Research Environment

Research Strategy

Progress against RAE2001 research plans

Publications for the UoA increased from 220 to 352, refereed journal articles 67 to 78, refereed conference papers 153 to 258. UoA activity is focussed in two research groups Signal Processing, System Analysis and VLSI Design Cluster - **SPAVIC** - (RAE2001 VLSI and Signal Processing) and Communication Systems and Compunetics Cluster **CSCC** – (RAE2001 RF, Microwave and Wireless Communication) and is as follows.

SPAVIC

An overall increase in activity from five to seven full time registered research students over the period with twelve PhD completions, nine in RAE2001, and one MPhil; three, up from one, EC projects, a Knowledge Transfer Partnership programme, five patents filed, (previously one), £150k worth research contracts with UK, and foreign owned firms. New research direction, FP5 funded, on the application of artificial intelligence in industrial and medical applications with Institut fur Mikroelektronik Stuttgart, Karl Storz, Tuttlingen, Katholieke Universiteit Leuven, Schola superiore Sant'Anna, Pisa which led to a patent filing. Future directions providing theoretical guidelines and practical solutions for designing efficient circuits and systems by developing

- novel signal processing algorithms and their low-cost implementations in software, firmware and VLSI hardware;
- intelligent systems for advanced signal processing and system analysis

Objective to maintain steady growth in number of full time PhD students (2001=>5, 2007=>7, 2012=>*10*) and completions (2001=>9, 2007=>12, 2012=>*15*). Continue to increase the number of publications to 250, with 60 in refereed research journals.

CSCC

An overall increase in activity to nine, from four, full time and one, from zero, part time registered research students, six (previously zero) PhD completions two (previously one) EC projects. New research direction, FP6 funded, on future applications of wireless networks in cooperation with France Telecom, BT, Siemens, RAI, Motorola and more than ten other European partners. Future directions include

- techniques and methods of designing RF circuits and systems;

- developing ICT-based Assistive Technologies actively supporting vulnerable people (e.g. ill or elderly).

This work will be complemented by research into user profiling and personalisation, trust and security, intelligent decision support in contemporary and future mobile networks.

Objective to stabilise growth in number of full time PhD students (2001=>0, 2007=>9, 2012=>*12*) and completions (2001=>0, 2007=>6, 2012=>8) and continue to increase the number of publications to 150, with 40 in refereed research journals.

Shared objectives

- Increase by at least 60% the number of research active staff engaged at internationally recognised level. Realisation of this task has already started by:
  - engaging more of current staff in research activities
  - recruiting replacement staff with good research track records
- Proportionally expand research study programme by maintaining 5+ (current mode 4) research students per FTE research active staff at any time
- Engage more with industry through FP7, applied research (eg building on Rolls Royce contract, and Mitsubishi) and knowledge transfer activities including 2 KTPs
- Maintain the growing rate of financing research from government and research councils
- Increase publications from 352 to 400 and in refereed journals from 78 to 100 achievable growth with a greater proportion of refereed articles.

Research Structure

Similarly to RAE2001 Electronic Engineering research is clustered in two main activity areas:

- Signal Processing, System Analysis and VLSI Design Cluster (SPAVIC) comprising staff from the Applied DSP and VLSI Research Group, and the Centre for System Analysis: Izzet Kale (IK), Professor of Applied DSP and VLSI Systems, Vassilis Kodogiannis (VK), principal lecturer, Andrzej Tarczynski (AT), reader, School research director, ten research students, two visiting Professors and two RAs.
- Communication Systems and Compunetics Cluster (CSCC) comprising staff from Communications and Compunetics Research Group, and Wireless Communications Research Group: Djuradj Budimir (DB), reader and Prof. Kambiz Madani (KM), ten research students, four visiting Professors and one RA.

These teams are supported by seven academics who aspire to become fully research active.

