Institution: University of the West of England, Bristol (UWE)

Unit of Assessment: Computer Science and Informatics (11)

a. Overview

The Unit's research is organised into four groups: 1) Unconventional Computing Group (UCG); 2) Bristol Robotics Laboratory (BRL); 3) Artificial Intelligence Group (AIG); and 4) Centre for Complex Cooperative Systems (C3S).The Unit contributes to the discipline's foundations through to its application: from novel substrates to humanoid robotics; and, from new machine learning algorithms, to large-scale distributed systems, respectively. The membership and areas of interest of these groups are not mutually exclusive and collaborative research between them, together with other UWE, national and international partners, occurs frequently. The AIG, C3S and UCG are spatially co-located in independent labs, not far from the BRL. All four groups existed prior to the 2008 Research Assessment Exercise (RAE). A group submitted previously merged with the AIG upon retirement of its lead Professor (Parmee) in 2010. Each group is led and managed by a Professor (Associate Professor in the case of AIG), who also serves as its representative on the Faculty's Research and Knowledge Exchange (R&KE) Committee where issues such as local UWE strategy implementation and research investment are addressed.

b. Research strategy

UWE's research vision is to have an outstanding reputation for its user-led research applicable to real-world problems and to conduct world-class research in clearly identified areas of strength. The Unit was identified by the University as one of its five priority research areas after the 2008 RAE, in which UWE more than doubled its HEFCE R funds. Consequently, the Unit has benefited from approximately £1M of UWE's Strategic Research Development Funding (SRDF) over the reporting period. The Unit's overall aim is to concentrate on maintaining the vitality of its existing groups while supporting promising trajectories within them which may emerge ultimately as new groups. The SRDF funding has been allocated in 3-year plan cycles allowing groups to plan ahead for investment in research studentships and staff. Following the stated objectives for the equivalent Unit in 2008, the overarching strategy continues to be to (i) extend and sustain the level of external funding and (ii) maintain a vibrant, intellectually rigorous research culture, characterised by: adventurous, interdisciplinary collaborative research; strong support for individual initiative; encouragement for dissemination to students and the public; and, a mixed-economy of fundamental and applied research with impact. The details given below demonstrate how both of these overall objectives have been firmly met – external funding has increased by ~80% over the period, for example. The Unit's overall aim is realised through appropriate local strategies for each of the contributing groups, monitored through regular reporting to the R&KE Committee and the annual personal development reviews of group leaders.

The **Unconventional Computing Group** (UCG, lead: **Adamatzky**) is an interdisciplinary cooperation spanning theoretical and experimental studies of novel principles of information processing in physical, chemical and biological systems. Its *vision* is that massively parallel unconventional computers which exploit the phenomena of non-linear dynamics intrinsic to a given system will enable computational capabilities beyond current technology. The UCG research *strategy* is and will continue to be based upon interdisciplinary modelling and experimental verification, with the following core objectives: to have a leading international reputation for the construction of experimental prototype devices in a wide range of substrates; to publish definitive papers and monographs in the discipline; to maintain and build a network of international collaborations with key people; and, to attract external funding from a portfolio of sponsors, including the silicon industry as a route to achieving impact (e.g., Samsung). Since 2008, UCG has become an established international leader in its field, as evidenced by its leading EU collaborations over the reporting period (e.g., FP7 PhyCHIP) and journal editorial roles. Moreover, income has increased, three monographs have been published, as well as a high-performing PhD student progressing through to Research Fellow within UCG (**Jones**, 2013). Current fields of research include bio-inspired architectures such as cellular automata (**Adamatzky**), chemical computing (**Adamatzky, De Lacy Costello**), slime mould computing (**Adamatzky, Jones**),

memristors (**Adamatzky, Bull, De Lacy Costello**), massively parallel simulations (**Scarle**), and the programming of novel substrates through artificial intelligence techniques (**Bull**).

