performance management process has had an increased emphasis on research (first principle of the Concordat) and publications form a criterion for promotion. DISC provides financial support, including around £150k annual funding for research studentships on top of DTA funding. There is an additional £100k per annum ring-fenced research funding provided by the department, which is used to support the development of new lines of research as well as conference attendance. The School's focus on interdisciplinary research is supported through internal funding for interdisciplinary projects, both within the School (between DISC and Mathematics) and between DISC and the Brunel Business School or the School of Health Sciences and Social Care. Brunel's research ethics committee assesses relevant research.

Career development. Brunel's staff development programme supports staff at all points of their career and new staff at Lecturer or Senior Lecturer level can apply for a Brunel Research Initiative Enterprise Fund award of up to £15k. F. Wang received such an award for 2010-11, with this supporting collaboration with British Telecom Group, UK and Tongji University, China. This led to a journal paper, a joint EPSRC proposal to be submitted, and new collaboration with Samsung and Vodafone. Several DISC researchers have benefitted from research leave (Counsell; Ghinea; Lycett; Perry; Shepperd; Taylor; Z. Wang), Knowledge Transfer (KT) leave (Swift), and KT Secondment (Love). KT leave allowed Dr Swift to visit Quantel Ltd, with this leading to changes in Quantel's IT systems, input into a PhD, and two papers. Dr Love's project funded an employee of consulting firm Manaman Ltd to work with him (at Brunel) one day a week. This led to Hutchison 3G and Manaman Ltd having input into our research and provided both Dr Love and his research students with real industrial field work within mobile telecommunications.

Support provided by Brunel is augmented by activities within DISC and informal networks. Early career researchers are mentored by senior colleagues, have a reduced teaching load, and are not allocated major administrative roles. Support is provided through funding research activities, internal peer review of papers/grant proposals, and workshops, often around interdisciplinary themes. All funding proposals are reviewed internally. For staff at all levels, the annual appraisal scheme includes career planning. Professors and readers appraise lecturers and senior lecturers and readers and professors agree targets for the coming year and a rolling three-year plan with the Head of School. The needs of fixed-term and part-time staff are integrated into these procedures. There is an annual departmental away day, which helps encourage interdisciplinary research. Promotions reward research excellence and since 2008 these included two to Senior Lecturer (Brooks; Tucker), three to Reader (Counsell; Perry; Taylor), and one to Professor (Lycett).

Research Fellows and Research Assistants. Brunel has career development activities designed for the needs of research assistants and the Graduate School runs development programmes that include training in core skills (including research ethics and knowledge transfer). Workshops cover a wide range of topics, such as career planning, interview skills, and presentation skills. Researchers are encouraged to attend staff training sessions on career guidance and one-to-one coaching is provided for research staff to explore personal development and career aspirations. Promotion procedures for research staff are transparent and outlined in the staff handbook, available via Brunel's intranet (second principle of the Concordat). DISC provides funds for attendance at conferences and summer schools. Research assistants can choose to gain teaching experience where appropriate, this being supervised by the module leader. Some mentor research students. The Graduate School plays an active role in the Vitae London Regional Hub Steering Committee which informs Vitae's central planning. We participate in Policy Forums enabling us to contribute and respond to national priorities and initiatives. Research assistants are encouraged to participate in developmental opportunities provided by Vitae and, for example, the Graduate School covers the costs of researchers attending the annual UK Research Staff Association

Conference. These activities support the third, fourth, and fifth principles of the Concordat.

In addition to opportunities provided to research assistants, Brunel provides training for their managers and supports and recognises good research management through appraisals. Brunel is developing a code of practice for the management of research staff and is evaluating examples of good practice. Sector-wide CROS (Careers in Research On-line) and PIRLS (Principal Investigators and Research Leaders) Surveys are conducted at Brunel every two years and the feedback is used to inform strategies for further support and development. The response rate for CROS 2011 was higher than the average response rate in the HE sector. These activities support the second principle of the Concordat.

International recruitments and visitors. We have links with many organisations outside of the UK and Dr Alessio Malizia joined us from Juan Carlos III University, Madrid and Dr Crina Grosan joined us from Babes-Bolyai University, Romania. Our international links have led to a healthy programme of international visitors. Since 2008, this has included over 30 visitors from a range of countries including China, Germany, Italy, New Zealand, Norway, Spain, and Turkey. In addition, members of DISC have held over 20 visiting positions.