SPAVIC - Principal activities

IK – Ultra-low-power digital signal processing algorithms and systems, design and implementation of fixed and adaptive digital filters, hardware processors, sigma-delta-based systems and A/D- D/A converters, methods of alleviating RF impairments in communication receivers, re-configurable system design, image processing for biomedical applications, global navigation satellite systems;

VK –Artificial intelligence applications in image and signal analysis, pattern recognition, system control and modelling, robotics, data mining, knowledge discovery, and bioinformatics.

AT – Digital signal processing including Digital Alias-free Signal Processing (DASP), optimal filter design, system analysis and modelling, control engineering, monitoring quality of signal transmission over communication networks;

SPAVIC researchers have close cooperative links with more than 20 academic centres and similar number of industrial / commercial partners around the world.

The main achievements:

- Advances in DASP – a DSP methodology based on nonuniform sampling facilitating processing signals in wide frequency ranges. This work has been supported twice by EC (EURODASP and DASPTOOL). Example applications of DASP demonstrated in these projects include:
    - A versatile computer-aided system for quality assurance tests and measurements in integrated (voice, data, video) networks,
    - A system for electrical bioimpedance based health monitoring (impedance tomography)
    - A wide-dynamic range (140dB) signal digitiser for acquisition seismic data.

- Participation in development and evaluation of a miniaturised videoprobe comprising a micro-electronic image sensor and wireless communication link for use in medical diagnosis and therapy. This work has been supported by a EC (IVP- Intracorporal Videoprobe)
- Development of Digital Hearing Aid – one of the of the world's lowest-power hearing aid available on the market. The work accomplished in cooperation with Starkey Labs USA and Zarlink Semiconductor in USA, Canada, UK and Sweden.
- Development of a fully configurable GPS receiver for Mitsubishi Electric. Follow up research led to the filing of a University patent related to Galileo receivers.
- Research and patent on "Jitter Insensitive Continuous-Time Sigma-Delta Modulators" – a technique facilitating the construction of low-power wide-

band, high-precision Sigma-Delta based systems. The work is being commercialised by the University through a spin-out company.

CSCC – Principal activities

DB – Advanced CAD of circuits, antennas and systems for frequencies ranging from RF to terahertz in wireless communications (GSM, WCDMA, UltraWideBand, WiFi, WiMAX), satellite and collision avoidance systems; reconfigurable metacircuits and antennas; numerical electromagnetics (simulation of coaxial, dielectric resonator, planar, quasi-planar and waveguide transmission line structures); advanced literalisers for multi-carrier power amplifiers.

KM – Intelligent reconfigurable radio networks for software radio applications, seamless personalised telecommunication services, smart homes and ambient intelligence, remote physiological and lifestyle monitoring, mobile health and healthcare.

CSCC cooperates closely with research groups in the School of Informatics (SoI) that are engaged in mobile computing, software engineering and information systems. It has cooperative links with more than 10 academic centres and a large number of industrial / commercial partners around the world including leading companies such as BT, France Telecomm, Panasonic, Siemens and Motorola.

The main achievements:

- Research into future software radio techniques. Development of new broadband RF front-end for software radio using sub-harmonic sampling methods for down-conversion. This work has been supported by EC (CAST).
- Development of selected elements of infrastructure for creating personalised networks of digital devices (ePerSpace). This research aimed at increasing user acceptance of networked audiovisual systems and applications at home and virtually anywhere by developing innovative interoperable value-added networked services with an international consortium consisting of telecom operators (France Telecom, British Telecom, Telenor, & Telefonica), manufacturers (Siemens & Motorola), broadcasters (RAI & NRK), and several SME's & Universities. The work was supported by a 7.3 Million Euro FP6 award (CSCC 304,521 Euros).
- Research into design techniques of high frequency filters and antennas. This work has been supported by EPSRC grant "Waveguide Filters with Improved Stopband Performance and Novel Antenna Filters for Millimetre-wave Applications" and EPSRC PhD studentship "Novel 3D Multilayer Passive MIC and MMIC Components for Microwave and Millimetre-wave Applications"

