Institution: University of Southampton

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

a. Context

The Faculty of Physical Science and Engineering (FPSE) is made up of Electronics & Computer Science (ECS), the Optoelectronics Research Centre (ORC) and Physics & Astronomy (P&A). ECS, founded in1947, is internationally recognised for leading in priority research areas, including information and communication technologies (ICT), energy, healthcare, advanced materials and nanotechnology; the ORC is a research institute of 25 years standing in which many of the major developments in today's global telecommunications technology were pioneered. The UoA13 return relates to ECS research concerned with electronics and electrical engineering plus the ORC.

1. The major non-academic user groups, **beneficiaries or audiences of impact** from UoA13 research may be divided into three categories:

(i) Commercial Organisations: including industry and local spin-out activity.
(ii) Government Agencies, Policy Makers and Practitioners: including professional and standards bodies.
(iii) The General Public, Young People and the Media, through radio, TV, newspapers, and major national and international public engagement events.

2. The resultant main types of impact arise from the breadth of our research and include:

(i) Economic Impact and Job Creation: UoA13's research has led, in total, to the creation of 15 spin-outs (e.g. SPI Lasers, Perpetuum, Fianium, Mars Space Ltd, and Covesion), which are currently delivering a total turnover in excess of £60M and employing more than 350 people.

(ii) Improved Business and Environmental Performance of Industry: our research has been exploited by industrial companies and national bodies in key areas, including security and defence (e.g. AWE, BAE Systems), energy (e.g. ABB, National Grid, Shell), healthcare (e.g. Philips, Sharp Corporation), ICT (e.g. ARM, ST Microelectronics, Samsung, Nokia, Siemens), optoelectronics (e.g. Leica, Horiba) and aerospace (e.g. Rolls Royce, Airbus).

(iii) Improved Standards and Professional Practice: our research has informed government agencies and policy makers (e.g. the police, security services and Parliamentary select committees), international standards bodies (e.g. IEEE and CIGRE), influential professional societies (e.g. OSA, EPS, IEEE, IET) and national bodies (e.g. the Royal Society and RAEng).

(iv) Improved Public Appreciation of Research, including inspiring the next generation of researchers***,*** through: interacting with the media (e.g. radio, TV news and documentaries, newspaper coverage); events for schools and colleges; open days; industrial days; forums such as the South East photonics network; the Royal Society summer exhibition (2010); "The Big Bang Fair"; the Cheltenham Science Festival.

b. Approach to impact

Generating Impact

UoA13 has long maintained a highly proactive approach to identifying and exploiting research impact, and maximising its reach and significance, which is a consequence of the enormous scope of electronic and photonic devices for the general public, industry and commerce. Our philosophy can be outlined as follows.

1: Engagement with Key Beneficiaries and Audiences. This involves three distinct elements.

(i) Dissemination. We aim for dissemination of research findings to potential end users to maximise the reach of our research – without this, there can be no initial awareness-raising that may lead to mutual benefit. *Evidence* of our commitment to wide-ranging research dissemination is provided by the open access ***ePrints*** (http://eprints.soton.ac.uk) publications repository system that was developed in ECS and has now been adopted by more than 500 registered users worldwide and by our contributions to industrially-focussed publications and trade shows (e.g. CWIEME 2013 and magazines such as Laser Focus World.).

(ii) Maintaining Links. We value personal interaction, as a result of which, we have built up a strong network of business contacts. *Evidence* of our commitment to this is provided by the initiatives we have in place to grow and sustain links. For example, ECS hosts an annual alumni reception, most recently in London on 21st May 2013 (~250 alumni in attendance); the ORC hosts equivalent events in California that are normally attended by ~60 people and maintains

contact with its 650 current alumni through the *Light Times* newsletter (over 1800 recipients). *Evidence* for the success of this strategy is provided by the research funding that follows (e.g. ~£6M via alumni links into the ORC alone).

(iii) Engaging the Public with Research. We embrace a coordinated policy of dialogue with the public and the broader spectrum of potential stakeholders to understand and influence public appreciation of science and engineering and to engage with potential employers to discuss their needs. *Evidence* of our commitment to activities in this sphere during the REF period, include: *Light Express* (http://www.lightexpress.soton.ac.uk/) and associated photonics-based activities, which have attracted a total audience of ~28,000; undertaking teacher-focussed events such as *IOP Physics Update* (University of Southampton, 26-28 March 2010); our collaborations with the *Science Learning Centre South East* (SLCSE) have proved another highly successful means of interacting with teachers – the success of events initially supported by RAEng and National Grid led to the concept being taken up nationwide; working with EPSRC at "The Big Bang Fair"; staff and students have presented at Parliament three times in 2012/13; contributing to the media (e.g. *Secret Life of Materials*, first broadcast BBC4 16/4/12).