The **Bristol Robotics Laboratory** (BRL, lead: **Melhuish**) is a collaboration between UWE and the University of Bristol, based at UWE and containing a core group of UWE staff and students working in the area of intelligent autonomous systems. Since 2013 BRL also incorporates UWE's Centre for Machine Vision (being submitted to UoA15, as in RAE2008). BRL's *vision* is to realise a union of science and engineering to create physical artefacts capable of working independently, with each other, or with us in human society. Its research *strategy* continues to be based upon an interdisciplinary approach: to have considerable strength in all of the disciplines necessary for advanced robotics; to have close links with all of the required life/social science disciplines and appropriate industrial sectors for work in these areas, in the UK and the EU; and, to have an international reputation as a leading research centre in advanced robotics research. BRL has secured involvement in EU FP7 projects including SYMBRION, CHRIS, and BIOTACT, alongside advisory roles within the EU. Since 2008, there has been further significant internal investment in infrastructure capabilities. Current priorities of the BRL for UWE staff include: human-robot interaction (**Melhuish**), swarm intelligence (**Winfield**), robot energy autonomy (**Ieropoulos**), and new adaptive control approaches from real-time mammalian brain modelling (**Pipe, Pearson**).

The **Artificial Intelligence Group** (AIG, lead: **Smith**) undertakes research into adaptive computing, with an emphasis on evolutionary computation. Its *vision* is that as computing becomes increasingly embedded within the fabric of the environment, and is used in new and novel ways, so intelligent algorithms will be needed to aid the realisation of such systems at all levels – from the substrates to the interfaces. AIG's on-going *strategy* is: to introduce and formally understand nature-inspired approaches to adaptive computing; to apply such basic research to practical applications with impact; to undertake collaborative projects funded by a variety of sponsors; and, to maintain a significant presence within the international evolutionary computing community. Since 2008, external funding levels have been maintained, work on disclosure control with the Office for National Statistics has yielded significant impact (in collaboration with colleagues in UoA15, submitted as a Case Study there), a heavily-cited evolutionary computing text book has had a second edition published (ISBN: 978-3-540-40184-1), and journal editorial board roles have been increased. Upon the retirement of its lead in 2010, the other staff member of the Advanced Computation in Design and Decision Making group joined the AIG (**Simons**), whose work on search-based software engineering aligned well with the AIG; two journal papers with the AIG's lead have since been published. Other current areas of interest include human-centred adaptive interfaces (**Smith**) and cell-inspired algorithms (**Bull**).

The **Centre for Complex Cooperative Systems** (C3S, lead: **McClatchey**) undertakes applied research in large-scale distributed systems and data and process management, motivated by the rapid convergence of the telecommunication and information system industries and a critical requirement for effective ways to integrate and handle information. C3S's *vision* is that information systems are adaptable, available and evolutionary in nature. Its research *strategy* continues to be to develop medium-to-long term collaborations with commercial bodies and research leaders in its core areas of large-scale distributed data and process management (**McClatchey)**, grid and cloud computing (**McClatchey**), mobile computing (**Liaquat**), and process and system modelling (**Odeh**). C3S currently houses the fledgling Software Engineering Research Group (**Odeh, Simons**) which is providing focus for staff research efforts and becoming an increasingly important vehicle to engage with industry (e.g., Airbus, Case Study 2). Since 2008, EU project income for C3S has doubled, work in both large-scale distributed databases and process modelling have achieved significant impact (see Case Studies 1 and 2 respectively), and the number of PhD completions has increased. Members of C3S (**McClatchey, Odeh**) are proud co-authors of the 2012 *Physics Letters B* paper reporting observation of the predicted Higgs-Boson particle through their on-going, long-standing collaborative work at CERN.

