| **Institution:** |
| Glasgow Caledonian University |

| **Unit of Assessment:** |
| 11 - Computer Science and Informatics |

1. Unit context and structure, research and impact strategy

<u>Context and Structure</u>

Since REF2014, the Unit has vigorously pursued its strategic objectives per the University's mission "for the Common Good" and within the framework of the University's Research Strategy that addresses three societal challenges: Inclusive Societies, Healthy Lives and Sustainable Environments, which in turn are guided by the UN Sustainable Development Goals. The Unit's staff are located in the School of Computing, Engineering and Built Environment (SCEBE) and distributed across three academic departments (Computing, Cyber Security & Networks, Applied Computer Games).

The University has seven Research Centres that collectively create a research environment for achieving the strategic research goals of the University. SCEBE is host to three of these: SMART Technology, Climate Justice and Built Environment & Asset Management. The Unit's work is conducted within the SMART Technology Centre and its associated research groups, but often in collaboration with colleagues whose work is aligned with other Research Centres. The University's Research Centres and research groups are very well supported by several other University departments including Graduate School, People Services, Research and Innovation Office, the Careers Service and the Communications & Engagement Directorate.

<u>Progress since REF2014</u>

The Unit has focused on improving the quality of its research environment rather than expansion, and on strengthening its collaborations with regional partners in line with the University's role as an anchor for the regional economy. The evidence includes:

- an increase in staff submitted <u>from</u> 13 FTE (2 professors) <u>to</u> 14 FTE (6 professors)
- an increase in research doctoral degrees from 14.0 FTE to 36.34 FTE (160% increase)
- an increase in the percentage of journal outputs from 65% to 97%
- an increase in regional industrial collaboration funding such that it forms c50% of all funding
- the co-location and shared administrative resources of the SMART Technology, Climate Justice and BEAM Research Centres to enable colleagues to share ideas and collaborate to solve large complex problems
- enhanced researcher recruitment, development and peer review processes
- richer impact engagement and interactions with industrial sectors, policymakers, government, schools and the general public.

<u>Research Strategy and its Implementation</u>

The aim of the Unit is to research into the design, development and evaluation of computer-based systems for applications in two thematic areas: Sustainable Environment and Digital Health. These themes are shaped by the University's strategy, its intellectual strengths and its collaborating partners' requirements. The general approach is the development and evaluation of new products in terms of fitness for application purpose and impact, whilst advancing knowledge about the selection and adaptation of processes, methods, and tools for product development and evaluation.

The formulation, implementation, and management of research strategy is the responsibility of the SCEBE Research Committee of which the three hosted Research Centre Directors are members. The strategy is monitored via the annual performance review of the Research Centres and Research Groups. Key Performance Indicators (KPIs) include international research publications, PhD completions, grant awards, knowledge transfer, engagement with stakeholders and the public, and the planning and management of research impact.

Research Organisation

Research Centres and groups are determined both strategically, from emerging research areas that look to be of lasting importance and present substantial research challenges, and by developing successful growth activities from current research themes. New Research Centres are approved by the University's Executive Board. Within the Unit, each research group leads on a coherent intellectual investigation of its sub-discipline within Computer Science.

The SMART Technology Centre was formally constituted in 2019 to reflect the co-ordinated interdisciplinary research carried out between colleagues working across the University on technologies and applications that drew upon ideas from Data Science, AI, IoT and End User Efficacy. The Centre's key application themes are Sustainable Environments and Digital Health and its work is most closely aligned with UN SDGs 3 (Good Health and Well-being), 4 (Education), 7 (Affordable and Clean Energy), 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production) and 17 (Partnerships to achieve Goals). The Centre ensures that groups are outwardly focused, responding to opportunities for applications and cross-pollination of ideas. The research groups are:

- Cyber Security, Networking and Communications (CSNC)
- Applied Games and Engaging Technologies (AGET)
- Artificial Intelligence & Internet of Things (AI/IoT).

The CSNC group was formed from the merger of two REF2014 research groups, Network and Communication Systems (NACS) and Interactive and Trustworthy Technologies (ITT). It explores the design, development and evaluation of computer network architectures that balance communications performance and security requirements. The scale, scope and location of these networks varies and includes low power and high power environments, building and city infrastructures, above water and underwater.

The AGET group was formed by refocusing the efforts of the REF2014 group, Visual, Affective and Pervasive Systems (VAPS). It examines the effect of computer games and other technologies, notably music, in professional contexts such as supporting health and wellbeing, understanding climate change impacts, awareness-raising of contemporary social issues and organisational development.

The AI/IoT group was formed in 2017 to investigate the design, development and evolution of computer-based systems that collect, manage, analyse and visualise large real-time datasets typically from sensors attached to physical artefacts. Industrial engineering equipment and physical infrastructure monitoring applications have been a common problem focus. Different neural network configurations have been a solution focus.

Staff Appointments

Appointments are made to reinforce the work of existing groups or establish new groups, and to build synergies with other groups. Senior appointments and academic promotions are made to build leadership strengths. Since REF2014, Mannion, having served 4 years as Vice-Principal (Research) 2012-16, has joined the AI/IoT Group and led the formation of the SMART

Technology Centre. The Unit has also appointed Morison (now promoted to Professor), Zhang, Gibson and Jenkins to this group.

Research Funding

Following REF2014 one aim was to increase research funding from regional partners in line with the University's role as an anchor for the regional economy. This tactic is paying off. The Unit's work has seen a significant increase in regional collaboration funding and this now forms c50% of all the Unit's funding. Much of this is through the Innovate UK KTP scheme on the application of AI to industrial engineering problems.

