Institution: University of Abertay Dundee

Unit of Assessment: 15 General Engineering

a. Overview

Abertay University is a compact institution, comprising approximately 200 academic staff and 5,500 students. For this Unit, such concentration enables us to integrate expertise over 4 (of 5) academic departments to deliver engineered solutions to real-world problems. The Unit is underpinned by research in engineering, modelling and simulation, human computer interaction, and materials surface science. This Unit is coupled to the wider context of a University-level strategy involving the operation of a small number of focused, interdisciplinary groups:

- SIMBIOS (Scottish Informatics, Mathematics, Biology and Statistics Centre) linking complex behaviour of individual organisms and the bio-physical structure of their environment;
- UWTC (Urban Water Technology Centre) providing research and consultancy services to UK and international water industries;
- CCSB (Centre for Cancer Systems Biology) a partnership with St Andrews and Edinburgh Universities combining complex systems modelling and interactive visualisation;
- WhiteSpace, a cross-University research group integrating computer arts, computer science, psychology, sociology and environmental sciences;
- I-SPI (Investigation, Security, Policing and Intelligence) integrating the disciplines of forensics, computer security, psychology, sociology and law to deliver real-world impacts.

This Unit submission (14.2 FTE researchers (1.2 Professors, 1 Reader, 1 Senior Lecturer, 6 Lecturers, 5 Early Career Lecturers)) constitutes four Groups: Engineering; Interactive Media; Modelling & Simulation; Security. The links between Unit Groups and University groups are:

- **Interactive Media** is embedded within WhiteSpace;
- **Engineering** is aligned to UWTC and CCSB;
- **Modelling & Simulation** to underpin scaling challenges facing both SIMBIOS and CCSB;
- **Security** links to I-SPI (forensics, cyber-security) with KT activity in the latter.

These activities have impacted directly on our portfolio of REF2014 returns. They have allowed us to consolidate existing groups and form new links with academic and industrial partners, and have helped determine our pattern of teaching provision to promote RKE–Teaching links, essential in our operating context. Within the REF period, interactions among these University and Unit groups have delivered innovative solutions and Unit impact case studies. This has given Abertay confidence to adopt a new 5-year Research Strategy, R-LINCS (see below), that integrates activities into a single Abertay-wide RKE initiative to stimulate new developments and partnerships.

b. Research strategy

Abertay Context: The University has committed in its Strategic Plans to maintaining our internationally leading role in aspects of environmental sciences (**Engineering** and **Modelling & Simulation** Groups), developing our nascent groups in policing, forensics and criminal justice (**Security** Group), and further developing our approach to demand-driven KE activity to make a significant contribution to the UK's economy, particularly in creative industries (**Interactive Media** Group). Discipline expertise from a range of subject areas is integrated and used to support discovery, innovation and translational research across traditional disciplinary boundaries.

Unit Specific Approaches to research by Group: Our **Interactive Media** Group is driving the research agenda in Creative Industries, where we have international recognition for our activities in teaching and KE (UK Centre for Excellence in Games Development (£3M, SFC funded); UK Prototype Fund for games development (£5M, ERDF & UK Govt.). Our strategy is to integrate the disciplines of computer arts, interactive computer graphics and psychology to design (arts, psychology), develop (arts, graphics) and evaluate (psychology) computer-based solutions to industry problems. For example, we work with NCR ($5B revenue), world leader in consumer transaction technologies (450 million transactions per day supported by hardware and software solutions) on the development and evaluation of self-service checkouts (NCR has more than 100,000 SSCO units enabling 14 million transactions every day) detailed in an impact case study. Another example is our interactive software to support sensory analysis for testing in the food & drink sector (with Macphie, a highly innovative food and drink SME) that Abertay will co-license.