Devolution of the Unit's strategy implementation to individual group leaders continues to be both successful and to contribute to a sense of cohesiveness, ownership, and motivation within the groups. Moreover, it provides an effective level of responsiveness to changes in both the internal and external environment for each group. This was a major factor in the Unit's decision to maintain the policy during the current and coming periods.

c. People, including:

i. Staffing strategy and staff development

The Unit's submission consists of a lively mix of promising early career staff (**Liaquat, Scarle, Jones**) through to experienced senior staff, spread relatively evenly across the groups: 1 research fellow, 2 senior research fellows, 3 senior lecturers, 3 associate professors, and 6 professors. In the period, a senior lecturer and a senior research fellow were promoted to associate professor (**Odeh, Ieropoulos** respectively), as was one associate professor to professor (**Pipe**). Recruitment of research assistants is largely based around externally funded projects, with selection panels chaired by the host group's lead to ensure an appropriate profile for group development, alongside the project requirements. Over 30 such positions have been created during the reporting period across a wide portfolio of projects. The research fellow, both senior research fellows, and one of the senior lecturers submitted here were originally recruited in this way, reflecting career development paths within the Unit. Several new-blood Faculty lectureships have recently been created to target mixed teaching and research positions, thereby securing promising research capability - **Liaquat** (C3S) and **Scarle** (UCG) for this Unit. SRDF funding helps ensure a significantly lighter teaching load. These posts underpin established areas but with a view to moving into emerging topics, as identified at the group level. Target areas are sought to achieve synergy between teaching and research. An annual competitive early career research scheme provides pump-priming (funding/time) to promising staff, each with the support of a senior researcher mentor.

All staff (research assistants and Faculty) undergo a performance review process overseen by the University which involves an annual meeting and follow up(s). These meetings are carried out by the line manager, with the annual meeting the main focus for determining development activities with respect to UWE, Faculty, and Unit/group priorities. Staff are encouraged to deliver and participate in joint group seminars, as well as to attend the regular development courses provided by the Research Business & Innovation (RBI) service at the University. These include transferable research skills (project management, communication skills, proposal writing) and specific technical skills required for their disciplines. The service also provides advice suitable to staff at all levels in the development of business skills such as intellectual property rights, entrepreneurship and spin-out companies, and patent applications. Support to attend external training/events is also available.

UWE is actively working towards the implementation of the 'Concordat to Support the Career Development of Researchers' in partnership with research staff and their managers. Reflecting this, the European Commission has recognised UWE's progress on supporting the career development of researchers through the Human Resources Excellence in Research Award granted in January 2012. This identifies organisations as 'providers and supporters of a stimulating and favourable working environment for researchers' and 'recognises the University's outstanding work in developing and supporting its research staff'. UWE is currently working towards the Interim Review early in 2014 which should re-confirm the recognition of the award. A key vehicle for taking forward the Concordat is the UWE Researchers' Forum, established in 2005, which provides a network for UWE research staff. The Forum helps ensure staff are fully informed about research strategy and policies and relevant Human Resources policies pertinent to fulfilment of their roles and to career advancement. It enables the sharing of good practice and common issues across UWE and operates through both online and face-to-face exchanges.

A key contribution to the Unit's staff development is academic enrichment through externally funded fellowships and visiting scholars. Visitors and wider virtual academic networks establish and extend collaboration and encourage research 'without borders' thereby enabling, for example, involvement of the most appropriate international individuals in research challenges currently being faced. Notable examples during the period include:

EPSRC Career Acceleration Fellowship - Waste Made Useful by Microbial Fuel Cells for Energy Generation (EP/1004653/1**, Ieropoulos**, BRL, 2010-14). This Fellowship addresses the strategic priority of Carbon-Neutral Sustainable Energy using microbial fuel cells. Awarded for the development of a dedicated and multi-disciplinary research team for the benefit of both the academic community and UK plc, it is led by Dr. **Ieropoulos**. Starting at UWE as a research

student, Dr. Ieropoulos, now Associate Professor, has been strongly supported and mentored by the Unit throughout his career. He currently holds 3 EPSRC grants, TSB funding, and a Phase-I grant awarded under the Global Health Programme open competition by the Gates Foundation.

