Institution: University of Wales Trinity Saint David

Unit of Assessment: 15 (General Engineering)

a. Overview

The University of Wales: Trinity Saint David was created through the merger of Trinity University College, Carmarthen, and the University of Wales Lampeter through Royal Charter in November 2010. A further merger with Swansea Metropolitan University (SMU) was completed in October 2012. Provision is offered across four campuses in South West Wales and London. The unit comprises members of staff located on the Swansea campus. Research is centred on three mature activities. Firstly, research into computer networking supported by a TSB research grant; secondly Non-destructive Testing (NDT) applied research in collaboration with locally based, international NDT companies supported by ERDF, EPSRC grants and Prince of Wales Innovation Scholarships (POWIS); and thirdly light-tissue computational work led by Prof Donne, in collaboration with Cyden Ltd, a major UK manufacturer of light-based medical devices, sponsored by POWIS and other ERDF grants. To support the research environment, research coordinators have been appointed to stimulate a culture of good practice and the encouragement of early stage researchers. The unit is part of the Faculty of Applied Design & Engineering, which is a diverse Faculty that submits under other UoAs. The research strategy necessarily covers the breadth of this diversity and aims to develop an environment that encourages cross-disciplinary groups.

b. Research strategy

Position regarding plans set out in RAE2008. With reference to the development strategy highlighted in RAE2008, the Faculty has invested strategically in new 8 staff appointments to build a critical mass in key research groups:

- Dr Kemi Ademoye, Dr Carlene Campbell, Dr Kapilan Radakrishnan and Dr Nik Whitehead have been appointed in the School of Applied Computing, primarily to strengthen the networks research group. Prof Tony Toole has been appointed as a visiting Chair in Computing and Tim Bashford has been appointed as a Research Associate for the HPC Wales Research & Innovation project, which supports the computational modelling group.
- Dr Steve Mosey was appointed as a Senior Research Assistant in NDT, Dr Peter Charlton and Dr Ala Al-Hussany were appointed as Senior Research Fellows in NDT and Computational Modelling. Prof Rod Thomas has been appointed as a visiting Professor in NDT.
- Prof Vanessa Cutler was appointed to lead the research agenda in the School of Glass.

Research student capacity has significantly increased since RAE2008, due to additional Faculty, EPSRC, POWIS and KESS studentships. Currently, the Faculty has the largest number of PGR students in its history, with 25 full-time and 17 part-time students. Research and knowledge transfer income has also significantly increased from £1.7m for RAE2008 to £3.2m for the eligible REF2014 period, with additional funding from ESF and ERDF for 11 PGR students from Knowledge Economy Skills Scholarships (KESS) and POWIS. The Institute of Sustainable Design forms the basis of the interdisciplinary research within the Faculty, and also to those submitted in UOA34, where a team of designers and manufacturing engineers provide support for knowledge transfer activities. Collaborative research with other institutions has increased significantly since RAE2008 through engagement with all Welsh HEIs in the £27m Advanced Sustainable Manufacturing Technologies (ASTUTE) project, which has established collaborative research in NDT, while two POWIS PhD projects with TWI Ltd (also in NDT) has further enhanced our partnership with this prestigious research organisation. The Automated Sensing Technologies for Coastal Monitoring (ASTEC) project provided a launch-pad for collaborative research between the Environmental Research Group and the Computer Networks Research Group and this work has now extended to design and develop intelligent sensors for river pollution.

Research Groups. The unit's research strategy covers all seven schools that constitute this diverse faculty. These are:

- School of Automotive Engineering

- School of Logistics & Manufacturing Engineering
- School of Applied Computing
- Swansea School of Digital Media
- Swansea School of Industrial Design
- Swansea School of Glass
- School of Built & Natural Environment

The research culture, seminar programmes and support environment is deliberately cross-disciplinary, and responds to the core research groups outlined below. The majority of applied research undertaken reflects this integrated approach to solving industry-led near-to-market problems. For example, applied research projects relevant to regional companies often require innovative design solutions and an environmental management system target. In this way, although General Engineering is the driver, the solutions are truly cross-disciplinary. Each school has established focused and coherent areas of research that are realistic in scope and depth. These are informed and influenced by external factors such as Wales and UK Government policies and strategies. These groups are centred around the areas of:

