Institution: Abertay University

Unit of Assessment: 12 Engineering

1. Unit context and structure, research and impact strategy

1.1 Unit Context and Structure

This Unit submission (**26 FTE)** is structured into four Research Groups: **Engineering** (8 FTE), **Forensics** (3 FTE), **Cybersecurity** (9 FTE) and **Modelling & Simulation** (6 FTE).

Our REF2014 UoA15 General Engineering return (14.2 FTE) comprised *Engineering* (computing, construction), *Security* (Forensic Science), *Modelling & Simulation*, and *Interactive Media*. Our environmental engineering research was submitted to UoA7 Earth Systems and Environmental Science, and our cancer biology modelling & simulation to UoA5 Biological Sciences. REF2021 Research Groups are linked to REF2014 UoAs as follows:

- **Engineering**: we integrate our construction and environmental engineering (FTE commensurate with REF2014);
    - We no longer return to UoA7 owing to a strategic shift towards UoA6; our environmental science research (REF2014 UoA7) is now submitted to UoA6;

- **Forensics**: submitted as per REF2014 (FTE commensurate with REF2014);

- **Cybersecurity**: we include this **new research group of 9FTE**;
    - This was a planned strategic growth in REF2014;

- **Modelling & Simulation**: is now distributed over UoA12 and UoA32 (Art and Design) based on research focus (complex systems modelling to UoA12);
    - UoA32 is a new Unit for REF2021 and has grown out of our REF2014 UoA15 *Interactive Media* Research Group (**REF2021 19.6 FTE**; REF2014 4.5 FTE). Strong links remain in REF2021 between UoA12 and the new UoA32, evidenced in our strategy and income.

Our REF2021 Engineering return to UoA12 reflects an increased research capacity from REF2014: the Unit now comprises 15 FTE Professorial and Senior (Grade 9 and 10) staff compared to 3.2 FTE in REF2014.

The Unit operates within the context of Abertay's Research and Knowledge Exchange (RKE) Strategy (2014-19 and 2020-25 (see Section 1.3)), R-LINCS: Research-Led Innovation Nodes for Contemporary Society, which integrates our research into an Abertay-wide initiative designed to capitalise on our compact, focused and collaborative nature. R-LINCS bridges conventional boundaries among disciplines to addresses key local, national and international priorities, particularly in partnership with private, public and third sector parties. Our strategy is ***focused collaborative research and interdisciplinary innovation for impact.***

R-LINCS has 4 cross-cutting themes: Environment (including **Engineering** and Life Sciences), Security (including **Cybersecurity** and **Forensics**), Society and Creative Industries (including **Modelling & Simulation**). R-LINCS provides:

- A single, **pan-University research leadership** to drive our discipline strengths and interdisciplinary research agenda and foster external collaborations (Sections 1, 3 and 4);
- A **cross-University Graduate School**, which provides an integrated training programme for staff and postgraduate research students (PGRS) (Section 2);
- Intra- and inter-theme support for RKE (including **funded doctoral studentships**) (Sections 1 and 3);
- Facilitation of **public engagement,** including STEM outreach (Section 4).

R-LINCS strategy is overseen by Abertay's Research Executive, led by the Dean of Research and implemented by Theme Leaders; RKE governance is managed by Abertay's Research and Knowledge Exchange Committee. R-LINCS is thus **centrally led and managed**: UoA12 research integrity and progress towards an open research environment **wholly aligns with the institution**. Abertay is fully engaged with (and a signatory of CSCDR and KEC):

- the principles of the Concordat to Support Research Integrity (CSRI)
- the Concordat to Support the Career Development of Researchers (CSCDR)
- the Knowledge Exchange Concordat (KEC)
- the Concordat on Open Research Data (CORD)
- the Concordat for Engaging the Public with Research (CEPR), which we use to guide development of supportive RKE policies, practices and structures (see Section 2).

We are compliant with our CSRI commitments: all staff, students and visiting researchers are required to adhere to the highest standards of integrity in research conduct as set out in the Abertay Research Code of Conduct (ARCoC) and engage in mandatory research integrity training (including GDPR for Researchers).

We are developing our open research environment; published outputs are open-access compliant, and we are working towards compliance with our research data (freely accessible repository) by 12/2021. Our Open Access and Research Data Management Policies, researcher development training and individual support provided by our dedicated Research Support Manager, has been used to increase staff engagement in open science/research practices, pre-registration, and the use of open-access data repositories. We are committed to the responsible use of metrics in research evaluation and are a signatory of the San Francisco Declaration on Research Assessment (DORA). Our policy and practice on research metrics use for research assessment is included within our ARCoC and is mainstreamed within our Recruitment and Promotions Policies and procedures and our REF Code of Practice.

1.2 Unit Research and Impact Strategy

Our Research Groups neatly aligns to the R-LINCS Strategy: to deliver **research with impact** by combining academic excellence with stakeholder collaboration. Much of our research depends on the interoperation with disciplines beyond UoA12 (sociology, psychology, allied health, art and design).

This interdisciplinary approach with stakeholder engagement has led to **high quality funding**, and as part of large consortia, including UKRI (AHRC, EPSRC, ESRC, MRC), Innovate UK, EU MED-ERDF and Interreg Europe, together with Knowledge Exchange (KE) funding from KTP, Scottish Government and the Scottish Funding Council (SFC).

In REF2014 we set out **Objectives** for each Group:

a. *Engineering* will (i) drive RKE in the R-LINCS Environment theme with increased stakeholder engagement; (ii) invest in new environmental engineering labs (1,200 m2; £4.1M planned);
b. *Security* will (i) optimize evidence recovery for multiple materials and evidence types with stakeholders; move from qualitative to quantitative forensic evidence; (ii) develop a new socio-technical methodology for cybersecurity; (iii) appoint a Chair in Cybersecurity;
c. *Modelling & Simulation* will integrate process-based and data-driven models, for multi-scale complex systems modelling coupled to interactive visualisation;
d. *Interactive Media* will lead the R-LINCS Creative Industries theme to (i) deploy new games-based technologies in a range of domains to attract Interactive Media funding; (ii) increase REF returned FTE.

1.2.1 Engineering

Engineering (8FTE; REF2014 9FTE) strategy has been driven through the Urban Water Technology Centre (UWTC) and the Division of Engineering and Food Science. Engineering is the **largest, longest running group** within the R-LINCS Environment theme, has sustained income streams and has benefited from R-LINCS investment to stimulate new interdisciplinary partnerships with sociology and machine learning (Objective a(i); for Objective a(ii) see Section

3.1). The Group focuses on: (i) **sustainable technologies**, **sustainable urban drainage systems** and **decision making for sustainable systems** and (ii) **geo-environmental, geo-technical & structural engineering**. For (i) we have developed a significant reputation internationally for high quality applied research over 20 years, delivering **two Impact Case Studies**. Area (ii) has largely developed within this REF period.

In **sustainable technologies** our research focus is technology use and technology at the water-waste-energy nexus. We have applied our expertise to determine the capability of decentralising wastewater treatment systems and of technologies to reduce environmental pollution. We have evaluated technological solutions for hospital wastewaters in Saudi Arabia and examined how natural flood management can be applied in Scotland and Nigeria. Our energy research spans bioenergy production including development of new bioenergy technologies.

Since 2003, Abertay has played a leading role in **sustainable urban drainage systems** (SuDS) research nationally and internationally, where we have stimulated adoption of an urban water management strategy that mimics natural ecosystem processes for drainage. We co-lead the UK-wide SUDSnet network (~1,000 members). In our **Impact Case Study**, we informed development of new statutory instruments in Wales, provided municipal land-use criteria for SUDS adoption in Malta, and influenced legal instruments for SuDS adoption in Brazil.

