

<b>Institution: Plymouth University</b>
<b>Unit of Assessment:</b> 15 General Engineering
<p><b>a. Context</b></p> <p>Engineering research is strategically focused on marine research issues. It is carried out within the inter-disciplinary Research Centre for Advanced Engineering Systems and Interactions (CASEI) which links five engineering research groups: Coastal, Ocean and Sediment Transport, Materials &amp; Structures, Composites &amp; Manufacture, Analysis &amp; Dynamics, and Engineering &amp; Society. CAESI facilitates and drives strong interaction and joint research projects between mechanical and civil engineering staff within these groups and proactively leads collaboration with disciplines such as applied mathematics, marine physics, and coastal processes. Excellent experimental research facilities complemented by advanced theoretical/numerical modelling capability provide integrated research solutions to the increasingly complex problems faced in coastal and offshore engineering, energy generation, and manufacturing. CAESI research is strongly aligned with the priorities identified by RCUK and the EU, and proactively responds to the needs of industry. This has created critical research mass with an international reputation in marine and offshore engineering and in energy generation and provides substantial impact in national and international communities as evidenced by evidenced by CAESI commitments in many national and international research partnerships.</p>
<p><b>b. Approach to impact</b></p> <p>A key commitment is a deep recognition of the need to translate 'blue skies' research into commercial impact in support of enhanced industrial competitiveness and greater resource sustainability. CAESI has a philosophy of active networking and dissemination to enhance research impact, built on long-established practices of engagement and translation through KTPs, collaborative projects with industrial partners, industrially funded PhD studentships, and a strong commitment to continuing professional development.</p> <p>KTP projects originate from the R&amp;D needs of the companies and the new knowledge and skills developed through these projects are embedded in the companies to improve their existing products or develop new products. At their best, KTP projects provide a springboard for further research and can lead to international collaborative projects. At Plymouth, a good example of this is where work in fibre-reinforced polymer matrix composites led to TSB funding for in-mould gel-coating that is currently being extended in a Plymouth-led FP7 R4SME project InGeCt.</p> <p>An international partnership example is the long established and highly productive collaboration in friction stir welding research between Plymouth, Nelson Mandela Metropolitan University (NMMU), South Africa, and ESKOM (the South Africa power utility company with an installed capacity of some 40GW). This has also involved collaboration with the European Synchrotron Radiation Facility and the Institut Laue-Langevin in Grenoble, TWI, and Corus. The Coastal, Ocean and Sediment Transport (COAST) Engineering Research Group at Plymouth has collaborated since 2002 with the Coastal Research Group of the University of Hannover and the Technical University of Braunschweig to enable the tests of full-scale breaking wave impact on coastal structures. The Group has taken a leading role in the European Network for Coastal Research, ENCORA. Researchers are also involved in a number of European projects, including the current projects SOWFIA, THESEUS, MARINET and MERIFIC. SOWFIA involves organising four key workshops with wave energy developers, stakeholder groups, regulating authorities and policy makers; the project involves consultation with these groups leading to the development of guidelines for wave energy impact assessment to be implemented at national and European levels. In each case, these projects involve industrial or end user advisory boards or partners and are focussed on deliverables that will be implemented to aid coastal management decision making (THESEUS) or marine renewable energy (MRE) development (SOWFIA, MARINET, MERIFIC). A further European project (PROTTEC) focussed on knowledge transfer processes between Universities and businesses in France and the UK. In addition, the COAST research group has active international collaborations with the University of Tokyo, University of Miami and Woodside Energy Ltd (the Australian Oil and Gas company), shipping industry (Det Norske Veritas), Electricité de France, University of Turin, University of Oslo and KU Leuven within Europe.</p> <p>Business links have been fostered since 2007 through PRIMaRE, the Peninsula Research Institute for Marine Renewable Energy, a partnership between Plymouth and Exeter Universities.</p>

Initially funded through ERDF (European Regional Development Fund) and SWRDA (South West Regional Development Agency), it continues as a research forum and the research arm of the South West Marine Energy Park (SWMEP). PRIMaRE has developed a strong research base in MRE and has considerable interaction with regional businesses with interests in MRE. Led by Greaves, the team ran a series of PRIMaRE Research Conferences and Business Engagement activities that were open to the general public and targeted MRE and supply chain businesses. In total, PRIMaRE has interacted with over 450 businesses in 33 countries between 2007 and 2011 and has attracted considerable media coverage, including 213 press articles, 4 radio interviews, and TV coverage on 3 occasions.

PU 'Enterprise Solutions' provides a further gateway to external bodies wanting to interact in research collaborations or consultancy with academics and whose staff receive initial contact from companies, are involved in meetings with relevant academics from the outset and advise on the suitable level of collaboration and funding opportunities. This structure enables academics to engage with businesses at a range of levels from undergraduate and postgraduate projects through collaborative research and development funding bids, e.g., grants for SME, TSB, CASE etc. Many of our KTPs have come through this route. An example of our involvement is a relationship with IT Power that led to a successful TSB project partnership and with SeaEnergy that led to a collaborative bid for DECC entrepreneurial funding.