Supporting equalities and diversity. Brunel has an Equality and Diversity Office and an Equality and Diversity Champion. These manage the development and implementation of the Equality and Diversity Policy, which is updated on an annual basis and includes concrete objectives. They also support women intending to apply for promotion. The promotion process is subjected to an annual Equality Impact Assessment, which is used to drive improvements in the equity of the process. Brunel also provides a Disability Dyslexia service. Brunel has achieved an Athena SWAN Bronze award for its efforts to promote the representation of women in science-related subjects. Brunel has also introduced the Athena SWAN Research Awards, which support members of academic staff who have recently returned from a period of maternity leave, statutory adoption leave or additional paternity or adoption leave in the continuation of their research career. Over one fifth of returned staff are female (7 out of 31) as were about one third of our PhD completions.

To support equalities and diversity, DISC encourages all academic staff to participate in research groups and apply for grants. Personal development workshops help staff to plan their careers and provide advice to those applying for promotion. We encourage staff to attend University run workshops, designed for particular groups, if applying for promotion. DISC uses the Flexible Working policy and extended probation where applicable to accommodate family and/or caring responsibilities. We carefully manage the workload of those returning from maternity leave in order to ensure that they have time to re-establish their research and aim not to give them new modules. Since 2008, three colleagues have had periods of maternity leave and all have been returned. Finally, equality and diversity training is compulsory for all staff. These actions support the sixth key principle of the Concordat.

ii. Research students

The department's PhD cohort is critical to the health of its research environment. We attract research students through our external profile and have found this to be a successful approach; we have graduated 83 research students since 2008. We provide school PhD bursaries in addition to those funded through the EPSRC Doctoral Training Account. Furthermore, we have had seven CASE studentships since 2008 as well as one recipient of an Isambard Scholarship, which includes fees and a stipend of £13,590.

We place a heavy emphasis on the training of research students, complementing the developmental activities provided by the Brunel Graduate School (for issues such as time management, library and computing facilities, communications and project management), by providing more specialised research methods training, including a one year long Research Methods Course led by senior members of the department. The library also provides a training programme to help PG students develop their scholarship skills and the Language Centre provides English language training and support. The focus of this training is the development of core skills in line with the Researcher Development Framework.

We provide substantial support for students to attend and present at national and international conferences (up to one EU and one non-EU conference for each student). This is supplemented by

the competitively awarded Vice Chancellor's travel prizes of £500, won by eight of our students since 2008. There is an annual away day for research students, which helps foster a community as well as contributing to research training. Brunel's Graduate School acts as a hub for research students, providing advice and support, facilities, opportunities to meet PG students from other schools, and workshops and seminars (1240 attendees at 74 events in 2011-12). It works with other London Universities (including UCL and KCL) in an informal collaboration to provide a broader context for researcher development. Brunel recognises excellence and encourages interdisciplinary work through its annual Research Students Poster Conference, with in the order of 150 students contributing posters each year (10 DISC students in 2013).

Research students have two supervisors and regularly meet with their first supervisor, with summaries of meetings being recorded. Having two supervisors provides input from researchers with complementary expertise and allows senior staff to share their expertise with junior colleagues. Research students produce, at least annually, a report regarding their progress, which they discuss with their first supervisor and an independent academic. A summary of the discussion is submitted to the University Registry and a copy is given to the student. Three of our research students won Brunel's Doctoral Research Prize. On completion, many moved to lectureships or postdoctoral positions at other universities, including Oxford, Cambridge, Imperial and UCL, while others moved to positions in industry (for example, as a data analyst at The Times). Our research students authored papers in top journals, including IEEE Transactions on Evolutionary Computation, IEEE/ACM Transactions on Computational Biology and Bioinformatics, ACM Transactions on Computer-Human Interaction, and the European Journal of Information Systems.

d. Income, infrastructure and facilities

Brunel has a strong research infrastructure including a Graduate School and the Research Support and Development Office (RSDO). In addition, its library provides electronic access to a large selection of journals and conference proceedings and facilities such as Web of Science. It also has an institutional archive (BURA), an Open Access Mandate, and an Open Access Publishing Fund. DISC was one of the first of the UK's departments to mandate the archiving of papers. Our physical environment has received significant investment in recent years, with particular focus on our research students' offices (including a £70k spend in 2009-10).