Doctoral Supervisions

Another strand of the strategy was to recruit more postgraduate research students directly to the Unit but to also increase the supervision contributions to the many projects located in different Units requiring considerable computing input. The significant increase in research doctoral awards from 14.00 FTE to 36.34 FTE is a testament to the success of this approach.

Research Culture

The enhancement of the research culture is enabled by a range of activities including annual research celebrations, capacity building and innovation events, Research Centre seminar series, journal clubs, hackathon activities, and strong encouragement to attend and present work at networking events e.g. seminars, conferences, workshops.

Impact strategy and its Implementation

The aim of the Unit's impact strategy is for its research to be translated into demonstrable impact for the benefit of the different communities that it serves. The strategy's objectives are to:

- Raise understanding of the scope of impact
- Embed impact thinking across the research project lifecycle
- Develop a shared resource base to collect ongoing impact
- Increase the number of projects with external partners having clear pathways to impact
- Curate impact.

SCEBE have collaborated with the University's Graduate School and Communication & Engagement Directorate to run training and development seminars for researchers that cover impact management, stakeholder engagement, public engagement and media training. Colleagues are also pointed to publicly available online resources.

Beyond the researcher training and development programme, researchers are strongly encouraged, through the peer review and mentoring processes, to consider impact early and often, during grant preparation, post-award implementation and post-project reflection.

Resources

The Unit benefits from Knowledge Exchange Officers in the Research and Innovation Office (RIO) to support the planning and management of its impact as well as from a Research Impact Officer appointed to the School in 2017. They have provided significant guidance to researchers about approaching stakeholders for planning, collecting and curating evidence of impact. SCEBE has a business partner in the Communications & Engagement Directorate that is also

very helpful in targeting media outlets and explaining the research and its impact to suit each media outlet's target market.

Future Strategy

The Unit will remain committed to the two application themes of Sustainable Environments and Digital Health and to strengthening its collaborations with regional private, public, and third partners in line with the University's role as an anchor for the regional economy. Its work will be guided by the University's Research Enabling Strategy 2030 and the strategy of the SMART Technology Centre.

Academically, in Sustainable Environments, future research will focus on algorithms, protocols and processes for automated monitoring, diagnostics and self-adaptation of engineering systems infrastructure, computer network architectures and cyber-security management, and will include an examination of the risks and limitations of self-adaptation. In Digital Health future research will focus on exploiting opportunities that machine learning can provide in supporting automated patient monitoring and predictive diagnosis whilst exploring the strengths and weaknesses of machine recommendations towards patient diagnosis and their role in the decision-making process. Both themes will be supported by a programme of work that examines the integration of different engagement and visualisation technologies, AR, VR, audio and the appropriate blend of these for different application contexts.

To underpin both academic themes the Unit is developing an initiative called Data Science for the Common Good that will enhance the Data Science capability and capacity across the University. There will be a new programme of work to examine the notion of Common Good Datasets and the different governance mechanisms for those datasets. The work will include collaborating with colleagues in the University's Research Centre for Health (ReaCH) who have secured GCU's approval as an ESRC Data SafePod Network site from July 2021 (one of only two in Scotland) enabling safe access to large data sets including those from the NHS and the ONS.

Operationally, the Unit will broaden and deepen the application reach of its ideas and outputs by expanding the range of its interdisciplinary collaboration with research groups inside and outside GCU. The Unit will also develop its work to drive more citizen engagement in shaping its research agendas as part of the University Research Enabling Strategy 2030 goal to be a world leader in social innovation.

2. People

Staffing Strategy

The aim of the staffing strategy is to place research excellence at the heart of academic recruitment and staff development. Specific objectives are:

- to require academic appointments to demonstrate existing or potential leadership
- to ensure all research group themes are supported by staff at a range of levels of seniority and experience
- to provide all staff with the research support and development to enable them to achieve their full potential
- to conduct and govern its research following the principles of the UUK Research Integrity Concordat.

Recruitment & Retention

All academic staff are involved in research, teaching, and knowledge exchange and so candidates must have existing capabilities or the potential to excel in each of these. The Unit's recruitment strategy is to strengthen the number of professors through professional development and academic promotions (e.g. Cassidy, Larijani and Morison secured Professorships in the REF period) and then invite them to mentor and support new, talented, but less experienced appointments (e.g. Zhang, Jenkins, Gibson, Farrell) as well as existing staff (e.g. Knox, Moore were promoted to Senior Lecturer). The academic interests of new hires have to align with the broad themes of designing, developing and evaluating computer-based systems for applications in Sustainable Environment and Digital Health, and their technical expertise has to be aligned with one of the three research group areas.

Compared to REF2014, there has been a small increase in staff submitted from 13 FTE to 14 FTE, but the number of professors submitted has increased from 2 (13%) to 6 (43%).
In 2020 the three Research Centres (SMART Technology Centre, Climate Justice and BEAM) collaborated to appoint a shared Office Administrator to support conference and event management.

Staff Development

The University holds the HR Excellence in Research Award (HREiR) committing to the implementation of the Principles of the Researcher Development Concordat. This framework includes actions around Researcher Recognition and Value, Researcher Support, and Personal and Career Development.

Staff development programmes are guided by the Vitae Researcher Development Framework. The University recognises the importance of maintaining a balance between different academic activities, and this is supported by policies covering flexible working, workload management, sabbaticals, and a Professional Development Annual Review (PDAR) Scheme in which time allowances are given to engage with research work based on pre-agreed deliverables and line management support.

