Institution:
Robert Gordon University

Unit of Assessment:
11 Computer science Informatics

1. Unit context and structure, research and impact strategy

Computing research at the Robert Gordon University (RGU) operates under the broad theme of data science. We are driven by both the interests of our researchers and the industrial collaborators who help to test research findings in a practical, real world context.

1.1 Research Vision and Unit Structure

We focus on the data, methods, and processes needed to generate actionable insights for decision support across a range of sub-disciplines in the energy, healthcare, medical and tourism sectors.

We are recognised for leading research in Artificial Intelligence (AI) reasoning methodologies (specifically case-based reasoning); computational and nature inspired algorithms and machine learning in the context of complex and heterogenous data streams.

Since REF2014 we have also developed capacity in immersive technologies and the blending of machine vision algorithms to create real-world simulations for autonomous systems in complex environments. We have continued to work extensively and collaboratively with external partners, and often with municipal authorities from across the North Sea region.

The staff cohort from which the submission is drawn has evolved during the REF period and at its core are a team of ten members with a balance of early (three), mid-career (four) researchers and professors (three); these appear as **bold**, *bold-italic* and **bold-underline** respectively below.

A further complement of Research Assistants (RA)/Research Fellows (RF) (thirteen) and Early-Career Lecturers (ECR) (six) form critical mass and play an important supporting role.

- **Artificial Intelligence and Reasoning** (AIR) – Prof **Wiratunga** (F); Dr *Massie* (M); Dr **Corsar** (M)
  Supporting Members:
     o RF/RA: Dr Nkisi-Orji (M), Dr Wijekoon (F), Mr Palihawadana (M)
     o ECR Lecturers: Dr Kalutarage (M), Dr Martin (M), Dr Snaith (M))
- **Computational Intelligence** (CI) – Prof **McCall (M)**; Dr *Petrovski* **(M);** Dr **Zavoianu (M)**;
  Supporting Members:
     o RF/RA: Dr Christie (M), Mr Dang (M), Mr Dobos (M), Mr Fayyed (M), Dr Han (F), Dr Lacroix (M), Dr Nguyen (M), Mr Santos (M),
     o ECR Lecturers: Dr Bartlett (M)
- **Interactive Machine Vision** (IMV): Prof **Elyan** (M)**;** Dr *Isaacs* (M); Dr *Jiang* (F)**;** Dr **Moreno-Garcia** (M)**;**
  Supporting Members:
     o RF/RA: Dr Ali-Gombe (M), Ms Jamieson (F)
     o ECR Lecturers: Dr Johnston (F), Dr Piras (M)

1.2 Evidence of achievement at Unit level

The AIR and CI groups strategically set out in REF2014 have been maintained to a significant degree and have promoted greater quality through multi-disciplinary research in the Energy and Healthcare sectors.

Both groups have each provided an impact case study related to optimisation and scheduling algorithms (CI) and representation and retrieval methods (AIR).

The IMV group has evolved from the demand for real-world data science systems that increasingly involve both machine vision and immersive technologies.

We regard the integration of our research groups within multi-disciplinary projects to be critical to the development of a strong intellectual culture within the host disciplines.

Indeed, our funding success during the submission period is evidence of this multi-disciplinary approach enabling us to respond to external challenges in creative and agile ways. It has also been possible to develop a thematic framework for the University's activities within data science and its application in health care systems, architecture and built environments; creative art and design; and energy sustainability; where the topics, challenges and activities of our research are often conveniently integrated in research projects from those disciplines.

1.2.1 Evidence of achievement in relation to increasing funding and publications
Our income total of £4,6M+ in this assessment period has nearly tripled our previous REF2014 income generation (2014: £23K per head per annum, 2020: £65K per head per annum).
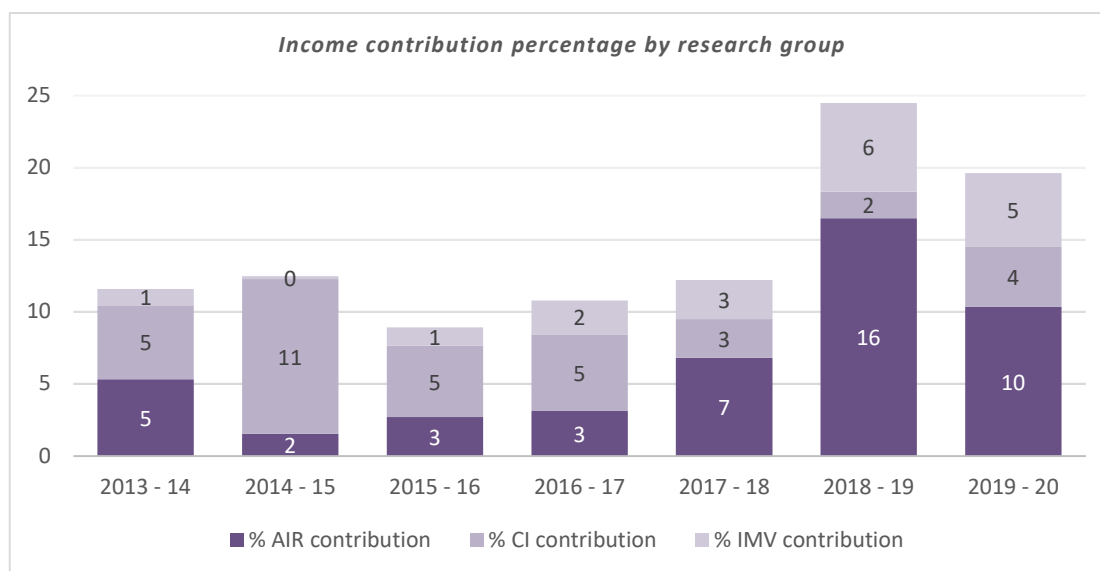
The percentage contribution of each research group (in the stacked graph) over the current REF period shows a general increasing trend of AIR and CI as established groups having contributed a total of 46% and 35% respectively; with support from the growing IMV contribution of 19%.

Our publication track record in the submission period maintains on average 45 papers per year. Since REF2014 we have increased our journal publications (forming 60% of our accepted papers) and increased submissions to high-impact venues.