Our approach to **decision making for sustainable systems** recognises that engineered environmental systems are complex and management requires trade-offs among multiple competing factors. We use multi-criteria decision analysis tools, co-designed with stakeholders, and computational models linked to games technologies for interactive visualisation of sustainability criteria. In our **Impact Case Study** with Scottish Government, we have implemented a new decision-support framework to select drinking water treatment technologies and identified specific interventions to support sustainable development in Malawi. New R-LINCS funded research with sociology is exploring the adaptive capacity of communities in the face of unreliable access to water.

Our **geo-environmental, geo-technical & structural engineering** research investigates pedogenic carbon sequestration process, engineering soils for carbon sequestration and investigating critical on/near-shore soft sediments. We undertake modelling of complex systems such as thin-walled structures informing European guidelines, thermo-active geo-structures and pipelines, and dynamic event behaviours such as earthquakes.

1.2.2 Forensics

Forensics (3 FTE; REF2014 2FTE) works closely with stakeholders to improve latent fingermark detection to maximise evidence recovery (**Impact Case Study**). Recovery challenges arise when multiple evidence types occur in combination on the same substrate, such as latent marks and inks, and when recovering from complex surfaces such as fabrics and banknotes. We have identified a single step process to reduce detection time from over 24hrs to 30mins.

We worked with the Home Office and industry (Objective b(i)) to optimise recovery of evidence of multiple types from a range of substrates; e.g. we have shown fingermark ridge detail is recoverable from fabric using vacuum metal deposition, providing information for targeted DNA analysis. Our research on fast, effective fingermark recovery techniques has informed policy documents and research strategies published by the UK Home Office, Interpol and the International Fingerprint Research Group, which form the basis for operational practice. Recent work has identified fingermark development formulations that are less harmful to the environment and are better or as effective as the currently recommended techniques at developing marks with minimal interference, which are also part of Government's guidance to UK police forces.

1.2.3 Cybersecurity

Cybersecurity (new Group, 9FTE) is the largest group within R-LINCS Security. In 2017 we established the Division of Cybersecurity to manage our rapid growth. The Group adopts a socio-technical approach (Objective b(ii)), spanning human factors, networking and machine learning. Consistent with R-LINCS, **Cybersecurity** has worked across disciplines and with stakeholders, has been supported by strategic R-LINCS investment (3.5 studentships) and has attracted funding from industry, Royal Society of Edinburgh, EU and RCUK.

Our **socio-technical research** partners with psychology and sociology to undertake research at the human-technology interface. Examples include identifying predispositions associated with computer hacking performance (R-LINCS funded), working with primary school teachers and Education Scotland to develop teaching materials to support cybersecurity in the curriculum (R-LINCS studentship), exploring mobile security awareness in adults, and investigating how socio-organisational factors influence organisational security behaviour (R-LINCS funded).

Our **technical research** spans design patterns for cybersecurity (RSE-funded, Section 3.4), machine learning for intrusion detection, critical infrastructure protection, security auditing, post-exploitation analysis and attack aware software toolkits, GPGPU accelerated digital forensics privacy-preserving modelling, and secure image banks for NHS Scotland (MRC-funded, Section 3.4).

Working with NCR Corporation (world leader in consumer transaction technologies, co-funded R-LINCS studentship), we identified the impact of social presence on dishonesty at self-service checkouts. We worked with Droman Crime Solutions, Police Scotland and games company Hyper Luminal to co-design an app for training police officers to respond to cyber-crimes which is now part of Droman's training provision. New cybersecurity research in training is EU-funded (see Section 3.4).

For Objective b(iii) we appointed **two** (rather than one) **professors**: Karen Renaud (formerly University of Glasgow) and Graham Johnson (formerly NCR Corporation) to develop our socio-technical research with leadership from academia and industry. The rapid growth of cybersecurity continues: Section 1.3 outlines a £18.2M cyberQuarter (**£11.7M external investment**) to extend our working with industry.

1.2.4 Modelling & Simulation

Modelling & Simulation (6FTE (and 4FTE in UoA32); REF2014 4.5FTE (and 8FTE in UoAs 5 and 7)) explores complex phenomena over multiple scales (*Objective c(i)*), and interactive visualisation (*Objective d(i)*) in **engineering**, **physics**, **health** and **computer games**. Note *Objective d(ii)* is met by returning a new UoA32 Art and Design submission (19.9FTE).

REF2014 Modelling & Simulation was distributed across mathematical biology and computer games (returned in UoAs 15, 5 and 7). In 2017, **Modelling & Simulation** was consolidated into the Division of Games Technology and Mathematics. The Division was formed in response to the strategic importance of computer games to Abertay (in which we are a world leader) and the fundamental role that Modelling & Simulation has in games technology.

Modelling & Simulation worked with **Engineering** to provide interactive visualisations that underpin sustainable decision-making (Section 1.2.1). In Stepping Up (led by University of Manchester, EPSRC) we developed a better understanding of the water-energy-food nexus; Abertay led multi-scale systems modelling with interactive visualisation to support multi-objective decision making with stakeholders. **Physics** research focuses on high-precision simulation of multi-scale dynamical systems: we exploit games engine efficiencies for molecular dynamics simulations for plasma processing (with University of Glasgow). In work supported by R-LINCS, Royal Society and Carnegie Trust, we have procedurally generated clouds and lightning in games. With the University of Bern, our lightning model is being used in planetary Global Circulation Models.

For **health** (with Universities of St Andrews and Edinburgh) we characterised tumour tissue and cell signalling dynamics in response to therapeutic interventions and oncological mutations. With UoA32 we developed a real-time interactive visualisation of a cancer cell and this work has led to a new partnership with Macmillan Cancer Support to use network visualisation to improve cancer support provision **across the UK** (see Section 4).

In **computer games** Abertay (lead) and partners Universities of St Andrews and Dundee, were awarded **InGAME: Innovation for Games and Media Enterprise**, an **£11.5M AHRC and SFC** funded research and innovation centre. Within InGAME, **Modelling & Simulation** is playing a leading role in technology experimentation and diversification (Section 3).

1.3 Future Strategic Aims and Objectives

R-LINCS 2020-25 (Figure 1) is an evolution of our 2014-19 strategy: themes have evolved into Challenge Spaces. In a new development we are building research leadership in Pools of Excellence, i.e., distinct ways of working that cross-cut Challenge Spaces areas and discipline strengths encapsulated in academic Divisions. Over the next five years, Abertay will invest in and support c.15 fully funded PhD studentships, funded PhD studentships for newly appointed academic staff (subject to the approval of a research plan that is aligned with the R-LINCS objectives), Abertay Futures Scholarships, Pump Priming awards, and Open Access Publication awards.