Our two centres (CSS, CIDA) have associated specialist hardware facilities that support their research. This includes a PC-based GRID infrastructure used by our Modelling and Simulation researchers within CSS. Our interest in PC-based GRID is motivated by the needs of the user groups with whom we work, who typically have many PCs but do not have access to facilities such as clusters. The school has two 48-core cluster machines along with dedicated GPU based machines, which support our Big Data research and is primarily used by researchers from CIDA. The GPU computing research is also supported by individual Tesla cards.

A new University Interdisciplinary Centre for Systems and Synthetic Biology (CSSB) was established in 2010 by Gilbert, followed by the creation of the Interdisciplinary Chair of Systems Biology for Saunders, a joint appointment with the School for Health Sciences and Social Care (SHSSC). Saunders has established the Laboratory for Systems and Synthetic Biology, comprising 150 m^2 of wet and dry lab space, and £60k computing equipment funded by the University. The core biological systems analysis informatics resources consist of a 32-core computer system supported by a dedicated Bioinformatician, with a primary focus upon microarray, RNAseq, and DNA sequencing / re-sequencing data. DISC researchers actively collaborate with Saunders and his group, as members of CSSB, resulting in joint papers, funding proposals and research projects. The collaboration draws on the facilities in the Laboratory for Systems and Synthetic Biology but also the computational resources provided within DISC.

We will sustain and extend the infrastructure, maintaining excellent computational and wet lab facilities. This will be achieved by a mixture of large funding proposals, typically with a significant Big Data element, and school funding to support developing areas. A recent example of the latter is the purchasing of GPU computers to support initial work on implementing Intelligent Data Analysis algorithms on such computers. The expectation is that as this work matures it will lead to the purchase of specialist facilities through funded grants.

Funding portfolio. Given our vision to carry out world-leading applied research, we see external

funding and engagement as being crucial and aim to grow both further. We strongly encourage colleagues to apply for external funding so that we can continue to produce high quality research and maintain a world-class research culture that includes high calibre research fellows/assistants and research students. In the current REF period we were awarded in excess of £13M in grants. This includes over £8M from the research councils and £3M from the EU. We were awarded grants of approximately £125k from UK charities and over £300k from UK central government. The UK government funding mainly consists of KTPs and grants from the Technology Strategy Board and the Ministry of Defence. We were awarded over £180k by UK industry/commerce and over £90k from parts of the NHS. Our industrial/commercial sponsors included Hutchison 3G UK Ltd; GlaxoSmithKline; Level Business Ltd; Sharp Laboratories of Europe Ltd; Fujitsu Laboratories of Europe Ltd; Microsoft Research Limited; and Ford Power Train Operations.

Much of our research funding has been in the two areas we previously identified for growth: healthcare and biomedical informatics. We will continue to apply for funding in these areas but also in digital economy. Currently most grants have a significant Big Data element and include investigators from both centres and we expect this trend to continue. Research groups are typically formed to both support on-going projects and develop funding applications.

While we have had much success in obtaining funding from the Research Councils, we recognise that in future we will have to obtain more funds from other sources including the EU. CSS and CIDA will continue to support the development of large funding proposals through, for example, mentoring, internal peer review and the provision of internal funds for activities that facilitate the development of high-quality proposals. We will develop large funding applications and through this look to further develop our presence in Big Data, which is an area we will grow. We expect most large projects to involve members of both centres and so will continue to organise focused workshops around themes that involve both centres and provide internal funds to support the development of interdisciplinary proposals. This will be supported by Brunel's Research Development Fund (for researchers working on major grant applications) and its panel, chaired by the PVC for Research, that provides additional peer review for large funding applications.

Consultancies and professional services. Our researchers frequently collaborate with user groups and this has led to alternative sources of funding. As explained above, the funding awarded includes over £180k from UK industry/commerce and over £90k from parts of the NHS. However, in addition to this we are involved in a significant amount of consultancy (over £110k) and this helps develop the impact of our work. This consultancy was with a mixture of medical bodies, Fujitsu Laboratories of Europe Ltd., Daiichi Sankyo Development Ltd., Systematic Software Engineering Ltd., and ANGLE Technology Ltd.