Research Promotion

UoA 24 shares research environment with colleagues active in UoA8, UoA12, and UoA23 under the administrative umbrella of the School of Informatics. This makes for a multidisciplinary culture which is exhibited in joint supervision of PhD students, bids for and work on multidisciplinary projects, joint publications, participation in common research seminars and, when appropriate, sharing resources. The research groups and individuals are subject to, and linked by, the same internal scrutiny of research quality. Electronic Engineering research is surrounded by rich, multidisciplinary cooperative activities and clearly benefits from as well as contributes to this environment.

Formally established research groups, play the central role in promoting research. Groups are led by senior academics and loosely relate to postgraduate teaching activities in the areas relevant to their research interests. They are responsible for undertaking and managing research activities in those areas, bringing non-HEFCE income through research and consultancy contracts, creating and supporting external links with industry and academia, providing academic support for research students, creating positive expectations of research development by new staff members and those new to research. The groups comprise not only academics and research students but also research assistants, non-academic staff involved in research, visiting Professors and members of other institutions eg

SPAVIC Visiting Professors

- Dr Steve Morris, Vice-President for Engineering in Nanotech Semiconductor. Until recentlyhe was Director of R&D, Worldwide, for Zarlink Semiconductor Ltd UK, Sweden and USA

- Professor Vedat Tavsanoglu, Yildiz Technical University, Istanbul

CCSC Visiting Professors

- Professor X Chen, QMUL

- Professor Danilo P. Mandic, Reader in Signal Processing in Department of Electrical and Electronic Engineering, Imperial College

- Dr Andy Marsh member of The Executive Board of The International Council on Medical & Care Compunetics

who work jointly with our researchers. The groups operate their own budgets including a share of research income they bring to the University. Additional financial support is despatched by the School after agreeing its level and purpose during annual monitoring of research groups. The aim of annual monitoring is to assess the achievements and relative weaknesses of the groups, agree research plans and linked financial and organisational support. Staff members can join more than one group including those in other schools.

Weekly research seminars are attended by staff and students across the University and the general public.

Group	Books and book chapters	Refereed journal papers	Refereed conference papers	Patents filed
CSCC	2	26	110	
SPAVIC	14	52	148	5

Table 1 Research publications

Research Infrastructure

Substantial improvement to the physical environment has been made since 2001. In September 2004 brand new purpose built workspace was opened providing dedicated spaces for research laboratories as well as comfortable offices and pleasant working environment for staff and research students. Research infrastructure received SRIF funding (SRIF1: £225,000; SRIF3: £406,000) and acquired

- A new Real-Time DSP Research Laboratory (Multiprocessor DSP/FPGA prototyping environment, real-time video prototyping systems/boards, image acquisition equipment, high-performance workstations equipped with real-time tools, real-time communications prototyping systems, including RF/IF and ADC/DAC development facilities, instrumentation for signal synthesis and analysis.)
- 64-node computer cluster providing ample computational power for advanced numerical analyses, simulations and design of signal and image processing systems and VLSI circuits. This facility is shared with other research groups in SOI;
- Equipment for Wireless Communications Research Laboratory including 67GHz Agilent PNA E8361A vector network analyser to support research in microwave circuits and systems; 20GHz Tektronix spectrum analyser, 26.5GHz Agilent 8970^{TM} noise figure meter and on-wafer probe station with four positions for testing MMIC circuits
- 20TB data back up system (shared within school),
- Computers and other computer equipment to support Electronic Engineering research staff and students;

Support for Research Students

All research students are eligible for financial support. Fee waiver scholarships can be supplemented by three-year maintenance scholarships. The University offers a programme of 23 specialised training sessions that research students take over three years. The sessions support progression through the research programme but also arm the students with generic skills that will be useful in their professional life. The students are encouraged and supported to take part in research events: participation and presentations at school research seminars, attending external events such as competitions and conferences. These policies bring positive effects as can be seen in the growth in cohort, increase in full time to part time ratio and completions. PhD

student Dongdong Qu (SPAVIC) won "the best student paper" prize in the 10th International Conference on Systems, Athens, 2006. Another student Drasko Draskovic (CSCC) was one of five finalists at the IET Annual Short Papers' Evening, 2007.