In **Engineering**, our strategy is to link with areas where we have expertise and deploy that expertise in these areas to maximize value. For example, our **Interactive Media – Engineering** (as part of UWTC) research has partnered with Dundee City Council to develop an interactive computational modelling and visualisation tool (detailed in an impact case study) to support the planning process of the Dundee Waterfront project, a 30-year £1B investment into Dundee and the 3rd most active regeneration project in 2013 in the UK (1st Queen Elizabeth Olympic Park; 2nd Wembley City). This development includes Dundee attracting the Victoria and Albert Museum as an international centre for Design (Abertay is a partner in the V&A project). Another example is research with Biology leading to a commercially available hand-held, low cost protein aggregation monitor that has relevance in drug delivery and water pollution arenas (Norton Scientific Ltd.).

In **Security** we consider surface science and more recently cyber-security (see future strategy). In surface science, we use novel screening processes to recover forensic evidence (fingermarks, shoeprints, markings) from challenging surfaces e.g. fabric (UoA15; also atomic force microscopy for forensic analysis (UoA5)). This work is supported by the Home Office and will feature in the forthcoming Home Office Fingermark manual. In **Simulation & Modelling** we develop data- and process-driven mathematical and computational approaches to model a wide range of systems. Some alignment exists with the larger Abertay groups (e.g. simulation technologies for up-scaling in complex systems; artificial intelligence for mining large biological data sets). We will continue to work to align this expertise with strategically important research groups (see Future Strategy).

UoA15 context: Evaluation of current position against RAE2008 strategic objectives:
In 2008 General Engineering (GE) returned 10 staff. UoA15 is now returning an increased number (14.2). We have met all GE RAE2008 objectives in a dynamic staffing environment: **12 staff** returned here are **new returns** for Abertay (4 RAE2008 GE staff are returned elsewhere). The strategy of the GE RAE 2008 submission was embodied in the following (summarised) objectives:

1 Engineering to further develop UWTC and its links with SIMBIOS, and also continue the research programme on ultra-fast optical techniques;
2 Development of then IC-CAVE (now within WhiteSpace) as a centre for games-based research, and support for games-based research from our work in simulation, visualisation and mathematical modelling; develop WhiteSpace beyond four pump-priming studentships;
3 Development of a smart systems initiative with increased KT activity (from 4 projects), where smart systems encompasses hardware technologies, mathematical and complex systems modelling, system performance analysis, networks and communication, HCI, cyber-security; research in display technologies for human interaction with smart systems;

All objectives have been met as follows:

1 Since 2008 the links between UWTC and SIMBIOS have deepened to the extent that 3 of 10 staff in the GE RAE2008 submission are now returned in UoA7, an integrated SIMBIOS/UWTC submission. Another GE RAE2008 staff member is now supporting a new biological sciences submission (UoA5); Our **Engineering** Group submission concerns the preparation of (saturated) soil for construction and on stress responses of structures to loading pressures; **Engineering** also continues its research in ultra-fast optical techniques;
2 Our games-based research agenda is now a strategic research theme for Abertay and beyond this UoA15 return we are contributing in cancer systems biology (UoA5 Biology) and in food & drink (see future strategy); our research approaches in modelling, simulation and visualisation have supported our games-based research (e.g. HCI for evaluation; modelling underpinning our games-based urban planning tool); our broader **Modelling & Simulation** return also includes artificial intelligence, statistical machine learning, solar eruptions and surface modelling; WhiteSpace has helped position us as a UK Centre for Excellence in Computer Games Education and was a key influence in shaping R-LINCS (see research strategy below);
3 Our interpretation of smart systems was broad in 2008; we have since refined our work in this area to focus on mathematical modelling (1 KTP in healthcare (UoA5)), cyber-security and HCI (2 KTPs), with GE RAE2008 staff contributing to 2 KTPs in environmental science (UoA7); our KT activity has diversified beyond KTP to include Industrial Secondments, Fellowships and Interface awards; work on display technologies for human interaction spans interface display design and evaluation e.g. self-service provision, universal access.

