Institution: University of Southampton

Unit of Assessment: 13 Electrical and Electronic Engineering, Metallurgy and Materials

a. Overview

Research Structure across UoA13

The University of Southampton comprises eight Faculties, which are further subdivided into academic units (AU). This return relates to the ***Faculty of Physical Science and Engineering*** (***FPSE***) and involves ***Electronics and Computer Science*** (***ECS***) and the ***Optoelectronics Research Centre*** (***ORC***). These units act as autonomous entities under the FPSE umbrella, such that some processes are common whilst others differ in order best to meet ECS or ORC needs.

ECS is research-led and undertakes both undergraduate and postgraduate teaching. It comprises 127 academic staff, 124 research and enterprise staff and 456 postgraduate research students; its annual economy is ~£37 million. A major strength of ECS is its interdisciplinary culture, hence its REF return is split between UoA11 and UoA13. ECS possesses a strong research group structure in which all academic staff and researchers belong to a dedicated research group; the Head of ECS (**Prof Neil White**) manages through the Heads of Group (HoG). The ORC is a research institute led by a Director (**Sir David Payne**) and is research-focussed with teaching undertaken at postgraduate (taught and research) level only. ORC comprises 28 academic staff, 9 fellows funded via fellowships from EPSRC, RAEng, etc., 51 contract research staff, and 6 seconded academic staff, who hold posts in ECS, but conduct their research in the ORC. The ORC has a current PhD student cohort of 99.

1. Research within ECS is structured into 6 research groups, of which ***Communications Signal Processing and Control*** (***CSPC***) ***Electronic and Software Systems*** (***ESS***) ***Electronics and Electrical Engineering*** (***EEE***) and ***NANO*** undertake research relevant to UoA13. In addition, a virtual group system is used to address specific thematic areas, by bringing together staff with complementary skills, without the need to disrupt established line management structures. For example, the ***Pervasive Systems Centre*** (***PSC***) is a virtual group that combines expertise in efficient hardware and software systems, wireless communications, sensors networks and energy harvesting, while the ***ARM-ECS Centre*** is an industry-university centre that focuses on research in advanced design methods, architectures and their practical validation for energy-efficient and dependable multi-core processor systems.

2. Research within the ORC covers the following broad topic areas: photonics systems, circuits and sensors; nanophotonics; fibres and lasers. It also hosts three cross-cutting themes related to its success in winning three EPSRC Programme Grants – HyperHighway (2010-2016, £7.3m) the Centre for Nanostructured Photonic Metamaterials (2010-2015, £5.0m) and Silicon Photonics for Future Systems (2013-2019, £6m) – and an EPSRC Centre for Innovative Manufacturing in Photonics (2010-2015, £5.1m). The ORC has a high degree of vertical integration and operates a "from Electrons to Enterprise" technology pull-through strategy that is underpinned by fundamentals, materials and processes. This leads to devices, systems and demonstrators, with the eventual goal of a start-up company. It is this long-term market-focussed strategy, that has led to a surrounding 'photonics valley' of companies (e.g. Covesion and Fianium) that owe their origins to the ORC, providing *evidence* of the success of the strategy. The monolithic, integrated nature of the ORC, as well as its research within the area of optoelectronics, optical communication systems, and materials, makes it a natural choice for submission entirely through UoA13.

b. Research strategy

Research Vision

Research vitality is central to all our activities, including teaching and enterprise. Our vision is of a vibrant, integrated research-led community with a reputation for the international significance of our scholarship and research, our technological impact and for the excellence and relevance of our educational programmes. Consequently, there is a strong emphasis on promoting research and sustaining an active research culture that:

- ***Aim 1: Delivers Excellent Science***, which is world-leading, advances fundamental understanding and drives technological innovation.
- ***Aim 2: Addresses Societal Challenges,*** such as energy, healthcare technologies, digital economy, and manufacturing the future.
- ***Aim 3: Maximises Research Impact,*** through interacting with industry and national bodies

(e.g. BAE Systems and NPL) founding successful spin out companies (e.g. SPI Lasers and Perpetuum) generating and protecting valuable IP (typically, more than 20 patents per annum) and by influencing policy makers and practitioners, through interactions with Parliamentary select committees, international standards bodies, leading learned societies, etc.

- ***Aim 4: Develops Research Leaders***: examples of the long-standing success of our approach include **Payne**, **White, Prof Tariq Durrani OBE** (PVC Strathclyde) and **Prof Teck-Seng Low** (CEO NSF, Singapore). Further *evidence* is provided by the 16 fellowships won from RS, EPSRC, ERC, etc. in the REF period.

Evaluation of Current Position with reference to RAE 2008

Comparison of key metrics with comparable data submitted to RAE2008, reveals clear *evidence* of the success of the overall strategy that we have adopted.

- *Journal papers: 2705 (increased by 104% compared with RAE2008).*
- *Conference papers: 2461 (increased by 28% compared with RAE2008).*
- *PhD degrees awarded: 243.1 (increased by 24% compared with RAE2008).*
- *Total research funding: £59,592,610 (increased by 16% compared with RAE2008).*
- *Research funding from EU Governmental Bodies: £9,969,137 (increased by 186% compared with RAE2008).*
- *Research funding from industry, charities and other organisations: £9,436,349 (increased by 13% compared with RAE2008).*

The REF period has seen significant investments in staff and infrastructure, which have contributed greatly to the achievement of our stated strategic aims and are now providing new opportunities.

(i) Staffing. During the REF period, we have strengthened existing areas of research excellence and made new appointments that broaden our research into areas we identified as of strategic importance. Notable recent senior appointments include **Reed's** group (silicon photonics) and **Saito** (nanoelectronics).

(ii) Major Facilities. The £120m cleanroom complex was completed in 2011 and constitutes a multidisciplinary research facility with an outstanding range of capabilities. To exploit this, the ***Zepler Institute*** (***ZI***) was established in 2012 in order to coordinate research in photonics, electronics, nanoscience and quantum technology. The ZI is one of the largest research institutes in the UK (~300 research staff from across FPSE) and is unique in covering the whole innovation cycle from basic research, through technology development, to final exploitation.

Achievement of RAE2008 Strategic Aims

In RAE2008, prior to the formation of FPSE, the research covered by this submission was spread across two units of assessment, namely UoA19 (Physics) and UoA24 (Electrical and Electronic Engineering) and was related to two autonomous entities – ECS and ORC. Consequently, the achievements of these two AUs against their strategic aims are best described separately.