Support for implementing the Vitae Researcher Development Framework is led by the Graduate School, with input from People Services, RIO, the Careers Service, the Communications & Engagement Directorate and SCEBE, but also draws upon the services offered by the networks the Unit is connected into e.g. Deans & Directors of Graduate School Network, the Scottish Informatics and Computer Science Alliance (SICSA), the Scottish Government's Data Lab and CENSIS Innovation Centres. The Graduate School leads on researcher development e.g. project planning, PhD research supervision, managing research teams, writing retreats, managing impact; People Services on general HR management e.g. recruitment, running PDARs, unconscious bias, mental health, equality & diversity; RIO on locating research opportunities, grant writing, research integrity, post-award grant management, commercialisation; the Careers Service on career planning; the Communications & Engagement Directorate on public engagement, media training, marketing; SCEBE on local support mechanisms and processes.

Industrial Experience

Many projects have been with collaborating partners from different sectors, notably KTPs. Throughout these collaborations, researchers and PGR students learn about the scope and scale of partners' short-term and long-term problems and the constraints within which solutions must fit. Over time researchers develop a sharper understanding that bold solutions to cross-sector problems must be capable of being contextualised to be effective in different settings. Cultivating this attitude has enabled the building of new collaborative partnerships.

Peer Support

All researchers seek feedback from experienced colleagues in both informal and formal settings, such as writing retreats and grant-writing proposal workshops. Writing retreats are valuable in offering feedback from colleagues who specialise in academic writing, and from colleagues from different disciplines who can provide objective, technically uninformed perspectives. All researchers submitting work for external funding engage in the SCEBE Peer Review process to improve the quality of grant applications over £50,000 and where GCU takes a lead role within a consortium. Proposals are reviewed early and regularly in the process by a group of experienced researchers and project leaders. The peer-review process serves as an ongoing support mechanism. SCEBE's Research Management Group, which is made up of the Associate Dean Research, Research Centre Directors, Senior PGR Tutor, Impact Officer and Senior Research Administrator, oversee the peer review process and formally record peer review outcomes.

Early Career Researchers (ECRs) are assigned a mentor, typically an experienced researcher who provides confidential support for all aspects of the academic role, such as advice and guidance on the establishment and maintenance of a research programme, workload management, grant proposal writing, and lecturing and tutoring. There is also a School-wide ECR Group that meets regularly and provides additional support. This group has representation on the SCEBE Research Committee. ECRs have reduced teaching loads in their first year of employment (at the rate of 50% of normal loads), to give them opportunities to develop their independent research career.

Established researchers are also recognised by GCU as having particular challenges in sustaining a high level of research activity throughout an entire career, and provides mechanisms that enable staff to maintain research productivity and focus. This is built into reduced teaching workloads (typically by 50%). There is also a sabbatical programme for those who take on significant managerial roles for fixed terms. Staff who are relieved from teaching and administrative duties for a term are provided with travel support based on an agreed, realistic productive research plan.

PGR Student Management

PGR students benefit from a comprehensive programme supervision structure in line with the University's processes and enhanced by the Unit.

Recruitment & Registration

The Unit has strengthened its approach to ensuring prospective candidates are well prepared and clear in their understanding and motivation about undertaking a PhD programme. Typically, staff have an informal engagement with prospective candidates before a formal interview is conducted with two or more staff members including an experienced supervisor.

A Director of Studies and supervisory team are appointed to support each student. Directors of Study have experience of successful supervision into completion. All supervisors have secured PhDs or have significant industrial experience in their cognate areas. All supervisors undergo initial and on-going training in the supervision of PhD candidates. Each PGR student typically has a minimum of two but often three staff members who provide different technical but also pastoral perspectives. PGR students are embedded in their relevant research groups but also have ample opportunity for cross-discipline discourse via co-location in a mixed-discipline office environment and the annual student-led GCU postgraduate research conference.

Following recruitment, the student's initial registration is reviewed by the cognate area PGR Tutor, Senior PGR Tutor and/or Associate Dean Research to ensure that the project is of

sufficient PhD quality, aligned with the University strategy, supervised by a suitably experienced team and that resources will be made available to deliver the research.

There are two induction events for new PhD students. The first is carried out by the Graduate School and the second is carried out by SCEBE. The Graduate School induction covers general information on the University including the Graduate School, registration processes, what to expect, personal development plans, and a tour of the University facilities. The SCEBE induction event focuses on summarising its support mechanisms including supervisory teams, seminars, research groups, student networks, important contacts e.g. Associate Dean Research, the PGR Programme Administrator, PGR Tutors, and includes a tour of SCEBE facilities.

Progression & Retention

Research students submit a progress report after nine months. The quality of the report is assessed and the student is orally examined by two academics to determine eligibility to progress to PhD. Their recommendation is considered by the SCEBE PGR Progression and Awards Board. On satisfactory examination, the student is permitted to progress to the completion of the PhD. The outcome and feedback are given to the student.

All PGR students submit monthly meeting records with the supervisory team. These records enable a SCEBE PGR programme administrator to follow up any related progress issues with one of the PGR Tutors or the Associate Dean Research. These records are also used by the UK Border Agency to assess the visa status of international students.

Student Development

Each PhD student develops their own learning development plan that includes opportunities to apply for graduate teaching roles and other relevant work experiences. Students receive feedback on the development and implementation of the plan from their supervisory team. They are also encouraged to write a reflective log so that their personal development can be self-evaluated.

