Institution: University of Strathclyde

Unit of Assessment: 11 Computer Science and Informatics

a. Overview

UoA11's research is entirely drawn from the Department of Computer and Information Sciences and is structured into three research themes:

Theoretical Computer Science: This research theme spans research on programming languages and combinatorics. Researchers within this theme have been awarded 6 substantial EPSRC and Microsoft grants during REF2014 totalling £1.6m and have supervised 10 PhD students.

Information Systems: This research theme spans user-centered research on information seeking behaviour through to large-scale experimentation on massive data sets. This research group combines both breadth and quality as demonstrated by the range and size of its research funding. During REF2014 it attracted approximately £2.3m from AHRC, ESRC, EPSRC and EU and supervised 19 PhD students.

Software Systems: This research theme focuses on advanced software systems with a particular focus on autonomous planning and software evaluation. During the REF2014 period it attracted approximately £1.3m in funding and supervised 12 PhD students. 2011 saw the departure of the Strathclyde Planning Group from this theme and since then group members have re-oriented the theme to develop new lines of research on the engineering of complex software systems, their security properties and how we can empirically evaluate their correctness.

b. Research strategy

Strategic research aims and achievements since RAE 2008:

The strategic aim during the REF2014 period was to evolve into a highly research-intensive Department with a sustainable, broad-based, internationally recognised reputation for top quality research, underpinned by a strong grant income stream. Much of the strategy for achieving this goal was centred on refocusing our research profile by recruiting high quality staff (more detail is given in Section C) This strategy has been implemented successfully as indicated below:

Quality and Quantity of Research: Approximately 50% of eligible staff (13.4 FTE) were submitted to RAE2008, whereas approximately 75% (20.2 FTE) are submitted to REF2014. We also have increased the quality of our research from being 50% internationally leading to 75% internationally leading on the basis of journal impact and citation data. **Grant funding**: We have diversified our funding portfolio from being mainly reliant on EPSRC and the EU in 2008, to now having obtained funding from a broad range of sources including EPSRC, EU, ESRC, AHRC, and industry (e.g. BAE, SciSys, and Microsoft). During the period of REF2014, in comparison to the period of RAE2008, our RCUK grant income has more than doubled (£1.0M to £2.1M), the grant income base has broadened as the number of holders of substantial grants (over £50K) has doubled (10 to 20), and 5 academics who had never been a Principal Investigator on grants have won funding. These improvements have moved the department to a more sustainable grant income stream.

International Profile: The Department recruited two world class research groups, namely the Mathematically Structured Programming Group in July 2008 and the Strathclyde Combinatorics Group in January 2011. The purpose of these appointments (and 4 additional appointments) was to achieve our goal of increasing the quantity and quality of research within the Department. However, the fact that most appointments were from outside the UK has had the added benefit of increasing the international perspective of our research and so has further strengthened our profile. Our international influence has also been strengthened through our increasing visibility as senior programme committee memberships, keynote addresses, and journal editorships (see Section E). Overall, developments during the REF period have a significantly expanded the international research profile of the department, thereby meeting one of our strategic goals. **Diversity and Inter-Disciplinarity**: The recruitment of the two groups in theoretical areas of computer science added greater diversity to our research portfolio and has already proved successful. For example, when EPSRC increased funding in Program Verification, the Mathematically Structured Programming group was able to take advantage by getting a substantial grant funded. We also increased participation in inter-disciplinary research and examples that indicate the range of activity are Wilson's research applying biological data analysis to drug discovery, Duke's research applying combinatorics to quantum physics, and Ruthven's research on information poverty, as applied to sociological analysis of immigrant communities' use of ehealth. The diversity of our

research base means the department is well placed to attract grants from across the spectrum of funders and is more able to respond promptly to the growing number of opportunities for inter-disciplinary research.

Future research aims:

The REF2014 period has been transformational and has established a research culture where internationally competitive research is the minimum and internationally leading research is becoming the expectation. Our vision for the future is both simple and clear – we will complete the transformation of our Department into one which is 100% research active and able to harness effectively the breadth and depth of our research portfolio to solve problems in the world around us through appropriate knowledge exchange activities. To achieve this vision, we are already progressing well towards the following targets:

Firstly, we will make further gains in our research stature and in particular move to a situation where all academics produce research which is on average roughly what would be expected of an REF2014 3* paper and are engaged in the supervision of PhD students. These commitments are in line with statements included in the latest University Strategy documentation.