ECS Strategy, as articulated in RAE 2008, focussed on a range of topics that continues to reflect the breadth and diversity of ECS research. *Evidence* for the notable successes that this strategy has brought within the REF period is given below:

(i) Nanotechnology. The manipulation of materials and structures on the nanometre scale and its application to a variety of problems has been an on-going theme. Highlights include the development, in conjunction with Sharp Labs Europe and Oxford Plasma Technology, of novel low-cost top-down techniques for fabricating nanowires, for use in healthcare and display applications and new designs of single electron transistors for quantum information processing, in a joint project with Hitachi Cambridge.

(ii) Electronics. Two of the great challenges in this area have been designing for low-power consumption and managing unreliability, as device variability and system complexity increase. Notable successes include the establishment in 2008 of the ARM/ECS strategic partnership that now involves 30 staff, our lead role in one of the EPSRC Microelectronics Grand Challenges (*Batteries not Included*) and our subsequent leadership of the EPSRC-funded project *Next Generation Energy-Harvesting Electronics*, involving a consortium of 4 universities and 5 industrial partners.

(iii) Communications. The growing importance of wireless communication technologies was clearly articulated in our RAE2008 return. Notable successes in this area include the development of a radical genetic algorithm that aids joint data detection and channel estimation for multi-carrier code division multiple access and orthogonal frequency division multiplexing,

our involvement in major international initiatives (e.g. EPSRC India-UK Advanced Technology Centre; RCUK China-UK Science Bridge on 4G Wireless Communications), the receipt of a European Research Council Advanced Fellow Grant (€2.5m) and the publication of 7 John Willey-IEEE Press research monographs totalling over 3200 pages.

(iv) Energy. Energy-related research has spanned different activities within ECS, from high voltage engineering through energy harvesting to novel photovoltaic devices. Our success in this area is evinced by our strategic partnership with National Grid and our participation in national initiatives such as the EPRSC *HubNet* programme, *Transformation of the Top and Tail of Energy Networks* Grand Challenge in Energy and the Energy-Harvesting network.

(v) Healthcare. A key feature of much of ECS's strategy has always involved inter- and multidisciplinary research and, here, interactions with colleagues in the life sciences and in areas associated with healthcare, have been of great importance. Significant advances have been made in the area of microfluidic systems, which have led to new and important partnerships with Philips Research, Sharp Labs Europe and the Health Protection Agency in connection with novel point-of-care diagnostic systems.

2. ORC Strategy. The REF period was based upon a vertically integrated, applications-driven approach that spanned fundamental physics and materials science through device demonstrations to direct applications and systems-led studies. All of the key topics that were identified in the RAE2008 documentation have advanced considerably, as detailed below.

(i) Sensing. Developing a complete suite of mid-IR technologies (including establishing a mid-IR characterisation lab) through new materials and light sources is central to our approach; for example, 3-5 μm fibre light sources for optical countermeasures.

(ii) High Power Fibre Lasers. Our work in this area has led directly to a global market approaching £1 billion for industrial lasers, with one of the key players, SPI lasers, being an ORC spin-out. Our work continues to extend the wavelength range, improve efficiency and increase peak pulse power. Consequently, the ORC has been one of 4 partners (with CERN, Fraunhofer IOF, and Ecole Polytechnique) involved in a design study funded by FP7 (€0.5m) for a new paradigm in high-intensity lasers (petawatt peak power; kw-mw average power) needed for applications such as particle acceleration and nuclear transmutation.

(iii) Super-resolution Imaging. Extensive work on optical imaging below the diffraction limit through the use of the new concept of super-oscillation has led to patented approaches to improving optical microscopy at the nanoscale (US 20130235180 A1; WO 2013114075 A1).

(iv) Biotechnology. Extensive work continues in the lab-on-a-chip area, that seeks to combine the attributes of guided wave optics, fluidics and optical sensing in practical, low cost configurations, including paper-based laser-printed point of care diagnostics.

(v) Telecommunications. ORC telecoms work has been globally prominent for decades. Our recent work has demonstrated a significant increase in transmission capacity over conventional systems through innovations in amplified transmission at 2 μm and spatially efficient systems (e.g. the first amplified mode-division multiplexed and multi-element fibre systems).

(vi) New Materials and Fabrication Technology. Central to all of the above topics has been clean room innovations in materials and fabrication processes, such as work on chalcogenide glasses and new glass and crystal deposition processes.

(vii) Nonlinear optical devices. We have reported extensively on switching metamaterials-enabled ultrafast (patented) and non-volatile devices at the nanoscale, nanostructured reconfigurable meta-surfaces and metamaterial filters, ultrafast plasmonic switching in new highly-nonlinear glasses and periodically-poled structures.

In addition to their academic merit, many of the above highlights have also generated significant impact, as demonstrated in our impact case studies.

UoA13 Future Strategic Directions

The spectrum of research conducted within UoA13 includes numerous national priority research areas, such as information and communication technologies (ICT) autonomous systems and energy-efficient computing, photonics, energy, healthcare and advanced materials. Indeed, "new industries such as photonics and renewable energy, have been identified as both globally important and areas in which the UK is well placed to develop strategic global leadership" (A Landscape for the Future of High Value Manufacturing in the UK, TSB, 2012). In 2009, the European Commission identified photonics as one of the 6 enabling technologies that are key to

our future prosperity.

The development of our strategic priorities within this range is an on-going process, in which each AU draws up an annual plan, which then contributes to the overarching FPSE strategy. Our research strategy is best considered as a combination of top down and devolved approaches that combine the establishment of clear priority directions, with means by which research groups and individuals are able to pursue opportunities as they arise. Our objectives can be considered under the following headings.

***(i) Major Research Programmes*.** We believe that a key element of future research success centres on collaborative research that brings together complementary skills to address problems of societal importance. As such, a major strategic objective here is, progressively, to consolidate experience of generating successful bids for programme grants with the aspiration to have large grants in every major research area. *Evidence* of recent successes that have come about as a result of this approach include:

*(a) Power-efficient, Reliable, Many-core Embedded System*s (EPSRC, EP/K034448, £5.6m, 2013-2018).
(b) *Nanostructured Photonic Metamaterials* (EPSRC, EP/G060363, £5.0m, 2010-2015).
(c) *Transforming the Internet Infrastructure: The Photonic HyperHighway*, (EPSRC EP/I01196X, £7.2m, 2010-2016)
(d) *Centre for Innovative Manufacturing in Photonics* (EPSRC, EP/H02607X, £5.1m, 2010-2015)
(e) *Silicon Photonics for Future Systems* (EPSRTC, EP/L00044X/1, £6.0m, 2013-2019).