Leverhulme Trust Visiting Professorship – Leon Chua (F00577J, **Adamatzky**, UCG, 2010-11). Leon Chua is Professor of Electrical Engineering and Computer Science at the University of California at Berkeley. In a seminal paper in 1971, he predicted the existence of a fourth fundamental electrical component known as the memristor. To complement the EPSRC project "Learning and Computation in Disordered Networks of Memristors: theory and experiments" (EP/H014381/1, **Adamatzky, Bull, De Lacy Costello,** UCG), Professor Chua undertook a nine month visit funded by the Leverhulme Trust. As well as working with the two research assistants employed by the grant, along with members of the AIG and BRL, he co-authored two papers with Adamatzky, and presented a series of lectures. Chua's knowledge transfer activities culminated in his two public lectures, one at Hewlett Packard Labs, Bristol and one at Imperial College.

EU International Researcher Exchange Scheme (IRSES) - Marcos Aranales, Socorro Rangel and Silvio Aurajo (PPExt, **Smith**, AIG, 2010-13). Marcos Arenales is a Professor of Applied Mathematics and Statistics at the University of Sao Paolo, Socorro Rangel is an Associate Professor in Operations Research at the State University of Sao Paolo (UNESP), and Silvio Aurajo is an Associate Professor in Mathematics at UNESP. This brought together the expertise of the visitors in mathematical modelling with that of Smith in meta-heuristics for large-scale production planning. The Brazilians delivered seminars to staff and students. In turn Smith and colleagues made complementary visits to Brazil. The funding was matched by the Brazilian Government.

In 2010 UWE and Hewlett Packard, Bristol formed a strategic partnership, one consequence of which has been the appointment of three senior scientists as Visiting Professors to the Unit: forensic computing (Kuhlmann), cloud computing (Edwards), and unconventional computing (Kitson). Building on many years of occasional collaboration, this formalisation has spurred a variety of beneficial activities including publications, research seminars, short periods of residency by staff and students in both directions, graduate and postgraduate student co-supervisions, project collaborations, guest lectures on final-year courses, and opening new routes to potential impact. In addition to regular visits from the many partners involved in the Unit's projects, all the groups host visitors from a range of national and international institutions. During the reporting period, this has included Visiting Professors from international (e.g., Willers, CERN; Solomonides, North Shore; Gunji, Kobe) and national (e.g., Moore, Sheffield; Wuensche, Sussex) organisations.

The Unit aims to create an environment that respects the diversity of staff and students and to enable them to derive maximum benefit and enjoyment from their involvement with the University. For example, UWE is the third highest ranked UK University in the Stonewall Workplace Equality Index Top 100 (2013). This Index is the leading tool for employers to measure their efforts to tackle discrimination and create inclusive workplaces for lesbian, gay and bisexual employees. UWE has achieved a Bronze Award under the Athena SWAN Charter which recognises excellent work in addressing gender inequalities and advancing women's careers in science, technology, engineering, maths and medicine (STEMM) in higher education, as well as promoting best practice in recruitment, retention and promotion of high quality staff.

ii. Research students

Within the Unit, there is a commitment to maintaining a viable and high quality population of research students. For example, as noted above, a proportion of SRDF full-time bursaries (~£15k pa stipend) have been provided to help enable a strategic approach to support areas of strength or development within groups, as determined by the groups. Over fifty PhDs were awarded within the Unit over the reporting period. All research students have a Director of Studies (DoS) supported by other academics within a supervisory team. The DoS is the academic lead with overall responsibility for supporting the student through their degree. Each potential student is interviewed by a panel prior to enrolment, chaired by a member of the Faculty Research Degrees Committee. The member of staff identified as most likely to become the DoS, either from having set the topic of an advertised bursary or from the application form, and those most likely to form the rest of the supervisory team (up to 3) will constitute the interview panel.