1.2.2 Evidence of adopting research integrity and principles
We are committed to the Concordat for research integrity and recognise that a proactive and collaborative approach is required between all stakeholders, to create and develop positive environments and cultures in which all researchers can achieve their full potential and be rewarded for excellence.

We maintain a public access GitHub repository of our main codes (https://github.com/RGU-Computing) and encourage all researchers to share datasets publicly where possible (e.g. this dataset from 2019 has had 15K+ hits https://archive.ics.uci.edu/ml/datasets/MEx).
In this way we address requirements for open data and open-source code to ensure reproducible research by ensuring access to data is as open as possible, and closed as necessary, and where appropriate in line with the *FAIR Principles* for data management.

1.2.3 Evidence of achievement in relation to supporting the research community
Following from our REF2014 submission, we have had significant HR policy changes that have helped to create a clearer research career progression for our research staff (lecturer to senior lecturer A and B; and RF to Senior RF and Reader).

Several of our REF submitted staff have benefitted from these changes, for instance **Jiang** promoted to Senior Lecturer, **Massie** to senior RF and then Reader; and both **Elyan** and **Wiratunga** from Reader to Professor. **McCall** was promoted to a cross-university role,

Professorial Lead in Predictive Data Analytics and seconded as Research Director of the new National Subsea Centre (a multimillion-pound partnership between RGU and The Oil & Gas Technology Centre, OGTC, which is part of the Aberdeen City Region Deal). Accordingly, **Isaacs** was promoted senior lecturer to Head of School.

Our submission includes ECRs recruited during this period, **Corsar**, **Moreno-Garcia** and **Zavoianu**; and others more recently recruited (Bartlett, Piras, Snaith) who we plan to develop for the next REF. ECRs in the UoA are supported with a minimum research allocation of 40%. Overall, these changes have helped us develop a stronger research culture and community. All ECRs are linked to PhD supervision teams to create necessary momentum towards developing research independence and encouraged to take an active role in managing departmental seminars and contributing to regional initiatives (Scottish Informatics and Computer Science Alliance and National Subsea Centre, see Sections 1.5 and 1.6).

Other plans from REF2014 to improve research culture have resulted in a range of changes from simple approaches such as using informal communication channels to nurture a supportive environment, discussing successes and "failures" through mentoring roles, embedding research integrity within the Unit's senior management team, ensuring our research leaders are supported by administrative support and most importantly ensuring that they lead by example. This has paid dividends in creating an increasing trajectory in our funding successes and of strengthening the outputs from our research in terms of both published academic outputs and through engagement with research-led practice.

1.2.4 Evidence of achievement in relation to supporting research students
We have had a long-standing strategic aim to create a vibrant culture for our early-stage researchers (ESRs). We maintain a research student community of around 30, with four completions on average each year and supported by four fully funded studentships each year by the Unit of assessment (UoA).
It was also extremely important within the UoA to ensure that there was a close connection between the three research groups and studies undertaken by our ESRs.

During the submission period RGU established an institution-wide Graduate School, which has effectively managed processes and formal training in relation to our research degree candidates. One clear and distinctive benefit of this university wide initiative has been the establishment of a strong peer group of research degree candidates, which is cross-disciplinary in nature. The strength of that community is perhaps most strongly evidenced by its continuation throughout the COVID pandemic of 2020, where students continued to meet in significant numbers, to present their work, and to engage in discussion and debate (albeit online).

1.3 Evidence of achievement at the research group level

1.3.1 Artificial Intelligence and Reasoning (AIR) group
Strategic research focus
AI reasoning methodologies like Case-Based Reasoning (CBR) form the basis for organising problem-solving experiences to create intelligent systems. We develop new ways of combining representations from learned models for reasoning with structured and unstructured heterogenous data. We explore how reasoning can be supported though personalised models for information search and browsing, recommendation, and decision support.

KPI: Publications
Our research has produced 57 publications (1/3 in journals) during the submission period, with world-leading work in personalisation of models for human activity recognition, semantic indexing for search and browse, recommender and reasoning algorithms in the healthcare and Energy domains.

KPI: Research Income
During the submission period, the AIR research group attracted 46% of the total Unit's funding.

Notably this included funding from EU (Horizon2020 selfback.eu, FP7 socialsensor.eu), national funding (InnovateUK projects) and Scottish funding through Oil&Gas (AZOTH and Prophecy projects) and Datalab (FITsense) Innovation Centres.

This income helped to significantly increase our research capacity through several externally funded (eight) and internally funded (five) studentships; (four) research fellowships (Wijekoon, Nkisi-Orji, Palihawadana, Sani now at BT, Horsburgh now at QuantumBlack); and to create career progression opportunities (from research student to lecturer (Martin) to readership (**Massie)**, and to professorship (**Wiratunga**)).

Following our funding successes in AI and health (selfback.eu and several InnovateUK projects in Diabetes management and radiology fracture detection), our group is known for our contributions to organising and participating in the AI and health workshops that are annually co-located with the main AI conferences (IJCAI, ECAI and BCS-SGAI).

Innovation Activities
Successful research activity has birthed <u>two</u> award-winning spin-outs: Storical (**Massie**) and Attendr (**Wiratunga** and Martin). Both spinouts completed an innovation accelerator in 2020, (with Attendr winning Most Innovative Start-Up, and Storical winning Best Pitch) and are now in pilot phase testing with potential customers. Storical has been incorporated, while Attendr is pre-incorporation. Leveraging this experience, in the future the AIR group intends to create and incorporate a company as a vehicle for commercialising research activities.

1.3.2 Computational Intelligence (CI) group
Strategic research focus
The CI group has long-standing strategic focus on search, optimisation and machine learning and their performance in complex, data-driven decision-making environments. We develop new algorithms and problem representations, explore the problem-solving interface between optimisation and simulation, and drive computational efficiency through surrogate modelling and online statistical reasoning. Our research is informed by our experience of challenging real-world problems across a variety of industries. Forming long-term research partnerships with industrial collaborators is, therefore, a key component of our strategy.

KPI: Publications
Our research has produced 68 publications, (62% in journals) during the submission period, with world-leading work in permutation-based algorithms, vehicle routing and scheduling, multi-objective (industrial) optimisation and intrusion detection in cyber-physical systems.