Each PGR student is allocated a nominal budget of £1,800 to support their professional development. The scope is varied and includes enhancing technical skills, soft skills development and conference attendance.

Students are invited to participate actively in SCEBE's Research Groups by attending meetings and seminars. PhD candidates are strongly encouraged to disseminate their research to wider academic communities by publishing in refereed journals and through participation and presentations at national and international conferences. Students also have the opportunity to participate in research doctoral colloquia over their 3-year PhD tenure. SCEBE also run a student-led postgraduate research conference, where PGR students can present their research work and ideas in a supportive peer environment and receive critical feedback from the wider School research community. In September 2019, SCEBE opened this internal event for participation by PGR students from other Universities, so that GCU students can benefit from a more extended peer support network.

Some students have also been involved on the Steering Committee of the annual SICSA PhD Conference.

Evidence of Success

During the REF period, the Unit has returned a year-on-year average of 35 registered PGR FTE. The number of research doctoral degrees during the period was 36.34 FTE compared

to 14 FTE in REF2014, a 160% increase. Overall PGR student satisfaction is sitting at 88% compared to a cross-sector average of 81%.

Equality and Diversity

GCU takes a whole institution approach to advance equality, diversity and inclusivity and it is an integral part of the University's Strategy 2030. It is part of our identity and this flows through our Common Good mission and strategy, and supporting activities, and is reflected in our culture. The embodiment of the University's Values and Behaviours Framework guide and reflect our day-to-day interactions.

GCU's Equality Outcomes Framework describes the actions and activities that the University is taking to implement a commitment to equality and diversity. The Equality and Diversity and Dignity at Work policies and practices are deployed across all aspects of the recruitment and career management of all staff and students. The University undertakes Equality Impact Assessments (EIAs) when making strategic decisions, operational decisions, and writing and implementing policies to ensure that any adverse or negative impact on equality is identified and addressed. All staff undergo training to ensure that individual and collective approaches to policy implementation are robust and embedded in practice.

The University and SCEBE have both been formally recognised for their commitment to promoting gender equality by attaining the Athena SWAN Institutional Bronze Award (2016) and are awaiting the outcome of Athena Swan Silver applications, with a growth in the percentage of female academic staff from 22% to 26% and has a short-term target of 30% by 2022 (percentages for this Unit cannot be shown due to the low numbers of staff within the Unit). Black Minority Ethnic academic staff have increased from 19% to 24%.

Of the 36.34 FTE research doctoral awards reported to REF2021, 32% were UK students, 68% from outside the UK.

In SCEBE a special appointment of PGR Student Equality and Diversity Champion for PGR students across SCEBE, an addition to the University's mandated representatives, ensures that different PGR perspectives are listened to, represented, supported and advised appropriately, in an impartial, non-judgmental and confidential manner. The role also provides input into the design of University policies and procedures.

In 2020 SCEBE introduced financial support for PhD stipends during pregnancy and parental or adoption leave.

3. Income, infrastructure and facilities

Income

The overall funding for the REF2021 period (£1.47m) is slightly down from the equivalent REF2014 period (£1.59m). However, there have been year-on-year funding increases since 2017/18 and several recent awards have not yet realised their full income (£218k with Aggreko awarded Jan 2020, £485k with Mitsubishi awarded Apr 2020). The Unit has secured 8 KTPs amounting to £1.8m awards during the REF period.

The Unit's income can be separated into two SMART Technology themes: Sustainable Environments and Digital Health and includes:

Sustainable Environments

- Morison was awarded £218k in 2020 for a project called Machine Learning for Asset Prognostics with Aggreko Ltd. It is using machine learning technologies for manufacturing and assembly asset prognostics in an Edge Computing Environment.
- Morison was awarded £493k in 2019 for a project called the Smart Factory in collaboration with Mitsubishi Electric Air Conditioning Systems Europe Ltd. It is using IoT sensing technology and machine learning to provide predictive maintenance to improve factory efficiency.
- Morison & Mannion were awarded £242k in 2018 for a project called Supply Chain Security Optimization with Intrallect Ltd. It is developing a novel software-based platform for secure data sharing of sensitive information using crypto fragmentation, biometrics and blockchains.
- Mannion was awarded £212k in 2018 for a project called Automated Software Systems Integration with Eureka Solutions. It is developing a novel automated API integration solution drawing on techniques from advances in natural language processing.
- Morison was awarded £181k in 2017 for a project called Enhanced Visual Inspection using Deep Learning with Geckotech Solutions Ltd. It developed new real-time deep learning algorithms for automatic detection and segmentation of faults within transport infrastructures e.g. tunnels, bridges.
- Morison was awarded £166k in 2015 for a project called Structural Monitoring of Tunnels with Geckotech Solutions Ltd. It developed a novel Imaging Data Acquisition system for the capture of tunnel structures.
- Larijani was awarded £161k in 2017 for a project called Real-time Security monitoring of IoT Environments with Stream Technologies Ltd. It developed new methods of real-time security monitoring random neural networks.
- Larijani was awarded £145k in 2015 for a project called Low Power Wide Area Wireless Sensor Network (License Free Spectrum) for Environmental Sensing with Stream Technologies Ltd. It developed an autonomous Radio-Frequency Identification (RFID) solution with energy harvesting for implementation in low power wireless sensors.