Secondly, in the next five years we expect to see our new research profile, especially its increased international dimension, lead to an expanded grant portfolio with a greater number of external partners; in particular, we will expect all members of the Department to hold substantial (>£50K) external funding. This is certainly a tough goal, but by being ambitious we provide the inspiration to do better. Indeed, several mechanisms to help achieve this target have already been put in place (see below) and so we are confident that, just as colleagues were inspired over the period of REF2014, they will be similarly inspired to even greater success in the period after REF2014.

Thirdly, we will improve the practical application of our research. Meaningful impact can only be built on relevant research of the highest quality and, now that we have improved our capacity to produce such research, we are in a realistic position to expand our already positive impact activities. Doing this is also very natural within the context of the University of Strathclyde whose Strategic Plan emphasises the fundamental importance of developing strategic partnerships with industrial, commercial, professional and government organisations. The University's Technology and Innovation Centre (TIC) provides engagement opportunities with a host of companies looking for research-based solutions to their problems.

The £89M TIC project is the University's largest investment in its research and knowledge exchange capacity. The TIC strategy is to undertake research that is outward facing and focussed on real-world needs, while retaining academic and discipline excellence to underpin this approach. The agenda is set by global research challenges, and so this necessarily requires a collaborative and cross-disciplinary approach. Researchers from UoA 11 will contribute to a number of TIC themes and also to the City of Glasgow's successful £24M "Smart City" award that will have a range of requirements in computer and information science, especially in research involving large data sets.

Several departmental initiatives have been introduced to enhance our environment and help achieve the above aims: We have started a Grant Writing Challenge to support our goal of increased grant income and a Knowledge Exchange (KE) committee to support expansion of impact activities (details are provided in Section C and in the Impact submission, respectively). Also, the research committee has started receiving at each of its quarterly meetings a 12-month snapshot of all grants submitted and funded so as to monitor progress towards our targets on grant income, while the KE committee is similarly charged with monitoring progress towards impact-related targets. Furthermore, to enhance our international profile, we will be hosting significant international conferences in the future. Further details of how we will improve the impact of our research are contained in the Impact section of our REF submission.

Summary:

The Department's research strategy has been successful in expanding current areas of excellence in computer and information science research at Strathclyde, both discipline-specific and interdisciplinary, augmented through the addition of new internationally leading initiatives. The information presented above shows that UoA 11 has an increasingly strong research trajectory that will be further boosted by involvement with the TIC project and the City of Glasgow "Smart Cities" award. The policies that have been established during the REF2014 period will, over the next five years, bring to fruition our vision of a Department able to both produce research of the highest quality and have a transformative impact on society.

c. People, including:

Staffing strategy and staff development:

The strategy for staffing and staff development was based on (i) recruiting only academics who are, or have the capacity to become, world-leading researchers; (ii) sharing best practice and supporting members of staff to become world-leading researchers; and (iii) rewarding success so as to incentivise further success**.**

Overall responsibility for monitoring the standards of research quality falls within the remit of the Department's Research Committee, while the responsibility for monitoring the integrity of research undertaken within the Department lies with the University Ethics Committee. The Research Committee's importance is reflected by its membership consisting of the most senior researchers across the Department, including the Head of Department and leaders of the research groups.

Examples of how we implemented this staffing strategy are given below:

Recruitment: The recruitment of new staff introduces new ideas and a chance to change the direction of the Department. As our aim was to transform into a research-intensive department, all new academic staff were required to have an internationally successful research profile with independent research programmes, and the potential to become world leading researchers. In order to encourage diversity, we were successful in recruiting top class scientists from across the world, with 8 of our 12 appointees during REF2014 having a non-UK PhD. As expected, the cultural transformation brought about through international recruitment has also helped existing members of staff to improve the quality of their research. As a result of a successful recruitment campaign we now have a much greater breadth of subject coverage than before and (as discussed in Section B) this has been vital in expanding our grant income stream.