During the reporting period, a UWE-wide Graduate School has been formed, drawing in the previous Faculty-based Schools. The potential for better sharing of good practice and support for cross-discipline research have all been exploited as a consequence. The UWE Code of Practice for Postgraduate Research Study, closely aligned to the QAA Code of Practice, sets out the support with respect to postgraduate research degrees. The University's Graduate School offers general and personalised advice to research students about their training needs and each newly enrolled student has their training needs assessed with the supervisory team. A generic series of research training workshops is provided to give both essential research skills and transferable skills. Topic-specific level M taught courses offered by the University can also be taken. All students are expected to write and present papers, closely mentored by the supervisory team, with further support via writing courses available in the Graduate School. Faculties run annual one-day conferences at which students from all Departments present work in mixed sessions thereby encouraging cross-discipline discussions and the sharing of good practice, as well as aiding preparation for external events. Sessions are chaired by senior academics, with further questions and feedback provided by present supervisory team members and other academics. Groups encourage their students to attend and/or give regular seminars, and to interact with visiting academics and project-based researchers. Each group maintains a coherent lab space in which all such people are based, alongside the other UWE group members. The Unit's wide portfolio of externally funded projects has also enabled students to undertake brief placements at collaborating institutions. This practice is exemplified by the BRL's current Marie Curie Doctoral Training Network – Interactive Robotics Research (**Pipe,** 2012-15). This ITN funds six PhD students, involving six partners (UWE plus Umea, TU Berlin, Ben Gurion, Space Applications, Robosoft). Two of the students are based at the BRL and as part of the Network's operation two further students will visit the BRL for 3 months each – from partners in Germany and Israel. It can be noted that the BRL will also host the EPSRC Centre for Doctoral Training in Future Autonomous and Robotic Systems (2014-22) which will expose over 50 doctoral researchers to its activities.

Student progress is formally monitored annually with separate forms from the student and supervisory team scrutinised by a Faculty Research Degrees Committee enabling, for example, the identification of good practice and students requiring extra support. Supervisory teams are expected to meet with the student regularly and maintain an agreed record of the outcomes. Students must produce a Progression Report before the end of the first 12 months (or equivalent for part-timers) of study, which is examined via viva voce by two members of staff not directly involved with the research/supervision. The outcome determines whether the student continues.

d. Income, infrastructure and facilities

In comparison to the equivalent 2008 submission, external research income spent during the period has increased by 80% to ~£9M (>£0.6M per FTE on average), with a number of projects running until 2015-2016. Meanwhile UWE's SRDF (along with external funding, e.g., EP/F037104/1, **Melhuish**, BRL, ~£100k, 2011) has been used to improve infrastructure within the Unit. As noted above, the Unit's strategy continues to be for groups to maintain a wide portfolio of external funding. More specifically:

The **Unconventional Computing Group** is a cross-University venture with dedicated lab space in the Unit's Faculty and in the life sciences Faculty (micro-biology, chemistry). Moreover, the Hewlett Packard Visiting Professor associated with the group enables access to an industrial high-tech clean room with capabilities such as aluminium spluttering and spin coating. The research portfolio and value to UWE over the period is:

- EPSRC: 5 grants, £1.3M to UWE (£1.5M total)
- EU FP7: 2 grants, £1.1M to UWE (£3.5M total)
- Industry: 1 grant, £93k to UWE (Samsung)
- Charities: 2 grants, £286k to UWE (both Leverhulme Trust)
- SRDF: £125k