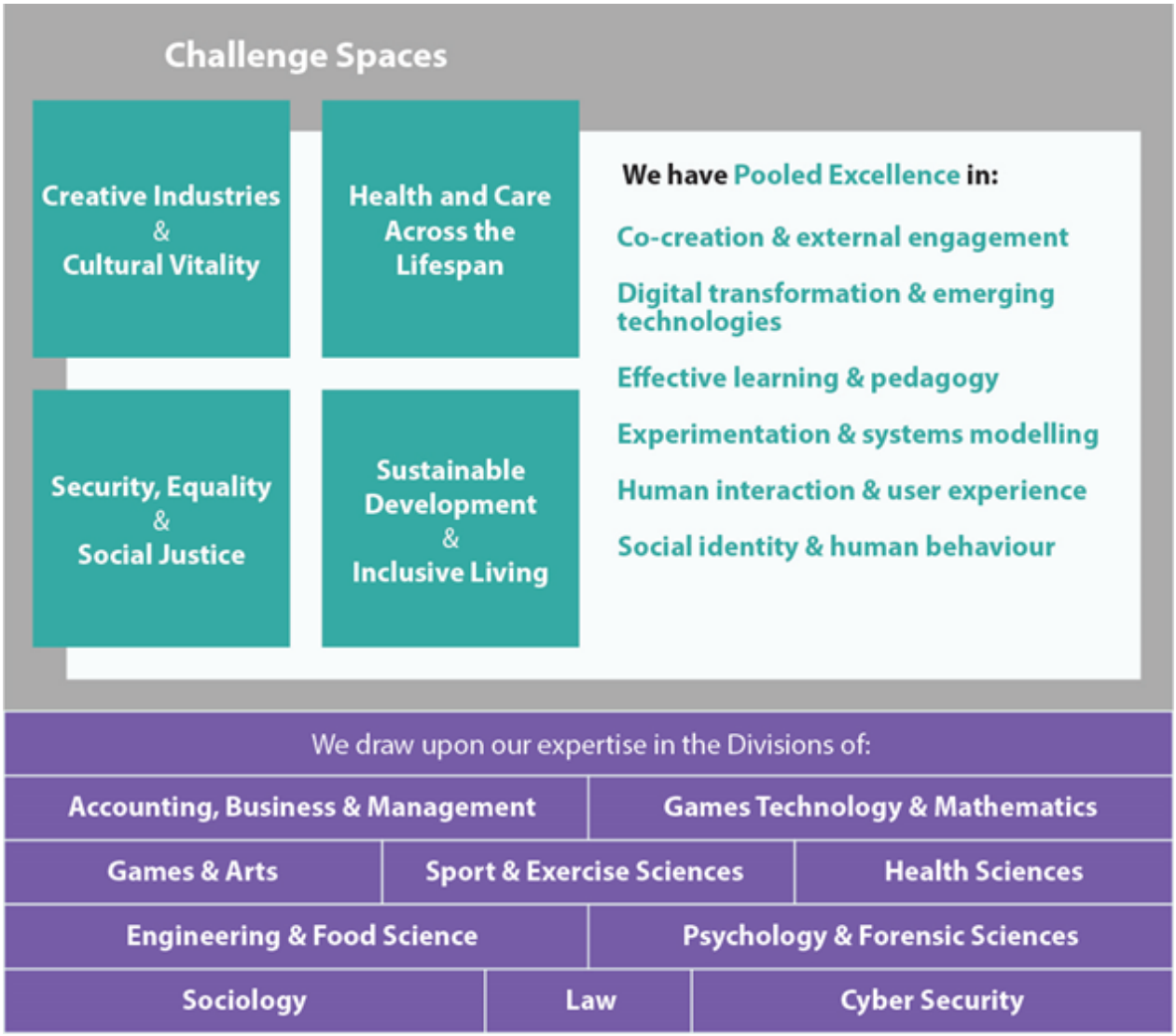


Figure 1: R-LINCS 2020-25

Engineering will maintain deep links with Scottish Government to inform policy and practice nationally and internationally. A developing focus is research on soil carbon processes in (i) micro-scale mineral carbonation in agricultural and urban soils, (ii) fate of water treatment sludges and wastewater treatment sludges (recalcitrant micro-organic pollutants from use of pharmaceutical compounds); and (iii) with **Modelling & Simulation**, developing machine learning to extract soil information from mobile phone images. **Engineering** will play a leading role in "Sustainable Development & Inclusive Living" and, based on our stakeholder engagement expertise, in "Co-creation and external engagement".

Objective 1: (a) to inform policy and practice in sustainable technologies, systems and decision making nationally and internationally; and (b) to develop our focus on soil carbon processes.

Forensics will collaborate with industry, government agencies and supra-institutional organisations to develop underpinning scientific evidence to improve forensic science and its practice. We will align to UK/Scottish Governments' strategic priorities in evidence-based policing and quality assured forensic science (including ISO17025). In addition to detecting fingermarks on complex surfaces, we will develop methods for the extraction of intelligence from crime scenes. This includes holistic interpretation of examination of evidence (e.g., effects of human factors on micro dynamics of fingermarks; chemometrics and Bayesian network analysis) with psychology and biomedical science. With **Engineering**, we will research trace evidence detection and interpretation (e.g., micro-plastics in water). Forensics will contribute to "Security, Equality and Social Justice" and, through its development of evidence interpretation "Experimentation and systems modelling".

Objective 2: (a) working with industry and government to inform policy and practice in fingermark visualisation and interpretation; and (b) to expand our work on intelligence from crime scenes, trace evidence, and environmental forensics by building interdisciplinary collaborations.

Cybersecurity will frame its future activity through a new **cyberQuarter**, an **£18.2M** (£11.7M Tay Cities Deal, £6.5M Abertay investment) on-campus Centre (~1000 m^2). The cyberQuarter will bring together academia and industry (currently 18 partners) to: create new products, markets and services; catalyse the growth of a Cybersecurity cluster that will retain and attract talent and investment; and make businesses and citizens more cyber-resilient. Central to our research will be usable security, i.e., security measures that are technically robust and realistic in their expectations of users. The scale of the cyberQuarter means that Cybersecurity will make a major contribution to "Security, Equality and Social Justice", and cybersecurity is fundamental to "Digital transformation and emerging technologies".

Objective 3: cyberQuarter will **work with industry** to research and deploy socio-technical solutions to enhance cybersecurity in the SME sector.

Modelling & Simulation will continue to enhance core technological competencies through funding in applied areas. A key growth area is emerging technologies (machine learning, high-performance simulation, dynamical systems models, etc.) linked to interactive experiences (games, games engine technologies and both entertainment and applied games contexts (e.g., manufacturing). To support this growth Abertay has invested in the Emergent Technology Centre (ETC, see Section 3) which will house a 5G network core, part of a **£4M 5G R&D Testbed** partnership with Dundee City Council and Scottish Futures Trust; Abertay is the lead R&D partner and will host the Scottish 5G Centre's first innovation hub to support R&D on enabling technologies for applications where mobile plays a key role (e.g., service delivery, Internet of Things). The 5G network will be a testbed located on the city's £1B waterfront development adjacent to the V&A Museum for Design in Dundee. Modelling & Simulation will drive "Digital transformation and emerging technologies" and contribute computational techniques to "Experimentation and systems modelling".

Objective 4: **Modelling & simulation** will work with UoA32 and **Cybersecurity** to undertake research in machine learning for network management, dynamical systems modelling, the Internet of Things and 5G-backed interactive experiences.

2. People

2.1 Staffing strategy and staff development

The Unit size has almost doubled since REF2014 (14.2FTE-26FTE) and has a broad demographic: 5 Professors (one of whom is Head of Division (HoD)), 2 further HoDs, 8 Senior Lecturers (SL, Grade 9) and 11 Lecturers (Grade 7 and 8).

In contrast, REF2014 Engineering had 1.2 Professors and 1 SL and this **increase in research capacity** has arisen from a **strategic, systematic and sustained approach to staff recruitment and development**. All Category A staff are on permanent contracts.

Recruitment: We have aggregated recruitment (see Equality, Diversity & Inclusion, Section 2.3) by School: School of Applied Sciences (SAS: Engineering, Forensics) and School of Design and Informatics (SDI: Cybersecurity, Modelling & Simulation (drawn from the Division of Games Techology and Mathematics). Recruitment and associated EDI data is only available from 2017 owing to a system update. Since 2017, SAS made 6 appointments (82 applicants): 1 HoD, 1 SL; 3 Lecturer; 1 Research Associate. Since 2017, SDI made 14 appointments (104 applicants): 2 Professors, 1 SL, 4 Lecturers, 2 Research Fellows, 3 Research Assistants and 2 Teaching Fellows.