2: Relationship Development and Follow-through. The second phase is critical for the all-important interaction and engagement process to enhance the significance of the research impact. For this, we adopt different research-specific approaches. The following examples provide *evidence* of our commitment to evolve on-going relationships with stakeholders.

(i) Embedded Industrial Structures. The ORC runs Industry Days for its Centre for Innovative Manufacturing in Photonics (CIMP), for its Metamaterials Group and for its newly established Silicon Photonics Group. These events invite engagement between photonics companies (120 for the 2012 Industry Day) and Southampton researchers. In ECS, the Industrial Advisory Board includes senior representatives of technology-focussed companies (e.g. Prof Vincent Mifsud, VP Technology Cobham plc and Richard Greaves, Technical Direct, Meggitt plc) with whom the unit has strong relationships. Such events provide a mechanism that reinforces links and enables dialogue that assists us to: evolve strategy concerning research direction; identify areas for collaborative activity; ensure the continued supply of suitably skilled employees to industry.

(ii) ECS Partners Ltd provides consultancy services that demonstrate the value of our skills and facilities to industry through highly focussed pieces of work. Since its inception in 2004, it has worked with an increasing spectrum of organisations ranging from the smallest enterprise to global companies. *Evidence* of 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 (8 PhD scholarships; 9 chip fabrications; 2 person-years of engineering time).

(iii) IT Innovation Centre is an international leader in applied research and innovation leading to the deployment of information-based technologies in industry, commerce and the public sector. It has taken part in 42 major projects in collaboration with business in the last five years, 25 of them in FP7, and has worked with over 100 companies as project partners and clients. A notable recent success was the development of technology for decision support in crises, which was recognised by the receipt of an IRM Global Risk Award in 2013.

(iv) Access to our Unique Capabilities. We regularly engage with beneficiaries and project partners by providing access to a range of facilities, two of which are described below.

a) The £120M Zepler Institute (ZI) cleanroom complex is a newly-established multidisciplinary research centre that brings together and builds upon the University's research capability in photonics, electronics, nanoscience and quantum technology. The ZI is one of the largest research institutes in the UK in this area (~300 research staff) and is unique in covering the whole innovation cycle from basic research to exploitation. In the REF period, the constituent elements of the ZI attracted more than £4.5M from industrial funders, including major technology organisations such as Sharp Laboratories of Europe and Rolls Royce, thereby providing clear *evidence* of the industrial engagement with the initiative.

b) The Tony Davies High Voltage Laboratory (TDHVL) provides a means for us to interact with industry, initially, to test new plant prior to deployment and, subsequently, to build research relationships. The laboratory has provided services and consultancy for over 70 companies and organisations over the REF period, including National Grid plc, Centrica plc, Prysmian Cables and Services Ltd, Mott MacDonald Ltd and Network Rail. TDHVL's commercial testing income rose from £120k in 2011/12 to more than £450k in 2012/13.

3: Exploitation of Research Outcomes. Exploitation strategies are considered both locally and through the use of specialist institutional expertise.

(i) Utilisation of Institutional Resources. Research and Innovation Services (RIS) and Southampton Asset Management Ltd (SAM) provide the specialist institution-wide expertise needed to support relationships with research users, deal with legal issues, manage IP, etc. RIS is a University department with over 60 staff, who provide dedicated support to facilitate interactions with our business partners, incubate spin-outs and train staff on IP issues. SAM is the legal entity that manages the University's IP portfolio and oversees spin-out activity and licensing within the University's strategic framework for enterprise and impact. *Evidence* of the University's commitment to furthering the knowledge transfer agenda and of the success of the institutional structures can be found in a number of metrics, including: growth of consultancy income from £11M in 2008/9 to £28M in 2011/12; over 40% of research projects involve one or more commercial partners; at any time, the University is working with over 1000 external organisations; over £95M of investment into spin-out companies has been attracted in the REF period; across the University, 15 companies have been spun out since 2000, of which, 4 have floated on London's Alternative Investment Market with a combined market value of £180M; the University holds a rolling patent portfolio of some 300 active patent families with an annual license fee income of about £1M. Effective interactions between UoA13 staff and this wealth of institutional expertise are ensured through dedicated staff within RIS, including the Faculty Collaboration Manager (**Woolley**) and two Faculty Research Support Officers (**McCourt** and **Di Chio**) who, in the REF period, have liaised between UoA13 and 27 companies and facilitated funding from industry, charities and other organisations worth nearly £10M. Across UoA13, spin-out activity is considered the 'norm'; 6 of these are central to our impact case studies.

(ii) The Faculty Patent Panel provides a mechanism for assessing research outputs that show commercial potential. It is comprised of Faulty staff experienced in IP, who prioritise patent strategy and make recommendations on a case-by-case basis. Where appropriate, IP protection is sought using a patent budget of £45k per annum, which is matched by RIS.