a. **Computational modelling of optoelectronic medical devices.** The work is focussed on the interaction of low energy photons with human tissue. Typical light sources are lasers and broad-band flashlamps. The medical devices are concerned with hair epilation, skin rejuvenation and fluorescence diagnostic techniques for Basal Cell Carcinoma. Over the last twenty years, the group has developed two computational models that each considers the radiative transport problem and the consequent photo-thermal and photo-chemical processes in the tissue that result from the incident radiation. The first model is a 3D time-dependent Monte Carlo based approach on an unstructured mesh. The second model employs a 3D time-dependent Boundary Element Method approach, again using an unstructured mesh. The computational models are critical in assisting medical device companies that wish to apply their technology to markets with darker skin tones. The model is particularly useful for identifying the optimal temporal profile and spectral content of the applied light energy. Since 2008 the group has been working on collaborative research projects with locally-based international companies, in particular Cyden Ltd and Energist Ltd. Since 2008, the appointment of a Senior Research Fellow, Dr Ala Al-Hussany, has significantly improved the speed of development of the transient BEM algorithm, using the Dual Reciprocity extension, with particular emphasis on the choice of radial basis function. The work has been further enhanced by a succession of three PhD students and the use of High Performance Computing Wales facilities in the development of a MPI-based parallel version of the models.

b. **Glass for architectural contexts.** The School of Glass has had significant investment in its research environment since 2008. The appointment of Prof Vanessa Cutler, a specialist in waterjet technology has created exciting cross-disciplinary research projects with Manufacturing. For example, one project is concerned with exploring new architectural products using three-dimensional curvilinear bas-relief forms created using 5 axis CNC and waterjet techniques. See, for example, Cutler's outputs (a) and (b) at www.uwtsd.ac.uk/research/glass.

c. **Coastal erosion and the maritime environment.** Cross-disciplinary research between the School of Applied Computing and the School of Built & Natural environment led to a major TSB-funded project where a network of intelligent sea-bed modem/sensors has been developed using a novel network protocol design. Field trials have been undertaken to assess the integrity of the prototype design, developed in partnership with the private sector. This technology has now been exploited by WFS Ltd, one of the private sector partners in the TSB funded ASTEC project. The research is now extending into mobile surface-based maritime sensors to monitor pollution.

d. **Product Engineering and Design, particularly covering innovative design and manufacture of composites components.** This is a major strength of the Faculty, which unusually has both design and engineering disciplines. To date, the emphasis has been on

knowledge transfer to regional companies; for example, the establishment of the £4.7m Institute of Sustainable Design in 2011 (www.isdwales.com) and the Cerebra Innovation Centre (www.cerebra.org.uk/english/gethelp/cic/products/Pages/default.aspx). In particular, an emerging strength is innovative design solutions for the elderly and the disabled. The strategy over the next five years is to publish the underpinning research behind the Cerebra work, which has had a transformational effect on the community, producing over 168 bespoke design solutions for the disabled. Further research in this group is concerned with design optimisation of compliant vehicle chassis components www.uwtsd.ac.uk/research/manufacturing.

e. **Computer networks.** The appointment of Dr Carlene Campbell in January 2013 forms part of the Faculty strategy to strengthen this research group, which also includes Dr Kapilan Radhakrishnan, Dr Kemi Ademoye and Prof Ian Wells. The focus of this group has been in the area of protocol optimisation for wireless communication. This group currently has two full-time PhD students, including one funded by a Faculty scholarship.

f. **Non destructive Testing.** Research in NDT was first evidenced in 1993, with papers on the Magnetic Flux Leakage technique and thermography. Since 2008, the emphasis has been on ultrasonic time-of-flight methods, using novel digital signal processing and parallelisation techniques for real-time diagnostic applications. Dr Peter Charlton was appointed in July 2010 as a specialist in ultrasonic NDT and his collaboration with locally based international NDT companies such as TWI Ltd, Silverwing Ltd, Oceaneering Ltd (the UK's largest offshore NDT inspection company) has added considerable research capacity. Building upon continued research in thermographic NDT by Prof Donne, this group has established itself as recognised centre of expertise. This group is supported by EPSRC and POWIS PhD scholarships.

Research in categories (b) and (c) are submitted in UoAs 34 and 17. Outputs from (a), (d), (e) and (f) are included in this Unit of Assessment.