New staff benefit from a comprehensive Induction Programme covering PGR regulations, R-LINCS, ARCoC, CSRI, CORD and CSCDR. Depending on experience, new staff undertake our PgCert Academic Practice (PgCAP) which includes an optional taught module on research covering regulations and policies underpinning research practice, building RKE networks, research planning and funding.

Consistent with the CSCDR, all staff have personal **Development Discussions** with their HoDs (Line Managers) twice a year. Development Discussions appraise both short-term research objectives and long-term plans, discuss development needs, and review any well-being and workload issues. UoA12 includes HoDs for Engineering, Cybersecurity, Modelling & Simulation and the HoD for Forensics (2014-18), which affords a strong alignment between Unit and staff development.

Development needs are met through the Graduate School and HoDs. The Graduate School has three Researcher Development Staff who, together with senior Abertay staff, provide **>100 development opportunities annually**. Training includes advanced statistics, GDPR, impact, enterprise, PGR supervision, public engagement, paper and grant writing. Where necessary, staff development needs were met by external organisations, (e.g., Fast Track Impact; Transparent and Reproducible Science training). In addition to externally sourced funding (Section 3), Divisions provide internal support for travel, conference attendance, etc. (~£135K for UoA12 over REF2021).

Academic Enterprise: R-LINCS provides leadership in Academic Enterprise (two academics with excellent KE track record). Abertay initiated Bell Street Ventures (2019), an enterprise hub to develop enterprise and entrepreneurship skills and is supported by a charitable donation and Santander Universities Network.

Mentoring: Abertay provides internal mentoring through the PgCAP. In addition, we joined a **Cross-Institutional Academic Mentoring Scheme TRAM** (from 2016) with the Universities of Dundee and St Andrews. Originally aimed at ECRs it has since been extended to senior academics and to three more HEIs. Academic staff are matched annually with mentors/mentees at external institutions to provide objective support for career development. UoA12 benefits from and contributes to TRAM (2 female, 3 male mentees; 2 female, 4 male mentors).

Promotion: In 2014, a new promotion process was adopted and a panel consisting of the Principal, Deputy Principal, all Deans, the Head of Human Resources, and an external member (usually university senior management) is convened annually to consider written submissions for promotion. Table 1 illustrates the outcome of the promotion process for SAS and SDI Divisions contributing to UoA12. The overall success rate was **34%**.

Grade	G9_SL to G10_Prof		G8_L to G9_SL		G7_L to G8_L		TF to G7_L		total apps	total success	% overall
Year	apps	suc.	apps	suc.	apps	suc.	apps	suc.			
2014	3	2	6	2	0	0	0	0	9	4	44
2015	0	0	2	2	2	1	0	0	4	3	75
2016	1	0	0	0	0	0	0	0	1	0	0
2017	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	2	0	4	2	1	0	7	2	29
2019	0	0	1	0	1	1	0	0	2	1	50
2020	0	0	2	1	4	2	1	0	7	3	43

Table 1: UoA12 promotion applications for grade (G) transitions from Teaching Fellow (TF), Lecturer (Grades 7 and 8), Senior Lecturer (Grade 9) and Professor (Grade 10).

2.2 Research students

The number of doctoral degrees awarded has **almost doubled** from REF2014 (14 over 5 years to 33.5 over 7 years). This increase has been **sustained** over REF2021: the average annual number of registered PhD students is 35.6 for a Unit of 26 FTE. Viva voce success rates have increased to 100% from 2016/17 due to a structured approach to support PGRS progress provided by the Graduate School.

All PGRS are based in Abertay's Graduate School, allowing access to training and a large peer group from other disciplines. As well as providing physical resources (allocated desk in an open-plan office, social area, IT equipment), the Graduate School provides:

- **Progress panels:** Students complete an annual progress report and presentation to a Review Panel to assure student progress, supervision quality and provide an opportunity to address any issues.
- **Personal development planning:** Students track meetings, achievements, goals and training needs into a Vitae Researcher Development Framework system, which must be submitted for approval one month before the PhD thesis. This ensures that students are systematically focused on progress, and are able to articulate research, experience and wider achievements attained throughout their PG training.
- **Annual Graduate School conference:** All PGRS are required to present their research to peers, supervisors and academic staff from across Abertay, helping students develop presentation skills and confidence in a professional context.
- **Training:** Weekly skills-based seminars are held to meet training needs, including research methods, statistics, qualitative analysis, public engagement and outreach training, academic writing, funding applications and business development.
- **Access to Researcher Development Staff**: providing tailored statistical support, and academic advice e.g., funding applications.
- **Funding opportunities:** students can apply to a dedicated fund for conference attendance and researcher training support.

To further support PGRS, staff inexperienced in postgraduate supervision are required to complete an online Epigeum course on **Supervising Doctoral Studies** and our in-house training before being mentored through a first PGRS supervision. Those new to Research Degrees examination must engage with our **Novice Internal Examiners Process** which involves in-house training and observation of *viva voce*.

Discipline-specific support is also provided. Abertay is a (subscription) member of several pan-Scotland Research Pools that are funded to stimulate collaboration amongst Scottish HEIs, including PGR training. For example, we are part of the Scottish Alliance for Geoscience, Environment and Society (SAGES), which has provided PGRS international travel grants for research visits and conference participation. PGRS have engaged in the Scottish Informatics and Computer Science Alliance (SICSA) Graduate Academy (PhD conference) and Demofest, an RKE showcase event for PGRS and staff. Internal and external funds are used to provide PGRS with conference/ summer school attendance, nationally and internationally. PhD students were also part of our showcase for UKRI research on the UKRI main stand at the American Association for the Advancement of Science conference (2019).

We have received studentships from SAGES (co-funded by Abertay), industry (e.g., NCR (Section 1.2.3)), Scottish Government (co-funded by Abertay), Northwood Trust (that leveraged additional external funds (£0.4M)) and Research Degree registration by externally funded RAs.

Recruitment is centrally managed, and our procedures adhere to the UK Quality Code for Higher Education requiring that selection is undertaken by at least three suitably trained staff and is compliant with our Equality & Diversity Policy. The University's Admissions Policy states that, subject to availability, admission is open to all those that have the ability to benefit from the opportunity to study for a given degree. The University will only admit students to programmes of research degree study that are properly resourced and supported.

2.3 Equality, Diversity and Inclusion (EDI)

To maintain consistency, inclusion and fairness all REF2021 Units have followed a centralised approach to EDI.

Abertay's ethos embeds inclusion, diversity and equality in all our policies, operations and strategic thinking. We recognise and value colleagues and students with different backgrounds, experiences and attitudes who bring fresh ideas and perspectives to the University. Since REF2014, the University has been awarded the **Athena SWAN** Bronze award (2015, 2018). Led by the Graduate School, the self-assessment team helped drive development of fair and equitable policies and practices to support researchers, staff and students across Abertay. In 2016, we were the first Scottish university to achieve the Race Equality Charter Mark.

Our **Academic Recruitment and Promotion Policies** are applied to ensure a fair, equitable, transparent and consistent process for appointing and reviewing the grade of academic staff, which is integrated with the University's grading, Role Profiles and underpinned by the principle of 'equal pay for work of equal value'. As a signatory of **DORA**, when considering appointments and promotions, we evaluate research on its own merit rather than on the journal Impact Factor.

Consistent with CSCDR commitments, all staff have undergone mandatory Diversity in the Workplace and Unconscious Bias training, and Recruitment and Selection training is required for all involved in recruitment and promotion decisions. Our **EDI Action Plan** requires an **Equality Impact Assessment** (EIA) for policy, statements and procedures and makes accessible relevant software systems and supporting information.

Our **Sabbatical Policy** encourages staff to apply for sabbatical leave for research. The policy provides for particular consideration of leave following maternity/adoption/shared parental leave to help re-establish an employee's career and allows for sabbatical leave to be explored as positive action to promote career development for under-represented groups.