Group	2001	2002	2003	2004	2005	2006	2007
CCSC	4/0	3/0	5/0	6/1	7/3	6/2	9/1
SPAVIC	3/4	4/4	7/4	10/5	10/7	8/5	7/3

Table 2 Headcount of registered research students FT/PT

Group	2001	2002	2003	2004	2005	2006	2007
CCSC		1		2	1	1	1
SPAVIC	3	2	1		2	3 + 1MPhil	1

Table 3 Number of awarded research doctorates

Support for Interdisciplinary and Collaborative Research.

The University offers a dedicated service to support collaborative research. This includes promotion and distribution information about such research opportunities and initiatives including EC funded projects. Help is offered on administrative, legal and financial aspects of contracts and IPR issues. The School of Informatics has strong research in parallel computing, agent technology, mobile and wireless computing, operational research for healthcare management and information systems which complement SPAVIC and CSCC activity. A real interdisciplinary environment has been created inside the School eg Terstyanszky's (UoA23) parallel processing expertise was deployed in support of Tarczynski to solve numerically demanding optimisation problems in advanced DSP systems – the work resulted in joint publications. Kale used the expertise of the School of Biosciences to support research on automated detection and diagnosis of malaria infection from digital images of blood samples. This cooperation resulted in successful completion of a PhD project and the results of this work are applicable for commercialisation once a reliably working prototype is developed. WestFocus (a consortium of seven London Universities in West and South West London) funded Kale's involvement with physicists at Royal Holloway on intelligent signal and image processing to analyse signatures in precious stones with cheaper lasers than those in standard use.

Colleagues in UoA 23 have also participated with Madani in EU-funded collaboration including ePerSpace described above. International links with external research centres eg Institute of Electronics and Computer Science (IECS), Riga, Latvia led to joint research with Tarczynski on DASP resulting in two FP5-funded projects; mutual visits supported by the Royal Society (Prof. Ivars Bilinskis, IECS, Riga), and the joint organisation of the 2007 Workshop on DASP. Kodogiannis worked with the Agricultural University of Athens (including a visit by Dr. E. Panagou) to develop artificial intelligent inspection systems for food analysis resulting in joint publications including one in the

prestigious International Journal of Food Microbiology. Prof. Andrew Dempster of the University of South Australia makes regular visits and there is tangible ongoing cooperation with Kale resulting in joint publications and supervision of a PhD student. Kale collaborated on a number of applied research projects with UK, European and North-American industrial involvement to develop a digital hearing aid now productised by Starkey Labs, USA; investigation and correction of tonal contamination in an Audio Sigma-Delta Codec, Zarlink; blind source separation for FM signals and digital filter design for front end dab processing, Radioscape; Software Defined Radio for a Global Positioning System Receiver, Mitsubishi. Tarczynski collaborated with SORTEX Ltd on development of a simulator of a fruit sorting machine for designing and testing control systems, also Rolls-Royce developing algorithms to detecting and measuring turbine blade oscillation in jet engines.

Research Commercialisation:

The University provides comprehensive support for commercialisation of research. This includes: proactive search for commercialisation opportunities, help in evaluating commercial potential and preparing funding applications, providing access to pre-commercialisation fund of up to £25,000 followed by early stage funding up to £50,000. Both funds are obtainable through WestFocus. This support could be furthered by the University in the form of financial, managerial and legal assistance with first filing of patents and assistance in their commercialisation.