In this way we will address:

- Aim 1: To deliver excellent science
- Aim 2: To address societal challenges

(ii) Exploiting our Unique Facilities*.** The ZI represents a major university investment to create a world-class facility that contains a unique mix of technologies from the nanoscale, through biophotonics, to a full silicon fab and the world-leading ORC fibre fabrication facility. These capabilities provide major opportunities to undertake research across the electronics/ photonics boundary and generate global impact. As such, we will grow the breadth of this through strategic appointments that fit the capabilities of the institute and complement existing areas of work. The recent appointments of **Saito** and **Reed's** group demonstrate the University's commitment to this strategy. Other pertinent areas include power electronics and BioMEMS, which have the potential both to innovate within the existing facilities and create links with other activities within FPSE (e.g. energy-related research) and across the University (e.g. Institute for Life Sciences – IfLS). We are also developing a business plan to establish a major new national high voltage facility, which will address the UK need for research and testing capabilities to support the installation of remote offshore renewable generation. We are currently building an alliance of key stakeholders from academia, the power industry and the City of London, to facilitate a bid for a TSB Catapult Centre in 2014. In addition to providing distinctive research capabilities for our researchers, the facilities described above and others (e.g. Tony Davies High Voltage Laboratory - TDHVL, ORC FASTlab, Southampton Marine and Maritime Institute – SMMI) provide a powerful mechanism for engaging with external collaborators, thereby ensuring the relevance of our research, maximising its impact and opening up additional funding streams (e.g. EU, TSB and direct industrial funding). *Evidence* of the success of this approach is provided by the range of current collaborators that exploit our unique facilities (e.g. Sharp Laboratories, Rolls Royce and National Grid). ***In this way we will address:

- Aim 1: To deliver excellent science
- Aim 2: To address societal challenges
- Aim 3: To maximise research impact

***(iii) Agility in Research*.** The areas of electronics, photonics, telecommunications and materials are fast-moving, and it is imperative that we seek funding from the widest range of sources spanning RCUK, TSB, the EU and industry, as well as fellowships from the RAEng, EPSRC, Leverhulme, etc. A key strategic objective is therefore to broaden our funding base and, in particular, to grow the funding we receive from industry, either directly or through collaborative routes. In the REF period, the total value of the funding we obtained from UK industry alone was over £6.6m – the amount received in 2012/13 was nearly three times that in 2008/09. In view of

the technological relevance of our research areas, we feel there is considerable scope for further growth here. To address the consequent challenges, the concept of the virtual group has been shown to be a successful means of driving new initiatives in more multidisciplinary areas, and of involving non-ECS members in our research. This concept will therefore be expanded to accommodate nascent initiatives and seize funding opportunities. ***In this way we will address***:

- Aim 1: Deliver excellent science
- Aim 3: Maximise research impact

(iv) Growing Research Partnerships. Partnership management is another area that is key to our current success and long-term strategy. *Evidence* of our commitment to this is provided by the number of mechanisms we employ to form and sustain links with research end users (e.g. alumni events, ECS Industrial Liaison Committee, Industry Days, etc.) our large number of spin-out companies (15) the initiative to create ECS Partners Ltd to provide consultancy services to clients, ranging in size from SMEs to multinational corporations and our success in winning a Royal Society Industrial Fellowship (**Morgan** – 2013) with Sharp Laboratories. A key element of the ECS Partners concept is to exploit the broad range of skills and capabilities available across UoA13, to provide an agile structure by which short-to-medium term projects can be used to build relationships with future research partners, thereby opening up additional funding opportunities. In this way we will consolidate existing partnerships and build new relationships, based on technology need, market pull and our own internal innovative research focus. In addition to forging new relationships, with consequent downstream benefits, ***this will address:***

- Aim 3: Maximise Research Impact

***(v) Training the Next Generation*.** PhD students are the research engine of the ORC and ECS and we therefore intend to grow the size of our Graduate School (GS). FPSE already allocates more than £500k per year in research scholarships from our MSc and research income, in addition to our EPSRC Doctoral Training Account (DTA) and Doctoral Training Centres (DTC). To grow the GS further, we will need to access new funding routes, and intend to raise awareness and provide support across UoA13 for EPSRC CASE awards and develop industry-relevant and co-sponsored PhD studies. We will increase our overseas marketing campaign, to attract more self-funded postgraduate students, and are actively establishing joint programmes with institutions in the far east, (e.g. in Singapore and Korea). By sustaining a vibrant research atmosphere in which PhD students and early career researchers (ECRs) flourish ***we will address*:**

- Aim 1: Deliver Excellent Science
- Aim 2: Address Societal Challenges
- Aim 4: Develop Research Leaders

c. People, including:

i. Staffing strategy and staff development

STAFFING STRATEGY

Our staffing strategy is driven by the requirement to maintain a vibrant community that is able to sustain all of our research, enterprise and education activities. In considering this, it is convenient to discuss the topic in terms of three broad categories that, together, constitute UoA13.

(i) Academic Staff undertake education, research and impact generation. Our staffing strategy reflects all of these elements and can be divided into 3 approaches.

(a) ***Reinforcement:*** this is driven through junior appointments ***within existing areas of research strength*** to ensure the sustainability of these topics, reflect resource availability and facilitate the delivery of our portfolio of taught programmes. The recent appointments of **Pilgrim** (2012) and **Andritsch** (2013 from Delft) are examples of this approach to sustainability. Their research reinforces existing work in EEE, capitalises on capacity in the TDHVL and meets a need driven by strong growth in our MSc in Energy and Sustainability. The appointment of **El-Hajjar** from industry (2012) and **Prodromakis** (2013) met similar needs in CSPC and NANO respectively.

(b) ***Complementarity:*** this involves making junior appointments in key areas that will generate new multidisciplinary activities and ***bridge existing areas of research strength***, thereby opening up new areas of strategic importance. Examples of this approach within the REF period include **Merrett** (2008) **Maunder** (2009) and **Weddell** (2013).

(c) ***Strategic Initiatives:*** this approach to staffing involves attracting proven research leaders

to Southampton, in order to acquire expertise and inspire entirely new research areas. A recent example of this approach is the movement of **Reed's** group (**Reed**, **Gardes**, **Mashanovich**, plus 11 researchers and students) from Surrey to Southampton in 2012.