The **Bristol Robotics Laboratory** moved into a major new facility in 2012, providing significant infrastructure expansion with workshops, rapid prototyping, 'wet' laboratories, and 2,000m^2 of

general purpose lab space, representing an investment of £1.6M by UWE. The BRL consists of twenty six research bays, each covering an area of approximately 25 m^2, and two flying arenas of approximately 180m^2 and 100m^2, the larger of which is equipped with infrared motion tracking and an overhead camera. All six wet laboratories comply with the Containment Level 2 (CL2) standard and cover an area of approximately 335 m^2. Three full-time, dedicated technicians support the BRL. The facilities are available to undergraduate project students (e.g., BEng Robotics), postgraduate students (e.g., MSc/MRes Robotics), and the other groups in the Unit, independently, or to undertake more formal collaborative research (e.g., EP/H023631/1, **Adamatzky, Bull, Melhuish**; PhyCHIP, **Adamatzky, Bull, Ieropoulos**, both UCG, AIG and BRL collaborations), or as a way to explore new areas of potential mutual interest (e.g., memristors). Current plans include further investment into the area of medical robotics, such as in new forms of minimally invasive surgery tools and artificial limbs. The research portfolio covers fundamental research through to user-facing work, and its value to UWE over the period is:

- EPSRC: 13 grants, £2.7M to UWE (£9.2M total)
- EU FP7: 5 grants, £2.3M to UWE (£27M total)
- Industry: 4 grants, £129k to UWE
- Charities: 4 grants, £272k to UWE (£439k total)
- SRDF: £350k

The **Artificial Intelligence Group** enjoys dedicated lab space and computing resources. The nature of most of the Group's work requires predominately excellent workstation-based resources, updated bi-annually, networked to lab space recently equipped with a range of user-interface technologies, such as auditory, touch, gesture and 3D sensors as part of its work on adaptive interfaces. The research portfolio covers basic research through to knowledge transfer activities, and its value to UWE over the period is:

- EPSRC: 6 grants, £1.2M to UWE (£1.3M total)
- EU FP7: 3 grants, £442k to UWE (£2.5M total)
- Industry: 4 consultancies, £30k to UWE (all Office for National Statistics)
- SRDF: £250k

The **Centre for Complex Cooperative Systems** has lab space with bespoke network and server resources at UWE. One set of servers hosts an OpenStack based cloud platform, with another set of hosting code repositories, etc., including the CRISTAL software releases (Case Study 1). It also has dedicated lab space at CERN for the group members based there, with remote access to the aforementioned servers. The research portfolio is primarily based around large-scale, international projects involving academic and commercial partners, and its value to UWE over the period is:

- Knowledge Transfer Partnership (KTP): 4 grants, £580k to UWE
- EU FP7: 6 grants, £2.1M to UWE (£24M total)
- Industry: 2 consultancies, £30k to UWE (Airbus)
- SRDF: £300k

e. Collaboration or contribution to the discipline or research base

As evidenced above, collaborative research projects between members of the Unit and other national and international partners is the norm: the majority of external funding comes from either the EPSRC or the EU. Project bidding and subsequent management is supported by Faculty-aligned staff in the Research Business & Innovation (RBI) service at the University that provide expertise in funding regulation, including EU, KTP, and RCUK specific experts, budgets and accounting, contracts and licensing. Travel funding is available from RBI for meetings with prospective project partners. RBI also runs regular training workshops on bidding and management. RBI was heavily involved in the creation of the BRL which is having increasing impact upon the related discipline both nationally and internationally: its lead role in building strong links with the UK robotics industry has resulted in the formation of the Academic Forum for Robotics within the British Automation and Robot Association in 2011 (Vice-President, **Melhuish**); and BRL was selected to be the UK liaison between UK funding agencies and the EU Robot

Companions Flagship Consortium.