Support and Development: The Department has put in place a number of mechanisms designed to support staff and their development. New recruits, especially early career researchers (ECRs), are given lighter teaching and administrative loads so they may focus on their research. They are also given start-up funds to help initiate new research activities (currently £10K each) and allow them to conduct research whilst developing proposals for external funds. A lightweight application process is operated by the Department to access the start-up funds – this ensures that new recruits immediately begin to think about how their own research strategy aligns with that of the various funding agencies they will be applying to.

Many of the support initiatives involve dissemination of best practice throughout the Department. For example, all grant submissions are given comments during an hour-long meeting open to all staff. In addition, the Director of Research reads all grant proposals in depth to ensure they are of as high a standard as possible. However, we consider that it is not sufficient to only comment on nearly complete grant proposals and so we also run a departmental Grant Writing Challenge to provide peer support and feedback to those currently engaged in the planning and writing of grants. This group meets roughly every month and partially developed proposals are read and given comments so that they can be improved further. Dissemination of best practice in the early stage of grant writing has already brought success for first-time Principal Investigators (PI) and will continue to be important in increasing our grant income.

All early career academic staff have a mentor to support the transition to academic life. These mentors are chosen so as to be able to provide research-area specific guidance, if and when that need should arise. Currently, we have four such mentee-mentor relationships. More generally, all staff are carefully monitored to ensure there is continual development of their research careers. This is done informally throughout the year and formally through the University's Annual Development Review process. These meetings are an opportunity to pass on strategic advice and best practice within the Department. We do not view these meetings as prescriptive, but rather opportunities to reflect on how well academics are doing and to offer advice on where improvements can be made. Members of staff who have been a PI of a substantial grant for the first time during REF2014 have commented on the invaluable nature of the comments and support they received through these Departmental activities and their feedback provides a basis to monitor the effectiveness of such schemes. The department's support and development strategy has clearly been very successful. Two academics who were not submitted to RAE2008 are being submitted to REF2014 even though our standards of research quality have been increased. Furthermore, 5 academics who had not previously been a PI on a substantial (over £50K) grant, became PIs on such grants during REF2014.

All staff are encouraged to take part in the Strathclyde Researcher Development Programme

(RDP), a comprehensive university-wide programme of development activities. It has been specifically designed to meet the needs of Strathclyde's researcher community, providing a range of opportunities to continue development of personal, professional and career management skills. The RDP recognises all career paths and aims to help researchers (postgraduate researchers and research staff) enhance their skills and competencies for current and future roles within academia and other sectors. This programme has been nominated in 2011 and 2012 for the **THES** award for early career research support. Many of our research students and academic staff have led courses in the programme as well as participating in different activities, and we actively encourage this. A good example of recent of success was a research student-led interdisciplinary project on the use of IT to support disabled students at Strathclyde resulting from training in social innovation.
A specific stream within the RDP program, called SPIRAL, designed to enhance the development of established researchers has led to successes including a significant grant for a member of staff who had not previously held a research grant and training in being an expert witness for a major patent investigation (section D). In addition, the Concordat to Support the Career Development of Researchers is implemented at a University level to ensure best practice is disseminated throughout the University. Implementation of the Concordat and the schemes mentioned above has meant that the University achieved the EU HR Excellence Award in September 2011.
Equality and Diversity: The University uses Equality Impact Assessment (EIA) as a systematic and evidence based process which verifies that the University's policies and practices are not discriminatory. In 2011, the Institution received the Athena Swan Bronze award to recognise its good employment practice for women in Science and Technology. In spite of the relatively low number of female academics in computing, all appointment panels have included at least one female candidate (included on merit) and at least one female panel member, and four of our last 11 academic appointments were female. All duties are allocated in a gender-neutral fashion; staff with parenting or caring duties can negotiate flexible working relationships; and all major departmental committees contain at least one female member. Other Equality and Diversity issues are overseen by a University Committee which sets best practice standards for all Departments, monitors performance in this area, and also surveys staff on a regular basis to judge progress.
External engagement: Staff are also encouraged to see participation in the broader research community as part of their development. We hold a regular seminar series, host international visitors**,** and are regular participants in the Distinguished Visitor Fellowship programme organised by the Scottish Informatics and Computer Science Alliance (SICSA). All staff are strongly encouraged to serve on programme committees, review committees and editorial boards, and to organise conferences and workshops (see section E for details).
Incentivising Research: We made the conscious decision to reward success both because this is worthy in and of itself, and because this will further incentivise research. For example, staff research time is protected using the departmental workload model which ensures that all staff have dedicated time for research. Indeed, we incentivise research by reducing teaching and administrative duties for those members of staff who, through successful research, have taken on additional tasks such as supervision of PhD students and RAs and management of grants. Furthermore, during 2012 we introduced a one semester sabbatical scheme for staff who wish to undertake transformational changes in their research activities either by taking on a new type of activity or changing research direction. To inculcate a "can-do" attitude to research, sabbaticals are not given as a matter of right, but rather to those who are taking determined, demonstrable steps to produce world class research. The scheme operated during the final two years of the REF period, when 3 sabbaticals were funded. The introduction of sabbaticals improves the research environment within the UoA and hence the Department took the decision to prioritise the scheme and fund it from its own resources. Another way that success in research is rewarded is in the distribution of university-allocated funding for new studentships. University and Departmental PhD studentships are awarded on a competitive basis and successful applicants are required to show alignment with Departmental, Faculty, and University strategies and the priorities of external funders. ECRs and those with a record of research successes are prioritised when staff are nominated to the internal studentship competitions.
Research students
The majority of research students since 2008 have been recruited and funded through rigorous competitive procedures. Students funded by SICSA, Commonwealth Scholarships, and AHRC, are peer-reviewed by external institutions; studentships funded by the University are on projects which