Research strategy for the next 5 years:

Abertay has established R-LINCS (Research-Led Innovation Nodes for Contemporary Society). R-LINCS is driven by a University-wide Research Executive that manages internal research funds and drives external fund-raising activity to support innovative solutions to societal problems through 4 cross-Abertay themes: Environment, Security, Society and Creative Industries. These themes recognise Abertay's major income and output streams. R-LINCS provides the following:

- Single, pan-University research leadership to drive our discipline strengths and interdisciplinary research agenda, propose strategic research-focused appointments and mentor early-career researchers and foster external collaborations, including with industry
- Intra- and inter-theme support for research (18 doctoral students over 3 years (current Abertay has 73 PhD students) housed in a single Graduate School, which offers us a coherent, University-wide integrated training programme (e.g. research methods, writing & presenting skills, entrepreneurship); a single Graduate School serves to inculcate interdisciplinary working in our next generation of researchers, driving new research areas through cross-fertilisation;
- The Graduate School will also encompass all taught PGT and so stimulate R-T links;
- Funding for proof-of-concept RKE projects, staff training and open-access publication;
- Facilitation with public engagement channels including our STEM outreach activities, the Dundee Science Centre, our local Café Science organisers and public exhibition spaces.

UoA15 is well served by this strategy due to its large proportion (~1/3) of early career researchers and strong industry partners (especially in Engineering and Interactive Media). Our **Interactive Media** Group is the major thrust of research upon which the Creative Industries theme is founded and UoA15 staff will play a major role in theme development (e.g. new game play interaction styles and audiences); and across themes through visualisation of complex system dynamics (e.g. soil-microbe interactions in Environment, cellular signaling in cancer, computer forensics data in Security), and in development of highly interactive software to inform food and drink product design and selection (Society) and supported by external funding.

Regarding the **Security** Group, a major motivation for the R-LINCS Security theme is to develop our research strength in cyber-security. Abertay has established the UK's first taught programmes in Ethical Hacking, founded on and supported by industry-facing KTP activity. Our nascent work in cyber-security (not returned to UoA15) seeks to design out crime from systems by building in countermeasures to cyber-attack and taking account of the perspective of an attacker. We will use R-LINCS to enhance cyber-security research and increase activity levels. Likewise, R-LINCS will develop our forensic science agenda: we will use our long track record in image analysis (primarily developed in soil science (UoA7)) to develop novel quantitative approaches to forensic image processing (we have already made progress analyzing air pellet penetration into materials using our CT scanner and algorithms from modelling soil via a joint MRes (between staff in UoA7 & 15).

Our **Engineering** Group is already embedded in the Environment theme (which will be driven by SIMBIOS and UWTC). We will use our expertise in systems engineering to support the broader research agenda of sustainable living in both agricultural (SIMBIOS) and urban-rural interface (UWTC) systems. Our **Modelling & Simulation** group will continue to develop its research expertise in artificial intelligence, complex systems modelling and concurrent systems simulation technologies to underpin our applied research investigations in R-LINCS Environment (soil and cancer ecologies) and Security (forensic imaging and data mining, network analysis).

UoA15 objectives for the next 5 years are as follows:

- **Interactive Media** will lead the R-LINCS Creative Industries theme to (i) deploy new games-based hardware and software technologies in a range of research domains (entertainment, serious games, soil, cancer, food & drink) enabling us to attract Interactive Media funding from a wide range of sources and domains; (ii) increase the number of REF returned staff;
- **Engineering** will (i) drive research and KE in the R-LINCS Environment theme in partnership with our internationally leading SIMBIOS and UWTC groups, evidenced by expanded stakeholder engagement (with attending income) and in particular our distinct method for sustainability assessment with national and international stakeholders; (ii) invest in new environmental engineering labs (1200 m^2; £4.1M planned)

