Institution: Swansea University
Unit of Assessment: 15 - General Engineering
a. Context

Each of the College's three Research Centres (Civil and Computational Engineering Centre, Systems and Processes Engineering Centre, and Materials Research Centre) delivers impact as an integral part of an agile culture of innovation across three application themes: Aerospace and Manufacturing; Energy and the Environment; and Health. The College's research yields **industrial and societal benefit globally and nationally**, with non-academic beneficiaries drawn from four broad user groups:

1) **Industry**: manufacturing companies such as Rolls Royce, Tata Steel, BAESystems, EADS, Airbus, Unilever, HP, Renishaw. Energy companies such as Exxon, BP, Shell. Water companies, and mining companies such as Rio-Tinto. Manufacturers of new medical technology and diagnostic tools such as Calon Cardio Technologies, Haemair Ltd, Pulse Medical, Algipharma. Pharmaceutical companies such as GSK and Unilever. Also a large number of SMEs.
2) **Local authorities and agencies**: for example the Environment Agency through marine energy and coastal hydrology research.
3) **NHS Trusts and hospitals** through the development of new medical devices.
4) The **general public**: consumers of products manufactured by the University's partners; patients using devices/techniques developed at Swansea; public engagement activities, such as the University's Materials Live initiative and BLOODHOUND SSC.

Research has led to **economic impact**, including the establishment of spin-out companies such as Rockfield and Haemair. The College is improving the competitiveness of multinational companies such as Tata, Rolls Royce and BAESystems through the development of advanced materials and the adoption of new techniques in aerospace design. The unit's research has also achieved **environmental impacts**, for example through reduced carbon consumption of the new generation of aero-engines and aeroplanes made possible by the Centres' computational design techniques and development of advanced materials. It is delivering **health impacts** through the development of new medical technologies and diagnostic tools that will ultimately benefit patient outcomes. The College is also achieving societal impacts, for instance through improved predictions of the impacts on communities of extreme weather, such as flooding, and through significant **engagement** activity that enhances science and engineering-related education in schools and at major public events.

b. Approach to impact

Industry- and user-led research of international quality has characterised the unit since the University was established to meet industry needs in 1920. The approach is to embed impact across all research activities through **three complementary mechanisms** that encourage and support the early engagement of researchers with end users and beneficiaries, fostering closer collaboration with industry and maximising the impact of research in term of its reach and significance:

1) ***Strategic collaborations*** with industrial partners, developed over several years and harnessing the unit's creativity and talent in enabling innovations to a shared research-vision driven by the immediate needs of the users. Strategic relationships have been forged over many years with companies such as Rolls-Royce (through a University Technology Centre and Doctoral Training Partnership); Tata Steel (e.g. Engineering Doctorate Centre); chemical processing industries in the food and pharmaceutical sectors through the Multidisciplinary Nanotechnology Centre; and BAESystems, Airbus, Unilever and others through the development of unstructured computational technologies and advanced materials. Knowledge generated by these collaborations is taken to market by users, delivering benefits to society, within five to ten years.

2) ***Operational partnerships***, adapting proven research concepts to address user needs to improve products, processes or services. The aim is to incorporate the research output within the industrial environment (over one-to-three years) in order to improve products, processes or services of the industrial partners. By participating in a range of schemes that fund such activities, the College has ensured that it maximises the opportunities of exploiting its research.

3) The College supports the commercialisation of its research through ***licensing, spin-out companies, and consultancy***. Within the last five years, 32 patents have been submitted and 21 spin–out companies created. Examples include Swansea Materials Research and Testing Ltd, now a key supplier of material characterisation for Rolls–Royce; and the attraction of an Enterprise Fellowship from the Royal Academy of Engineering, which has accelerated the development of a new medical diagnostic technology within a University spin–out company (RCUK designated this project an '*Excellence with Impact*' exemplar). **Consultancy** plays an important role; knowledge transfer contracts with international organisations such as Airbus, Cassidian and IHPC Singapore are the result of consultancies carried out by the unit.

Staff collaborate extensively with industry through mechanisms such as **Collaborative Industrial Research Projects (CIRPs), Knowledge Transfer Partnerships (KTPs), and Knowledge Transfer Centres** (formerly CETICs/Centres of Excellence in Technology and Industrial Collaboration) in areas such as Simulation-based Design; Complex Fluids and Membrane Technology; and Composite Materials. Larger collaborative projects such as SPECIFIC have been funded by TSB and EPSRC as **Innovation and Knowledge Centres**. The Department of Research and Innovation (DRI) manages programmes that bring together businesses, academics and research groups, such as **Knowledge Exchange Wales** and **Enterprise Europe Network,** supports IP protection, launches spin-out companies and facilitates consultancy services through a subsidiary company, Swansea Innovations Ltd.

