Institution: University of Aberdeen

Unit of Assessment: 15 (General Engineering)

a. Context

As a genuine general engineering unit the School of Engineering at the University of Aberdeen is unique in the Scottish higher education sector. The general engineering approach is matched by our broad basis for research impact through a number of designated Application Areas. It is through these Application Areas that we seek to deliver impact to end users and other stakeholders. Our location in the oil capital of Europe results in a significant engagement with the UK oil & gas industry through our Subsea Technologies Application Area and Energy Technologies Application Area (illustrated, in particular, by Impact Case Studies 1 and 5). However the Unit also achieves impact in all aspects of our research, and across all our Application Areas. We also strive to influence industry policy and best practice, whether in design codes and computer networking standards, e.g., significant contributions to Digital Video Broadcasting (DVB) standards, ETSI TS 102 606 of the European Telecommunications Standards Institute in the Digital Technologies Application Area, or in mitigation of environmental change in the Engineering and the Natural Environment Application Area. We are making significant contributions to engineering science, development of new technologies and knowledge transfer to industry. At the same time, the fundamental nature of much of our research makes it applicable beyond traditional engineering.

Our commitment to research commercialisation has increased substantially since 2008. We maintain an excellent track record of involvement in Knowledge Transfer Partnerships (KTP) - 12 KTP awards since 2008, the majority with the oil and gas industry. We have also been a partner in 4 European Space Agency (ESA) ARTES applied research projects. Our research has resulted in 3 Proof of Concept (PoC) grants supporting innovation in the sector, 14 patents and 2 new spin-out companies since 2008, with another in planning. Innovation and knowledge exchange with end users of both research needs and findings remains a priority.

The reach and significance of the impact of our work is extensive due to the nature of our engineering research, and in particular the research environment in which we operate. The exemplar case studies have had a global impact in economic and professional terms.

b. Approach to impact

In order to maximise our research impact we implemented in 2009 a new research structure in the School of Engineering and established problem-focused Application Areas, which integrate disciplines' expertise and serves as the main interface with stakeholders and end-users. The main approach of each Application Area is outlined below.

The Subsea Technologies Application Area has developed through strong links with the UK subsea industry. Aberdeen is the base of Subsea UK, the national trade association representing more than 200 companies operating in the global subsea market, from large multinationals to SMEs. This connection resulted in the joint creation in 2008 of the National Subsea Research Institute (NSRI) by the University of Aberdeen and Subsea UK. Based in Aberdeen, NSRI was a partnership involving 21 companies (including major oil & gas operators, service and construction companies and specialist technology developers) and several UK universities. It provided a vehicle to deliver innovative solutions to the principal challenges facing industry extending operations into very deep water. NSRI was developing novel research programmes to deliver breakthrough solutions, currently including deep water corrosion resistant materials, analysis of weld and materials performance for higher grade stainless steels (and potentially other materials). This research is expected to deliver impact beyond the current REF period, and offers an excellent example of how our strategy of strong engagement with our local key industries is forging long lasting and productive relationships. Other examples include core research in composite materials and solid mechanics in a KTP with Ziebel UK, resulting in a new revolutionary design of composite fibre rods able to withstand a combination of complex loading and harsh environmental conditions during deep well intervention; and research into computational fluid dynamics resulting in leak sealing technologies for the oil and gas industry (see also Impact Case Study 5).

The Energy Technologies Application Area is focused on providing solutions to the problems faced by the wider energy industries. This includes innovative drilling solutions, grid integration of offshore wind farm arrays, power transmission and distribution systems, marine energy devices, bioenergy and biofuels, fuel cells and energy storage. Evidence of our successful interaction with industry can be found in PoC programmes for commercialisation of novel DC-DC converter packages. The converter has demonstrated the feasibility of DC/DC conversion at high power, with good efficiency and most importantly tolerance to DC faults (see also Impact Case Study 1); attracting the attention of many industry organisations, including the French company RTE (Réseau de Transport d'Electricité). Another example is a £6.8 million 5 year grant supported through Scottish Enterprise for novel drilling technologies (Resonance Enhanced Drilling – RED): commercialisation routes are currently being explored to exploit this technology. Similar core research in power electronics and dynamical systems has been used in KTPs resulting in better understanding of vortex induced vibrations and improved designs of riser systems, and applications of chemical engineering research for novel fuel cell and solar technologies. The Offshore Renewables Institute (ORI), which brings together experts from different disciplines at the Universities of Dundee, Aberdeen and Robert Gordon, aims to develop and deliver solutions for the offshore wind industry in the North Sea and globally. The Oil & Gas Academy of Scotland (OGAS) - in which Aberdeen is a partner - was established to improve oil and gas training facilities and develop other energy sector skills courses, with a substantial investment in hydrocarbon equipment for the University of Aberdeen.