KPI: Research Income
Over the period CI has attracted 35% of overall income generated. The group operated as a self-sustaining Smart Data Technologies Centre (SDTC) with **McCall** as Director from 2014 to 2017. During that period, CI was the dominant source of research income for the UoA. During the period 2017 – 19, when **McCall** was Head of School of Computing, CI partnered successfully with other groups to maintain activity and cross-fertilise with the other groups, and in other UoAs (Engineering UoA 12, Creative and Cultural Business UoA 34 and Architecture UoA 13) with a significant involvement in projects with other PIs. This income is recorded with the PI's of AIR and IMV research group tables. In 2018-19, **McCall** was Co-I on **Massie**'s (AIR) £400K Azoth project and Nguyen, Lacroix and Dang worked on the project. Santos and Dang have provided technical support on several projects led by **Elyan**, **Moreno-Garcia**, and **Jiang** (all IMV). Over the period, the CI group has doubled in size from two academics and three research staff in 2014 to three academics and eight research / early career staff in 2020.

Innovation Activities
The CI group has two spin out companies. Both are fully described in the Unit's impact case study "Transforming the North Sea Logistics Supply Chain".
- **Celerum** was established in 2013 as a general optimisation consultancy but has specialised in road freight logistics since developing an AI-supported truck operations control system for ARR Craib in 2016. One full-time software engineer job was created at Celerum in 2017 and a full-time CTO has been employed since August 2020.
- **PlanSea Solutions** (established 2017) focusses on providing fleet optimisation and vessel scheduling software for the offshore Oil&Gas marine support sector. This will be

commercially released in Q3 2021. In partnership with the Oil & Gas Technology Centre (OGTC), the study highlighted potential savings of up to £100M p.a. in the North Sea and identified the contribution that optimisation software can make to reduce the sector's CO_2 emissions.

1.3.3 Interactive Machine Vision (IMV) group
Strategic research focus
Key research areas are focused on learning from small, imbalanced and unstructured data, including images, video and 3D representation. Methods developed were successfully applied to a wide range of applications across different domains such as Oil & Gas (**Elyan**), Medical Image analysis (**Moreno-Garcia**), Immersive Technologies and Computer Graphics (**Jiang**) and Simulation of movement in confined spaces (**Isaacs**).

KPI: Publications
IMV's outputs have been published in top international journals and top-tier international conferences and constitute 37% of the share of outputs generated by the UoA. Our world-leading work in machine vision is focused by addressing the challenges with imbalanced and few data.

KPI: Research Income
Funding attracted by IMV contributed 19% of the Unit's research spend during the REF period. As the newest of the three groups, IMV plays an influential role by developing cutting-edge solutions to various real-world problems across different domains including Oil & Gas, Fashion and Textiles, Health, Environment and Sports Sciences.

1.4 Evidence of achievement at the international level
The Unit has extensive collaborations and links with international universities, the wider research community and industry.
- CI regularly collaborates with similar groups at Stirling and Napier universities to organise academic workshops and invite world-leading academics in computational intelligence to Scotland (**McCall, Petrovski**).
- The AIR group's research has motivated renewed interest in deep metric learning in the international CBR community (**Wiratunga**, **Massie**, Martin). The group has supported this strand of research through organising and chairing the annual CBR-DL (Interplay between Deep Learning and CBR) workshop since 2017 until present.
- IMV have several links established with:
  - Chinese research institutes through the £1.3 million AHRC funded collaborative project on "Augmented Fashion: Immersive Interactions for Sustainable Heritage in Fashion and Textiles" together with textile companies such as Harris Tweed (**Yang**); and
  - Universidad Nacional Autonoma de Mexico (UNAM), which is the largest university in Latin America, through a Newton fund grant aimed at early diagnosis of cardiovascular diseases (**Moreno-Garcia**).
- **Wiratunga** and **Massie** have collaborated in four international consortia to successfully attract European funding of over £1M for RGU (with total consortium funding over £6.5M). Most of these are multidisciplinary projects which have led working closely with the Schools of Health Sciences (UoA 3), Architecture (UoA 13), and Creative and Cultural Business (UoA 34).

1.5 Evidence of achievement at the national level
A distinctive feature of the Scottish research environment is the existence of "Research Pools" that encourage collaboration in particular disciplines across Scottish HEIs. The Scottish Informatics and Computer Science Alliance (SICSA) is our relevant pool www.sicsa.ac.uk. The goal of the pools is to coordinate activity where relevant and to ease reaching critical mass by pooling across the different HEIs in Scotland.

Our unit aligns very closely with several strategic SICSA themes: Artificial Intelligence, Data Science, Human Computer Interaction, and Modelling and Computation.

We have also made use of SICSA's Postdoctoral and Early Career Researcher Exchanges (PECE) funding for research training and development opportunities for our early career researchers (**Moreno-Garcia**).

The Graduate Academy Distinguished Visiting Fellow (DVF) scheme provides a mechanism to facilitate collaborations between Scottish-based Computer Scientists and leading academics helping to fund linked activities with the textiles sector in China (**Yang**).
Our Unit has organised workshops and has participated in SICSA annual events (see Section 4).

1.6 Evidence of achievement at the regional level
RGU and OGTC (formerly the Oil & Gas Technology Centre), have partnered to create the National Subsea Centre, (NSC), a £10M Centre of Excellence for Subsea Research Technology development funded by Scottish and UK Governments as part of Aberdeen City Deal. Launched in 2021, NSC will harness the University's academic expertise, research capability and facilities to establish a world-class research and development centre focused on tackling the underwater challenges faced by all marine industries tackling sustainable economic development. Expected value to the UK is shown in the graphic below.