Doctoral Training Centres are integral to impact delivery, and include: the *Steel Training Research and Innovation Partnership* (STRIP), *Manufacturing Advances Through Training Engineering Researchers* (MATTER), *Centre for Advanced Training of Engineering Doctorates* (COATED), and the *Swansea, Birmingham and Cambridge Doctoral Training Partnership with Rolls-Royce*. The *EngD in Steel Technologies* has trained cohorts of ten doctoral candidates per annum since 1992. The College has engaged with more than 25 organisations through these initiatives. Collaborating companies employ a large percentage of graduates from these programmes, demonstrating **transfer of knowledge between academia and industry**. Swansea participates in the Bangor-led Knowledge Economy Scholarship Scheme (KESS), which part-funds PhD students engaged in collaborative research projects with industry.

The College has a measurable impact in raising **public awareness** of engineering in society. Public engagement activities are underpinned by the unit's research activity; over the last five years activity has included: the College's major contribution to the **BLOODHOUND SSC** project's Education Programme, which has engaged with over 5,400 schools and colleges. This has attracted public engagement funding from EPSRC and the Royal Academy of Engineering, and resulted in Swansea being designated one of five hubs in the £21m, HEFCE-funded HE-STEM project. Other activity has included presentations at the 2012 and 2013 **Cheltenham Science Festivals**, the establishment of a **Materials Live** outreach project, and the University's **Research as Art** competition, managed by an ECR in Engineering, which has resulted in international media exposure and an exhibition in the Royal Institution.

The unit **supports staff to achieve impact** through initiatives designed to encourage and promote impact–led research. Academic appointment panels consider candidates' potential to interact with industry and research users. Recent appointments have been in areas that support and broaden the capabilities of high-impact research groups, for example within the Centre for NanoHealth and the Rolls-Royce UTCs. The College has **provided substantial funding** to enable the contracts of 10 research officers to be extended, with the aim of maximising the impact of their research. A **staff loading model** recognises participation in knowledge transfer and activities and industrial projects (including EngD supervision and public engagement) and leads to reductions in teaching

load in order to facilitate these activities. The College grants **sabbatical periods** to staff to enable them to concentrate on enhancing impact. E.g. Bache was granted leave to focus on developing the Rolls–Royce partnership and SMaRT. The University's academic career pathways scheme includes an enhanced strand for innovation and engagement, **recognising and rewarding staff** who demonstrate their impact through knowledge transfer.

Staff have access to a range of **institutional facilities that attract commercial collaboration**, including the National Mass Spectrometry Service Centre in the College of Medicine; the £22m Centre for Nanohealth (a collaboration between the Colleges of Engineering, Science and Medicine, delivering impact in the field of nanotechnology applied to novel healthcare innovations); and the HPC Wales supercomputing facility and other major supercomputing facilities on campus that enable the further exploitation of strong computer-based simulation activity within the College of Engineering.

The College evidences success in **responding with agility to opportunities** to initiate projects that yield impact. For instance, the European Regional Development Fund has supported the College in delivering benefits to the local economy: large collaborative ventures include the Advanced Sustainable Manufacturing Technologies project (ASTUTE) in the area of innovative manufacturing, and the Marine component of the Low Carbon Research Institute (LCRI), which is exploiting Swansea's modelling strengths to optimise the placement and design of tidal renewable energy installations. These two projects will **create over 150 jobs** by improving the competitiveness and productivity of the local industries.

Sêr Cymru, the Welsh Government's £50m, pan-Wales programme, aims to attract world-leading scholars and their teams to Wales, and to establish National Research Networks (NRNs). Swansea responded swiftly and has been **awarded £17m** from this source (for two research teams to be based in Engineering, and to lead the NRN in Advanced Engineering and Materials) and has been awarded a further **£10m of additional Sêr Cymru funding** to establish a National Centre for the Impacts of Extreme Weather with the Met Office. All initiatives have commercialisation of research for industrial and societal benefit at their core.