The research strategy for the next six years will build on the multi-disciplinary engagement with industry, which is a distinguishing feature of this unit, that provides an integrated approach to engineering, design, environmental and computational solutions for near-to-market industrial problems, particularly the SME segment of the Welsh manufacturing sector. The NDT research group will continue to expand its strategic relationship with TWI Ltd, with MSc and PhD students undertaking project work. The Computational Modelling Group on medical devices will continue to develop the transient Boundary Element Method for light-tissue analysis and apply its work in an industrial context.

c. People

i) Staffing strategy and staff development

In a predominantly teaching orientated Faculty, the research strategy is based on the key objective of increasing the standard and quantity of research across all seven Schools, as detailed in Section B. There is a solid foundation to build upon in this regard for, in addition to the papers submitted in REF2, there has been a significant growth in research capacity since RAE2008, with 25 staff producing over 120 published outputs since 2008, compared to a modest 32 over the equivalent RAE2008 period. Four staff have been awarded Personal Chairs (Phillips, Donne, Wells and Cutler) in recognition of their contribution to the research environment, while a further three have been promoted to Head of School (Hole, Hazel and Williams), with a responsibility to develop focussed areas of research in their schools. Since the UWTSD merger (2012), the University has adopted a global sabbatical scheme, with applications invited on an annual basis. Staff in the unit will be supported in applications to this scheme to develop this research base. The Faculty has a strategic target of increasing the number of academic staff with Doctorates from the current level of 33% to over 50% by 2017. Currently the Faculty is supporting 14 academic staff to obtain higher degrees. The Faculty also actively supports the principle of equal opportunity with ten support staff supported for Masters degrees. This staff development policy has been successful over a number of years and seven staff have obtained their PhDs since the 2008 (Hazel, Hole, Walsh, Jenkins, Mosey, Oseng, Beeton). In addition to such CPD schemes, research active staff have a

reduction in non-research duties, using an objective system of workload assessment, where research-led performance indicators are agreed. Through the staff appraisal processes, academic staff are identified for mentoring in early-stage research and other staff are mentored as research supervisors. This policy has significantly increased the number of approved Directors of Studies in the Faculty from 6 to 19 since 2008. These targets will also be achieved by imposing criteria for new and replacement staff. The recruitment policy now normally requires a research degree and evidence of research activity. Three of the staff submitted in this UoA are new appointments due to this policy, increasing the FTE staff submitted from a modest 2.2 in 2008 to 5.0 for REF2014. Such an increase in capacity also supported by strategic investment in research posts. Since RAE2008, the faculty has introduced new research-led appointments to support the key research areas. Examples include a Senior Research Fellow (SRF) (Dr Peter Charlton) to support the NDT research, a SRF in Boundary Element Modelling to support the computational modelling group (Dr Ala Al-Hussany), a SRF in Architectural Glass (Rodney Bender) and Visiting Professors in NDT and Computing (Prof Rod Thomas and Prof Tony Toole). The University monitors compliance with the Equality Act 2010 and has relevant targets that are monitored by the University Staff development Committee.

In addition to this strategy to increase the proportion of staff with PhDs and the number of research supervisors available, the Faculty supports staff engagement with the wider research community, by publishing in journals and conferences, membership of conference committees and conference/workshop attendance. For example, members of Faculty staff are members of the scientific and organizing committees of the Logistics Research Network Conference, the International Conference on Sustainable Design and Manufacture, the International Conference on Advanced Materials for Demanding Applications and the former HEA Engineering Education Special Interest Group.

ii) Research students

The complexion of the Faculty's research student profile has changed significantly since RAE2008 as a result of its active participation in two major PhD studentship initiatives, including 4 full-time HEFCW funded KESS (Knowledge Exchange Student Scholarships) and 7 full-time POWIS (Prince of Wales Innovation Scholarship) students. A further EPSRC PhD CASE student, 4 full-time Faculty scholarships and international research students has helped to generate the unit's current PGR population of 25 full-time and 17 part-time students. Over the eligible period, 11 full-time PGR scholarships have been established from funds received from the further POWIS and KESS initiatives. In addition four full-time Faculty studentships have been generated. The Faculty intends to increase the number of Faculty scholarships from the current 3 to 7, allowing each school to achieve a level of modest sustainability in the focussed areas of research activity. The scholarship levels for the POWIS and KESS schemes are equivalent to, and in the case of POWIS, higher than RCUK recommended levels, while the faculty scheme approaches the RCUK funding level.

The University has a robust Quality Assurance infrastructure which all supervisors adhere to. This enables the Faculty Research Committee to regularly monitor student progress prior to the annual monitoring processes administered by the University Research Degrees Committee. The Postgraduate Research Office (PGRO), reporting to the Research Degrees Committee (RDC) is responsible for the administration of all PGR students, while the Research Committee (RC) considers the university's strategy for research. There is PGR student representation on both Faculty and University committees. The University has a policy of undertaking the Post Graduate Research Experience Survey (PRES), which is a key mechanism for monitoring the quality of the students' experience.