Digital Health

- Farrell was awarded £238k in 2016 from Southampton University under an NIHR-funded project called Engaging Adolescents in Changing Behaviour (EACH-B) project to design a diet education game as part of a large complex multimode behavioural intervention.
- Cassidy was awarded £117k in 2015 from NESTA (37K), Edinburgh & Lothian Health Foundation (60K) and Playlist for Life (20k) to design, develop and evaluate a new mobile application to enrich wellbeing for dementia sufferers through the use of personalised playlists, and create a Citizen Science platform for data collection and knowledge transfer.
- Cassidy & Knox were awarded £35k in 2014 from the Carnegie Trust to establish the Scottish Music and Health Network, an interdisciplinary collaboration to set up new pathways of translating research findings into clinical practice, by involving patient organisations and health and/or music practitioners.
- Cassidy was awarded £41k in 2018 from AHRC to establish, with the University of Ghent, an International Games Network of experts in games studies, digital learning and the music industry.
- Cassidy was awarded £10k in 2019 from the SingFit charity to evaluate the impact of a SingFit Music Therapy mobile application on the wellbeing parameters of those living and working with dementia in the Care Home.
- Cassidy was awarded £17.9k in 2018 from Creative Scotland with ABC Creative Music to gamify their music provision in schools

- Cassidy was awarded £3k in 2019 from the Sporting Memories charity to design a novel mobile application to engage older adults living with dementia and/or loneliness through sporting knowledge.

Infrastructure

The University is located on a single campus in the city centre of Glasgow in which the Centre's laboratories and facilities are concentrated, underpinning many of the Unit's research projects and funding applications.

Laboratories

There are nine principal laboratories used for research, all housed in a single building on campus:

- AI Lab: equipped with high-end data processing machines to support the application of resource-hungry machine learning algorithms.
- Networking Lab: supports design and analysis of the next generation of digital wired and wireless networking infrastructure.
- Advanced IoT Lab: deep learning servers, wireless sensors, IoT, measuring equipment, smart home and other IoT platforms.
- Cyber Security Lab: allows students to experience and combat 'real-life' cyber-attacks.
- eMotion UX Laboratory: a unique facility supporting staff and students in the design and development of user experience evaluation and psychophysiological technologies including face reading technology, physiological and brain wave measurement, motion and emotion capture, behavioural and interaction recording studio.
- Serious Games Lab: a cutting-edge design space to support serious games design and development featuring a range of engagement technologies e.g. VR/AR/Audio.
- Audio Laboratory: enables the role of sound and music to be explored in professional contexts.
- Virtual Reality Lab: a resource for projects aiming to understand the dynamics and implications of interactions among people in immersive virtual reality simulations (VR).
- Virtual Reality Driving Simulator Lab: the VRDS Lab is the only VR driving simulation and testing facility in Scotland and one of the few in the UK and Europe. It is a fully immersive CAVE facility that entails a real-life Mercedes A-Class vehicle rewired for simulation purposes offering surround visual projection, 7.1 audio and vibrotactile devices installed in the vehicle's cabin to simulate the tarmac imperfections. The simulator is fully customisable to accommodate different vehicular equipment, driving scenarios, VANETS, weather and traffic flow conditions in a Digital Twin Model of the motorway network around Glasgow.

Office Accommodation

The office accommodation for the three Research Centres (SMART Technology, Climate Justice and BEAM) are co-located on the same floor, in the same building as the laboratories. The University has also invested in office accommodation to co-locate many SCEBE PGR students. This enables the students to build networks that broaden their understanding of different technologies and application contexts and to enhance their support of each other. Some students, but not all, need regular access to specialist equipment in laboratories. In these cases, consideration is given to re-locating them to offices closer to this equipment.

Facilities

The Glasgow Caledonian University Ltd is the University's commercial arm that provides a professional framework within which staff can undertake consulting. Working through the Research and Innovation Office, it handles both legal and administrative aspects (e.g. contracts, insurance, invoicing) as well as providing a single point of contact for third parties looking for specific expertise.

The commercial exploitation of novel ideas emergent from students, alumni and staff is supported by an incubator facility, UHatch, managed by the Research and Innovation Office. UHatch is positioned as the first step on an escalator of enterprise accelerators and business support offered within an overarching Scottish Government Business Development framework. It provides members with time-limited free office space, professional mentoring, enterprise workshops and talks, direct and indirect funding, networking and one to one guidance, and receives sponsorship funding from Santander Bank.

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

Collaborations

As described in Section 3, the Unit works closely with several key stakeholders through collaborative projects and strategic partnerships. The Unit also collaborates with colleagues in other GCU Units being submitted. For example, Morison collaborates with Alkali and McGlinchey (engineers in the SMART Technology Centre) on the Mitsubishi project (see Section 3) and Cassidy collaborated with Mason (GCU Yunus Centre for Social Business & Health) on the musical playlist for dementia sufferers.

Networks and partnerships

During the REF period, the Unit has been an active partner in 15-20 Innovation and Advanced Innovation knowledge transfer projects involving two national Scottish Innovation Centres: Data Lab and Sensors & Imaging (CENSIS). Morison was awarded an industrial doctorate scholarship funding from the Data Lab to run alongside the second Geckotech KTP, has given a keynote talk and been a panel discussant at Data Lab events.

Cassidy was a Trustee and Advisor for Playlist for Life, Sporting Memories, ABC Creative Music and SingFit, advising on the opportunities and outcomes of music and engaging technologies in the processes and practices of the charities/companies.