The central goal of the *Digital Technologies Application Area* is to provide a technology platform for developing advanced digital applications. Activities focus on digital platforms, internet engineering, pervasive communications and sensor networking. The topics in this Application Area include ubiquitous network access for rural communities via satellite, network and transport protocol design for the future internet, digital platforms; applications of digital holography; advanced visual techniques; and evolution of TV transmission systems. Aberdeen researchers have established a leading role in the development of standards for the internet and DVB broadcast standards, e.g., the second generation satellite terminal recently announced by STM Networks, Inc. The Generic Stream Encapsulation (GSE) developed in collaboration with industry under ESA ARTES funding has been implemented by at least 7 different vendors (e.g. Newtec, Work Microwave, Advantec Wireless, Comtech, and KS Transpleneta - see also Impact Case Study 4). Interdisciplinary applied research, with strong end user interaction, has been also stimulated by participation in the Aberdeen RCUK dot.rural Digital Economy hub, with links to natural resource conservation, enterprise & culture, and accessibility and mobility threads. For example, the dot.rural WiSE project is developing sensor networks, engaging with stakeholders from the land management sector, including a range of agencies, non-government and membership organisations (e.g.; Association of Deer Management Groups, Cairngorm National Park Authority). Inclusion of the James Hutton Institute ensures results are disseminated to the key rural policy makers using connections to government advisory structures.

The *Engineering and the Natural Environment Application Area* aims to advance current engineering capabilities to address a range of multidisciplinary issues related to mitigation of environmental change. In particular, it is offering improved understanding of local environmental conditions including development of models for the Aberdeen beach monitoring programme and new beach defences, aquaculture engineering, flooding predictions, modelling of sea water circulation for pollution and sediment transport control, and novel construction materials and the built environment (see also Impact Case Study 2). To accelerate the impact, applied research is typically organised through jointly funded initiatives, projects, and MEng or PhD studies. Examples include the establishment of hydrodynamics of aquatic ecosystems as a newly emerged interfacial branch of environmental fluid mechanics, biomechanics, and aquatic ecology; the development of the hydrodynamics of geological carbon sequestration and enhanced oil recovery; and fluid-mechanical mechanisms of evolution of volcanic domes. This development is driven by close exchanges with potential end users, including HR Wallingford Ltd, Scottish Environment Protection Agency (SEPA), Scottish Aquaculture Research Forum (SARF), Deltares-Delft, Arcadis Nederland BV and ENBE Ltd.

At an individual project level, we seek to disseminate our research findings through as wide a

range of media as possible, including methods beyond traditional academic means. Our researchers regularly engage with the press, TV and radio media, professional industry bodies (such as through evening lectures to members), and special interest groups. Since 2010, the School has run a very successful series of public lectures attracting presentations from prominent engineers across the world – The RV Jones Lecture Series (6 lectures so far). Speakers are invited on the basis of their international standing in a research area of engineering that links well with active research within the Unit, with the lectures geared towards a general audience.

Our approach to maximise impact of our research is also supported in various ways at the University and College levels. At the institutional level, a Research & Innovation (R&I) unit advises researchers on available funding options, supports applications, and organises frequent visits by representatives of end-users. Also, the University has a dedicated Researcher Development Unit (RDU) providing a progressive, institutional programme of personal, professional and career development opportunities for researchers, including our Principal Investigator training in which approaches to research impact are embedded. A strong University Public Engagement with Research Unit (PERU), which is closely aligned with the RDU, and a College Public Engagement champion help with the dissemination of research findings and development of Impact. The University is one of 7 successful UK institutions (and sole Scottish HEI) to secure an RCUK Catalyst award to support institutional cultural change around public engagement with research. In the past few years, the public engagement activities of the Unit have included Lunchbites talks, Café Scientifique, SpeedScience evenings, lectures in National Science Week, and the inaugural PechaKucha Night in Aberdeen. In 2012-13, the University's Centre for Environmental Sustainability and Centre for International Sustainable Development ran a series of workshops to build knowledge, skills and capacity among staff and participants to design, undertake and disseminate research leading to social and economic benefits. Researchers are committed to visiting local schools, with active participation in TechFest, an annual public science festival. Research outcomes have featured on local radio, and national radio (e.g., BBC Out of Doors).

c. Strategy and plans

Our four Application Areas are founded on established discipline strengths that address key challenges identified by government (e.g. TSB) and industry locally, nationally, and internationally. All four Application Areas are also aligned with the University priority inter-disciplinary research themes: the Subsea Technologies and Energy Technologies Application Areas being aligned with the University Energy research theme; the Engineering and the Natural Environment Application Area with the University Environment and Food Security research theme. Application Areas are not administrative units. Rather, they are research communities with representatives from several Research Groups working together to address particular problems that can take advantage of inter-disciplinary interaction. The Application Areas serve as an interface between Research Groups and Centres (whose main role is creation of new knowledge and engineering methodologies), and the external world of industry, policy makers, governments and their agencies who use the new knowledge and solutions. Each Application Area is led by a senior academic whose main role is to initiate, stimulate and coordinate research activities in particular areas inspired by practical needs or societal and governmental demands. They serve as champions for their Application Areas and work closely with Research Group Leaders and Centres and their members.