are competitively awarded and where strict recruitment criteria apply; studentships that are funded through block-grants, such as ESRC, are selected by independent panels based on national competition. In most areas, our research reputation means that we have little trouble filling PhD positions. The only areas which have proved more challenging are those cutting edge areas, such as tangible computing, where the applicant pool is smaller. Nevertheless, we have been able to secure talented European students in these areas.

Research students are supported by both in-house Departmental activities and also by university wide activities as part of the Researcher Development Programme mentioned above. Within the Department, all students have their progress monitored by interim reports, annual reviews (with independent reviewers) and participation in research group meetings which are largely student led. Students are required to undertake 60 postgraduate credits (600 hours) of instructional training in research development – this covers topics such as research ethics, how be an entrepreneurial researcher and creating research impact. Their progress in this aspect is monitored regularly and forms part of their annual review**.** To instil independence, a sense of community, and breadth of knowledge, our research students organise their own research seminar group which meets weekly. Many of our students have gained experience working at external institutions during their PhD programme and a significant proportion have taken part in inter-disciplinary research collaborations with our Chemistry, Education, English, Electrical Engineering and Design and Manufacturing departments. We strongly encourage such outward facing activities to strengthen the students' networking and communication skills and understanding of different research traditions. Students also take part in the annual SICSA PhD Students Conference. Evidence of the success of our strategy for supporting the development of PhD students was the prestigious award of an EPSRC Postdoctoral Research Fellowship to one of our PhD students, Dr Amanda Coles during REF2014.

At the university level, the Researcher Development Programme underpins the university's strategic aim of 'supporting a vibrant postgraduate research student community'. Provision is designed to help postgraduate researchers enhance their generic skills, attributes and competencies for future employability both inside and outside of academia. Highlights of the programme are: (i) a three-day residential course accredited by the Institute of Leadership and Management and designed to develop enterprising behaviours and support researchers in communicating their work to a wider audience;(ii) a credit-bearing module which aims to enable postgraduate researchers and research staff to develop their skills in achieving high-quality public engagement in their research; and (iii) six half-day sessions aimed at engaging with broadcast media, and developing activities for public audiences and spaces, and community engagement. Researchers also benefit from participation in events such as the University Research Day and "Engage at Strathclyde", which provide forums for obtaining new collaborations internally and externally. These collaborations are important for many of the multi-disciplinary projects undertaken by researchers in UoA11.