PGR students are given considerable support in career and intellectual development in line with the Concordat to Support the Career Development of Researchers. The first of two Faculty Research Facilitators oversees all PGR student activities and is Chair of the Faculty Research Committee. All Faculty research students are required to undertake an induction course covering the four domains of the Research Development Framework. A particularly well-received element of this induction is a series of one-to-one sessions, amounting to ten hours for each student, on the

employability and transferable skills elements in Domains B and D of the RDF. The Faculty employs an external consultant, with senior management experience in the private sector to run these sessions, which have received very positive feedback from students. The appointment of a second Faculty research facilitator to manage the Faculty seminar series has been very effective and the cross-disciplinary environment of the Faculty is reflected in the seminar content. All research students and research active staff are expected to present their research at these seminars.

d. Income, infrastructure and facilities

Academic Infrastructure. Monitoring of all PGR activity is undertaken by the University's Research Degrees Committee (RDC), which has administrative support from the Postgraduate Research Degrees Office. This reports to the University's Research Committee (RC), which is the Senate standing committee for oversight of all research activity, including strategic planning. At Faculty level, the Faculty Research Degrees Committee (FRDC) maintains oversight of all unit's research activity and reports to RDC on PGR student matters and reports to RC on matters of strategic interest and cross-disciplinary research. Each of these committees has terms of reference and a constitution approved by Senate.

Operational Infrastructure. The unit is supported by Research, Innovation, and Enterprise Services (RIES) (formerly Commercial Services and the Research & Development Office) which provides considerable support in the development, management, and ongoing delivery of research and knowledge transfer projects. Through RIES, support is given in the preparation of applications for grant funding, research leave and fellowships. The Unit has made use of this central support to apply for collaborative research and knowledge transfer projects and has received funding from ERDF, EPSRC, TSB, Welsh Government and the private sector.

Facilities. The majority of physical resource for undertaking research in this Unit has been procured through ERDF and private sector investment. Key areas of note that reflect our focussed areas of research, are:

- **Specialist NDT** facilities that include Pulsed thermography; Lock-in thermography; Laser scanning vibrometer; Digital photoelastic polarimeter; Full matrix ultrasonic time-of-flight NDT system; Ballistics facility for impact studies with temperature controlled chamber, and ultra high speed videography. These facilities have been regularly accessed by other HEIs in wlaes, including Cardiff University.
- **Composites facility** with large volume 5 axis CNC for full scale composites mould machining; Hot press for composite fabrication; Large volume autoclave for composite fabrication; CAE for composite component design.
- **Computational Modelling**: dedicated Transtec 32 blade medium size HPC cluster; Access to pan-Wales large scale Fujitsu HPC clusters.
- **Product Engineering & Design**, that includes: comprehensive range of Rapid Prototyping machines and optical reverse-engineering systems; High-end CAE systems: Simulia (ABAQUS), ANSYS, Siemens NX;

Research Income. Significant Knowledge Transfer income has been received to procure large items of equipment and research staff. Over the eligible period the Faculty has generated the following income streams relevant to this UoA:

- Technology Transfer Centre TTC 1003: £242,674 enabling purchase of thermographic and ultrasonic NDT equipment.
- Knowledge Transfer Centre KTC 1001: £305,000 enabling purchase of composites manufacturing centre.
- Knowledge Transfer Centre KTC 1004: £439,904, enabling purchase of Full Matrix Ultrasonic NDT and a Research Assistant.
- ASTUTE: The Faculty's contribution to this pan-Wales ERDF Manufacturing project is in the area of NDT and the income of £131,157 over the eligible period has enabled the purchase of

thermographic NDT equipment and a Senior Research Fellow, who has now become a permanent member of staff funded by the University.