Moore was the organiser and committee member of the Scottish and Audio Acoustics network. He served as Chair for the Audio Engineering Society Scottish Group until 2019 organising various research events including the 26th UK Audio Engineering Society Conference on Audio Education.

Academic Collaborations

Tianfield collaborates (co-authored papers, PhD supervision) with the Research Group of Artificial Intelligence, a Ministry of Education of China Key Laboratory for Industrial Process Systems Engineering directed by Qian, Fellow of Chinese Academy of Engineering, at East China University of Science and Technology, Shanghai. Some of this work was supported by the National Basic Research Program of China (2012CB720500), the National Natural Science Foundation of China (U1162202, 21276078, 61203157), and the New Century Excellent Researcher Award Program from the Ministry of Education of China (NCET-10-0885), the Shanghai Rising-Star Program (13QH1401200), and the Fundamental Research Funds for the Central Universities. Tianfield also collaborates with Mu (Tianjin University) to design and

develop a cloud computing-based platform for smart grid environments with funding from the Royal Society of Edinburgh (RSE) and the National Natural Science Foundation of China (NSFC); with Tang, Xu and Zhao (Chongqing University of Posts and Telecommunications) to investigate different designs of software-defined wireless networks with funding from the National Natural Science Foundation of China (NSFC) and the Chongqing City Government; and with Lin (Beijing University of Posts and Telecommunications) to investigate federated learning in edge computing.

Charissis has co-authored papers with Drikakis (Vice President for Global Partnerships, University of Nicosia, Cyprus) and was invited to Nicosia to present his work in VR/AR training research and applications in the Greek Cypriot Ministry of Defence; co-authored papers with Altarteer (Dar Al-Hekma University, School of Design and Architecture, Jeddah, Kingdom of Saudi Arabia) presenting new methods of VR e-Commerce and Technology Acceptance Methods; collaborated with Wang (Volkswagen R&D Beijing, China) on Intelligent Transportation Systems; with Alfalah (The University of Jordan) on human rehabilitation and Falah (Al Balqa Applied University, Jordan) for vehicular AI and VR medical training.

Mannion has collaborated (i.e. co-authored papers, tutorials) with: Savolainen (Vice-President Global Software Danfoss Electronics, Denmark) and was invited to Danfoss to present work on software product line engineering; Kaindl (University of Technology, Vienna) on Requirements Engineering for product lines; Ozcoc (Baskent University, Turkey) on cyber-security and who spent six months as a Visiting Academic to GCU in 2019/20.

Farrell collaborated with Milkoreit (Political Science at Purdue) and Vervoort (Copernicus Institute of Sustainable Development at Utrecht) on the Mellon Foundation-funded work on a climate change game design and implementation. Farrell also hosted Vervoort in 2016 to run a Game Jam with food-production-under-climate-changes as a theme.

Nazir has collaborated (co-authored papers) with Kaleem (COMSATS University – No.3 in Pakistan). He collaborated with Newey (James Hutton Institute at Aberdeen) and van der Wal (School of Biological Sciences, Aberdeen but now at Swedish University of Agricultural Sciences) to develop and exploit wireless sensing environments. He has also collaborated with Camvista, the remote monitoring live streaming video company, to enhance their product suite.

Zhang has collaborated (co-authored papers) with Liao (Central South University, China).

Gibson has collaborated (co-authored papers) with Amira (Qatar University); Dali (University of MEDEA, Algeria); Guessoum (University of Blida, Algeria); Cuntz & Palke (HTWK Leipzig).

Contribution to the Discipline

Professional Societies

- Tianfield - Chair, Technical Committee on Cyber-Physical Cloud Systems of IEEE Systems, Man and Cybernetics Society.
- Charissis – Technical Committee Member IEEE Consumer Technology Society (IEEE CTSoc).

Funding Bodies

- Tianfield - a member of EPSRC College.
- Cassidy has reviewed funding applications for AHRC and ESRC.

Journal Editorial Boards and Reviewers

- Tianfield: Editor-in-Chief, Multiagent and Grid Systems, an international journal of data science and engineering; Associate Editor, IEEE Transactions on Systems, Man, and Cybernetics: Systems.
- Charissis: Editorial Board Member of Applied Sciences, an MDPI Journal; Special Issue Editor for Digital Health Applications of Ubiquitous HCI Research, Multimodal Technology and Interaction (MTI) MDPI; Special Issue Editor for Artificial Intelligence and Emerging Technologies, Applied Sciences MDPI.
- Shahrabi: Serves on the Editorial Boards of Hindawi/Wiley International Journal of Wireless Communications and Mobile Computing, International Journal of Internet of Things and its Applications, International Journal of Cloud-Computing & Super-Computing, and has served on the Editorial Boards of Journal of Urban Design for Ubiquitous Computing (2015-18), International Journal of Wireless Communications, Networking and Mobile Computing (2014-16), International Journal of Smart Home (2007-18), and as an Associate Editor of the Journal of Information Processing Systems (2009-19).