Value	**Jobs**	**Aberdeen City Deal**
£20-£100 billion Global market value by 2035	**45,000** Jobs currently supported	👑 **HM Government**
£8 billion Current value to the UK of 40% market share	**1,000+** Companies currently operating in the sector – 600 in Scotland	**The Scottish Government** Riaghaltas na h-Alba
£40 billion Potential five-fold increase in value to the UK	**180,000** Potential additional jobs created by five-fold market share increase	

The NSC working across industrial sectors (oil and gas, offshore marine renewables, marine aquaculture), will draw from and extend our research into areas involving communications, data, energy integration, remote monitoring and underwater robotics. It provides a new and unifying focus for all three research groups on applied Data Science coupled with Subsea Engineering (UoA 12) and Energy Integration.
Our Unit shares research staff with the NSC, which has already led to the development of some initial funding successes (**Elyan** SAIBOK £112K project on underwater autonomous systems) and joined up activities and events.

1.7 Future strategic priorities for research and impact:
We have generated £4.6M+ spend in this REF period, but our plan for the next five years seeks to double that, in a move that will support up to 45 research staff a year (i.e., ~50% increase) as we generate 20 outputs and attract funding of around £2M per annum. That makes our plan the most ambitious since previous REF commitments.
This is reflected in each of the individual research group development plans for the next five years as detailed in the table below.
It is feasible with the recent £10M NSC investment and OGIC backing as well as the recent NSC professorial appointments to achieve our ambitious **five-year** targets.

Research Group	Next five years
AIR	The AIR group will consolidate its position as a leading research group on intelligent healthcare and medical systems research. We will develop new themes to incorporate more complex multi-modal inputs (increased number and complexity of sensors, free-text, clinical dialogue and AI conversation systems, etc). We are committed to working in collaboration with the Triple Helix initiative (NHS-Grampian, Aberdeen University, Scottish Enterprise and healthcare companies),

	towards the goal of maximising the potential to commercialise health care research.
	We intend to establish the AIR research group in the rapidly growing field of "AI Matters" research. To this end we have recently secured funding for the three-year iSee project (EPSRC, EP/V061755/1) to produce a technological platform to empower industries to explain the output of their intelligent systems and comply with national and international law supporting an individual's right to an explanation. The iSee platform will be co-designed with users and evaluated using real-world case-studies (including radiology and medical systems). Input from industrial and academic advisory members will be used to help identify commercialisation opportunities (e.g., explanation-as-a-service).
	The group have also recently obtained EU Interreg funding for the Story-tagging Northword project (Interreg 304-9126-2019) to develop a digital story platform for Europe's Northern territories. Research will focus on integrating personalised recommendation components to the AI platform. Sustainability to allow the project to continue beyond the funded period is a key consideration and Storical, a spin-out company, has been developed to aid this transition.
CI	CI will build on its strengths and experience in industrial optimisation to focus on four globally important challenges: energy transition, smart subsea, smart mobility and smart supply chains. From Q3 2021, the group will be physically located at the National Subsea Centre (see Section 1.5), co-located with major energy companies and contractors operating in both hydrocarbons and renewables in the North Sea.
	For **energy transition**, the group remains engaged with a large consortium of industry and academic partners through a £10M H2020 Green New Deal funding bid to construct a mixed energy systems demonstrator. An ongoing EU collaboration with Johannes Kepler University (Austria) is extending CI methods for use by electrical engineers to optimise design of electrical machines (motors and actuators). This is being considered for a four-year extension.
	The **smart subsea** research aims to develop digital twins of subsea assets alongside advanced monitoring, control and cyber security capabilities. The NSC has been selected as a data repository for subsea image data and a pilot project Subsea AI Body of Knowledge (SAIBOK) has been funded by OGTC and supported by a consortium of industry partners to establish this capability. CI will contribute deep classifier expertise while IMV will contribute machine vision.
	The **smart mobility** theme will use CI research to design large scale sustainable transport systems. Recent projects include the EU-Interreg ART Forum consortium, HiTrans, the Highlands transport authority, Orkney Islands Council, West Yorkshire Combined Authority and the Highlands and Islands Food and Drink network.
	Smart supply chains will continue to extend our work on freight logistics and supply chains. Recently CI began a £260K project with Aberdeen Harbour Board. This adds a crucial link to our capability to model the full multi-model offshore supply chain and we intend to develop globally-relevant reference models and algorithms.
IMV	A key objective is to scale up the use of data-driven solutions across different domains to provide faster, more efficient and safer practises specifically in the Oil & Gas and renewable energies sector.
	To date, many key applications in this industry remain largely dependent on domain knowledge expertise. This is partly due to the complex nature of data and lack of annotations.

IMV aims to build a framework for streamlining the gathering, processing, and retrieval of visual content from complex subsea environments and the development of data-driven solutions to inform business practices.

Along with the data processes, the IMV group has also a long-term vision to create a generative immersive technologies platform. A recent networking fund from the Royal Society of Edinburgh to form the Immersive Scotland Network (as of March 2021) will help extend our strong international links with this research community.
It is our aim to build on these collaborations in both the Energy and Creative Design sectors to bring out a general platform for immersive and interactive vision technologies of the future.

2. People
The Unit adopts the university guidelines on employee wellbeing (updated for COVID-19) which covers amongst others health and wellbeing, financial wellbeing, supporting working parents and fair treatment.

2.1 Staffing strategy and staff development
We use staffing initiatives aim to help create capacity by balancing the need for expansion with the need to strength and promote research quality within our established and developing research groups. We have a healthy demographic profile in terms of age and nationality, and an improving gender balance; all of which provides additional evidence of the Units' sustainability in the long term.

2.1.1 Staff development strategy
Out of the 29-research staff (listed in Section 1), three of the core staff members (**Corsar**, **Moreno-Garcia** and **Zavoianu**); and all of the supporting staff members were recruited over the REF period. Many of these involve staff who progress from PhD to RF or lecturer; the remainder (excluding the professors) are new appointments.
Our commitment to strengthening our research groups standing is also evident with all recent employment focused on recruiting staff aligned to our research strengths.