- Technology Strategy Board (TSB) grant of £220,254, enabling the appointment of a Senior Research Associate in Computer Networks and the purchase of specialist equipment. This figure was the University's element of the £620,000 project grant. See http://www.internet-engineering.co.uk/ .
- High Performance Computing Wales: A one-year Research & Innovation grant of £39,208 commenced in March 2013 and has enabled the appointment of a Research Associate to support the computational modelling research group.
- Private Industry income. For the eligible period, the Faculty has received £113,000 from Belron PLC, the world largest automotive glass repair and replacement company, to undertake computational and experimental ballistics research .
- Charitable income from Cerebra - a UK charity for supporting brain-injured children. Over the eligible period the Faculty has received a total of £227,426 to undertake innovative product engineering and design work. See for example: http://www.cerebra.org.uk/English/gethelp/cic/Pages/default.aspx
- ERDF income of £1,218,723 over the eligible period to establish a new Institute of Sustainable Design, which commenced on 1 October 2011. This income supports the Faculty's Product Engineering and Design research group.
- ERDF income of £146,758 to undertake a project on 'Design for Successful Ageing'. This income supported the Faculty's Product Engineering and Design research group.
- EPSRC PhD CASE Studentship with Silverwing Ltd: Income over eligible period is £36,728
- EPSRC PHD CASE studentship with United Aerospace Ltd. Income over eligible period is £85,052
- Seven POWIS PhD studentships, each funding covering three years of study
- Four KESS PhD full-time studentships, each funding covering three years of study

The income listed above exceeds £3.2M plus the POWIS and KESS studentships.

The strategy for generating further income is based upon our distinctive applied research profile, which is evidenced through collaboration with the manufacturing sector. Consequently, we will actively submit bids for ERDF structural funds for the 2014-2020 'Coherence' Phase in Wales. Secondly, our research groups in Computational Modelling and NDT will collaborate with larger consortia for H2020 funds. The private sector income stream from Belron continues and we will pursue pan-EU bids with this market-leading, global partner.

e. Collaboration or contribution to the discipline or research base

Prof. Donne is on the editorial committee for the International Journal of Engineering Simulation. He is a regular reviewer for Institute of Physics Journals, including Physics in Medicine & Biology and J Phys D. He chairs the Institute of Sustainable Design, which is a £4.7 M project in partnership with Cardiff Metropolitan University. Over the eligible period he has examined 5 PhD candidates at other universities. He is the Principal Investigator at UWTSD for our contribution to the pan-Wales £27M ASTUTE project, led by Swansea University, and concerned with supporting the manufacturing sector.

Prof Wells is a member of the UK National Committee of the CPHC (Council of Professor and Heads of Computing) and is a founding member of the Welsh section of this body. He organised the 2013 national CPHC conference. He is also a member of the national committee of BCS Wales. He was the Principal Investigator for the TSB funded ASTEC project and has examined 4 PhD students at other universities.

The Faculty organised and sponsored the 7th International Conference for Quality, Reliability and Maintenance in 2010, in Swansea with over 50 registrants across the UK and Germany. Contribution to the research area of NDT is manifested through collaboration with:

- TWI Ltd. Two POWIS PhD scholarships: one in Ultrasonics (commenced May 2011) and the other in Thermography for composites (commenced April 2010). Each POWIS scholarship comprises £20k p.a. bursary and full tuition fees paid, for a three year period.
- United Aerospace Ltd. One three year EPSRC CASE studentship for the study of edge quality in machined composite components using pulsed thermography.
- Silverwing Ltd. One three year EPSRC CASE studentship for the study of multi-transducer configurations for ultrasonic time-of-flight.
- Swansea-based architectural company Grwp Gwalia Cyf, the largest Housing Association in Wales, which builds and maintains sustainable, high-quality housing. This collaborative project considered the application of NDT technologies for assessing the viability of recycled glass products for architectural applications. See, for example http://news.bbc.co.uk/1/hi/wales/south_west/7489576.stm
- Other industrial partners as listed in Case Study 2.
- Contribution to the research area of light-tissue computational modelling is manifested through collaboration with Cyden Ltd, evidenced by outputs declared in RA2 on computational modelling. Two further POWIS PhD scholarships in this area. This work has led to the development of a three-dimensional time-dependent radiative transport code with thermal transport and photochemistry included, based on 3D Monte Carlo and the Transient Boundary Element Method using an unstructured mesh.
- Contribution to the research area of product engineering and design is manifested through collaboration with industrial partners engaged with the £4.7 M ERDF project: Institute of Sustainable Design. Within the eligible period 72 companies have been assisted by the ISD and 5 collaborative projects undertaken. Further details at http://www.isdwales.com/en/ .
- The research undertaken for Belron PLC is led by Prof Donne and has been maintained for over ten years and will continue to develop vehicle glass damage models based on environmental factors.
- Contribution to the research area of computer networks is manifested through collaboration with two industrial partners in the TSB grant listed in section (d) above. The context of this research, which is led by Prof Wells, is in the monitoring of coastal erosion, using a distributed intelligent network.