- **Security** to (i) develop with stakeholders a workflow to optimize evidence recovery in materials with multiple, diverse types of forensic evidence treatment; and transform from qualitative to quantitative our screening processes to recover forensic evidence, and make these quantitative analytical tools available to stakeholders; (ii) develop a new socio-technical methodology, sensitive to company economics and individual circumstances, to systematically mitigate cyber-security risks and work toward solutions that offer unobtrusive cyber-security; (iii) appoint a Chair in Cyber-Security to drive this agenda and generate R-KT income via deployment;
- **Modelling & Simulation** will integrate process-based and data-driven models, exploiting the merits of each, to deliver a multi-scale complex systems modelling framework coupled to interactive visualisation able to link local processes to emergent phenomena in partnership with academic and key stakeholder partners (e.g. soil, cancer, big data).

c. People, including:

i. Staffing strategy and staff development

University-wide staffing strategy: Abertay is implementing all 7 principles of the Concordat to Support the Career Development of Researchers. Equality and Diversity (E&D) is supported by the implementation of E&D policies for all staff and students that undergo regular monitoring and evaluation. All members of staff are required to complete an e-learning module on Diversity in the Workplace and senior staff, including academic staff responsible for recruiting researchers, are required to undertake specific Recruitment and Selection training. HR staff are part of the selection panel for appointments at Lecturer grade and above. In line with our Public Sector Equality Duties, we have published an E&D Action Plan that maintains the process of Equality Impact assessment for admissions policy, statements and procedures and makes accessible relevant software systems and supporting information (in online formats). Abertay has made a further commitment (within our SFC Outcome Agreement) to enhancing equality (objective to achieve Athena Swan Bronze Award status (by August 2015) and subsequently to progress to Silver. The resulting principles will guide development of our E&D practices for STEM and non-STEM disciplines alike. Staff previously on repeated Abertay short-term contracts have been offered permanent positions.

Abertay's staff appraisal system and workload planning align personal objectives with University research objectives as it enables an appropriate balancing of teaching, research, administration and external engagement activities to support personal career development and the strategic priorities of the Unit. Thus, early career researchers are given more opportunities to develop their research, and probationary lecturers have a lighter teaching and administration load to free up more time for research-intensive staff development. In December 2012 the University's Human Resources department conducted an audit of the University's recruitment and staff development policies to ensure that these were in line with the recommendations and guidance provided in the Concordat to Support the Career Development of Researchers (2008). The Enhancement-Led Institutional Review report (2012) from the QAA noted that Abertay's policy of workload planning allows staff to balance time across teaching, research, administration and external commitments.

Career development, training opportunities and needs are discussed with individual staff members at 6 monthly appraisal meetings. An enhanced training package to support researchers to be adaptable and flexible in an increasingly diverse and global research community has been developed with a dedicated Researcher Training fund for staff and research students (£10K p.a.) and by discipline (School) specific Professional Development funding (approx. £16K p.a. for this UoA). General researcher training provision has included annual workshops and retreats focused on grant writing, statistical methods, European Framework funding and Knowledge Transfer Partnerships. Given our small size we make good use of regional and national development and training opportunities, for example we have offered courses provided by the University of Dundee, VITAE and Leadership Foundation, targeting both experienced managers and young researchers. Communication with and between the Abertay Research Community (staff and students) is aided via a social media tool to encourage discussion, awareness and to promote interdisciplinarity.

Unit specific staffing strategy: Our submission comprises 12 FTE staff who are new submissions for Abertay. To achieve this growth we have recruited nationally from leading universities (including Cambridge, Edinburgh, St Andrews) and internationally (Australia). In the reporting period we have recruited 2 staff to our UoA15 **Engineering** Group that are integrated into UWTC. These staff

benefit from being immersed in a strong RKE active environment (UWTC has 7 staff returned in UoA7 and 5 further staff devoted to KE/ consultancy). Abertay's approach to RKE and teaching in Creative Industries is characterised by strong industry links together with state-of-the-art technology and applied mathematics. In order to deliver this agenda we have adopted a differentiated staffing approach. The staff complement in this area comprises individuals with extensive industry experience, staff with strong research backgrounds in applied mathematics (Modelling & Simulation) and human computer interaction and visualisation (Interactive Media). For **Modelling & Simulation** we have recruited 4 new staff to support our expanded Creative Industries provision. For **Interactive Media** we have drawn in staff with expertise in Psychology and also developed our own staff (from 2 of 4 internally funded WhiteSpace studentships, 2008) who are skilled in their own technological arena and in the design and evaluation of their products.