Journal Reviewers

All colleagues submitted have served as reviewers for a variety of journals including: IEEE Access, IEEE Transaction of Computational Social Systems, IEEE Trans in Industrial Informatics, IEEE IoT Journal, IEEE Transaction of Computational Social Systems, IEEE Transaction on Consumer electronics, IEEE Consumer Electronic Magazine (CEM) Journal, Ad hoc Networks Journal, Journal of Building Engineering, Wireless Communications and Mobile Computing Journal, Journal of Information Security and Applications, The Journal of Electromagnetic Waves and Applications, Neural Processing Letters, Psychology of Music and Musicae Scientiae, Journal of Sounds and Music in Games, Requirements Engineering, Information & Software Technology, Systems Software, Automated Software Engineering, Empirical Software Engineering and Medical Informatics, MDPI Journal Sensors, MDPI Multidisciplinary Journal, MDPI Journal Applied Sciences, MDPI Multimodal Technology and Interaction (MTI), Springer Journal Virtual Reality (VIRE), Springer Journal Universal Access, Springer Journal Cognition, Technology and Work (CTW), Springer Journal Eurasip Advances in Signal Processing, Elsevier Computers and Security Journal, Elsevier Building and Environment Journal, Elsevier Journal of Applied Soft Computing, Elsevier Journal of Biomedical Signal Processing and Control, Elsevier International Journal of Human-Computer Interaction, Elsevier Journal of Applied Ergonomics, Elsevier Journal of Digital Signal Processing, Journal of Information Processing, International Journal of Internet of Things and its Applications (IJIoTA), Journal of Urban Design for Ubiquitous Computing (IJUDUC), International Journal of Cloud-Computing and Super-Computing (IJCS), International Journal of Smart Home(IJSH).

Conference Leadership

Tianfield: Chair of IEEE International Workshop on IoT Big Data and Blockchain (IoTBB'2019) at IEEE BigData 2019; Chair, International Workshop on Conversational Agents and Chatbots with Machine Learning (ChatbotML'2018) at IEEE BigData 2018; Chair, International Workshop on Big Data Analytics for Cyber Intelligence and Defense (BDA4CID'2017) at IEEE BigData 2017; Organiser and Chair, Special Session on "Cyber-Physical Clouds", 2015 IEEE International Conference on Systems, Man, and Cybernetics 2015; Co-Chair for 15th IEEE International Conference of Industrial Informatics (INDIN'2017); Co-Chair Future Internet and Networks Symposium, at 11th EAI International Conference on Communications and Networking 2016. He also won Best Paper Awards at the 15th IEEE International Conference on Intelligence and Security Informatics (ISI'17) and the 2nd IEEE International Conference on Cyber Security and Cloud Computing (CSCloud'15), New York, USA, 3-5 November 2015.

Shahrabi: Served as a board member for the World Congress on Engineering since 2007, General Co-Chair of the 33rd International Conference on Advanced Information Networking and Applications (2019); programme committees of over 80 international conferences including the 7th EAI International Conference on Industrial Networks and Intelligent Systems (2021), the 3rd International Conference on Big Data Engineering and Technology (BDET2021), the 5th International Conference on Systems and Networks Communications (ICSNC 2020), the International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (2020), the 3rd Smart Cities Symposium (2020), the 5th IEEE Annual International Smart Cities Conference 2019, the 11th International Conference on Computer Science and its Applications (2019), the 13th International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, and the 4th EAI International Conference on Industrial Networks and Intelligent Systems (2018); Morison was on the Technical Committee for International Conference on Signal Processing Systems (2014).

Nazir: Served as a Cloud Computing Working Group member for the ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE) for 2019 and 2020.

Larijani: Sponsor/Exhibit Chair of the IEEE World Congress on Computational Intelligence (WCCI) 2020 in Glasgow and has helped chair and organise several events including Cognitive and Computational Intelligence. He was also Programme Chair for the 2019 International Conference on Deep Learning and Machine Learning in Emerging Applications (Deep-ML).

Mannion: Served on the Programme Committees of ACM International Systems and Software Product Line Conference (2019, 2018, 2017), IEEE European Conference on the Engineering of Computer-Based Systems (2017), Euromicro Conference on Software Engineering and Advanced Applications (43rd in 2017, 40th in 2014).

Knox: Organised the SEMPRE Conference on Music and Health, Oct (2015); European Society for the Cognitive Sciences of Music's International Conference of Music Perception and Cognition.

Cassidy: Organised and helped to run Mapping the Future for Music and Health Research in Scotland (three meetings of the Scottish Music and Health Network in 2014 and 2015); AHRC Network: Guitar Heroes in Music Education? Music-based video games and their potential for musical and performative creativity (two workshops and an AHRC Network Award Public Engagement Event in 2014, 2015).

Zhang: Served on the Programme Committee of the 2nd International Conference on Blockchain and Internet of Things (BIoT 2021).

Charissis: Served as a Co-organiser of ACM Siggraph Asia (2015) special session workshop on Head-Up Displays and their Applications; Co-Chair IEEE (2014) for Big Data Architecture and Analytics session, in International Conference & Expo on Emerging Technologies for a Smarter World (IEEE CEWIT 2014).

Keynotes and Invited Talks

- Tianfield: Keynote at Blockchain and health services, at the IEEE International Workshop on IoT Big Data and Blockchain (IoTBB'2019); Protecting virtualization for cloud computing, 5th Holyrood Annual Conference on Cloud Computing in the Public Sector, Holyrood (Connect), Edinburgh, UK, 23rd September 2014.
- Morison: Keynote - International Conference on Industrial Engineering and Industrial Management (2017), International Conference on Frontiers of Signal Processing (2015).
- Cassidy: Keynote at Society for Education, Music and Psychology Research Conference (2015).