The University's suite of **Work Life Balance Policies** (**Flexible Working**, **Maternity Leave**, **Parental Leave**, **Shared Paternal Leave**, **Adoption Leave, Carer's Leave**) are designed to support staff to balance work and home-life and deal with personal responsibilities. Well established policies are in place which both comply with current legislation and aim to establish a "best practice" culture. The University supports any periods of maternity leave whether or not there is additional funding provided by funders of research.

UoA12 EDI
We report the following patterns in UoA12 composition, recruitment and promotion. Note recruitment and promotion data are aggregated by School: SAS (Engineering, Forensics); SDI (Cybersecurity, Modelling & Simulation).

Composition: The REF2021 Steering Group and the REF2021 Code of Practice (CoP) Working Group represents a diverse membership. EIAs were carried out by an independent panel during CoP development. The CoP was approved by University Senate and Court to assure transparency, consistency, accountability, and inclusivity. Unit composition adhered to the CoP.

Gender equality has improved: REF2014 was ~20% female, ~80% male; REF2021 is ~30% female, ~70% male. The breakdown of staff across grades is: Prof (2F,3M); HoD/SL (3F,7M); Lecturer (3F, 8M). The UoA12 group for selecting outputs comprised 6 staff: 2F (34%) and 4M (66%). Outputs attributed to female staff represent 34% of the pool, matching the gender balance in UoA12.

Recruitment: Tables 2 and 3 show EDI data for SAS and SDI recruitment respectively.

Characteristic	Applicants	Appointments
Gender	7% Female	50% Female
Age	Average age =38	Average age = 35
Race	57% BAME	17% BAME
Sexual Orientation	4% LGBT+	0% LGBT+
Disability	0% declared disability	0% declared disability

Table 2. SAS Recruitment EDI Data (from 2017)

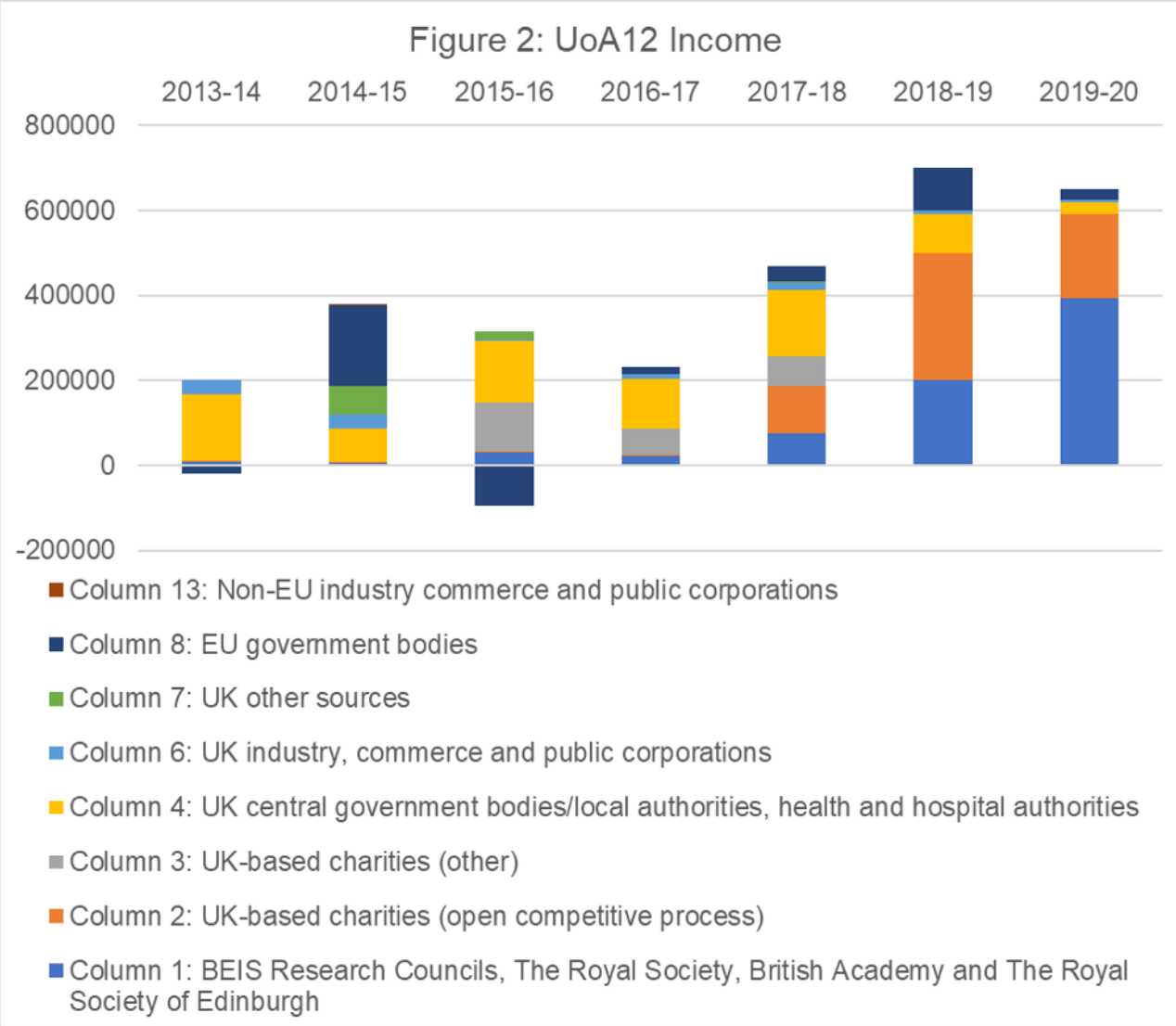
Characteristic	Applicants	Appointments
Gender	19% Female	15% Female
Age	Average age = 40	Average age = 41
Race	44% BAME	24% BAME
Sexual Orientation	8% LGBT+	N<5
Disability	7% declared disability	N<5

Table 3. SDI Recruitment EDI Data (from 2017)

Promotion: EDI data is not included in Table 1 (promotion) due to the potential to identify individuals because of the small numbers involved. For SAS 16 applications were submitted from 11 members of staff, with 7 successfully promoted (some on more than one occasion) (43% female). For SDI, 14 applications were submitted and 4 were successful (50% female).

3. Income, infrastructure and facilities

3.1 Overview
Figure 2 profiles income over REF2021 (£2.9M total), with ~50% of funding in the last two years. This rate of growth continues beyond REF2021 – we have already secured more funding than income generated over the entire REF2021 period in **Cybersecurity** (cyberQuarter) and **Modelling & Simulation** (5G R&D Testbed). Notable growth areas are (Column 1) BEIS Research Council (<5% of total (years 1 & 2) to 30% and 60% in years 6 & 7) and competitive UK Charity (Column 2) funding where a similar trend exists. The Unit has sustained support from UK and EU government, largely manifest through partnerships with stakeholders to deliver research with impact in **Engineering**.



Our achievements demonstrate an increase in ambition, reputation and experience, and reflects the strategic focus on supporting research funding submissions, strategic investment (including £330K of staff time as in-kind contribution across UoA12 to leverage external funding), and a new internal peer-review process for grant applications. The internal peer-review process has improved grant success rates and scale across Abertay (e.g., in 2020 30% success rate (average award £335K) with peer review vs 10% success rate (average award £53K) without). Research support is provided centrally by the Abertay Graduate School that provides research training (Section 2), individual researcher development support and grant development support (9.6FTE, £2.8M internal investment over the REF2021 period). Additionally, R-LINCS provides Research Leaders to coordinate and support development of collaborative ventures including stakeholder partnerships and cross-disciplinary RKE projects.