Our **Security** staff span two areas: Forensic Science and Cyber-Security. Our Forensic Science team comprises 10 staff (3 Chairs). Note two staff are returned to UoA15 (two others to Uo5, 7). Our Cyber-Security team comprises 10 staff, and has a mix of discipline expertise (digital forensics, computer system networking and penetration testing, databases, informatics, software engineering). To support our RKE activity in this area we have focused our general computer science expertise towards security and have developed staff to support this (e.g. supporting attendance at conference, workshop and international training events).

More broadly, our membership of and interactions with 3 inter-University SFC-funded Scottish Research Pools (SICSA (informatics, **Interactive Media, Modelling & Simulation**), SAGES (environment, **Engineering**), SIPR (**Security**)) also supports researcher development and provides opportunities to share facilities, research expertise (both among staff and PhD students) and access to pan-Scotland development programmes. Unit staff have regularly been supported to attend workshops and training events (e.g. hosted a UK-wide SICSA workshop on systems medicine; SICSA-linked 34th Conf. on Communicating Process Architectures and HCI2010; participated in multi-core challenge events for concurrent programming; participated in SAGES society theme meeting re 3D interactive media; surface science presentations at SIPR; contributed to SICSA research challenges in digital forensics). Staff are also supported to deepen links with Industry: for example, staff have benefitted from Royal Academy of Engineering Industrial Secondment to NCR; Royal Society of Edinburgh Scottish Enterprise Fellowship for digital media.

ii. Research students

University-wide strategy: The Enhancement-Led Institutional Review (2012) reported that Abertay's postgraduate research students (currently 73 PhD (and 21 MRes) across Abertay) were positive about what they described as a friendly, supportive and integrated academic community. This reflects the efficiency of our approach that combines a University-wide strategy with the integration of our students in the Unit's research environment. Nevertheless, we have developed ambitious plans for investment in a Graduate School to grow our postgraduate research (see Infrastructure). Our programmes are flexible to cater for a diverse range of students. We have introduced (2011) a Masters by Research, from which students may transfer to MPhil or PhD degrees. The postgraduate research student community is overseen by the Research Degrees Sub-Committee (RDS) which approves student recruitment and examination teams, ensures that research support is in place, that at least 2 trained supervisors are allocated, offers generic training events (for staff and students), and organizes an annual Post-graduate conference. Progress is monitored through 6 monthly reports on progress and thesis planning. The RDS also monitors the implementation of personal development planning (PDP), recorded in the form of an evidence-based training record which is assessed by the RDS prior to submitting the thesis to ensure adequate training has occurred. The University Roberts Fund is used to support researcher development, including support for attendance at conferences. For the coming 5 years, the University is committed to providing 18 fully funded PhD studentships (at 3.5 years RCUK stipend levels with expenses) and to developing the University-wide Graduate School, to provide a comprehensive training programme and flexible, cross-research community working spaces. Note as a compact University, much of this support is offered to both research staff and students alike.