The above elements of our staffing strategy are all closely aligned with our **Research Vision** and **Future Strategic Directions**. For example, approaches (a) and (b) above relate to the ***Development of Research Leaders*****,** (a) and (b) are closely aligned with the ***Exploitation of our Unique Facilities*** while (b) and (c) enhance our ability to ***Address Societal Challenges***.

(ii) Enterprise-related Staff. Clear *evidence* of our commitment to maximising the impact of our research can be seen through our investment in dedicated enterprise-focused staff. For example, **ECS Partners Ltd** was established in 2004 and a Business Development Manager (**Darlington**) was appointed to broker industrial engagement; **Wilcock** was recently promoted to Senior Enterprise Fellow. A Senior Fellow, Partnerships and Business Development (**Lewis**) was appointed in 2011 to assist in developing contacts with industry, while our Marketing Manager (**Howells**) and Marketing Communications Officer (**Williams**) are responsible for driving our media engagement programme. In anticipation of the launch of the ZI, a dedicated Research Funding Development Manager (**Carr**) and ZI Coordinator (**Churchill**) were appointed in 2012, specifically to grow the reach and significance of the major initiative. In 2013 **Tillotson** was appointed as TDHVL Business and Enterprise Coordinator.

(iii) Administrative and Support Staff. Administrative and support staffing strategy is determined through central University policy, with input from Deans, to enable the University to meet its strategic aims. The University adopts a holistic view of support across the institution, whereby best practice is shared to ensure consistency, efficiency and effectiveness.

Staffing Procedures and Appointments

The staffing strategy described above is implemented through a regular review process and the incorporation of the outcomes into the FPSE Strategic Plan. In this way, future staffing needs can be evaluated against Faculty targets and objective decisions made, based upon internal needs (e.g. succession management, educational requirements, availability of research facilities) and external factors, notably, the overall funding landscape and our existing and potential ability to ***address societal challenges***. Nevertheless, a central tenet of our procedures revolves around seeking the best talent worldwide, and subsequently developing tomorrow's research leaders.

1. International Staff Appointments. During the REF period, 13 academic appointments have been made in UoA13. Examples of overseas appointments include **Saito** (Japan), **Andritsch** (Holland) and **Slavik** (Croatia). Over the REF period, more than 50 noted researchers have visited ECS; examples include **Benini** (Bologna) **Capasso** (Harvard) **Cerf** (VP Google) **Chakbrabarty** (Duke) **Patel** (UCLA) **Andersson** (President NTU) and **Desurvire** (Thales, France). An inevitable consequence of our high profile is that staff are sought for appointments elsewhere; examples within the REF period include **Bagnall** (to Australia) **Mizuta** (to Japan) **Kraft** (to Germany) and **Loh** (to Singapore).

2. Personal Research Fellowships. During the REF period, 16 UoA13 staff members have held prestigious fellowships won in open competition from EPSRC, RAEng, ERC, etc. Successes include **Slavik** and **Beeby** (EPSRC), **Plum** and **Papasimakis** (Leverhulme), **Parmigiani** (RAEng) and **Brambilla** and **Poletti** (Royal Society). Further details are given in Section e.

STAFF DEVELOPMENT

The Institutional Framework

The University of Southampton has a track record of early and consistent engagement with initiatives that support and enable progression of researchers' careers. In 2005, the University was a founder signatory to the Athena SWAN charter, receiving a University level Bronze award in 2006 and successfully renewing the award in 2009 and 2013, thereby indicating continued engagement. In 2010, The University of Southampton signed up to the Concordat to support the Career Development of Researchers, while 2011 saw the European Commission present the University of Southampton with the Human Resources Excellence in Research Award, in recognition of its commitment to supporting the personal, professional and career development of its researchers. This acknowledges alignment with the principles of the European Charter for Researchers and Code of Conduct for their Recruitment, and incorporates both the QAA Code of Practice for Research Degree Programmes and the Concordat to Support the Career Development

of Researchers. Southampton was among just 12 institutions to achieve the award.

Career Development

A key element of our on-going research strategy is to ***develop research leaders*** and we are therefore fully committed to realising the potential of all researchers, in line with the ***Vitae*** initiative. Staff needs are met through a combination of local and institutional provision.

1. Local Provision. Integration of ECRs into the research community is a key objective, which is accomplished through local mechanisms guided by university policy.

(i) Induction. On arrival, ECRs are provided with a mentor and a personalised, targeted induction programme, to introduce them to the University, the Faculty and the AU.

(ii) The Personal Performance and Development Review (PPDR). Staff development is an important element of the mandatory annual PPDR process, which reviews each individual's prior performance, sets future objectives and agrees personal career development needs.

(iii) Implementation of the Concordat. In addition to enabling ECRs to benefit from the university's implementation of the Concordat, local initiatives aimed specifically at ECRs have also been established. *Evidence* of our commitment to implementation of the Concordat can be seen, for example, in the appointment of a senior member of staff (**Hewak**) as the ***Faculty Concordat Champion*** and the establishment in 2012 of the ***Dean's Awards for Early Career Researchers***, to recognise exceptional contributions in scientific publications, knowledge transfer, enterprise, public engagement, etc. In 2013, 10 of these awards were made.

(iv) FPSE Academic and Research Future Leaders Mentoring Network. This is chaired by the FPSE Associate Dean (Research) with membership including HoGs and Deputy Heads of AUs. The Network meets 4 times each year to identify and support outstanding ECRs to secure prestigious fellowships (e.g. RCUK and European Research Council) or permanent academic posts. It reviews applications, helps secure academic and industrial partners, allocates significant Faculty support (typically 1 PhD student plus £50k per successful application), organises mock panel interviews and assists with application reviews.

(v) The FPSE ECR Fund supports newly appointed junior members of academic staff to develop research leadership skills, for example, through the organisation of international workshops to set research agendas and develop network of contacts in their own fields. Over the last 18 months, the fund has supported 4 junior lecturers. As an example, the fund allowed **Merrett**, to organize an international workshop on Energy Neutral Sensing Systems, bringing together electronics engineers and computer scientists.

(vi) Initiating Research. Newly appointed academic staff receive pump-priming funding to enable new them to initiate their research. Other seed-corn funding flows through the research group structure, from RIS and through the ***ZI Collaboration Stimulus Fund***.