The RIGHT and MATCH projects explored methods for assessing the value of technology to healthcare delivery and the use of simulation and modelling in healthcare service provision. There has been significant industrial involvement in these projects, including links with 45 UK-based organisations through affiliation and membership schemes, and the projects have developed a number of professional services. For example, they provide courses and (potentially bespoke) in-company training workshops for both the public and private services, with over 170 attendees.

e. Collaboration or contribution to the discipline or research base

Research collaboration and interdisciplinary research. Since our vision is to be a world-leading centre for applied Computer Science research, we strongly encourage collaboration with academics from other departments/universities and, in particular, user groups. This facilitates the development of funding applications and further develops the relevance of our work and the resultant public benefit. Research collaboration with users is encouraged through financial support and the provision of Knowledge Transfer (KT) Leave and KT Secondments. Dr Love and Dr Swift benefited from periods of KT leave and KT Secondment respectively. The Research Support and Development Office assists with the development of industrial collaborations and KTP funding.

We provide funds to support collaboration and for junior researchers to network. This includes funds managed by two centres (CSS, CIDA) and ring-fenced DISC funds for interdisciplinary research. While we focus on our key areas, we support excellence in all relevant areas.

Members of DISC collaborate with many academic and user organisations, often in

interdisciplinary projects. One example of this is the Multidisciplinary Assessment of Technology Centre for Healthcare (MATCH), which is led by DISC. This involves four leading UK universities (Birmingham, Brunel, Nottingham and Ulster) and many (industrial and public sector) user organisations including the NHS. MATCH brings together expertise in health economics, engineering and social sciences to develop methods to assess the value of medical devices in order to improve decision-making. MATCH has produced a preliminary set of tools and has been supported by over £600k in industrial funding. Results are being rolled out to form a company.

Another example is EFACTS, a four-year €6M FP7 collaborative research project involving members of CIDA, four other leading UK groups (Imperial, MRC, Oxford, UCL) as well as eight other leading universities in Europe and one pharmaceutical company in the USA. EFACTS (the European Friedreich's Ataxia Consortium for Translational Studies) assembles a body of expertise to adopt a fully translational research strategy applied to the study and treatment of a rare inherited neurological disease, Friedreich's ataxia (FRDA). EFACTS gathers a critical mass of researchers and clinicians to exploit the patient base, research reagents and knowledge. The consortium possesses expertise ranging from clinical neurology, biochemistry, structural biology, systems biology, genetics and epigenetics. CIDA is the only computer science group in EFACTS and so plays a key role in the integration and analysis of diverse biological, clinical and genetic data.

Brunel supports and encourages interdisciplinary research and many of its University Research Centres are interdisciplinary. These benefit from marketing and promotion via Brunel's website and publications and have access to internal research funds. Of these, the Centre for Systems and Synthetic Biology includes researchers from DISC, Mathematics, the School of Health Sciences and Social Care, the Institute for the Environment, and the School of Engineering and Design. The URCs can apply for internal funding to support interdisciplinary activities.

How research collaboration has informed our research strategy. Since our research is relatively applied, most of our projects involve significant collaboration and this informs our research and our research strategy. Research findings are presented at meetings of the research groups and centres, leading to a wider awareness of the outcomes of collaboration. This feeds into our research strategy since the centre heads are members of the school's research committee, which annually reviews this strategy. In addition, input from our Industry Advisory Board feeds into our research strategy. The Industry Advisory Board is composed of senior individuals working in multinational companies, SMEs, public organisations, and charities. These mechanisms ensure that our research strategy has a sustained input from collaboration.

Interaction with users informs the direction of our research. For example, it has influenced our healthcare research through the MATCH and RIGHT projects. Another example is our IDA work, which involves close interaction with user groups with us having long-standing relationships with organisations such as Moorfields Eye Hospital. These relationships help us to identify important trends at an early stage and to then focus on key research challenges [Case Study: Diagnosis]. Similarly, our software engineers work closely with industrialists and this ensures that we can develop real cases studies in order to evaluate the methods we develop but also helps us to identify important themes [Case Study: Software Engineering].

Contribution to the discipline and leadership. We encourage our researchers to contribute to the discipline and they do so through a number of mechanisms, with a focus around CIDA and CSS. Since our strategy is to be a relatively applied department, we place an emphasis on involvement with user bodies in addition to our colleagues taking on traditional academic roles. The centres support our colleagues in this through guidance and by providing funding for activities such as attending meetings. The role of the centres ensures that the contributions fit with our areas of interest. Mentoring and peer support are used to ensure that an individual's contributions are consistent with their career plans.

Our colleagues contribute through traditional high-profile academic roles, such as editing journals and chairing international conferences, as well as an involvement in bodies with an industrial focus (within our core areas). The following provides some examples of this.