Our research is underpinned by facilities in two of Abertay's three Schools: the School of Applied Sciences (**SAS**: Engineering and Forensics) and the School of Design and Informatics (**SDI**: Cybersecurity and Modelling & Simulation). In line with R-LINCS, our investments impact multiple units. **SAS** (£4M, 2016-19) investment provided a fully equipped suite of Science Laboratories (analytical chemistry, molecular biology, microbiology, tissue culture, forensic science); Sensory & Consumer Science, Food Innovation and a Food Processing Plant. Abertay also has seven Engineering labs (Ph & Environment, Hydraulics Surveying, Concrete, Structures, Highway Materials, Geotechnics). Science and Engineering labs are supported by 3.4 FTE Technicians. These investments support UoAs 3, 4, 6, 24 and UoA12 (REF2014 Objective a(ii)) activity.

SDI was formed in 2017 to integrate Modelling & Simulation, Cybersecurity and Art & Design into a single collaborative working environment with a shared research space. This integration has been facilitated by a £5.5M investment (2019). Investment includes our ETC (valued at £1M), a research complex comprising four interconnected labs: a Game and IoT developer Lab with complex systems simulation capabilities; an Extended Reality Lab (augmented, mixed, virtual realities) with sensor tracking systems for interactive experiences; an Immersion Lab able to profile quantitatively user interactions with technology (including eye tracking, facial electromyography for reading emotions); an Observation Lab, comprising an instrumented observation space and a separate observation room. The ETC is supported by two technicians and is complemented by our Hacking and Computing Labs (see Section 3.4). This investment has supported UoAs 12 (REF2014 Objective a(ii)) and 32.

Below, we outline our income generation strategy and underpinning infrastructure and facilities for each Research Group and highlight major projects that have contributed to this pattern of income. Note that while REF 4B requires data reporting on spend our narrative reports on a research/applied research (KE) project basis to provide a clearer sense of the nature of funding received and to represent both cross-unit and cross-REF period income generation.

3.2 Engineering

Our income generation is characterised by working in partnership with stakeholders, and Scottish Government in particular, where we draw on >20 years' experience to undertake research with impact.

We are part of CREW, the Centre of Expertise for Waters (Scottish Government funded), which works in partnership with industry to develop real-world solutions. Our **funded portfolio of Scottish Government commissioned projects** includes: (1) Integrating water resource management in Southern Malawi to help Malawi's government meet sustainability goals (£109K, 2016); (2) Identifying innovative solutions for sustainable drinking water treatment (£36K, 2017); (3) Development of a Scottish Water Map (£80K, 2016) to interactively visualise the Scottish Water Sector (with Modelling & Simulation); (4) Rural SuDS to identify treatment systems for farm and field run-off (£35K, 2015). Projects (1) – (3) form an **Impact Case Study** for the Unit. A cross-cutting methodology was the use of participatory design to elicit stakeholder knowledge and developing interactive visualisations to increase stakeholder knowledge.

Our second **Impact Case Study** is founded on ESRC and EU MED Programme funding. ADEPT (ESRC, 2015-16) was a collaboration with Federal University of Minas Gerais, Brazil and Middlesex Universities. Our research justified inclusion of extensive green spaces for sustainable water management with multiple benefits within Belo Horizonte (Brazil) and has been translated into legal instruments which will deliver change for those communities. E^2Stormed (EU MED Programme, 2013-16) Influenced practice in seven Mediterranean municipalities by co-developing Strategic Action Plans to stimulate adoption of sustainable drainage approaches.

Our sustainable technologies research draws on the shared science laboratories outlined above (mass spectrometry, gas chromatography, high liquid chromatography, FTIR spectroscopy, scanning electron microscope) together with equipment for water analysis (chemical/ biochemical oxygen demand, total organic carbon, etc.), laboratory scale biochemical reactors, sewage treatment and industrial wastewater treatment pilot plants, portable landfill gas analyser and a range of remote samplers and analysers. Our geotechnics research laboratory has geo-mechanical testing apparatus such as triaxial, direct shear, vane, compaction and California Bearing Ratio.

3.3 Forensics

Forensics has worked closely with the Home Office (Dstl) where funding has been in-kind collaboration to ensure our research **contributes to UK policy and practice** published by the Home Office to improve forensic protocols for the police force **(an impact case study for UoA12**).

The Home Office match-funded a PhD (£8K to Abertay, partners Universities of Manchester and Huddersfield) to examine micro and nano scale behaviour of fingermarks on model surfaces. Findings show migration of fatty acids, with time-dependent formation and degradation of a component layer away from the fingermark ridge. We used the results of this study to develop fingermark–surface research, including two PhD projects (internally funded). We also work with industry, particularly equipment and process manufacturers, including West Technologies Forensics Ltd (UK), CST (France), and Specim Spectral Imaging Ltd (Finland), part-funding our research, enabling us to be at the cutting edge of development of innovative forensic techniques.

Our instrumentation to develop and visualise fingermarks (e.g., superglue fuming cabinets, alternative light sources, vacuum metal deposition chamber) are of the type and standard that are used in police forces and forensics providers. We also have analytical instrumentation (e.g., mass spectrometry, atomic force microscopy, X-ray computed tomography, micro-FTIR spectrometer). This combination of forensic-specific and analytical equipment enables us to link materials properties and the fundamental nature of fingermarks, or other evidence, to performance of development and visualisation processes. This in turn **uniquely enables Abertay to bridge the gap between the research laboratory, and the application of techniques at crime scenes or within forensic laboratories**.

Our approach to research feeds into Home Office and Defence Science and Technology Laboratory publications for forensic providers for operational use. Representing the only university with multiple inputs to the Home Office Source Book of experimental work on fingermark development techniques, Abertay staff were four of eighteen external contributors.

3.4 Cybersecurity

Cybersecurity is a **nascent research group** that has moved from small-scale awards to partnering in large consortia (H2020 and EPSRC/MRC funding).

Indicative small-scale awards: Our research explored the novel use of design patterns, a long-established technique for software design, in cybersecurity (R-LINCS funded) to effectively engineer cybersecurity into solutions at development time. This work led to a prestigious Royal Society of Edinburgh Enterprise Fellowship (2018-19, £41K) to develop a spin-out business. In partnership with industry and sociology, we took an interdisciplinary evidence review (including cybercrime and law enforcement) of policing responses to cybercrime in a range of countries and drew conclusions applicable in a Scottish context (£50K, Scottish Institute for Policing Research).

Consortia awards: Abertay is a partner in Foresight (€5.9M, £45K Abertay, H2020, 2019-21). Foresight is developing a federated cyber-range solution to train cybersecurity professionals. Foresight focuses on preparedness training in aviation, power grid and naval environments, thus enabling cybersecurity professionals to adapt to an evolving threat landscape and mitigate sophisticated cyber-attacks. We provide expertise on socio-technical aspects of security, contributing to the platform's interface design, exploring relevant design principles and visualisation techniques for displaying live cyber-attack data. In Pictures (£4.4M, £80K to Abertay, EPRSC/MRC, 2019-24) we are working with NHS Scotland and the Universities of Dundee and Edinburgh to develop a new national data platform for AI classification of clinical images. Abertay's role is to inform implementation of cybersecurity tools to guarantee patient confidentiality.

Our Hacking and Computing Labs together comprise 140 PCs with dedicated servers used for a mix of RKE, PGR and teaching activity. The Labs are isolated from the main University network to allow experimentation with software tools and security features without putting the wider University ICT infrastructure at risk.

We are now **leading our own partnership**, the cyberQuarter (see Section 1.3), which will provide us with a £5.1M dedicated cloud computing infrastructure (3000 Virtual Machines) which will complement the ETC (Section 3.5).