The **Academia for Business (A4B)** Programme, funded by the Welsh Assembly Government and European Structural Funds has supported 28 collaborative projects with industrial partners. The University holds an **EPSRC Impact Acceleration Account;** 60% of this funding (£360K) is being used to support the secondment of 1) a senior industrialist from TATA Steel to develop mechanisms for the rapid delivery of impact into the metals and materials sector, and 2) to fund a Commercial Manager in the Centre for NanoHealth, to develop research collaboration and commercialisation opportunities with industry.

c. Strategy and plans

The unit will continue to utilise and explore all avenues to enhance its approach to impact, supported by an **External Advisory Board** (established in 2007) to maximise the mutual benefits of the unit's strategic partnerships, exchange information on research priorities, and advise on the College's plans. Board members include Rolls-Royce, Tata Steel, BAeSystems, GSK and Atkins, as well as representatives from the Healthcare sector (NHS trust) and SMEs. Impact is fundamentally underpinned by the quality of the unit's research activities; the College has recently completed a period of unparalleled research-led growth resulting in the appointment of 32 new academic staff, with expertise in areas likely to achieve significant future impact. The College will **continue to seek the appointment of world-leading researchers** and to invest in its strengths by expanding activity in successful areas.

The **new, £250m, Science and Innovation Campus** will provide purpose-built facilities for the College of Engineering and Business School, supporting enhanced interaction with industrial partners and end users. The 31,000 m^2 facility will open in 2015 and is predicated on an open innovation model, co-locating industrial R&D activity with academic research. Agreements are in place with partners such as Rolls-Royce and Tata to develop facilities on the campus and the

College is engaged with other multinational companies and SMEs to provide additional **routes for exploitation and knowledge transfer**. Building on this initiative, the College will:

- pursue **new, long-term relationships** in areas such as printing and coating, which are currently constrained by space limitations;
- **exploit research carried out in UK priority areas** by Swansea researchers, such as coastal engineering and renewable and marine energy, by facilitating the integration of industrial staff within an Energy Safety Research Institute building that will also house the Swansea University-Met Office National Centre for the Impacts of Extreme Weather.
- further develop **industrial doctorate programmes** in the areas of Coatings, Aerospace Materials and Manufacturing, and will continue to engage in industrial PhD schemes such as the Knowledge Economy Scholarship Scheme and Knowledge Transfer Partnerships. Over the next REF period, the College aims to **train over 100 research students** through these collaborative mechanisms. The Swansea-led Sêr Cymru National Research Network in Advanced Engineering will establish a graduate school of at least 50 PhD students, with a significant proportion to be trained in Swansea.
- provide high-quality facilities for 750 researchers and doctoral students to allow for the expansion of the current portfolio of doctoral training schemes that integrate students with research users in order to maximise research impact beyond the life of the original project.

Technology transfer schemes will be used to enhance exploitation of established IP, particularly in computer-based simulation and nanohealth. European Regional Development Funding will also be used to generate impact through the award of projects supporting collaborative interventions with industry. (Such projects are audited on impact measures such as jobs created and companies assisted.) Spin-out companies will benefit from incubation facilities enabling interaction with research groups and utilisation of research laboratories.

The College will continue to **support academic staff** in their pursuit of impact by enhancing all good practice that has been developed over the past two decades and which is currently utilised in the approach to impact. This includes financial support to maximise dissemination of good knowledge exchange practice and ensuring that performance in relation to knowledge exchange is included in job descriptions and personal development reviews. The College will continue to support staff in their exploitation and technology transfer activities by adjusting other academic duties accordingly, including funding sabbatical leave. The University has recently approved **new promotion routes to Chair level** on the basis of outstanding technology transfer, exploitation, public engagement or similar impact activities. These routes formally equate achievements in the area of impact with those in blue sky research.

d. Relationship to case studies

- Case studies 1-4 (Unstructured computational aerodynamics, Multi-fracturing modelling, Membrane Systems, Multi-physics simulation) demonstrate the impact of **research driven by industrial needs**, and how collaboration with research users yields both world leading academic innovations and commercial benefits.
- Case studies 5-6 (Tata, Rolls-Royce) evidence the importance of developing **longstanding relationships with industrial stakeholders** through research excellence and industrial doctorate schemes. In both cases the impacts have been achieved through a combination of take up of research innovation and the transfer of expertise through the employment of research graduates.
- Case study 7 (Blood clotting) exemplifies growing efforts in the **application of engineering technology to healthcare**. This is a growing area of activity supported by the Centre for NanoHealth.
- Case study 8 (Manufacturing by Printing) shows how RCUK and regional development funding can **drive innovation** in a key sector of the manufacturing industry largely made up of small and medium size companies.