Exemplar: ADVRG Ltd Company Number 06245802, was founded in May 2007 by Prof. Kale together with Prof. Morling (UoW) and Peter Hicks (formerly of ARM) to provide ultra low power digital signal processor technology to industry and similar Intellectual Properties created with the help of the University. The company has already applied to the UoW to license its Jitter Insensitive Continuous-Time Sigma-Delta Modulator patent filed as W02006067382, published 29 June 2006.

Staffing Policy

In order to promote development of research active staff and encourage all academics to engage in research, suitable measures have been taken at the University and School level. To support networking between all researchers regardless of their track record the staff are encouraged to work in research groups. Staff members who are new to research are guided by their group leaders to help them start delivering publications, apply for research grants and supervise research students and have achieved publication. When recruiting new staff, the candidates' research potential is closely examined.

The University organises regularly open seminars on funding opportunities (EC, KTP, Research Councils), research commercialisation, financing research (e.g. full Economic Cost). There are also dedicated courses on supervising research students.

Staff development budgets are available to support academics in excelling as researchers, e.g. through participation in suitable training courses or attendance in research conferences and similar events. Staff are successful in securing the support of institutions such as Royal Academy of Engineering and Royal Society for such endeavours. Research active staff benefit from reduced teaching load and administration duties, which are reviewed annually. Incentives are created to encourage staff for bringing non-HEFCE income.

At the institutional level, the University motivates Schools to expand research by distributing a dedicated budget proportionally to the numbers of lecturers engaged in research and coordinating activities around governmental initiatives such as HEIF.

Esteem Indicators

SPAVIC

Plenary addresses or keynote papers at major conferences

ISCAS 2007 invited paper (**IK**); Technopark Summit, Famagusta, N Cyprus 2005 keynote speaker (**IK**); New Challenges in Biomedical Engineering 2003, Isik, Istanbul invited speaker (**IK**)

Prize-winning publications

8th World Multi-Conference on Systemics, Cybernetics and Informatics best paper (**AT**)

Filed patents

WO2007093790, WO2007045843, WO0221697, WO2006067382 co-inventor (**IK**); EP2006004054 (**VK**)

Learned society engagements

IEEE Prize Paper/Scholarship Awards Committee (**IK);** IEEE UK&RI Section Chapter co-ordinator (**IK**), Chair IEEE UK&RI Chapters Circuits and Systems (**IK**), Instrumentation and Measurement (**IK**); IEEE IMTC Session Chair *5 (**IK**); IEEE & IMTC Special Session Organiser Sigma Delta Modulators, *4 (**IK**); IEEE ISCAS Special Session Chair and Organiser Signal Processing for RF Impairment Mitigation in Comms.Transceivers (**IK**); IEEE Conference Program Committees *9 (**IK**) *20 (**VK**); SAMPTA'07 conference Scientific Committee (**AT**), WSEAS CSCC 2006 chair and organiser of the special session Nonuniform Sampling in Signal and System Analysis (**AT**)

Editorships or editorial board memberships

"IEEE Transactions on Instrumentation and Measurement" associate editor (**IK**); WSEAS CSCC 2006 conference associate editor of proceedings (**AT**); editorial board of Elsevier "Journal on Computer Standards and Interfaces" (**IK)**; Intelligent Decision Technologies editorial board (**VK**)

Participation in advisory, review, funding or standard setting bodies

EPSRC peer review college (**IK**), (**VK**)

Contribution to government committees, national/international advisory councils and

Boards for industry

Advice on research proposals to: Ministry of Science and Technology of Slovenia (**IK)**, Czech Ministry of Education (**IK)**, CNR-Agenzia, the Italian National Council for Research Agency (**IK)**, Austrian Science Fund (**IK**)**.** Advice on research infrastructure to Turkish Embassy N Cyprus – Technopark project (**IK**)

Collaborative research including details of companies contributing significant funding, together with evidence of the nature and timescale of the relationship