Within the Unit, industrial collaborations are encouraged through an Industrial Advisory Board and by taking part in professional body conferences and regional meetings. Industry contacts are encouraged to give specialist lectures on undergraduate and postgraduate programmes and to get involved with final year dissertations. This yields huge synergies. For example ITPower have given lectures to MSc Marine Renewable Energy students for the last 3 years, three students have undertaken research projects with ITPower, and one Plymouth PhD student is now an employee of ITPower. Pelamis Wave Power contribute as expert industrial advisor to the COAST Laboratory Strategy Group, were part of the Industrial Steering Group for EPSRC project EP/D077508, give an annual lecture to MSc MRE students and are funding a new PhD studentship supervised within the COAST research group. Raby is working with Trinity House in research identified by them to assess the long term resilience of rock lighthouses. A significant portfolio of events to support the public understanding of science and engineering also exists, such as Sci Bar in Plymouth, media interviews, presenting research as industry exhibitions, collaboration with the National Marine Aquarium over public display on MRE, as are outreach activities, such as school visits and workshops, Science and Technology Showcase for school children and teachers, Headstart and school maths conference activities hosted at the University. The COAST team also collaborated with composer Alexis Kirke, who produced a musical piece for the COAST Laboratory Opening involving music generated from the wave tank and at which approximately 300 invited guests attended. The COAST lab continues to provide opportunity for engagement with many specialist interest groups, schools and the general public. A Marine Commercial Director has been appointed to promote external collaborations with manufacturers and other research groups via the commercialisation of the School's extensive suite of marine resources.

**c. Strategy and plans**

Key aspects of the research strategy for impact are: (1) to work with industrialists and research end users to ensure that research is end user relevant and for easy dissemination and implementation of results, for example, staff are encouraged to appoint Industrial Advisory Boards to research projects; (2) to pursue appropriate research partnerships and collaborations with other universities and regional, national and international organisations and businesses; and (3) to enhance public engagement in, and understanding of, research and innovation through a range of channels and media, for example presenting research at professional meetings and to the general public through initiatives such as Sci Bar.

Research expertise within the Unit is aligned with the main theme of the University research in 'marine', and so a world class facility for coastal and marine research, teaching and commercial activity was prioritised. The £1.9M suite of nationally-leading Coastal and Ocean Sediment Transport facilities (COAST Laboratory) in the new £19M Marine Building has strengthened the research and industry engagement in coastal and ocean engineering, MRE, physical oceanography, air-sea interaction and other areas. The COAST Laboratory provides significant new potential for industrial collaboration, for developing new key relationships with industry, building and strengthening existing relationships with industrial partners through enhanced

capability, and for academic involvement with commercial contracts. An important component of the COAST Laboratory Strategy is to create conditions and pathways that support the exchange of knowledge and technology with businesses and other organisations including the commercialisation of research outcomes for public good. As part of this, we aim to attract high-quality, profitable commercial research projects and to develop a client base nationally, internationally and regionally to establish COAST as a central component of the SWMEP offer. In addition, we aim for students to benefit from these industry relationships through, for example, student involvement in academic/commercial research projects, invited lectures and work placements. The COAST lab is being managed for teaching, research and commercial use and is overseen by a Strategic Group with expert industrial advisors.

Structures and advanced composites were identified as close allies of coastal and marine engineering and as having an important role in the emerging MRE industry and supply chain. Research projects investigating the materials and structural integrity of new concepts for wave energy conversion are underway with industrial partners (SEA Energy Associates, EPSRC EP/K012177/1). Investment has been made in materials characterisation and analysis with investment of £439,179 in a FEG scanning electron microscope. £122k has been invested in X-ray CT scanning equipment for engineering materials and in enhanced dynamic testing facilities. These facilities will unlock greater insights and understanding from ongoing synchrotron and neutron diffraction experiments and widen research of advanced composites and nanomaterials. For example, Le is supervising two new PhD studentships investigating carbon nanotube reinforced ceramic bone replacement and titania nanotube coating on medical implants. Over the next few years, the opportunities unlocked by research into novel applications of friction processing and optimisation of structural performance will lead to even stronger collaboration with industrial partners who wish to exploit the opportunities offered by solid-state joining. This will lead to cost benefits and improved plant monitoring in thermal power plant. Marine renewable device manufacturers will have access to an increasingly sophisticated and complete suite of resources, expertise and equipment that will shorten time-to-market and reduce prototyping costs.

Our plan for the future has recognised numerical modelling and offshore engineering as additional areas of priority and potential growth for the Unit. The high performance computer cluster is being upgraded in 2013 (£186.2k); the University is investing in two PDRAs in numerical modelling across the structural integrity and MRE areas; recruitment is underway for an academic lead in offshore engineering. These developments will strengthen our numerical modelling capabilities in materials & structures, marine energy devices and fluid-structure interactions.

#### **d. Relationship to case studies**

Three case studies are submitted to this unit of assessment from Plymouth University. The first, 'Research algorithms for coastal and estuarine evolution inform flood protection policies and shoreline management plans' is based on research that has had a significant impact on coastal and estuarine flood risk management. The second case, 'Coastal erosion and management' relates to coastal engineering consultancy for Slapton Sands that led to developments in the Coastal Management Plans and the European Coastal Wiki. It demonstrates how fundamental research can be utilised within and inform coastal management plans and how such new information and understanding can be disseminated and taken up widely by European collaboration and use of internet tools. The third case, 'Innovative Friction Processing Platforms for Life-Extension Repair of Thermal Power Plant Components' is based on our innovative research into friction stir welding process with international collaboration.

The first two cases demonstrate the long research track record of coastal engineering at Plymouth University and the success of the strategy for strong industrial collaboration and for implementing innovative research findings within industrial contracts to the benefit of society. Reflection on this success has informed the development of our strategy and approach. As a result, new investments, such as the COAST laboratory, and new appointments have led to COAST establishing a strong reputation in marine renewable energy and ocean engineering to add to that in coastal engineering. The new research projects underway in these areas include EPSRC and EU funded research in partnership with end user Industrial Advisors and is likely to lead to valuable impact to wave energy device developers in the next REF period. The SOWFIA Project will report findings to European policy makers in 2013 and is expected to demonstrate strong impact on European wave energy project consenting in the next REF period. The third case exemplifies our approach of building and maintaining strong partnerships.