All groups are actively involved in interdisciplinary research, ranging from chemical computing (UCG) to urban planning and policy modelling (C3S). In addition to this on-going work, in 2009 individuals from the Unit were involved in a successful EPSRC Bridging the Gaps proposal entitled "Health, Environment and Technology Research: HEAT@UWE" (EP/H000380/1, ~£500k). This supported interdisciplinary collaborations between colleagues across UWE, including this Unit. A management committee consisting of the co-investigators (including **Bull, McClatchey**) oversaw a variety of activities to establish and support new interdisciplinary research areas. HEAT awarded £130,000 of start-up funding to 18 interdisciplinary projects involving 72 UWE academics. The main results included the formation of new collaborations and new bids to external funders, which included 17 external partners (national and international), e.g., EU FP7 project UrbanAPI (**McClatchey**, C3S), research papers, invited conference talks, as well as much increased institutional expertise in interdisciplinary research. The management committee authored the 'Best Practice Guide for Interdisciplinary Research' report for the EPSRC which was distributed to all Bridging the Gaps project holders. Since EPSRC funding finished, the University is maintaining the HEAT approach and supporting new collaborations which are brokered by an expanded committee and the HEAT facilitator.

The substantial knowledge transfer activities within the Unit have also influenced its research activities. For example, C3S has a KTP with local firm Blue Sheep (**Liaquat, McClatchey**) who have very specific cloud computing requirements - notably data security. As a consequence of this fundamental and yet still somewhat unresolved issue in cloud computing coming to the fore, two Visiting Professorships were created for senior scientists at Hewlett Packard Labs working in the area to become involved in C3S research activity. Beginning with the co-supervision of a PhD student, principles from C3S's CRISTAL software (Case Study 1) are being adopted and extended for security event and incident management as an initial promising theme within the area. As part of the BRL's emerging research in medical robotics (**Melhuish, Pipe**), work with surgeons from the Bristol Urological Institute in soft tissue robot surgery has raised a new avenue of research in laparoscopic surgery: the North Bristol NHS Trust funded an extra PhD studentship to look into anthropomorphic manipulation in laparoscopic surgery, in addition to the original researcher and PhD studentship. Also in the BRL, as part of Dr **Ieropoulos's** EPSRC Career Acceleration Fellowship (see above), a PhD studentship was funded by Wessex Water to explore the use of microbial fuel cells for waste water treatment. During the research it became clear that the amount of power generated can be used as a measure of water quality. Moreover, the presence of urine in waste water and its potential for energy production alone has been used to attract further funding for basic research from the Gates Foundation.

Members of the Unit undertake numerous national and international leadership activities, such as: founding Editor-in-Chief of 3 journals (*Unconventional Computing, Cellular Automata,* both Old City Publishing Ltd., **Adamatzky***; Evolutionary Intelligence,* Springer, **Bull**); Editorial Board membership >20 journals (**Adamatzky, Bull, Ieropoulos, Smith, Melhuish, Winfield**); EPSRC College members (**Adamatzky, Bull, Melhuish, Winfield**); six conference chairs (including IEEE and ACM events; **Bull, Odeh, Smith, Winfield**); and, 3 Visiting Professors (Sheffield, **Pipe**; York, **Winfield**; NUST Pakistan, **McClatchey**).

Some further specific examples of leadership during the period include: advisor EU FET Living Technology theme 2012 (**Adamatzky**, **Bull**); member of Scientific Board of EPSRC's Hydrogen and Fuel Cells SUPERGEN Hub (**Ieropoulos**); advisor to Research Council of Norway and to the Division for Physical Sciences of the Netherlands Organisation for Scientific Research (**McClatchey**); Vice-President British Automation and Robot Association Academic Forum (**Melhuish**); invited to give briefings on robotics to Minister of State for Universities (**Melhuish**); advisor EU FET FP8/Horizon 2020 Planning Meetings (**Melhuish**); member of IEEE SMC Society Technical Committee on Soft Computing and member of IEEE Computational Intelligence Society Emerging Technologies Task Force on Memetic Computing (**Smith**); Swiss National Science Foundation international review panel for National Centres of Competence in Research (NCCR) programme in Intelligent Robotics (**Winfield**); UK Space Agency Aurora (Mars mission) Advisory Committee (**Winfield**); and, British Standards Institute committee on Robot Ethics (**Winfield**).