Unit specific strategy: 14 PhD students graduated in the period. Those in the Unit (**Interactive**

Media; Engineering; Security) were embedded in an interdisciplinary research environment (White Space, SIBMIOS, UWTC) working on a daily basis and side by side with researchers with wide ranging expertise. Other students (**Modelling & Simulation**; **Security**) were housed in dedicated PhD student offices. Students have made use of opportunities to attend SICSA annual PhD conferences, SAGES Graduate Schools and SIPR annual conferences providing student-focused training and presentation opportunities. Note the Unit currently has 2 (PhD) SICSA-funded and two NCR-funded studentships (one PhD, one MRes). In addition to the Abertay-wide Post-graduate conference, requiring presentations in early years and papers in later years) students participate in departmental seminar series. Students were also supported to attend SICSA Demofest, an opportunity to present research to industry representatives and academia. Students are typically offered part-time teaching (demonstrating) duties to support career development.

d. Income, infrastructure and facilities

All of Abertay's research resources are based on one site – this encourages regular contact between researchers from different disciplines and thereby helps foster interdisciplinary research. We have further encouraged this through a move to open plan and shared facilities, with staff in different Unit groups co-located with other UoA staff (e.g. **Security**, **Engineering**, **Interactive Media** are co-located with SIMBIOS and UWTC (returned in UoAs 5 and 7)). This strategy helps ensure our facilities are used to maximum effect. For example, our HIVE (Human Immersive Virtual Environment (part of ~£0.5M SRIF development in 2006)) is used by **Engineering** and **Interactive Media**. The HIVE is a large (6mx2m) 3D back-projection facility with motion tracking and 3D sound system for immersive visualisations and is linked to our UK Centre for Excellence in Computer Games Education (£7M investment). A dedicated usability engineering lab houses a state-of-the-art eye tracker (£30K) and Bioharness telemetry systems used for monitoring behavioural and physiological responses and this is used by **Interactive Media** and in Food & Drink. Our **Security** group use our world leading X-ray CT and visualisation suite which houses 2 state-of-the-art X-ray CT machines and integrated computing facilities (>£200K growth and maintenance investment) to analyse the impact of firearms on materials. We have also invested £4.9M in a new RKE and T&L environment (30% of which is offices) including a dedicated cyber-security laboratory for RKE that offers a discrete network to enable system hacking and penetration testing in a safe environment.

The University's Estate Strategy is committed to supporting high quality research through our infrastructure, with a design philosophy that ensures new spaces are built to promote RKE-T links. We are currently planning to develop new facilities for the School of Science, Engineering and Technology (where this Unit primarily sits) together with the creation of the Graduate School. The project cost is estimated at just under £10M: approx. 1500m^2 of accommodation for the Graduate School that will include open plan office/study space, meeting rooms, workshops and social space; new staff accommodation and laboratories for the School. We have plans to develop specialist engineering workshops and laboratories, housed in a new engineering building for RKE&T in civil and environmental engineering (concept design envisages a building of ~1200m^2 with an estimated cost, including equipment of £4.1M). We have invested in a motion tracking studio that will be used for performance art / digital media research but also sports science (with emerging links to **Modelling & Simulation**). Abertay is also currently investing £2.8M to transform our ICT facilities.

Unit income is £330K per year on average and this comes from a diversified portfolio: RCUK, EU, TSB (KTP), direct industry funding for research and KT, charities. Over the course of the reporting period we have moved from largely separate funding streams in each Unit Group to awards that combine Groups both within Unit (e.g. **Engineering** & **Interactive Media**) and between units (e.g. **Interactive Media** with Food & Drink has recently secured ~£130K in industry projects). We plan to develop this approach, and the R-LINCS strategy is designing in cross-fertilisation among REF units in order to give us both a critical mass of researchers and also an agility to combine and develop core competencies in disciplines through interdisciplinary working. To support R-LINCS the University is increasing its academic staffing by 35 (~20%) research-active staff in 2013-14.

Our professional services are driven through our **Interactive Media** and **Engineering** Groups. In **Interactive Media** our UK Prototype fund has supported 72 SMEs UK-wide in creating new games IPs and 372 jobs: companies use on-site studio facilities alongside researchers and students. This project was used by HM Treasury to support the case for creative industry tax relief to the EC.