Mathworks, £21,000 (**IK**)**,** Mitsubishi, £15,000 (**IK**); Mitel Semiconductor, £88,000 (**IK**); Zarlink, £30,000 (**IK**); Radioscape, £21,000 (**IK**); Knowledge Transfer Partnership £150,000 DSPG Ltd and DTI (**AT**); SORTEX Ltd £5,000 (**AT**); Rolls-Royce £4,000 (**AT**)

Consultancies, company directorships

Barry University, USA Short-Term load forecasting in a Deregulated and Price based Energy Market using Soft Computing Approaches" (**VK**)

Research exploitation by industry

Starkey Labs hearing aid (**IK**)

EU collaborative research

FP5 training network: Autonomous Submarine for inspection and intervention (**VK**); FP5 EURODASP (€98,000) (**AT**); FP6 Intracorporeal Videoprobe (€219,000); (**VK**);FP6 DASPTOOL (€242,000) (**AT**);

Spin-out company activities

Director ADVRG Ltd 2007 onwards (**IK**)

PhD Examiners 22

Cutin Australia (**IK**), EMU N Cyprus (**IK**), James Cook Australia (**IK**), Manitoba Canada (2 **AT**), New South Wales (**VK**), Rostock (**AT**), Nanyang Singapore (**IK**), Imperial (2 **IK**), Manchester (2 **VK**), Surrey (4 **IK**), UCL (**IK**), UMIST (5 **VK**)

MPhil Examiners 11

Essex (**IK**), Hertfordshire (**IK**)**,** Manchester (2 **VK**), UMIST (7 **VK**)

CCSC

Plenary addresses or keynote papers at major conferences

Software Radio Seminar, University of Mauritius, 2003 keynote speaker, (**KM**), Sixth International Symposium on Communication Theory and Applications ISCTA 2001, Ambleside, invited speaker (**KM**), ARRMS 2001, Bracknell invited speaker (**KM**), Software Radio Workshop, Wireless design Conference, London, 2002 invited speaker (**KM**), The International Council on Medical and Care Compunetics (ICMCC) Conference, The Hague- Netherlands, 2005 & 2006 invited speaker (**KM**)

Learned society engagements

IEEE TELSIKS Programme Committee 2001-2007 (**DB*)*;** IEEE International Symposium Nikola Tesla Programme Committee 2006 (**DB**)**;** ICCSN-WOC Programme Committee 2002-2007 (**DB**)**;** WSEAS Programme Committee 2005 (**DB**)**;** WSEAS 2002 Session Chair (**DB**);EEE AP-S 2007 Session Chair * 2 **(DB);** IEEE MSMW 2007 Session Chair (**DB**); IEEE MMS 2002 Session Chair (**DB**); IEEE TELSIKS 2001 Session Chair (**DB**); IEEE TELSIKS 2003 Session Chair (**DB**); ISRAMT 2001 Session Chair (**DB**)**,** IEEE International Conference on Telecommunications Programme Committee 2001-2007(**KM**)

Editorships or editorial board memberships

Software Defined Radio Architectures, Systems & Functions, book co-editor (**KM**)

Participation in advisory, review, funding or standard setting bodies

National Science and Engineering Research Council (NSERC) review board, Canada (**DB*)*; EPSRC peer review college (**DB**)

EU collaborative research

FP5 CAST technical director €847,864 (**KM**); FP6 ePerSpace technical director €431,500 (**KM**); Enabling Technologies of Software Radio Systems in the European Commission IST programme on Reconfigurable Radio Networks European Coordinator (**KM**); FP7 Project PERFORM €200,000 (**KM**)

PhD Examiners 14

Belgrade (**DB**), Chinese University of Hong Kong (3 **DB**), Essex (4 **DB**), KCL, (**KM**), Lancaster (**KM**), Loughborough (1 **DB**), Manchester (1 **DB**), QMUL (1 **DB**), Surrey (**KM)**