2. Institutional Provision. The following structures provide *evidence* of the institutional commitment to the development of all staff. In addition to the provision described in this section, other relevant aspects, such as ***Researcher Mobility Programme*** and the ***Career Destinations Service***, are described below under ***RESEARCH STUDENTS***.

(i) The Professional Development Unit (PDU). This University resource provides a dedicated workshop programme with events themed within the four domains of the Researcher Development Framework (RDF), namely: knowledge and intellectual abilities; personal effectiveness; research governance and organisation; engagement, influence and impact. The RDF complements the PPDR process in supporting ECRs in undertaking self-evaluation and identifying their individual development needs. The range of support provided ranges from leadership programmes, which help staff develop skills in managing teams from small research groups to entire faculties, to writing funding or fellowships applications.

(ii) Postgraduate Certificate in Academic Practice (PCAP). All academic appointees with teaching commitments complete the PCAP training course if they do not hold a comparable qualification. Many ECRs aspire to an academic career and consequently, all ECRs have the opportunity to undertake PCAP training to acquire HEA accreditation.

Equality and Diversity (E&D)

All AUs within FPSE are fully committed to E&D, as demonstrated by the following *evidence*.

(i) Diversity Committee. This committee, chaired by a senior academic (**Butler**), develops and oversees E&D policy and monitors gender balance statistics. Examples of E&D activities include: the provision of Faculty diversity training to increase the cultural awareness, knowledge, and

skills of staff; commissioning a complete Culture Analysis for ECS by the UK Resource Centre for Women in Science in 2011, to enable staff to understand the impact of culture on diversity.

(ii) Athena SWAN. ECS made a successful submission to the Equality Challenge Unit that led to a Bronze award in November 2012. A consequence of this engagement with Athena SWAN has been a complete review of the recruitment, retention, recognition and reward systems to ensure that they are fair transparent and well-understood by all staff. On-going work as part of the ***ECS Athena SWAN Action Plan,*** includes an outreach programme aimed at increasing the number of female undergraduates, training for selection panels in overcoming unconscious bias and the appointment of an FPSE Diversity Officer (**Pau**). We are providing improved support for career development and promotion, including supporting Postgraduate and Research Fellow forums, career coaching and action learning sets. We are ensuring that the University's flexible and family-friendly working policies are properly understood and valued by all staff in ECS to facilitate greater uptake. We aim to be in a position to apply successfully for an Athena SWAN Silver Award for ECS, in 2015.

(iii) Maternity/paternity Entitlements. FPSE has mechanisms to ensure that research staff on fixed-term contracts have similar maternity/paternity entitlements to those on permanent contracts and provides systematic assistance with return to work. Where a funding body does not cover maternity pay, the Faculty covers the cost; 7 cases of maternity leave and 36 cases of paternity leave for UoA13 staff have been supported in the REF period.

(iv) E&D Commitment. Other examples of our commitment to E&D include: ***ECSWomen***, founded in 2005, a student-run organisation supporting women in ECS; ***Theano***, founded in the 1990's, a networking group bringing together women that is open to all female students and academic staff across the University; ***WiSET***, founded in 2002, a group that helps shape the policies and culture of the University for women in science, engineering and technology.

ii. Research students

FPSE Graduate School

The Faculty-wide Graduate School (GS) has overarching responsibility to ensure that University quality frameworks and regulations are applied rigorously. These include monitoring progression, training, supervision, registration status, and receiving and acting upon student feedback. The GS holds 3 Board Meetings annually, reporting to the Faculty Education and Research Committees. Board membership includes the Graduate School Director (**Shepherd**) senior academics and administrators from across FPSE, and postgraduate research (PGR) student representatives from each research group; PGR representatives also provide input into the ECS Staff Student Liaison Committee. The GS also oversees new initiatives, such as establishing quality frameworks and regulations for collaborative research supervision and joint PhD programmes, both in the UK (e.g. NExT Institute) and overseas (e.g. King Abdulaziz University, Saudi Arabia; NTU, Singapore; Japan Advanced Institute of Science and Technology).

1. Admissions. PGR recruitment and admissions are led by the individual academic units and the research groups, as they are best placed to know their requirements. Funding for students is provided through multiple routes including the EPSRC DTA, DTC funding, industrial funding, direct Faculty or University funding and self-funding (e.g. government sponsorship of international students). The GS routinely enables funding for any particular student to be made up from a number of these sources, to broaden access. The GS strategy is to attract the best students through funded scholarships for international and EU students while, for UK students (for whom DTA funding can be used) enhanced stipends are offered. University-funded scholarships are allocated on a competitive basis with a panel judging applicants on academic quality, the strategic importance of the research and any matched funding.

2. Induction. Induction occurs at a number of levels. The University provides students with a high level perspective, while the Faculty induction explains the progression stages to ensure successful completion of their PhD and the compulsory and optional training that exists. Local induction provides more in-depth guidance, in particular, concerning subject-specific training. Throughout the induction period there is a programme of Faculty, AU, and research group social meetings, at which the students get to know each other, co-workers and staff.

3. Supervision. Each PhD student has a supervisory team of at least 2 academic staff with a clear primary supervisor. At least one member of the team must have prior experience of PhD supervision to successful completion, enabling new academics to be mentored in supervision.

Mentoring is also available to the students should they wish to raise issues on a confidential basis.

4. Progress Monitoring. The GS has pioneered a web-based system, ***PGR Tracker*****,** which supports progression monitoring and records all the training activities undertaken by each student. This system prompts students, supervisors and examiners when tasks are due for completion – students submit reports through the tracker and supervisors/examiners give feedback on the reports and any subsequent viva. This ensures that a permanent, personalised and easily accessible record of the progress of every student is maintained. The Tracker also automatically records training activities undertaken at the University ***Researcher Development & Graduate Centre*** (RDGC) and allows the student to enter any additional training or other activities that they wish to note, so as to maintain a record of their personal professional development. Following its success within FPSE, PGR Tracker is now being implemented across the University.

5. Professional Skills, Training and Support. The RDGC provides a broad range of courses to enhance research-centred learning and transferable skills training to optimise the development of postgraduate students. Through ***personal development planning*** (PDP) each student is provided with a structured and supported process enabling them to reflect on their own learning and achievements, and to plan for their personal, educational and career development. Subject-specific training is delivered at Faculty, AU and research group levels, which includes: formal lecture courses; seminar programmes; attending high-level UG or PGT modules; etc. The Faculty ensures that each PGR student has a personal ***Research Training Support Grant*** (RTSG) of £1,200 per annum, conditional on progression, to present papers at conferences and attend summer schools. ***The Graduate Passport*** is a University initiative, whereby students build up an achievement record of personal development activities, to complement their academic studies.