Looking to the future, it is our intention that by 2015: (i) all our PGRs will be offered an international development opportunity in their study; (ii) all our PGRS will have the opportunity to engage with external agencies relevant to their research work, with >60% of these involving secondments and placements; and (iii) at least 80% of our PGRs and ECRs will participate in the full range of transferrable skills activities in the RDP. The internationalisation of our staff, increased collaboration with industry and international academia, and the availability of high quality researcher development activities have placed the department in a strong position to realise these expectations.

d. Income, infrastructure and facilities

Income: Since RAE2008, we have received over £5M in research funding from the EU, industry, and UK Research Councils. As mentioned above, our income stream has diversified significantly over the period of REF2014; we have won our first grants from AHRC and ESRC and increased our industrial income with major funding coming from partners such as Rolls Royce, BAE systems, and SciSys (total of £353K in REF period). We have also increased by 100% the number of staff who have held substantial (over £50K) grants, e.g. Buchanan has just been awarded our first collaborative ESRC PhD studentship and Dunlop has just been awarded his first substantial EPSRC grant. All told, the greater diversity of funders and the increase in staff with track records of obtaining funding has given us a vital new stability to our income stream. This was brought about by our strategy of supporting current staff to improve their performance and recruiting new staff with a proven international pedigree for world class research.

Looking to the future, we have already been awarded research grants totalling over £1M for the post REF2014 period and this gives us a great platform to build on for the future. Starting from this position we plan to continue to grow our research income stream as the transformation of the research culture in the Department (outlined in Section B) is completed and our goal is that all members of staff will hold grants. Further, the Strathclyde Combinatorics Group arrived too late to make a significant contribution to grant spend during the period of REF2014 and hence we look forward to them adding a significant new source of income for the Department.

In addition to our expanded research activity, we envisage a substantial increase in income from knowledge exchange activities, an area which currently provides a limited, but growing, stream of funding to the Department. We have a twin-tracked strategy to develop our KE-income. First, we have already put in place a Departmental Knowledge Exchange Committee to disseminate best practice and to organise events to help members of staff develop their activities in this area. The committee is modelled on the successful Departmental Research Committee whose experience in what works and what doesn't work is being used to shape the activities of the new Knowledge Exchange Committee. Second, we will increase engagement with the themes of the Technology and Innovation Centre (section B) at Strathclyde. The TIC's physical infrastructure is designed to allow industry and other collaborators to co-locate with academic and research staff so as to synergise a much closer integration of purpose than was possible before. This is a unique feature of the research environment at Strathclyde and becoming fully involved is an extremely exciting prospect for us. Indeed, given the ubiquitous nature of software and intelligent systems in the modern economy, we are confident of establishing many new collaborations within the TIC, which in due course will lead to increased income. As described more fully in our impact template we expect to make significant contributions in the particular area of health technologies building on successful collaborations with the NHS and local industry.

Another source of future income which will underpin the expansion of our PhD student numbers are Centres for Doctoral Training. We already participate in one CDT funded by ESRC, and are part of consortia bidding in the current round of EPSRC sponsored CDTs and are part of a newly announced £14.2m AHRC Doctoral Training Partnership. The rapid development of our research capabilities and the on-going improvements into the post-REF2014 period will allow us to play a leading role in CDT activities and other consortia activity such as the TIC and the follow-on to SICSA. Through these initiatives, we will have the opportunity to make fundamental and new contributions to our income stream.

Infrastructure: During the period of REF2014 we have made a number of improvements to our infrastructure to enhance our research environment. The needs of each research group were assessed separately to establish the infrastructure it required and appropriate provision was made accordingly. One example of this was a decision to build a dedicated PhD laboratory for the Mathematically Structured Programming and Combinatorics research groups. It was felt that these groups should have all their PhD students located in the same space so as to build a critical mass within each of these groups as they established themselves and also to allow synergies to develop between these groups. Being more theoretical research groups, a main requirement for their laboratory was space to hold simultaneously several discussion groups. Another investment was in the provision of a new laboratory to facilitate research into multimodal interaction. This laboratory provides projection facilities to allow realistic evaluations of mobile interactive applications within safe physical environments. It also provides space for research students to construct high-quality prototypes for evaluation and dissemination. Improving our environment in this area directly influenced our research output, e.g. prototypes developed in this laboratory have been demonstrated at the Media Façade Festival Europe, ARS Electronica, the Ark Dublin and Museum of Modern Art, New York. We have also invested in the creation of a new usability laboratory, including an eye-tracker, for researchers and students working on interactive systems, and a new computer forensics space to provide a laboratory for researchers working in computer security. Other dedicated infrastructure consists of space for exhibitions, posters, workshops and the demonstration of embodied interaction, available for the use of the whole department.