3.5 Modelling & Simulation

In line with R-LINCS, **Modelling & Simulation** has worked with other Units to generate income and sector impact. With **Engineering**, we led multi-scale modelling in Stepping Up (£1.5M, £0.18M to Abertay as partner, EPSRC) that unpacks the interconnections in management of our systems of water, energy and food provisioning. Working with partners and stakeholders Abertay provided multi-scale modelling to support complex systems decision-making process. Our work highlighted the need to face uncertainty in the decision-making process through multi-stakeholder scenario analysis.

In **health** we focused on cancer, from cellular through tissue to UK population scales. In Northwood Trust funding (£0.6M co-returned with UoA3 and UoA32) we developed systems models of the intracellular signalling dynamics of cancer cells and statistical descriptions of cancer tissue structures. To unravel the complexity of signalling model dynamics we developed a games-based playable simulation of the network that animates dynamics using an interactive interface. This visualisation tool catalysed a £0.4M partnership with Macmillan Cancer Support and the Digital Health and Social Care Institute (2017-21) to impact wider society (Section 4).

In **computer games**, with Art & Design (UoA32), our UKRI and EU funded work has influenced the creative industries sector. The project Design in Action (£5M AHRC, Abertay a partner, **UoA32 returned**, 2012-2016) demonstrated design as a key strategy for economic growth and innovation within industry. Design in Action was a precursor to **InGAME, (£11.5M, AHRC and SFC, 2018-2023**) which integrates our RKE practice from Design in Action, sector engagement from Create Converge (see Section 4) and our research in Modelling & Simulation (Applied Games in both Engineering and Allied Health (UoA3)).

InGAME – Innovation for Games and Media Enterprise – is the UK Creative Cluster for Computer Games. **InGAME is Abertay-led** with academic partners Universities of Dundee and St Andrews, and industry partners including Sony, Microsoft, 4J Studios (games include Minecraft), Beano, Outplay (UK's largest mobile phone games company). InGAME provides a R&D environment for new and experimental creative content, products, services and experiences. The InGAME Applied Games Lab enables industry to work directly with our R&D team to harness the power of computer games to solve real-world problems in games and outwith the games sector (diversification) and de-risk technologies (through experimentation).

InGAME, at its mid-point, has delivered 28 outputs (R&D projects, innovation labs, etc.) and provided networking/training opportunities to >700 people. InGAME has led to (1) InGAME International (£0.5M, AHRC, co-returned with UoA32) to develop new modes of working with games companies in China; (2) SmARtview (£250K total, £75K to Abertay Innovate UK, co-returned to UoA32) with AgriEpi Innovation Centre and Pocket Sized Hands games SME to develop an AI-powered Augmented Reality tool for animal health and productivity.

4. Collaboration and contribution to the research base, economy and society

Abertay has engaged with Scotland-wide SFC-funded initiatives to foster institutional collaboration, with academia through SFC Research Pools and with industry through SFC Innovation Centres (Section 4.1). The City of Dundee is also part of the EU Interreg North Sea Region and we have partnered in consortia to add value to industry and society (Section 4.2). Section 4.3 sets out our wider contributions to the research base.

Research with impact is fundamental to R-LINCS: we prioritise working on real-world problems. Below we give examples in environment, health, security and creative industries that map to R-LINCS Themes; much of this RKE activity funded by Scottish and EU government. To support

interaction with the research base, economy and society the Abertay Graduate School provides specialist support for research with industry including guidance on funding, IP, contracting, etc.

4.1 Research collaborations, networks and partnerships

The Unit has a leadership role in the **Research Pool** Scottish Alliance for **Geoscience, Environment and Society** (SAGES), leading the Theme "Transformations in Society and Environmental Policy" and co-leading Themes "Landscape Form, Use and Change: a dynamic Earth" and "Carbon & Biogeochemical Cycles: Sustaining Life". Theme leadership necessitates interaction and integration across Scottish research institutions and coordinating the Annual Science Meeting. Abertay is part of SAGES's Research and Innovation Committee and Executive Committee. SAGES provided PhD funding in geotechnics, and an industry placement for PhD students. SAGES has facilitated visibility and connectivity for Abertay via a hub (including Find an expert) for geo and environmental expertise and the loan of equipment (worth £40,000) for soils analysis.

With **Research Pool** the Scottish Institute for **Policing** Research (SIPR) we explored policing in the COVID-19 pandemic. In collaboration with Universities of Edinburgh, Edinburgh Napier and the Cambridge Cybercrime Centre we investigated how cyber-criminals leveraged salient events and governmental announcements to carefully craft and execute cyber-crime campaigns and profiled the impact on the workforce.

With **Research Pool** the Scottish Informatics and **Computer Science** Alliance **(SICSA)** we received networking funds (£5.5K) for international research visits (OTH Regensburg, Germany and Morgan Stanley, Baltimore, USA). The US visit involved various universities in Scotland (including Abertay), where events and workshops were attended and organised as part of the Cyber Nexus (2019), concluding with an event on women in Cybersecurity. Abertay staff co-organised and co-chaired the IEEE Cyber Science 2018 Conference, partly sponsored by SICSA (~90 participants, 26 countries).

Our cancer-cell signalling visualisation toolkit (Section 3) was a catalyst for a £0.4M partnership with Macmillan Cancer Support and the **Innovation Centre** Digital Health and Social Care Institute (DHI) (2017-). Initiated in an ideation workshop with DHI we identified the potential to combine our interactive network visualisation with machine learning to develop a service provisioning framework to allow Macmillan to profile current and future service demand for different age groups, cancer types etc. and the partnership will be rolling out an AI-backed service recommender engine **to support persons affected by cancer across the UK**.

In **Cybersecurity** we are partnering with Strathclyde University (Scottish Government funding) to (1) investigate what is deterring SMEs from pursuing Cyber Essentials accreditation, and (2) design an intervention to engage SMEs regarding cyber risks. We are working internationally with Rhodes University and Stockholm University / Örebro University to contribute to global sustainability by examining the role that cybersecurity and data protection play in an increasingly digitalised world.

We have engaged in international research visits: e.g. for **Engineering** geotechnics (University of Bremen and Geoverbund ABC/J, Germany, University of Technology Malaysia); for **Modelling & Simulation** physics (Instituto de Astrofísica de Andalucía, Spain, U. Ebert, Centrum Wiskunde & Informatica, Netherlands, the Space Research Institute, Austrian Academy of Sciences, Austria); in **Cybersecurity** (Ostbayerische Technische Hochschule Regensburg, Germany).

4.2 Wider contributions to the economy and society

In **Engineering**, and in addition to our CREW supported work (Section 3 and Impact Case Study), our pathway to impact includes LoCal-Net (initiated by ERDF funding, 2011) that stimulates innovation in low carbon technologies, products and services across Scotland. We were part of the Scottish Biofuel Project (2012-2016, Scottish Government and ERDF funded, 4 other partners) to enable Scottish businesses to access academic expertise available to achieve

lower waste disposal costs and introduce new income streams through innovation. Abertay led on anaerobic digestion, which counted for >60% of inquiries from Scottish businesses during the project. **Abertay currently plays a leading role** in the professional development and uptake of anaerobic digestion technology in Scotland.

The Unit provides **national expertise** to the working group for Eurocode EN1993-1-6 (Shell Structures) and the working group for the (not yet published) Eurocode EN1993-1-14 on Finite Element Modelling. Eurocodes are the Europe-wide standards for all aspects of the structural design and development of buildings. Eurocodes became mandatory for the specification of European public works in 2010. They are now the de facto standard for the private sector.

Engineering has contributed nationally and transnationally to the health and social care domain. We worked with the Environmental Health Department, Isle of Guernsey to study transport of pollutants in the urban air environment. “In For Care” (£154K, EU Interreg North Sea Region, 2014-20) is a 11-partner consortium seeking to optimise care provision in the face of an ageing population, the rising costs for (care) services and budget cuts. “In For Care” used the **same participatory design methodology and interactive visualisations from our CREW research** to understand user needs and to develop interactive tools to enable service access in special user groups.

