

Institution: University of Strathclyde
Unit of Assessment: 10
1. Unit context and structure, research and impact strategy

The Department of Mathematics and Statistics at the University of Strathclyde conducts cutting-edge research into practically relevant problems that arise in a wide range of real-world applications. Our research and impact activities fully align with the University's long-standing mission to be "A Place of Useful Learning". Our research is structured into focused research groups (Figure 1), each with key themes that link to our main research objectives and are in line with the research strategies of the Faculty and University. This structure greatly assists in supporting collaboration with other disciplines, attracting research funding, diversifying and sustaining our research activities, and attracting high-calibre staff passionate about our research ambitions. While each group organises its own schedule of meetings and seminars which complement Departmental activities, there is considerable overlap between their research activities, and collaboration between groups is actively encouraged.

Figure 1. Mathematics and Statistics Research Groups

Health and Ecology Modelling (Head: Robertson, 9.5 FTE)	Continuum Mechanics and Industrial Mathematics (Head: Wilson, 10 FTE)	Analysis (Head: Mao, 13.6 FTE)
• Health Statistics • Mathematical Ecology	• Fluid Mechanics • Liquid Crystals • Wave Propagation	• Applied Analysis • Numerical Analysis • Stochastic Analysis

Health and Ecology Modelling (Head: Robertson, 9.5 FTE)

The research conducted in this group relates directly to the University's strategic research themes in Health & Wellbeing and Society & Policy. Within these themes, the group is making an important contribution to the sub-themes of Healthcare Systems and Ecosystem Stewardship, joining forces with research centres and groups across the University to focus on improving understanding of complex societal challenges, supporting decision making, and driving business and economic growth.

Health Statistics: Ensuring a healthy population is one of the biggest challenges facing society today. Activity in Health Statistics contributes to minimising the impact of infectious diseases and emerging zoonotic diseases, through vaccination strategies, understanding the transmission and intervention strategies for plant health, and modelling the risks to society from infections from animals entering the food chain. One distinctive aspect of this work comes from strong and long-standing strategic links with external public health agencies such as Health Protection Scotland, NHS Greater Glasgow and Clyde, and the Animal and Plant Health Agency (APHA). The group benefits immensely by having academic staff (*Robertson* and *Kelly*) embedded within these agencies on a part-time basis, enabling synergy between research strategies and promoting multidisciplinary research in public, animal and plant health. A pertinent example is *Robertson's* membership of the Scottish Government Covid-19 Advisory Group which has reported directly to the Chief Medical Officer (Scotland) since April 2020. Health Statistics researchers are also closely linked with the Pharmaco-epidemiology and Health Care research group in the Strathclyde Institute of Pharmacy and Biomedical Sciences (SIPBS), with their contributions being crucial to the successful bids for significant funding from the Scottish Healthcare Associated Infection Prevention Institute (*Robertson*

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PI), the Cancer Medicines Outcome Programme (*Robertson* co-I), and the Health Data Research UK (HDRUK) collaboration (*Robertson* co-I). New collaborations begun recently by *Kleczkowski* include BBSRC projects on “Benign Infections or Damaging Epidemics”, to which he contributes essential bio-economic modelling skills as part of a consortium led by the Food and Environment Research Agency, and “A Decision Support Tool for Potato Blackleg Disease”, where he is part of a consortium led by the James Hutton Institute. Internationally, members participate in collaborations in Brazil, India and Malaysia on vaccination strategies, in H2020 programmes on vaccine effectiveness (I-MOVE+), and are part of Strathclyde’s partnership in Global Public Health with the International Prevention Research Institute in Lyon.