4: Staff Support and Recognition

Significant support and incentives exist to enable staff to engage in impact-focussed activities.

(i) Support. ECS and ORC employ a ***Business Development Manager*** (**Darlington**) and a ***Senior Fellow, Partnerships and Business Development*** (**Lewis**) 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 addition, a dedicated ***Research Funding Development Manager*** (**Carr**) and ***Zepler Institute Coordinator*** (**Churchill**) were appointed in 2012, specifically to grow ZI research impact, while **Tillotson** was appointed in 2013 as TDHVL ***Business and Enterprise Coordinator***.

(ii) Reward. To encourage staff involvement in ECS Partners, a large fraction of the resulting income (typically 85% gross) of relevant consultancy fees are paid to the staff involved.

(iii) Recognition. The University fully recognises enterprise as part of its job family structure. For example, **Wilcock** was recently promoted to ***Senior Enterprise Fellow***, to reflect his contributions in this area, and was nominated by the University and won the 2013 RAEng ERA Foundation Entrepreneurs Award. This award was established to recognise early career entrepreneurial researchers in UK universities working in electro-technology.

c. Strategy and plans

Strategy for Impact

UoA13's future impact strategy is designed to ensure the longevity and joined-up operation of the mechanisms outlined in section b. A key element of our overall research strategy is to align our research with global societal challenges and engage effectively with potential beneficiaries to deliver impact. The research topics we address are of great technological relevance and span many different spheres. Consequently, by working collaboratively with key stakeholders, we will increase both the significance and reach of our work. In addition to the above activities, namely:

1. **Engagement with Key Beneficiaries and Audiences;**
2. **Relationship Development and Follow-through;**
3. **Exploitation of Research Outcomes;**

we will achieve this by:

1. Expanding the Reach of our Core Research. In the REF period, the value of the funding we obtained from industry, charities and other organisations was worth nearly £10M, with income from UK industry doubling. To sustain growth, we will adopt the following strategies:

(i) Develop Local Interactions with major technological organisations (e.g. IBM Hursley and Roke Manor Research) and clusters of smaller technology companies, including our own spin-outs, particularly in the areas of ICT and optoelectronics.

(ii) Work with Major Multinationals to build on existing successes, such as the two Global Outreach Program grants Southampton holds with Samsung Advanced Institute of Technology.

(iii) Grow our Collaborative Research with industry in conjunction with national and international governmental organisations such as the Research Councils, TSB, and European Commission, both to access new funding streams and to increase the commercialisation of our research for economic and societal benefits.

(iv) Influence Policy. We will establish a mentoring scheme to assist senior staff to sit on steering boards, advisory panels and to act as directors of external bodies. This will exploit the experience of, for example, **Payne**, (Digital City Exchange Advisory Board), **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). In this way we will access and influence important decision and policy makers in UK and overseas.

2. Exploring New Research Frontiers. Our research has the potential to impact societal issues in many different spheres. We will identify and exploit new inter- and multidisciplinary research collaborations that complement our core capabilities, engage with local and national initiatives and interact with a range of stakeholders within academia, industry, government and the public.

(i) Opportunities for Innovation. We will continue to hold regular (~20 times per year) innovation meetings, which have led to many successful initiatives and subsequent funding in areas such as sub-wavelength imaging for the life sciences, novel nanoscale materials and the development of lab-on-a-chip technologies for use in healthcare.

(ii) University Strategic Research Groups (USRGs). Engagement with the USRGs provides a structured mechanism for furthering multi- and interdisciplinary research in areas of societal importance, including Energy, Healthcare and the Environment.

(iii) Engagement with Multidisciplinary Initiatives. A key plank in our impact strategy concerns exploiting the University commitment to establishing multidisciplinary centres of research excellence. Existing centres include the ZI, the Institute for Life Sciences (IfLS) and the Southampton Marine and Maritime Institute (SMMI). The last of these represents a £120M investment in partnership with Lloyds Register and constitutes ***the largest such business-focussed endeavour in any UK university***. Examples of on-going multidisciplinary activities that have emerged from these University initiatives include studies of issues relating to power cables on the seabed (TDHVL and SMMI), the development of novel imaging techniques (ORC and IfLS) and the Centre for Hybrid Bio-devices (ECS, IfLS, Philips and Sharp Labs Europe). Going forward, we intend to drive University's strategy in aerospace, as the sector moves towards increasingly electric aircraft.

3. Engaging with Beneficiaries. Dialogue with a range of beneficiaries, including government, the learned societies, industry, schools and the general public, will remain a vital part of our strategy to inform and advise on our activities. People are central to our on-going success and, therefore, maintaining the pipeline of talent from schools, through university and on to industry or academia is essential for us, the health of the discipline and the success of the UK economy. We will therefore continue to work with:

(i) The Learned Institutions, (the Royal Society, RAEng, IET, IoP, OSA, etc.).