Activity in **Cybersecurity** includes Co-Directorship of the Cybersecurity Capacity Centre for Southern Africa (C3SA, 2019) in partnership with the Global Cyber Security Capacity Centre (GCSCC) at the University of Oxford; Research ICT Africa; international and regional organisations. C3CA provides cybersecurity capacity-building activities in the Southern African region. We work with the Scottish Business Resilience Centre to provide internship students who undertake security assessments for clients using Abertay’s SME Security Assessment Methodology.

Modelling & Simulation are part of Create Converge (EU Interreg, 2016-21) **co-returned with UoA32** (£3M total, £0.12M to Abertay) focusing on transmedia – the convergence of creative technologies across sectors, (e.g., film, games), to deliver new ways of working and to reach new markets, (e.g., food, architecture). Our contributions include games for virtual film production (now an Erasmus+ project (UoA32)) and development of bespoke game controllers. Create Converge is on track to impact 30 SMEs (new ways of working) and 50 new transnational interactions.

4.3 Contributions to the discipline and research base

Engineering (8FTE)
Prizes/awards: **VIBES Award** (Scottish Environment Business Awards) 2015 Co-operation winner (with partners including Wimpey and Scottish Government) to create SUDS technology to help control rainwater and promote green infrastructure. Unit member named as an ICE (Institution of Civil Engineers) **invisible superhero**: ‘Eco-crusader’ by ICE Scotland in 2019 and selected as one of 80 participants for the prestigious international **Homeward Bound** initiative, a year-long women in STEMM leadership programme culminating in a voyage to Antarctica 2019 –2021.

Grant reviewing: EPRSC Reviewer, Panel Interviewer for NERC, ESRC Peer Review College.

Fellowships/ Honorary: Fellow of the Royal Society for the Encouragement of the Arts, Manufactures and Commerce.

Sector contribution: SUDSnet network and conferences: The network (~1000 members) has a mission to connect professionals and researchers in sustainable surface water management across the UK and Globally. The Unit has coordinated all SUDSnet events (including two international conferences). Scientific Committee for Association of Researcher in Construction Management.

Professional bodies: Membership of Institution of Structural Engineers, Chartered Engineer/ Civil Engineer/ Water and Environmental Management, Institute for Civil Engineers, International Society of Soil Mechanics and Geotechnical Engineering, British Geotechnical Association.

Reviewing for Journals: including Pressure Vessel Technology ASME and Advances in Structural Engineering, Engineering Geology, Nature Scientific Reports, Geosciences, Minerals, Measurements, Applied Sciences, Environmental Accounting and Management, Ecological Economics; Water, Air and Soil Pollution.

Outreach: Royal Academy of Engineering- Ingenious Awards (2015, 2019). Women in Science representative for Abertay (2011 – present). STEM Ambassador (2017 – present) undertaking multiple engagement activities for schools and public every year.

Forensics (3FTE)
Grant Reviewing: EPSRC

Fellowships/ Honorary: Fellowship of Institute of Physics

Sector contribution: Invited talk at VIET Vacuum, Ion & Electron Technologies 2017; Invited talk at IWSSPP International Workshop & Summer School on Plasma Physics 2014. Session Chair Chartered Society of Forensic Sciences DNA & Body Fluids Forum Conference.

Professional bodies: Trustee and Council Member of Chartered Society of Forensic Science, Institution of Engineering & Technology, Chartered Physicist.

Editorship: Editorial Advisory Board Member World Water: Stormwater Management

Reviewing for journals: including Science & Justice; Forensic Chemistry; Journal of Forensic Sciences; Journal of Forensic & Legal Medicine; Journal of Physics D: Applied Physics; Journal of Physics: Condensed Matter; Journal of Vacuum Science A; Materials Research Express; Nanotechnology; Surface & Coatings Technology.

Outreach: Forensics contributions to LIFT OFF delivers the Scottish Funding Council's national Schools for Higher Education Programme in Fife and Tayside raising awareness of opportunities to access HE (Abertay hosted).

Cybersecurity (9FTE)
Grant reviewing: Assessor for the 2017 and 2019 rounds of the EPSRC and GCHQ's Academic Centres of Excellence in Cybersecurity Research. Member of the GCHQ Master's Certification Panel for sessions 2016, 2017, 2019, 2020. South African National Research Foundation Thuthuka Programme (2017). NordForsk (2016; EU Call: Society, Integrity and Cyber-security); SICSA Cyber Nexus; Carnegie Trust for the Universities of Scotland.

Fellowships/Honorary: Visiting Professor at Dalian Maritime University. Honorary Research Associate 2020-2024 (University of Cape Town)

Sector contribution: Vice-Chair: IFIP Working Group 11.8 Information Security Education. Working Group member of the Joint Task Force on Cybersecurity Education assisting with development global cybersecurity curricular guidelines. Invited talks: KDU University (Malaysia) "Cybercrime and the security of connected cities" 2017. Member of Scottish Qualifications Authority's Development Team for cybersecurity in schools. Chair: Digital technologies, big data and cybersecurity, 2019 South Africa-Sweden University Forum. Programme committee: IFIP International Symposium on Human Aspects of Information Security & Assurance. Programme Committee, – International Conference on Cyber-Technologies and Cyber-Systems 2018. Chairing session on the Role of Education in Cybersecurity, Holyrood (2018, 2019).

Professional bodies: Association for Computing Machinery. Association of Information Systems. Chartered Psychologist and Associate Fellow British Psychological Society, Member of the Chartered Institute of Ergonomics and Human Factors.

Editorships: Associate Editor: Journal of Intellectual Capital. Associate Editor: European Conference on Information Systems (2019 Security/Privacy Track). Associate Editor: European Journal of Information Systems (2016 Special Issue on Security and Privacy in 21st Century Organisations)

Reviewing for Journals: including Computers & Security; European Journal of Information Systems; Behaviour & Information Technology; Information Technology & People; Decision Sciences Journal; International Journal of Human-Computer Studies; Journal of Information Security and Applications; African Journal of Information Systems; Information Technology and People

Outreach: SICSA Christmas Lectures *"How the Black Hat (Hackers) Stole Christmas"*, featuring a demonstration of an IoT child's toy, and a discussion on open-source intelligence (2018). Social Market Foundation event, SNP Conference, Digital security: how do we keep our money – and ourselves – safe online? *Glasgow, Scotland* (2017).

Modelling & Simulation (6FTE)
Grant reviewing: EPSRC Associate Peer; Expert reviewer for EU–Marie Skłodowska-Curie Actions individual fellowships and Innovative Training Networks.

Fellowships/Honorary: Fellow of the Royal Astronomical Society. Fellow of the Royal Society of Biology. Visiting Professor, Faculty of Business and IT, Ontario Tech University; Visiting Fellow, University of York; Honorary Research Associate, School of Physics and Astronomy, University of Glasgow.

Sector contribution: Abertay represented UKRI research on the UKRI main stand at the American Association for the Advancement of Science conference (2019, 2020). Women in Games Executive Board Member, Scottish Innovation Centre DataLab Ambassador, Keynote: We Love Games, Plenary: European Biotechnology and Technology Network (2016, 2017); Conference Organising Committee, ESCAMPIG XXIV, 2018.

Professional Bodies: American Institute of Aeronautics and Astronautics, Institute of Physics.

Editorships: Editor Scientific Reports

Reviewing for Journals: including American Institute of Physics: Physics of Fluids, Proceedings of the Institution of Mechanical Engineers, Journal of Aerospace Engineering, Solar Physics, New astronomy, PLOS One.