6. Career Development. Engagement with employers is an essential part of PGR career development. Many students within the Faculty are working on topics that are highly relevant to industry and their research often involves collaboration with industrial partners. Students frequently attend conferences which often incorporate large industrial shows, while industry-based engineers are regularly invited to Southampton to give seminars (more than 50 in the REF period). **Visiting Prof Max Toti** (ECS alumnus and MD of Captec Ltd) takes a leading role in developing the entrepreneurial skills of our students. All PGR students are encouraged to participate in University-organised ***widening participation*** activities where they both lead activities and mentor young students to consider university study; in ECS, there is a successful robot building schools' outreach programme, while in the ORC, the Lightwave initiative takes mobile optical demonstrations to local schools and colleges. PGRs are also encouraged and trained to take part in teaching activities, such as laboratory demonstrating to undergraduates.

(i) Mayflower Scholarships. In this special PhD programme, students spend 25% of their time on education and teaching-related activities and, consequently, is particularly appropriate for students intending to pursue a more education-based career.

(ii) PGR Internships provide an experiential learning environment through which research students contribute towards a project delivery and/or the strategic direction within a host organisation. As part of this, intern students are expected to reflect on their experience and undertake a skills audit to assist in their personal development. We appreciate that different researchers will have different time commitments and, as such, these internships are flexibly negotiated with a range of organisations throughout the year.

(iii) The Research Mobility Programme (RMP). The RMP offers PGRs and ECRs the opportunity to visit one of the international Worldwide Universities Network (WUN) partners in Europe, America, the Far East and Australia, to cultivate links. Since the programme began in 2001, 100 awards have been made; the University allocates up to £30k per annum to the RMP.

(iv) The Career Destinations service is available to all University staff and alumni, and includes dedicated PGR and international students web areas. It holds careers fairs and events, provides training on CVs, applications and interviews and helps with work placements. The service also arranges for alumni to act as ***Careers Contacts***, to advise students, to give careers talks or to contribute to our careers publications.

(v) The ECS Careers Hub. This was established in 2008 and now plays a vigorous role in building relationships with leading companies that bring benefits to research and education programmes across FPSE. Our first Careers Fair included 25 companies, with leading industry names such as IBM, Imagination Technologies and BAE Systems. Since then the Hub and the

Fair have grown each year, with 78 companies attending the 2013 Fair, such as, Schlumberger, BT and Transport for London. Over 100 companies are affiliated to the Careers Hub and we continue to seek new opportunities for further industrial engagement in research and enterprise.

Through the mechanisms described above, we provide a supportive environment that is effective in ***delivering excellent science*** and in ***developing the researcher*** concerned. This is evinced by the prestigious, competitive awards garnered by our students (12 within the REF period), including:

- **Sloyan**: 2012 IOP Very Early Career Woman Physicist of the Year.
- **Ingelsson**: 2011 IEEE European Test Symposium J**.** McCluskey Doctoral Thesis Award.
- **Plum:** 2011 IOP Quantum Electronics and Photonics PhD Thesis Prize.
- **Buchstaller**: 2010 IET Control and Automation Doctoral Dissertation Prize.

d. Income, infrastructure and facilities

Research Funding

Both ECS and ORC have a highly successful track record of winning research funding from the Research Councils, notably EPSRC, with a current combined EPSRC portfolio exceeding £68m – more than 40% of the total EPSRC funding to the whole of the University of Southampton.

Electronics, photonics and electrical systems are major components of the UK economy and are rapidly growing global markets, while the need to meet the increasing energy demands of both established and emerging economies within the context of climate change, poses a serious challenge, with both economic and environmental consequences. Consequently, we have a long track record of bridging the innovation gap with many industrial partnerships that have resulted in world-changing advances, in addition to wealth creating products and services for these industrial organisations. As such, we are well placed to contribute to such societal issues. The key element in our future funding strategy is diversification, in order to draw upon a wider range of funding sources, including TSB, Horizon 2020 and through interactions with pertinent industries. The unique capabilities of our facilities will continue to make us attractive to a range of established partner organisations (e.g. ARM, National Grid, ORC spin-outs) and the success of our consultancy services, ECS Partners, is providing a means of building new relationships.

Source	2008/09	2009/10	2010/11	2011/12	2012/13	Total
BIS Research Councils	6,166	8,465	8,418	6,487	7,894	37,430
EU government bodies	566	1,471	2,060	2,719	3,152	9,969
UK industry, charities and other	1,375	1,765	1,797	2,236	2,522	9,695
EU industry, charities and other	599	145	33	80	62	919
Non EU and other	280	201	260	464	375	1579
Total	8,988	12,046	12,568	11,987	14,004	59,592

Table 1: Direct research income from different sources during the REF period in £k

Specialist Infrastructure and Facilities

FPSE hosts a number of major facilities that are of national significance. A key strategic principle is to employ these in order to maximise the user base from within the Faculty, the University, the HE sector and industry, in order to increase efficiency, effectiveness and overall research impact.

1. The Zepler Institute. The ZI is a consequence of capital investment of £120m in state-of-the-art experimental clean room facilities in FPSE and provides a unique opportunity to create a structure that will attract increasing UK and EU funding in research and through support of industry. The laboratories include a world-leading suite of instrumentation, including optical and electron beam lithography equipment, comprehensive sputtering, evaporation and chemical vapour deposition facilities, plus a range of state-of-the-art characterisation instruments (e.g. Carl Zeiss Orion He ion microscope; Jeol JSM 7500F FEGSEM; Carl Zeiss EVO LS25 SEM including IFG iMOXS X-ray source, Xradia nanoXFi fluorescence imaging spectrometer and Gatan X-ray computed tomography attachments; Carl Zeiss NVISION40 focussed ion beam system). The scope of ZI research ranges from fundamental physics, through device fabrication to system testing. Product development that involves our spin-out companies is also in place. A key aim of the ZI is to bring a coordinated approach across multiple complementary research activities throughout the university. This will bring benefits in terms of critical mass, cross-disciplinary working, greater collaboration and the removal of boundaries between traditional units. For example, the Centre for Nanophotonic

Metamaterials, in collaboration with Chemistry, is developing chalcogenide materials for future metamaterial devices, including a new generation of optical switches and displays. Advances in solar cell technologies are being driven through the use of new families of sulphide- and selenide-based compounds, in collaboration with the NANO group in ECS, while a new generation of semiconductors based on tin, molybdenum or tungsten sulphide are being exploited for nanoscale transistors with the same group. Some of these materials are also finding application as lubricants, through work with the National Centre for Advanced Tribology at Southampton.