(ii) National Bodies such as the National Skills Academy for Power (27 competitive scholarships won 2008-2012) and the National Microelectronics Institute (29 Electronics Skills Foundation competitive scholarships won 2010-2012) in order to influence national policy.

(iii) Schools, both by direct research-focussed outreach activities and by engaging with bodies such as the IOP, Smallpeice Trust and SLCSE.

(iv) The Media, including TV, radio, newspapers and articles in special interest publications such as trade magazines. This strategy will continue to be subject to regular review through our Research & Enterprise Strategic Plan which is updated on a quarterly basis with inputs from

Heads of Units, Associate Deans and holders of major programme and platform grants.

Delivering Impact

We believe that delivering the strategy described above will require us to adopt new mechanisms to maximise impact.

1. New Internal Structures. Our strategy requires the ***delivery***, ***capture*** and ***coordination*** of impact. To do this effectively and efficiently, we are introducing the following initiatives.

(i) Establish an annual commercialisation fund within FPSE, which will complement the on-going activities of the FPSE Patent Panel. Researchers will bid to this for support for commercialisation of research that is close to exploitation.

(i) Expand the current role of the Senior Enterprise Fellow (**Wilcock**) to form a team, embedded within FPSE, with the expertise and capacity to assist in the commercialisation of research that is close to exploitation. The team, led by a new Impact Manager will: provide ***staff support***; ***capture*** the resulting impact; ***coordinate*** enterprise activities across the Faculty***.***

(iii) Appoint a Public Engagement officer (PEO) who will: identify audiences and opportunities; develop material; provide ***staff support*** in undertaking PE; ***capture*** and evaluate the resulting impact; ***coordinate*** PE activities across the Faculty***.***

(iv) Increase the prominence of impact-related activities in the promotion process, in order to enhance ***staff reward and recognition***.

2. Exploitation of External Opportunities. FPSE includes Physics and Astronomy and, consequently, is an integral element of HEFCE's recent investment of £2.75 million in the South East Physics Network 2 (SEPnet 2). SEPnet 2 will establish a coordinated Impact Framework across the region, support constituent units to work collaboratively across the consortium, evaluate the effectiveness of each initiative and spread best practice. Since the impact-focused objectives of this programme closely mirror our own, we intend to implement appropriate elements of this initiative across the whole of FPSE, to the benefit of UoA13. By exploiting this relationship we will:

(ii) Benefit from evolving best practice in impact generation.

(ii) Access and shape SEPnet 2 activities to mutual advantage.

(iii) Contribute to and benefit from the legacy impact structures that SEPnet 2 will establish.

This provides an exemplar of how we will adopt an agile approach to external opportunities.

d. Relationship to case studies

The following examples illustrate how the different routes describes above have resulted in impact, as described in our Impact Case Studies (ICS).

1. Engagement with Key Beneficiaries and Audiences. Impacts that have resulted from this theme include affecting policy, practitioners, professional services and public attitudes. ***Bragg Grating Technology for Energy Research, Monitoring and Biosecurity*** describes the impact of our research on a range of different user groups, including fusion researchers at the US National-Ignition-Facility, DSTL and the MOD, while ***Walk This Way: Leading the World in Gait Biometrics*** has impacted on forensics and national security in the UK and abroad. Other ICSs have impacted upon ***Professional Standards***: (e.g. ***Electronics*** and ***Reliable Cable Systems for Energy Security***) through engagement with international bodies (e.g. IEEE and CIGRE).

2. Relationship Development and Follow-through. A range of different impacts have been developed through this route. The ***Micro-technologies for Medical Diagnostics*** ICS demonstrates how sustained interactions with Philips and then Sharp have proven the commercial value of lab-on-a chip technologies, as evinced their major investments in this area. In the ***Reliable Cable Systems for Energy Security*** ICS, we show how long standing relationships within the energy sector (e.g. ABB and National Grid) have resulted in improved business performance and reduced environmental impact. Another ICS where sustained interactions with industrial beneficiaries has led to improved business performance is ***Distributed Optical Fibre Sensors***.

3. Exploitation of Research Outcomes. A significant number of spin-out companies have resulted from our research that have produced direct economic impacts and created jobs while their products improve the business performance of industry. The ***High Power Fibre Lasers*** ICS details the establishment of *SPI Lasers Ltd*, ***Good Vibrations: Advancing the Cause of Energy Harvesting*** concerns *Perpetuum Ltd*, while the **Microstructured Optical Fibres** ICS **concerns** *Fianium*, which has an annual turnover of ~£10million, employs more than 50 people and has won two Queen's awards, for International Trade (2009) and for Innovation (2012).