- Mannion: Half-day tutorials at IEEE International Conference on Requirements Engineering (2019, 2018, 2017, 2016, 2015), ACM International Conference on Systems and Software Product Lines (2019, 2018, 2017, 2016), International Conference on Advanced Information Systems Engineering 2018 (CAiSE 2018), International Conference on Software Reuse (2015), International Symposium on Applied Computing (2014).
- Knox: Audio Engineering Society Christmas Lecture (Dec 2014): 'The Psychology of Sound and Music'. Filmed and broadcast online by the BBC. Invited talk at the Royal Conservatoire of Scotland in Jan 2015: 'Music technology, effects on the listener and communication'.
- Jenkins: Several invited speaker engagements for The Data Lab and ScotlandIS.
- Charissis: Invited lecture to BCS Glasgow 2017; Invited lecture to Institute of Physics & Aerospace, Kinross 2016.

Consultancy

The Unit has participated in 15-20 projects funded under the Scottish Funding Council's Innovation Voucher scheme. These are small projects (value £10k) to support innovations in product design, processes or services at Small to Medium Enterprises. They allow the SMEs access to the R&D expertise within the Unit which is outside the SME's capability. Occasionally these projects lead to Advanced Innovation Projects and in one case an Innovate UK KTP (Safehinge Ltd, secured in 2021 due to Covid-related delays).

PGR Examiner Roles

Staff from the Unit have carried out external PGR examiner roles at the following institutions:

- University of Glasgow
- University of Wales Trinity Saint David
- University of Aalto (Finland)
- Liverpool John Moores University
- University of Jordan, Amman
- Auckland University of Technology
- University of Strathclyde
- Nottingham Trent University.

Media Coverage

- Charissis was interviewed by STV 9 O'clock News, STV Glasgow late bulletin, and Science (June 2015) about Head-Up Displays, and Virtual and Augmented Reality in future vehicles; by the Scotsman Newspaper (2016) about VR Current Trends and Future; by the Daily Record (Sept 2014) about VR/AR and collision avoidance systems; and by the Daily Mail (2014) about smart windscreen displays. This interview was also published by Le Figaro (France), WallStreet Online (Germany) and other media across Europe. Charissis presented the effects of drinking and driving in support of the new Scottish regulations in a radio and TV interview titled "Putting Scotland's New Drink Drive Limit to Test" (Dec 2014), broadcast by 13 radio stations across Scotland. Charissis was interviewed by Strategy Analytics New York (2020) about Digital Twin Cities and AI.
- Knox has provided expert comment about the science of hearing and sound perception on a range of radio broadcasts, including the BBC Radio Scotland Science programme Brainwaves.
- Cassidy has provided expert comments on music and wellbeing and applied games in a range of media forms from BBC radio shows to BBC and ITV segments.

- Jenkins received TV media coverage following an article in The Conversation about using satellite systems for monitoring birds of prey.
- Mannion was interviewed by the Scottish Daily Mail about AI in general and spiritual robots.
- Farrell's climate change game work was covered in The Conversation. He also provided expert comments on general gaming issues e.g. the promise of console-free gaming to Wired magazine: https://www.wired.co.uk/article/google-stadia.

Engagement with Research Users, Beneficiaries, Policy Makers

Mannion wrote GCU's Research Strategy in 2014 and contributed to its refresh in 2017. Between 2012-2016 he served on Universities Scotland Research & Knowledge Transfer Committees, represented GCU at UUK research events, and orchestrated GCU's input into the UK and Scottish Government's research and knowledge exchange policy developments. He was also a member of the Scottish Funding Council's FE/HE ICT Strategy Group to advise the Scottish Government on the FE and HE sectors' approach to the implementation of the McClelland Review of ICT Infrastructure in the Public Sector in Scotland. In 2020 he gave oral evidence to the Independent review of SFC's research pooling initiative (Sept 2020). From 2011-2015 he represented Universities UK on the board of the Higher Education Academy.

Charissis was invited to participate as a member of Transport Scotland specialists' advisory board Strategic Partnership Board (SPB) (2018-2019) for the planning of future policies of Scotland's Road Safety Framework 2030.

Farrell's climate change simulation game, funded by the Mellon Foundation, was co-designed and evaluated by climate change policy advisers. It was played and evaluated by international climate change policy negotiators at the UN Climate Change Conference in Bonn 2018 and the UN Climate Change Conference in Katowice 2019. Farrell's general knowledge of game-based learning was exploited and translated into a book resource for teachers (http://eduproject.eu/game-based-learning/downloads/GameOn-Book-V1.pdf) under an ERASMUS project Game-Based Learning in School Education (Game On) (2016-17). Farrell's diet education game for the Engaging Adolescents in Changing Behaviour (EACH-B) Games for Health project directly involved adolescents to help with its design, development and evaluation.

Cassidy's work on the Playlist for Life Project involved patients with dementia, their loved ones and carers, through stakeholder analysis, co-design and development of a unique app to support and enrich wellbeing for those living with dementia through the use of personalised playlists, while addressing the digital inclusion agenda. Her work on the Opportunities' and Outcomes of Music Games for Music Education involved engaging user beneficiaries in an event to transfer knowledge and practical experience of engaging with and applying music technologies to bridge formal and informal musical activity.

Gibson co-organised and ran the Video Quality Experts Group (VQEG) Glasgow Meeting (2015) in the University of the West of Scotland, involving participants from universities, including RISE (the Research Institute of Sweden), Ghent University, London Imperial, and participants from various companies, including Qualcomm, Intel, Adobe, Netflix, Amazon, Sky.

Moore ran the Action on Hearing Loss summer studentship (2016) in collaboration with the MRC/CSO Institute of Hearing Research Scottish Branch, a major hearing research group in the UK undertaking international-class research.