The ZI currently comprises 6 research groups from across FPSE that work together in a federal structure to exploit the synergies that exist and to realise the full potential of the facilities. The ZI is led by a Director (**Payne**) and its management structure is based upon the ZI Strategy Board, the ZI Executive Board and the ZI Clean Room Management Committee.

2. The Tony Davies High Voltage Laboratory. The TDHVL is one of 4 high voltage research facilities remaining within the UK HE sector. However, the distinctive feature of the TDHVL is its integrated approach to the study of high voltage phenomena, in particular, in connection with dielectric materials and insulation systems. The laboratory combines comprehensive electrical testing facilities, with a wide range of sample characterisation and material preparation facilities, to give a unique, multidisciplinary capability that ranges from the design, fabrication and characterisation of nanostructured materials, to the testing of complete items of high voltage plant. Electrical testing capabilities include: a wide range of high voltage test sets (up to 300 kV AC, 600 kV DC and 1 MV impulse waveform); breakdown, conduction measurements; thermally stimulated discharge current spectroscopy; electroluminescence and pulsed electro-acoustic experiments. We can design and form specimens through solution blending, melt mixing, extrusion and injection moulding procedures. Analytical instrumentation includes thermal analysis, dielectric spectroscopy and comprehensive optical spectroscopies. In addition to conducting multidisciplinary research, the TDHVL is also a commercial testing house offering consultancy services that are supported by a specialist engineering team. In the REF period, the laboratory has provided services and consultancy to over 70 organisations, including National Grid, Centrica, Prysmian Cables and Services, Mott MacDonald and Network Rail. TDHVL's commercial testing income rose from ~£100k in 2008/09 to more than £450k in 2012/13.

The TDHVL is led by a Director (**Lewin**) and has a management structure comprised of a strategy committee, a staff committee and an enterprise committee responsible for commercial testing. The laboratory governance reflects the requirements for ISO9001, 14001 and OHSAS 18001 and the TDHVL is in the process of gaining accreditation as an international testing and calibration facility.

Consultancies and Professional Services

The University has a strong commitment to enterprise and innovation within its core strategy. The approach is to encourage and support staff to carry out consultancy that will contribute to the University mission and enhance the skill set and experience of the staff. The governance framework of the University requires all consultancy activity to comply with University Financial Regulations, the Consultancy Policy and additional policies on Conflict of Interest.

Various consultancy mechanisms exist within the University, ranging from private consultancy by staff through to organized consultancy units & initiatives. However, within FPSE, a key initiative concerns ***ECS Partners***, which provides a route whereby complex consultancy can be undertaken for industry by bringing together teams of staff from across the Faculty. Consequently, ECS Partners constitutes an important element in our strategy to establish links with industry and *evidence* of its success includes: revenue growth from £462k in 2008 to ~£2m in 2013; the establishment of a long-standing relationship with BAE Systems; the formation of the ***ARM-ECS Centre***, which attracted nearly £1m of industrial research funding over the REF period. ECS Partners also manages the provision of ***e-Prints*** services to educational institutions world-wide.

As highlighted above, the existence of our specialist facilities provides further opportunities to build relationships with industry. In facilitating these, the University's ***Research and Innovation Services*** play a critical part, by providing the specialist expertise needed to support relationships with research users, deal with legal issues, manage IP, etc. A Collaboration Manager (**Woolley**) and two Research Support Officers (**McCourt** and **Di Chio**) provide dedicated support to UoA13.

e. Collaboration or contribution to the discipline or research base

The REF period has been notable for UoA13 staff in that it has included a number of significant

indicators of esteem. Particular highlights since 2008 include the receipt of:

1 Knighthood (Payne)
3 Fellowships of RAEng (Rutt, Al-Hashimi, Richardson)
4 Fellowships of IEEE (Al-Hashimi, Lewin, Chen, Sykulski)
2 ERC Advanced Fellowships (Wilkinson, Hanzo)
3 EPSRC Platform Grants (Eason, Al-Hashimi, Al-Hashimi)
4 EPSRC Programme Grants (Payne, Zheludev, Al-Hashimi, Reed)
1 EPSRC Innovative Manufacturing Centre Grant (Payne)

1. Research Collaborations. UoA13 research has enabled collaborations with a wide range of external partners. The 4 Programme Grants and the Manufacturing Centre identified above (*Nanostructured Photonic Metamaterials*, *The Photonic HyperHighway*, *PRiME: Power-efficient, Reliable, Many-core Embedded systems*, *Silicon Photonics for Future Systems*, *Innovative Centre for Manufacturing in Photonics*) have directly leveraged industrial funding from partners including AWE, BAE Systems, Imagination Technologies, Oclaro, Qinetiq, Selex-Galileo. Other stakeholders involved in our research activities include the BBC, the National Microelectronics Institute, Electronics Sensors and Photonics KTN and the US Office of Naval Research.

Successful collaborations have also been developed through funding sources such as the European Space Agency (collaboration with NPL) and the TSB (*SMART LASER* with SPI Lasers; *Low Cost Nanowire Diagnostic Platform* with Sharp Laboratories Europe; *Sustainable Power Cable Materials Technologies with Improved Whole Life Performance* with National Grid, Dow Chemicals and GnoSys Global). Our increasing involvement with the European Union, as shown by the 186% income growth over the REF period, has provided major benefits through enhanced international academic and industrial collaborations. Examples include *MODEGAP* (with Nokia Siemens Networks) *ISLA* (with Gooch and Housego, Oclaro and Rofin) *HALO* (with Trumpf) and the *MICROFLEX* (13 partners; €5.4m total; 2008 - 2012) and *CREATIF* projects (7 partners; €4.4m total; 2013 - 2016) that are led by Beeby and Tudor respectively.

2. Multidisciplinary Research. The integrated structure of FPSE provides a highly supportive environment in which researchers from complementary disciplines can collaborate to conduct multi- and interdisciplinary research. By bringing together researchers from across the breadth of world-leading expertise that is housed within FPSE, we are able to generate new ideas and research directions, collate research into coherent and aligned packages and thereby address major research challenges. An example of a structure that exists to foster multidisciplinary research is the ***ZI Collaboration Stimulus Fund*** (£100k allocated for 2013/14).