A University-wide Research Repository typically houses staff publications (taking into account any copyright issues). Staff research profiles are updated as an on going practice for all research active staff. We have a fund to meet the cost of publications in open access journals. In terms of governance, applications for external research funding are reviewed by an ethics committee and for their contribution to full economic costs, with bids where the level of overhead recovery is low requiring a case to be submitted by the Head of School. The University's Research Enterprise and Innovation Services office provides advice and support on research related matters, including costing and approvals of applications for external funding; management of the research degree students' process from their initial contact with the University to graduation; and management of IPR and contractual obligations with funders. Bringing these services together ensures that a consistent approach is taken across the University in relation to management of research projects and improves efficiency by providing a single point of contact for all research related matters.

e. Collaboration and contribution to the discipline or research base

Interactive Media has strong industry links as evidenced by our roles on e.g. Sony Computer Entertainment Europe - PlayStation First Academic Advisory Board, the Steering Group for Next Gen Skills (UKIE), membership of: Scottish Government Business Advisory Group (Chair of the Business Base Sub Group); Digital Media Industry Leadership Group; Programme Evaluator of the Technology Strategy Board. Examples of our collaborations with industry include an agreement with 20th Century Fox to allow access to technology developed by us – Fox used the technology as part of their production pipeline for a blockbuster film (yet to be released) (we are in negotiation with Disney Toons on a similar basis). Our SFC funded Moving Targets project, designed to develop new models for new media audiences, has conducted ~50 SME interventions. We have research collaborations nationally (e.g. AHRC Design in Action (6 partners); ESRC Institute for Capitalising on Creativity (4 partners) – both of which are industry/practitioner facing research hubs). The **Interactive Media and Engineering** Groups combine as a partner in an EU Interreg IVB project "iAge: e-inclusion in ageing Europe" an EU consortium (10 partners, 18 sub-partners).

In **Engineering** we have built close interactions with businesses to inform our research through Abertay-led KE networks including (in partnership with UWTC) **LoCal-Net,** our Low Carbon Land Use Innovation Network (ERDF-funded), which coordinates R&D in low carbon activities for SMEs across Scotland (123 SMEs). We have informed Scottish Government on mechanisms to promote stakeholder engagement through invited seminars. We have a strong contribution to the SAGES Society theme (sustainability assessment and stakeholder engagement, 8 Abertay members). We are a full member of the Association of German Engineers VDI, the IASS (International Association for Shell and Spatial Structures) Working Group on Tanks and Silos, ECCS (European Convention for Constructional Steelwork) Technical Working Group 8.4 on shell buckling and the CIWEM Air Expert Panel (Vice-Chair role since 2008). The **Security** Group has worked on forensic evidence recovery with stakeholders including the UK Home Office Centre for Applied Science and Technology, Scottish Police Authority, Metropolitan police with Kings College London (DNA recovery), Linde Canada, and Global Forensics. We hosted a Perceptions of Forensic Science event with 60 industry delegates. The **Modelling & Simulation** Group has national and international research collaborations. Nationally we work with York and Kent (ongoing from an EPSRC-funded CoSMoS project) on complex systems modelling, including regular participation in CoSMoS workshops (international), Strathclyde and St Andrews (astrophysics, Fellow of the Royal Astronomical Society and Member of the international study group on magnetic flux emergence at the International Space Science Institute in Bern). Internationally we collaborate with the National Science Foundation of China, and Nanjing University of Information Science and Technology.

We use these strong industry/ stakeholder links to help influence our research direction and use industry problems as case studies and resource to build our core research competencies. We then use our industry-partnership successes to instil confidence and so attract increased levels of funding (e.g. seed corn investment from NCR has grown to a sustained funding stream of ~£235K since 2010). Likewise in our work on urban planning we have used an initial internal investment (£~50K) aligned to a grant of £96K from Dundee City Council to lever a further ~£170K from diversified funding sources to continue to develop our planning tool. Across the Unit, we have co-founded the Mechatronics forum, chaired/organised major conferences (8), provided keynotes (4), edited international journals/issues (6) and regularly present at SICSA showcase Demofest.