Advisory board membership. Hierons: Member of Scientific Advisory Board, Austrian network for Software Testing and Engineering (Softnet II). Liu: Honorary Chair, The IDA Council

Leadership roles in industry, commerce. Lycett: Member of the IT Forum Education and Skills Commission. Louvieris: Member of the MoD's Command Inform & Battlespace Management Consortium (since 2009). Louvieris: Member of the Situational Awareness, Cyber and Influence Information Exchanges within the MoD's Cyber and Influence Science and Technology Centre (since 2009). Louvieris: Led a Work Group on Cyber Situational Awareness within the SA/Cyber & Influence IEs (2010). Taylor: Chair of Simulation Interoperability Standards Organization COTS Simulation Package Interoperability Product Development Group (SISO-CSPI-PDG).

Research Councils. EPSRC college (Gilbert; Hall; Hierons; Hone; Liu; Lycett; Perry; Shepperd; Taylor; Z Wang). BBSRC Pool of Experts (Gilbert; Liu). BBSRC Chair of the Biochemistry and Cell Biology Committee (Gilbert). EPSRC Grant Panels (Hierons; Liu; Lycett; Shepherd). Member of ITaaU network (Liu; Louvieris) and NEMODE network (Louvieris). Expert evaluator to the eContent and Leonardo da Vinci Programmes of the European Commission (Stergioulas).

Journal Editors. Hierons: The Journal of Software Testing Verification and Reliability (Wiley); Macredie: Virtual Reality (Springer); Z Wang: Systems Science & Control Engineering (Taylor & Francis); Taylor: Journal of Simulation (Palgrave Macmillan).

Membership of Journal Editorial Boards: over 35.

Membership of Programme Committees: over 400.

Keynotes. Members of DISC have given keynotes at over 30 international conferences and workshops. This includes keynotes at the following: 33rd International Conference on Information Technology Interfaces (Liu); 19th International Conference on Neural Information Processing (Z Wang); 8th International Conference on Quality Software (Hierons); 6th International Metadata and Semantics Research Conference (Alessio); 8th International Conference on Predictive Models in Software Engineering (Shepperd).

Learned societies. Fellows of the BCS (Capiluppi; Counsell; Hierons; Liu; Macredie; Shepperd). Brooks: President of UK Academy for Information Systems (UKAIS), 2007-09. Brooks: President UK Systems Society (UKSS), 2011-13. Stergioulas: Chair-elect of the SIG 3.9 Group of IFIP TC3.

Conference organisation. Members of DISC have chaired or co-chaired over 50 international conferences and workshops since 2008. This includes the following: 14th International Conference on Automation and Computing (2008); First IEEE International Conference on Software Testing, Verification and Validation (2008); Symposium on Biological and Chemical Informatics for Health: Foundations for Systems Biology (2009); 11th International Conference on Quality Software (2011); **1**0th International Conference on Computational Methods in Systems Biology; 27th British International Human-Computer Interaction Conference (2013); 2nd International Conference on Health Information Science (2013); 11th International Conference on Software Engineering and Formal Methods (2013); 5th International ACM/IEEE Symposium on Empirical Software Engineering and Measurement;12th International Symposium on Intelligent Data Analysis (2013); Fifth International Symposium on Empirical Software Engineering and Measurement (ESEM 2011).

Awards and Prizes. Our staff won many awards including: In 2013 Thomson Reuters included Z. Wang as one of the 21 hottest CS researchers for 2012. Ghinea won the Scott Helt Memorial Award for the Best Paper Published in the IEEE Transactions on Broadcasting in 2009. Liu and Z Wang were co-authors of the paper declared Neural Networks Most Cited Article 2006-2010. Tucker won the Frontier prize at the 10th Intelligent Data Analysis symposium (IDA 2011), awarded to the paper that makes the most visionary contribution. Shepperd won the best paper award at the IEEE/ACM International Symposium on Empirical Software Engineering and Measurement (ESEM 2010); Counsell won the best paper award at ESEM 2012. Coughlan and Swift won the best paper award at the third International Conference on Education and e-Learning (Eel 2012). Hall won the best paper award at Predictive Models in Software Engineering (PROMISE 2012). Capiluppi won the best paper award at the International Conference on Open Source Systems (OSS 2011). Louvieris won the best track paper at the 13th International Command and Control Research and Technology Symposium (ICCRTS 2008), C2 for Complex Endeavours. Paper by Sergioulas in European Journal of Operational Research ranked in top 10 of the 25 hottest articles in CS by ScienceDirect (October to December 2009).