AIR	• Ontologies and Reasoning: Nkisi-Orji (PhD student to RF), **Corsar** (new lecturer) • Explainable AI: Palihawadana (new RA and P/T PhD student), Wijekoon (PhD student to RF) • Dialogue and conversational AI: Martin (PhD student to Lecturer), Snaith (new lecturer)
CI	• Optimisation problems: Christie (PhD student to RF), Han (new RF), Santos (RA and P/T PhD student), Dr Bartlett (new lecturer); **Dr Zavoianu** (new senior RF) • Evolutionary algorithms for deep learning systems: Dang (new RA and P/T PhD student), Nguyen (new RF)
IMV	• Video and image manipulation and analysis: Johnston (KTP associate to PhD student to Lecturer), Ali-Gombe (PhD student to RF) • Digitising of technical drawings: **Moreno-Garcia** (RF to lecturer); Jamieson (RA and P/T PhD student)

Next REF period will focus on early career staff progressing in their academic careers. ECRs are included on PhD supervisory teams, participate in grant-writing as co-Is and are encouraged and assisted to apply for small grants as PIs. Opportunities are taken to include ECRs on organising

committees, review panels and other professional activities and to attend workshops and conferences to expand their academic networks.

2.1.2 Recruitment Initiatives policy and evidence of its effectiveness

All staff submitted under category 'A' are on long-term (permanent) contracts, and there is an appropriate mix between full-time and part-time contracts.

All recent vacancies within our Unit have appointed staff having a PhD and a record of publication and /or grant income. We ensure that all research staff have an opportunity to feed into the recruitment process by being involved in candidate talks and Q&A sessions.

We also developed a new initiative within our Unit to improve job security by introducing F/T RA posts with P/T PhD routes (Palihawadana and Dang). Active since 2018, this has helped to expand our pool of RAs, and enabled us to respond to resource requirements in an agile manner by balancing the needs of current and new funded projects with varying duration timelines (e.g. six months, up to three years). This meant that during the COVID period we were able to begin several funded projects without the need for project specific recruitments on fixed-term contracts.

Given our Unit's important role within NSC there have been recent recruitments (in 2021) of two new professors to lead research teams focused on building capacity in the areas of "automation and robotics" driven by a strategic deliverable related to creating "an integrated basin view". Specifically, these research leads will greatly enhance and complement our existing industry focused AI and data science capability. They will help to lead our future research on cyber-physical systems and interaction in complex environments.

The host school (Computing) for the majority of Unit members applies an operational workload planning model, which in part helps to ensure that ECRs are given sufficient time (40% minimum) to develop their own areas of research. In practice, this has resulted in staff, wherever possible, being engaged with research, PhD supervision and teaching which is thematically connected. ECRs are encouraged to build in the UKRI New Investigator Award scheme as a strategic objective target.

2.1.4 Supporting and integrating staff into the research culture

All staff are aligned with one or more established research groups within the Unit and have a planned induction programme to help them integrate within the Unit and extended through the quarterly probationary reviews in the first year.

We have an established programme of research seminars. All staff joining the Unit are expected to present their research through this venue. Professorial staff within the school are also active in public speaking, including through the University's own Professorial lecture series.
Staff are supported to attend and present at high-level research conferences, especially where these relate directly to ongoing research activity.
We have weekly "Research Group Scrum" sessions where members can share initiatives and updates with colleagues. These helps create a positive and supportive research culture. Informal communication is encouraged e.g., through our Research Scrum Slack channel or MSTeams.

Staff with leadership and management roles are supported by RGU's Leadership Development programme - a suite of both ILM accredited and non-accredited development programmes and activities. The Unit has a policy that supports attendance to these in-line with career progression. For instance, Senior RFs are encouraged to attend, the Discoverer, RGU's First Line and Aspiring Managers' Programme (ILM Level 3 Award in Leadership and Management); thereafter Readers and Professors to attend, the Voyager, RGU's Middle Managers' Programme (ILM Level 5 Certificate in Leadership and Management).
The Pioneer Future Leaders' Programme is open to anyone aspiring to be a leader. In particular female staff are strongly encouraged to apply to the Aurora women-only leadership development programme.

All staff access the Skills4Success portfolio of staff development workshops to help with generic and interpersonal skills such as time management, communication and personal effectiveness. Additionally, our VP (Research) office has during the REF period established a

strong programme of researcher development training, which includes guidance and support for proposal writing and submission, peer review, research project management and research impact.

2.1.5 Policy for research, impact leave/sabbatical leave

A University-wide scheme and procedures for sabbatical leave were approved in 2016 and thereafter renewed in 2019. The policy applies to all academic research staff and all research active academic staff, on permanent contracts of employment.

Entitlement to sabbatical leave is not automatic but is based on the merits of a proposal and how those fit with the strategic needs of the University, Faculty and School or Department at the time the application is made. Although staff from our Unit have not used the scheme during the REF period due to staff numbers and training requirements of newly recruited staff, we are now in a position to plan for several sabbaticals in the future. Specifically, we anticipate sabbaticals in the next REF period across our research groups e.g., **Elyan, Jiang, Massie**, **Moreno-Garcia** and **Wiratunga**.

2.1.6 Procedures to stimulate and facilitate exchanges

With a strong KTP track record of eleven projects funded in the REF period, we remain committed to stimulating and facilitating collaborations and exchanges between our academics and industry project partners.

We have had both placements and exchange visits between RGU and external institutions i.e., British Telecom (e.g., Martin and Santos spent 40:60 between company and University) and British Geological Survey (e.g., Nkisi-Orji on a one-year secondment).

We have detailed academic exchange under Section 4.

2.1.7 Recognising and rewarding staff achievement

Promotions during the REF period have recognised achievements (see Section *1.2.2).*

We have made our priorities clear, with a 40% research time allocation and PhD student allocation to our ECRs driven by a personal research plan linked to the Employee Progress Review (EPR).

Achievement is managed with KPIs that are agreed through the EPR process:

- **Funding**: targets are based not only on funding successes but also on the proposals submitted and their totals. This has enabled us to acknowledge the significant effort that goes into proposal writing as well as those that succeed to win funding. Successful projects are coupled with funded PhD studentships.
- **Public output**: targets are linked to increasing levels of protected research time. For instance, staff with protected time for research > 40% will be expected to produce at least two papers annually with at least one at REF 3* or above; whilst those with allocations between 40-20% at least one paper annually at REF 3* or above. Journals must be compliant with REF Open Access Policy.
- **PhD Supervision: o**ur ECRs with protected time for research will be expected to co-supervise PhD students. This is regulated with training from the Graduate School.
- **Innovation activity:** staff are encouraged to participate in the annual "Innovation Accelerator" competitions, and have the opportunity to focus on these through the sabbatical policy. As detailed in Section 1 (Innovation activity) we have had several recent success stories of spin-outs.
- **Peer esteem:** staff our encouraged to organise and be members of programme and review committees.