Support for our research at the level of institutional infrastructure comes in the form of events such as the University Research Day and Engage at Strathclyde which provide forums for obtaining new collaborations internally and externally. These collaborations are important for many of the multi-disciplinary projects undertaken by researchers, and have already promoted new joint research.

Thirdly, an important area for development will be the improvement and the practical application of

our research. This can only be built on research of the highest quality and, now that we have improved our capacity to produce such research, we are in a realistic position to deliver on this third aim. Doing this is also very natural within the context of the University of Strathclyde whose Strategic Plan emphasises the fundamental importance of developing strategic partnerships with industrial, commercial, professional and government organisations. We are fortunate in this goal as the TIC provides a host of companies looking for research based solutions to their problems.
Consultancies and professional services: Our research continues to inform professional standards and practitioner decision-making by acting as sources of expertise for professional practice. Dunlop, for example, acted as an expert witness in a patent case between Apple and Samsung in 2013; Buchanan has been invited to join the NHS Greater Glasgow and Clyde ehealth and clinical change leadership groups to provide advice on information strategy; McMenemy was invited by the Scottish Information Commissioner to advise on Freedom of Information requests by Scottish Local Authorities and Ruthven's research on decision-making in Web searching was used by AHRC as case study in public engagement in research;
Our research environment has also led to our research students being a source of expertise for the professions. Christine Rooney-Browne (supervised by McMenemy) was invited to become a Carnegie Trust Associate as a source of advice on public library evaluation in the States, Kirsty Henderson (supervised by Ruthven) is advising the Scottish Government on how to overcome barriers to ehealth uptake by ethnic minorities and Lauren Smith (supervised by McMenemy) is currently undertaking an internship with the Scottish Government to provide guidance on developing methodologies for investigating online hate speech and sectarianism, following up initial research by McMenemy into online sectarianism.
We are also a source of consultancy-based expertise. For example, Hornecker was commissioned as an expert evaluator for the visitor technology in the new £21m Robert Burns birthplace museum; Ruthven was commissioned to conduct a usability evaluation of Europeana, the European Union's portal for cultural heritage; Dunlop and Hornecker were commissioned to conduct evaluation studies of new interactive technology for Rolls Royce's marine navigation dashboards and by the Maritime and Coastguard Agency to trial new approaches to onboard safety.

e. Collaboration or contribution to the discipline or research base

Our ability to influence and collaborate with our research base is of paramount importance to us and we offer specific support mechanisms to further enhance this engagement. The support comes in a variety of forms, e.g. i) dissemination of best practice via the Department's Research and Knowledge Exchange committees and the new Grant Challenge Initiative; and ii) events such as Departmental Seminars, University events and SICSA sponsored activities, which introduce potential collaborators to the benefits of working with members of the Department.
Exemplars of collaboration with academia are Ghani's new EPSRC grant on "Logical Relations for Programme Verification" which involves collaborations with 5 world leading researchers to aid both the quality of the work and allow early dissemination. Two of these collaborators are from Microsoft, exemplifying our strategy to work with the best researchers in industry as well as in academia.
In a sign of the contribution of the MSP research group to its research base, it was asked to join a research consortium of 12 academic research groups across the world which successfully bid for EU funds under the IRSES program to facilitate collaboration between world class research groups within the EU with world class research groups outside the EU. McBride is also known as a leading expert on Dependently Typed Programming and an on-going collaboration will see his research inserted into Microsoft products. Similarly, the Combinatorics group are known for shaping the future of their discipline by introducing a number of novel concepts, e.g. Dukes new concept of web-worlds (which arose from a collaboration with quantum physicists and formed the subject of an interdisciplinary grant application) and Claesson's introduction of the concepts of ascent sequences and mesh patterns.
Some of the Department's collaborations have led directly to systems that contribute to wealth-creation and quality-of-life. An exemplar of this is Dr Dunlop's work on text entry for mobile phones and other mobile devices with KeyPoint Technologies, a Scottish-Indian company that develop intelligent text entry solutions for mobiles. His work has influence and directed their designs which ked to a recently funded EPSRC grant to investigate text entry on touch screens by older adults in which Keypoint have agreed to host a research assistant in their development office further syngerise collaboration. More generally, during the REF2014 period we have conducted