A clear exemplar of the benefits we have accrued from multidisciplinarity is provided by the ***Pervasive Systems Centre*** (PSC) within ECS. Pervasive systems represent a major market for the wireless and mobile electronics industries, and the PSC tackles the challenges of pervasive computing by drawing on expertise including sensors, signal processing, communications, system design and computer science. For example, work on battery-free electronic systems involving ECS and medical staff is combining ultra low-power medical sensors, signal processing algorithms and circuits to create intelligent mobile healthcare systems with decision-making capabilities, which can monitor symptoms and alert GPs if medical intervention is needed. The PSC is also home to the ***ARM-ECS Centre***, which undertakes research and practical validation of energy-efficient and reliable multi-core processor systems. Examples of the success of the PSC initiative include:

(i) Nearly £1m of industrial funding into the ARM-ECS Centre, over the REF period.
(ii) Recent EPSRC funding approaching £1m for research in energy-efficient and high performance communications to develop algorithms, architectures and their silicon implementation (**Maunder**, **Al-Hashimi**, **Hanzo**) to be carried out with BT, Nokia, Cambridge Silicon Radio, ARM and Altera.
(iii) The recent EPSRC *PRiME* programme grant (including **Al-Hashimi**, **Butler** and **Merrett**) brings together researchers from electronics and computer science. This will develop the hardware and software for future high-performance embedded computing systems with many-core processors for use in applications such as telecoms, transport and medical systems.
(iv) The European-funded *CHIRON* health management project (total value £18m), in which **Maharatna** is collaborating with colleagues in the School of Medicine at Southampton University Hospital NHS Trust.

Further examples of multidisciplinary and collaborative research are highlighted in our impact case

studies, which include:

(i) Optical telecommunications research: brings together optics and materials science and feeds into the digital economy.

(ii) Microfluidic diagnostic systems: this is a major theme which, in collaboration with colleagues in the life sciences and industry, is aimed at improved patient healthcare

(iii) Computer-based analysis of the way people walk, has led to novel forensic approaches and is being adopted by practitioners in areas such as crime prevention and national security.

(iv) The development of new dielectric materials bridges materials science and power engineering and, along with major industrial organisations, is leading to redesigned cables and optimised transmission system operation.

3. Leadership in the Academic Community. As befits a strongly research-led institution, engagement with the broader academic community constitutes a central theme of the activities of UoA13 staff. As such, our policy is to encourage all staff to interact with the relevant learned societies, to sit on steering boards and advisory panels, to act as directors of external bodies, etc. Notable examples of this include **Payne** (Digital City Exchange Advisory Board, Royal Society and Royal Academy of Engineering Council member) **Hanzo** (China-UK Science Bridge on 4G Wireless) **Zheludev** (Director, Centre for Disruptive Photonics Technologies, NTU, Singapore) and **Beeby** (TSB Steering Group on energy harvesting). A range of examples of academic leadership and contributions to the discipline base relating to the REF period are given below.

(i) Invited talks: Invited 731; Keynote 66; Plenary 47.

(ii) Journal editing/member of editorial board*:* Editor in Chief 20; Editor 52.

(iii) Prestigious research fellowships: Royal Society (**Brambilla, Gardes, Ibsen, Poletti, Morgan, Charlton**) EPSRC (**Fedotov, Slavik, Beeby, Prodromakis**), Royal Academy of Engineering (**Mackenzie, Parmigiani, Peacock, Price**), Leverhulme (**Papasimakis, Plum**), ERC (**Wilkinson, Hanzo, Markovsky**), Marie Curie (**Saito, Slavik**).

(iv) Fellowship of learned societies: IET (19); IOP (11); OSA (6); RAEng (6); IEEE (5); BCS (3); SPIE (1); EPS (1); RSC (1).

(v) National and international research review committees: UK bodies (EPSRC, BBSRC, RS, Leverhulme, RAEng, Welcome, Nuffield, IOP, Marconi); European governmental and research organisations); international governmental and research organisations (NSF, NATO, A*STAR, Australia, Canada, China, Hong Kong, Israel, Japan, Malaysia, Qatar, Singapore).

(vi) International conference committee membership/chair/general chair: total 315, including sustained involvements in international conferences, such as general chair of Conf. on Biometrics 2010 (**Nixon**), Computation in Electromagnets 2011 (**Sykuslki**), Scientific Committee NaonBiotech 2007-11 (**Morgan**), Design Automation and Test in Europe 2011 (**Al-Hashimi**), Optical Communication 2013 (**Payne**), Lasers and Electro-Optics 2013 (**Clarkson**) PowerMEMS 2013 (**Beeby**).

(vii) Prize winning publications/presentations: 37

(viii) Honours/medals/prizes: Knighthood (**Payne**) SPIE gold medal (**Payne**) The 60th Anniversary Jubilee medal of Scientific Association for Infocommunication (**Hanzo**) ESBMC medal (**Fischer**) Institute of Measurement and Control Sir Harold Hartley medal (**Rogers**) Institute of Measurement and Control Callendar Silver Medal (**White**) President of the Republic of Poland's Honorary Professor Award (**Sykulski**) Marconi Prize (**Payne**) Marconi Young Scholar (**Plum**) CIGRE Distinguished Member Award (**Swingler**) Puskas award of the Hungarian Telecommunications Society (**Hanzo**) IET Emerging Technology Award (**Tudor**) IET Innovation Award (**Richardson**) IET Sir Monti Finniston Award (**Hanzo**) IEEE Distinguished Lecturer (**Hanzo**) Royal Society Wolfson Merit Award (**Richardson, Zheludev, Hanzo, Al-Hashimi**) IEEE Radio Communications Technical Award (**Hanzo**).

(ix) Company spin-out activities: (**Gawith, Smith, Payne, Richardson, Zervas, Gabriel, Beeby, Swingler, Charlton, Harris, Tudor, White, Wilson**)

(x) Chair of prestigious bodies: Marconi Society (**Payne**); IEEE Behavioural Systems and Control Theory (**Rapisarda**); Vice President IEEE Dielectrics and Electrical Insulation Society (**Lewin**); Governor IEEE Communications Society (**Hanzo**); Governor IEEE Vehicular Technology Society (**Hanzo**).