2.2 Research students

Since REF 2014, the three Research Institute-based Graduate Schools were amalgamated into one single pan-institution School in 2016. The intention of this consolidation was to ensure that best practice was being followed equitably for all PGR students regardless of their individual discipline of study.

2.2.1 Approach to recruitment

The total number of doctoral degrees awarded annually as reported in REF4a in the assessment period relate to PhDs (i.e., we have not had any research-based professional doctorates).
A yearly breakdown on the basis of new intakes with continuing students organised into P/T and F/T counts appear in the table below. We aim to maintain around 30 students within our Unit.

Intake/ continuing	Full time/ part time	Academic Year					
		2015	2016	2017	2018	2019	2020
Cont.	FT	17	13	14	14	12	12
	PT	6	9	10	7	6	7
Intake	FT	1	4	5	2	4	9
	PT	3	3		1	3	2
Total		27	29	29	24	25	30

Studentships are advertised in regional, national and international websites (e.g., jobs.ac.uk, FindAPhd and LinkedIn). Candidates are invited to present their research proposal, followed by a coding task and a formal interview.
ECRs and successful grants are supported by a funded studentship. Additionally, an annual budget allocation supports a competitive call for fully-funded studentships distributed across the research groups. These are awarded on a competitive basis following review by the Unit's academic strategic lead for research, the research leads and the Head of School.

2.2.2 Evidence of monitoring and support
All research students complete a PGCert (Researcher Development) delivered by the Graduate School, within the first two years of their degree, and the development and career progressions are managed using the Researcher Development Framework (RDF) planner from Vitae.
The evidence from 2016 is unequivocal in confirming that the overall research degree experience from the PhD community has improved, based on returns from Advance HE and equivalent internal Postgraduate Research Experience Surveys (PRES). The Overall Satisfaction questionnaire in the internal PRES elicited a value of 89% (although the surveys are not directly comparable, the national Advance HE PRES value was 80% for Overall Satisfaction).

A contributory factor to the considerable improvement (from 77% previously) was in part the result of the introduction of the RDF in 2020 for all PhD students and ECRs within RGU https://www.rgu.ac.uk/research/the-graduate-school/researcher-development-programme.
RDF builds upon the PgCert Researcher Development course, a course that all PhD students must successfully complete, that was successfully revalidated in September 2019.
By necessity the programme since March 2020 has been delivered online and the most recent feedback from the module taught in November 2020 provided a rating of 95% Excellent.
PhD supervisors undergo mandatory supervisory training, with refresher training every three years.

Historically the research degree graduate success has been high, with those passing being above 85% (when taking into account those who had failed the initial attempt but passed on resubmission).
Despite the very positive outcomes mentioned above, the time taken for students to complete PhDs more commonly than not exceeded the maximum registration period of four years full-time or 6 years part-time. Although historic performance across the 11 academic Schools was variable, the Graduate School set the target of 70% completion within registration period for the whole PGR student community. In 2019/20, the data show that completions within registration period have moved up from less than 40% overall to just about 70% currently, and rising.

2.3 Evidence of how the submitting Unit supports and promotes equality and diversity.

Table provides a breakdown of equality and diversity statistics for both REF returnable and eligible staff in the Unit.

Sexual Identification	Eligible Staff	Returnable Staff
Female	8	<5
Male	31	8
Disability		
No known disability	35	10
Disability Declared	<5	
Unknown	<5	
Age		
<30	<5	
30-39	16	<5
40-49	8	<5
50-59	8	<2
60-69	<5	<5
>70	<5	
Ethnicity		
Arab	<5	
Black or Black British - African	<5	
Chinese	<5	<5
Other Asian background	<5	<5
Other Black background	<5	<5
Other mixed background	<5	<5
Other White background	15	<5
White - Scottish	10	<5
Unknown	<5	

Our research committee with the remit to "enhance, organise and shape all research activities in the School", meets quarterly and has representation from each research group, ECRs, PhD students and an equality and diversity champion.
The latter sits on the Unit's accessibility group, which takes guidance from the central RGU Accessibility group on applying equality and diversity requirements throughout Learning, Teaching and Research.

All management staff are expected to undertake relevant training and development related to equality, diversity and inclusion; training on wellbeing and mental health, including University processes for reporting and addressing incidents of discrimination, bullying and harassment, and poor research integrity. The University also has maternal and paternal policies and family-friendly working arrangements which have been useful for our staff (e.g., **Corsar** and **Jiang**).

Aligned with the University policy, we strive to ensure that all our committees are gender balanced; although this needs careful consideration to ensure that the smaller female population is not overly burdened with committee memberships.
As of 2021 a further female professor has joined the Unit through the NSC. Despite that we need to work towards balancing the current 20:80 gender ratio.

From the submitting Unit, **Jiang** undertook the AdvanceHE's *Aurora Women* in Leadership programme to develop, identify, crystallise and communicate her aims within academia. She contends that it also assisted with managing work, leadership responsibilities, politics and maintaining cordial and objective relations with colleagues.
Similarly, **Isaacs** and **Wiratunga** have also taken part in the Pioneer and *Voyager programmes respectively, both* aimed at the senior management level, which was planned to coincide with

their timely promotions to Head of School and Professorial Academic Strategic Lead (ASL) for Research respectively.

We also manage a 1-1 mentoring programme for ESRs & ECRs and staff undertaking PhD by publication.

Furthermore, with **Wiratunga**'s adjunct professorial role within NTNU (Norwegian Institute of Science and Technology, Trondheim), we are able to participate in the "IDUN- BALANSE project" (IDUN), aimed at increasing at least 15 – 20 % females at all levels, from PhD to professor. IDUN offers scientists a career catapulting and research focused mentoring program, where **Wiratunga** is one of nine IDUN mentors, enabling the sharing of best practice within our Unit.