collaborative research with a diverse range of industrial partners, including, Rolls Royce Marine, the Maritime and Coastguard Agency, NHS Scotland, MacMillan Cancer Care, Scottish Ballet, the European Space Agency, NASA, BAE Systems and the Metropolitan Police. Some of the Department's collaborations have led directly to systems that contribute to wealth-creation and quality-of-life improvements, which is discussed further in the Impact template.

Interdisciplinary research is also highly valued in our Department and this can be seen by our research strategy outlined in Section B which explained how we strove to support this and the successes we have consequently had. An exemplar of this is the Combinatorics research group who collaborate heavily with researchers outside Computer Science. For example during REF2014 Claesson and Dukes have collaborated with the world famous mathematician Ron Graham while Kitaev, Claesson and Dukes collaborated with another world famous mathematician, Bousquet-Melou. Other exemplars of interdisciplinary research include Buchanan and Ruthven's theoretical work on information poverty, originally supported by ESRC funding, and now being translated into practice-based research with partners such as Glasgow Life and Barnardo's through matched funding schemes.

All collaborations have directly influenced our research activities and strategies. An exemplar of this is McBride's work with Microsoft which originally consisted of a process where McBride's ideas on fully fledged dependently typed programming would be adopted by Microsoft. However, during this collaboration it became clear that Microsoft were also interested in limited forms of dependently typed programming which could be incorporated into Haskell without a radical redesign of the language. This more evolutionary process resulted in a Microsoft PhD studentship being funded. Buchanan has had similar experiences where user needs meant that his seminal work on information audit had to be extended to cope with features of the specific domains in which clients wished to deploy his theory.

We have learned a lot from these and other individual experiences and have striven to provide support to enable such collaboration, interdisciplinarity and feedback into research activity and strategy to flourish more widely. For example, we have realised that early alignment with end users –academic or non-academic– is hugely beneficial as research is focussed on areas which have a high potential end-user return and the problems tackled are those that potential end users see as significant. In a nutshell, we try to solve problems that have both academic and non-academic impact and we do this not by producing research and then looking for external impact but by understanding with end users the potential impact of research as judgments are being made as to which research problems to tackle. Concretely, our research strategy is to promote this attitude of early engagement through the various mentoring processes within the Department.

In terms of leadership activities within the academic community, members of the department sit on editorial boards of 22 prominent journals and have served as guest editors of 8 special issues of journals. Staff have contributed to the intellectual direction of the discipline by serving as members of steering committees and international advisory boards for conferences such as the IFIP WG 6.1 International Conference on Distributed Applications Interoperable Systems, Conceptions of Library and Information Sciences, MobileHCI, and the Information Interaction in Context conference series. Staff have served on numerous programme committees, acted as programme committee or conference chairs for 10 international conferences, and acted as keynote/invited speakers at 10 conferences. Further, four members of the Department have served on RCUK Peer Review Colleges during the REF2014 period. Dr Kitaev has written an influential book on permutation patterns. Prof Ruthven and Dr Hornecker have independently participated in the creation of new conference series while Prof Ghani is a leader of the SICSA "Complex Systems Engineering" theme. Members of the iLab research group won the Outstanding Paper award at the Emerald Literati Network awards in 2010 and 2011. Prof. Ghani also set up the Scottish Category Theory Seminar whose goal is to foster the development of that discipline within Scotland.

All of these activities are evidence of a vibrant research Department which has grown in strength over the REF2014 period, contributing impact across academic and non-academic arenas at a Scottish, UK, EU and international level. We intend to build on our successes and play an increasingly important role at the heart of a bold, imaginative and innovative University for the 21st Century.