We will maintain our strategy of close interaction with end users, and will continue to seek end user participation in our research from the outset. One way of achieving this is through the School of Engineering Advisory Board (until 2012 chaired by Sir Duncan Michael, former Chairman of Ove Arup) which comprises prominent engineering industry leaders, e.g. Bond (AMEC), Lawson (Chevron), O'Brien (ITF), Shand (Kongsberg), and leading academics of the Unit (Chandler, Guz, O'Donoghue, Wiercigroch). The Board informs the research strategy of the Unit and encourages engagement with research end users. This concept has been expanded with external advisory groups at an Application Area level (NSRI being an example for Subsea Technologies). This method ensures a close correlation between demand and output from the Application Areas, focussed on delivery of impact, while always ensuring that novel "off-the-wall" ideas can thrive to develop solutions for key challenges facing both industry and society, such as sealing pipeline leaks in the oil & gas and the water supply industries (illustrated by Impact Case Study 5) or

developing standards for Digital Video Broadcasting (illustrated by Impact Case Study 4).

We will continue to promote our research and build new alliances from engagement at industry-focussed exhibitions and conferences, including Offshore Europe, the largest offshore conference outside the USA, held bi-annually in Aberdeen, Offshore Technology Conference (OTC) in Houston, the largest offshore conference in the world, and the International Broadcast Convention in Amsterdam (The Netherlands).

Through collaboration with the University Researcher Development Unit (RDU), we have a comprehensive programme of training for staff and postgraduate students in engagement and development opportunities designed to overcome the barriers between skills acquisition and delivery, such as exploring and developing entrepreneurship for Early Career Researchers; a communication programme for impact and engagement; and an "Engaging Researchers" Programme about videocasting research. We also bring in staff from the University's Public Engagement and Research Unit (PERU) to provide training and advice. We include postgraduate students to underline the importance of collaborating with and disseminating to end users and to provide them with the required skills. Part of the Unit's Research Away Day in May 2013 was devoted to developing a closer collaboration with RDU and PERU. The University has signed the Public Engagement Manifesto 2012, and through this, endorses the principles of the Concordat to Support the Career Development of Researchers.

d. Relationship to case studies

We have selected case studies that offer exemplars of our approach to impact across a range of the stakeholders of our research.

- Impact on public policy and services:

Case Study 4. Internet Technologies. Work in Digital Technologies is an example of how our research influences the next generation networking equipment and professional services, through the design of new guidelines, norms and standards. This impact is at an international level supported by international research collaborations, industry awards with key European companies and European grants.

- Economic impact:

Case Study 3. GRANIT. The GRANIT (GRound ANchorage Integrity Testing) system is used for assessing the condition of rock bolts and ground anchors installed to support structures like tunnels. The GRANIT system is patented, currently licensed worldwide to Halcrow who undertake testing and provides a method of ensuring the safety of mines, tunnels etc. Halcrow received the NCE award for Technical Innovation Award for GRANIT in December 2010.

Case Study 5. Platelets Technology. Research initially emerged from the long-term fundamental sediment transport and flow dynamics research. Then, employing all the benefits of the multi-discipline engineering environment of the Unit, the concept has been transformed into the workable platelet technology.

- Impact on practitioners and professional services:

Case Study 1. DC-DC Converters. The power systems laboratory at Aberdeen has developed new converter topologies with applications in connecting MW size DC power sources with DC transmission/distribution grids. Scottish Enterprise funded a PoC project that developed a prototype and confirmed the feasibility for various applications with interconnecting renewable power sources. The technology has attracted the attention of George Adamowitsch, European Coordinator working group for offshore and onshore grid development.

Case *Study 2. Dynamic Insulation.* Research that started in the mid-1990s at Aberdeen University has established our understanding of the complex heat and mass transfer processes that occur in dynamic insulation. In 2004 this research led to the spinout of Energyflo Construction Technologies Ltd (ECT) and attracted SMART funding to develop the world's first commercial dynamic insulation product, the Energyflo Cell. A Carbon Trust Research, Development and Demonstration (RD&D) grant successfully trialled and demonstrated this product in 2006/7, with a similar trial in the UAE in 2007/8 to look at hot climate performance.