The University also conducts a mentoring scheme open to any staff member, and has noted the benefits to more senior women of the mentoring role and the benefits of the enhanced working relationships between cohorts of women involved in the programme.
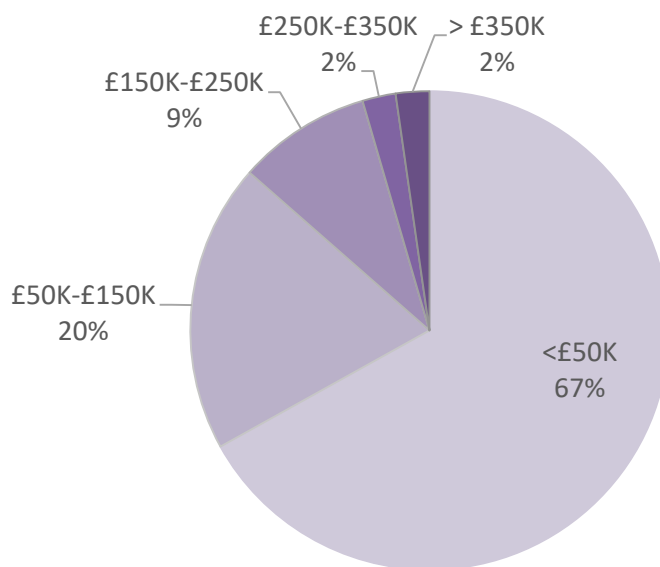
3. Income, infrastructure and facilities

3.1 Income

Research funding portfolio:
We evidenced our achievement in relation to increasing research income and publications in Section 1.2.1.
The submitting Unit has successfully undertaken just over 130 projects during the REF period, with a grant spend value of £4,668,217.70.

The pie chart analysis above provides a snapshot of the distribution of projects by value of bid to the funder, where it shows that 67% of bids fall under £50K. Our aim for the next period is to double our success instead in the £50K-£150K bid range and maintain at least 15% of £150K-£350K bids.

Our top funding sources (in REF5a) are UK Industry (30%), UK other (28%), UK central government sources (21%) and EU (14%).
The larger valued bids (>£350K) are through EU's FP7, H2020 and Interreg programmes. We are particularly successful in undertaking work funded by Innovate UK, including KTPs and funded research commissions.

Our funding from BEIS (e.g. UKRI) remains at 3% and it is our aim to increase this to 15% in the next five years. Although not included in this submission, we have already started to benefit from

this effort with substantial grants from both AHRC (AH/T011483/1) and EPSRC (EP/V061755/1) won since late 2020.

Infrastructure and facilities

The Unit has dedicated Systems (five) and Administrative (nine) staff teams, each with senior management representation. Both teams work hand in hand with all academic and research activities to ensure that day to day operations run smoothly.

RGU uses the cloud based Worktribe software for seamless end-to-end research proposal authorisation and management. This has positively contributed to team collaboration, and has ensured that there is continuous connection between staff details, research activity and governance.

Following REF2014, computing facilities were significantly enhanced to include:

- RGU Cloud Development Project (2014-15): The provision of a Big Data Server (£83k), a private Cloud Computing Server (£32k) and further high spec PCs (£33k) outlay for a proposed Digital Incubator. In 2015-16 a further £35K for a Render Farm and £50K for Desktop Virtualisation.
- Across the university (2016-2017) funding was pulled together to create a virtual environment of VMware Horizons server network (top-spec DELL 710 and 810 servers) with NVIDIA Graphics for virtualisation (400-node HPC) and 3D rendering work.
- RGU Cloud Replacement - Nutanix Cluster (With ITS) (2019): There was an £80K pot of money allocated for the enhancement of the RGU Cloud.
- Deep learning experiments required spend on an Nvidia DGX plus a support contract to manage it (2017, £125K).
- Video conferencing facilities to support research consortiums (2018-2019 £53K)
- VR headsets for immersive technology research (2018, £8K)

Our Unit works closely with NHS-Grampian on data science related projects. Access to patient data from the Grampian Safe Haven (DaSH) has required initial clearance from NNPAC after completing the MRC Research, GDPR and Confidentiality training. Following the Innovate UK SBRI competition on radiology image analysis award, several of our researchers have been authorised (e.g., **Moreno-Garcia** and Martin) and since then others (Lacroix, **McCall**, **Massie**, Nguyen, Wijekoon, **Wiratunga**, **Zavoianu**) have completed the necessary training for the Triple Helix initiative.

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

All national and international collaborations have a formal process of setup guided by the University's research ethics and integrity procedures and contracts. This helps to setup expectations and standards concerning research integrity, on the laws and regulations that will apply, on protection of the intellectual property of collaborators, and on procedures for handling conflicts and possible cases of misconduct.

4.1 Collaborations with the research community

Wiratunga has strong links with several International academic partners including the NTNU, Trondheim where she holds an adjunct professorship role. **Wiratunga** and **Massie** have also hosted sabbatical visits from Universidad Complutence Madrid, UCM (Prof Belen Diaz-Aguda) and University College Cork, UCC (Dr Derek Bridge) in 2019. These visits led **Wiratunga, Corsar** and Martin, to develop a generic explainable AI platform. With recent EPSRC funding this line of work has strengthened ties with both UCM and UCC; where in the past we have worked together on the hugely successful jCOLIBRI opensource platform (with over 25K+ sourceforge downloads) to provide textualCBR utilities for the CBR research community. Following the Horizon SelfBACK project's work package on human movement recognition, **Wiratunga** led a satellite project through the EPSRC Network+ GetAMoveOn project. This enabled the project RF, Wjekoon, to participate in their Fellowship programme to raise awareness of the SelfBACK project to widen impact of our AI research within the GetAMoveOn HCI and mobile computing research communities; and to successfully apply for a networking research grant with multi-disciplinary collaborators from GetAMoveOn.

McCall has a long-standing collaboration and a series of academic exchanges with University of the Basque-Country (UBC) in estimation of distribution algorithms (EDA) and permutation-based algorithms. Santos is a graduate of UBC and co-supervised in his PhD by Josu Ceberio at UBC (http://www.sc.ehu.es/ccwbayes/members/jceberio/home/). Another ex-UBC PhD student, Goñi, is supervised by **Zavoianu** with **McCall** as second supervisor. Ceberio visited **McCall** in 2018 and 2019 and **McCall** and **Moreno-Garcia** visited UBC also in 2019.

Since 2017, led by **McCall**, the Unit has been building a collaborative research relationship with IIMAS, at Universidad Autonoma de Mexico (UNAM). **Moreno-Garcia** together with **Corsar**, **Elyan**, **Massie** and **Wiratunga** has secured £250K funding (per partner) for a joint project with UNAM investigating image segmentation of cardiograms. Nguyen and Dang are providing support on Deep Neural Networks to that project. In February 2020, **McCall**, **Moreno-Garcia** and **Zavoianu** were invited to UNAM contribute talks to a Mexican industrial research workshop organised by IIMAS. Additionally, **McCall** gave a workshop on Principles of Industry Engagement with Academia and a Masterclass on Real World Optimisation.

4.2 Collaborations with Industry
The Unit has a world-class reputation for industry-led research. Industrial collaborators include large multinationals (BT, BP, EDF, Equinor, CNOOC, Intertek, Selex ES) and a range of national companies and SMEs (NEL, IDS (UK), ARR Craib, Accord, Albyn Healthcare, Jiva.AI, Azoth.AI, AskSenti, and Orkneyology) in domains such as Energy, medical imaging, healthcare and tourism**.**
McCall's research on North Sea supply chain modelling is globally recognised and forms one of the impact case studies from this Unit. Our relationship with BT is particularly longstanding and has funded seven PhD studentships during the period. Two former PhD students now occupy senior research positions at BT. Other research staff and PhD graduates during this REF period have moved on to industrial research positions at Airbus, Fujitsu Labs, and Accenture, and lectureships at Durham and Nottingham (Ningbo).
Wiratunga's work with the public funded British Geological Society (BGS) led to the creation of a GeoNER model which has had significant impact on international geoscience research through BGS. Indeed, it forms one of two impact case studies for this UoA. That work further helped to fund a PhD studentship for Nkisi-Orji and created a career path to a postdoctoral position with the AIR group.
The IMV group have led collaborative projects with leading International business partners (Det Norske Veritas, Norway; Shell, Total, British Petroleum, Intel) and National partners (Mintra, IDS and Harries Tweed Hebrides). More recently a collaboration with a Canadian business partner through an industry funded project (£215K) will create a platform for analysing complex documents and engineering drawings (**Elyan**).

4.3 Regional collaborations through SICSA
We have contributed to SICSA events including in 2019 the SICSA HCI workshop (co-chair **Jiang**); in 2018 AI Theme workshop on Reasoning, Learning & Explainability (co-chair **Wiratunga)**; in 2015 The SICSAWomen in Computing Research (co-chair **Wiratunga)**.
In 2014 RGU organised the DEMOfest North'14, with 40 exhibits attracting 135 attendees and 27 companies; and the SICSA PhD Conference 2018 was both organised and hosted at RGU.

SICSA funding was used to: Host Professor Ian Watson, University of Auckland; Professor Nik Kasabov, Auckland University; and Professor Rong Zheng from Donghua University.
Moreno-Garcia used PECE SICSA funding to arrange exchange visits to collaborate with Universitat Rovira i Virgili (Spain), University of Munster (Germany), Universidad Nacional Autonoma de Mexico & Tec de Monterrey (Mexico)

4.4 Other collaborations and peer esteem activities
Our **Editorial** services include 2016-2019, Associate Editor, IEEE Systems, Man and Cybernetics (**McCall**); 2014-2019, Associate Editor, IEEE Computational Intelligence Magazine (**McCall**); 2020 – date: Complex and Intelligent Systems (**McCall**). In 2018 Special Issue Editor of the Evolving Systems Journal (**Wiratunga**).

We have had **conference and workshops chairs** for, among others, International Joint Conference for Neural Networks IJCNN 2018-2020 (**Elyan**); also in 2020 ECPERM Permutation-based Optimisation Algorithms Workshop, GECCO (**McCall**); in 2019 IJCAI Workshop on Knowledge discovery from health data (**Wiratunga**); in 2018 Workshop on Intelligent Operations Management in the Energy Sector, GECCO 2018 (**McCall**); ECAI Workshop on AI and health 2018 (**Wiratunga**); in 2017 Model Building Evolutionary Algorithms Workshop, GECCO, 2015-17 (**McCall**).

Invited keynote lectures include in 2020 the 28th International Conference on CBR (**Wiratunga**); Islands deal Healthy Ageing Innovator project pitch to UK and Scottish govts (**Massie**); in 2019 International Conference on Intelligent Computing Systems and Data Analytics Applications (**Elyan**); in 2018 FIT for Healthy Living Event, DataFest18 Highlands & Islands Fringe (**Massie**); in 2017 Industrial Track at FUZZ-IEEE (**McCall**); Digital Energy Journal (**McCall**); ITF Tech Talk, Aberdeen (**McCall**); in 2016 Oil and Gas ICT Leaders Conference, Aberdeen (**McCall**).

Best paper awards in 2020 best application paper 28th International Conference on CBR (**Wiratunga**); in 2018 Connect Digital Health & Care Connect ICT Award (**Massie**); in 2017 Global Telecoms Award in Innovative Software Applications, with British Telecom (**McCall**); Finalist in Innovation category, Offshore Achievement Awards, with PlanSea Ltd (**McCall**); in 2015 Donald Michie Award for the Best Technical Paper (**Massie**); best technical paper award at International Conference on CBR (**Massie**)

We have **advisory roles** in the international case-based reasoning community (**Wiratunga**); senior programme committee roles in IJCAI (**Wiratunga**);
Peer Review memberships in 2020 Member of Future Leaders Fellowships Peer Review College (**McCall**); Member of EPSRC Peer Review College (**McCall**); and in 2016 international evaluation panel for Chistera 2016 (**Massie**).

Our **patents** and **licenses** include:
- two patent applications filed with BT (EP20160296.8 (GB2002946.8) Filed 1-MAR-2020; Title: Database relationship inference based on semantic clustering; EP20160295.0 (GB2002947.6), Filed 1-MAR-2020, Title: Database Relationship Discovery
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