Mathematical Ecology: Living ecosystems represent a massive financial asset. The UK National Ecosystem Assessment (2011) valued the benefits of the environment for nature itself, society and economic prosperity at between £21.5 and £23 billion per year in Scotland alone. The University’s Ecosystems Stewardship sub-theme has the marine world as its focus, with researchers in Mathematical Ecology and the Centre for Environmental Law and Governance providing the main input. This synergy between Humanities and Science has resulted in a successful Global Challenge Research Fund bid for the One Ocean Hub (*Heath* co-I), an ambitious £20M programme and the largest ever single grant awarded to Strathclyde. The Mathematical Ecology group developed from initial funding through the Marine Alliance for Science and Technology in Scotland (MASTS) and the Scottish Funding Council Research Pooling Initiative (2009-2016), and was subsequently expanded through the more recent arrivals of *Kleczkowski* and *Gomes* to include wider topics in mathematical biology and ecology. Embedding these specialists in a Mathematics and Statistics department makes the group highly distinctive both nationally and worldwide. For example, members of the group are the only participants from a Mathematics department in the GCRF One Ocean Hub, the NERC Changing Arctic Ocean Programme (where they participate in four projects and lead one of these), the international H2020 projects Mission Atlantic, SUMMER and MEESO (which are focussed on marine fisheries and environment), a research programme in Hong Kong, and an eco-forecasting partnership providing sustained-service decision support to health and environment agencies on the US West Coast (which they co-lead). Group members are also active in providing consultancy to the UK and North American Fisheries Agencies, fisheries certification organisations such as the Marine Stewardship Council, NGOs such as the Atlantic Salmon Trust and WWF, and fishing industry groups such as the Scottish Fishermen’s Federation. Taken together this means that the work across this theme has a truly global reach.

Continuum Mechanics and Industrial Mathematics (Head: Wilson, 10 FTE)

This research group is focused on using various mathematical approaches to bring new scientific insight to problems in manufacturing, medicine, geology, and beyond. The group’s research is necessarily multidisciplinary, with members having expertise in continuum mechanics, material science, fluid dynamics, and mathematical modelling in general, leading to collaborations with physicists, engineers, chemists and a range of industrial partners, and is directly relevant to Strathclyde’s strategic research themes in Advanced Manufacturing & Materials, Energy, and Measurement Science & Enabling Technologies.

Fluid Mechanics: Advances in the understanding of fluid mechanics arising from the group’s work are relevant to a wide range of industrial applications, especially those underpinning manufacturing. Particular strength lies in applications concerning droplets, coating and wetting processes, led by *Wilson*. For example, group members are currently collaborating with different divisions of Merck on methods for manufacturing liquid crystal displays, developing and analysing mathematical models for the drying of droplets arising in the manufacturing of organic light emitting diode displays via industrially supported studentships, and have extensive collaborations with experimental groups in Durham and Edinburgh.

Liquid Crystals: Strathclyde has longstanding involvement in the development and mathematical analysis of theories of liquid crystal materials, dating back to the pioneering work by Professor Frank Leslie FRS, who co-developed the Ericksen-Leslie theory for nematic liquid crystals. Research in this topic continues apace, enhanced by the recent appointment of *Majumdar* who is rapidly becoming an international leader in the analysis and mathematical applications of the Landau-de Gennes theory for nematic liquid crystals. *Majumdar's* research is transforming the landscape of mathematics-driven liquid crystal research. Group members currently work on wide-ranging modern challenges in liquid crystal modelling e.g. theory of nematic defects, liquid crystal device design, new composite liquid crystal-based materials etc., together with many national and international collaborators (from e.g. Chicago, Delhi, Glasgow, Kent State, Mumbai, Nottingham Trent, Pavia, Peking, and the Russian Academy of Sciences). This work is at the forefront of the mathematical analysis of liquid crystals worldwide, as evidenced by the recent awards to *Osipov*, *Mottram* and *Majumdar* (see Section 4).

Wave Propagation: The research in this area covers a wide range of topics, from numerical modelling of microwave imaging in medical applications to non-destructive evaluation in ultrasonics. Researchers have collaborations with major pharmaceutical companies GlaxoSmithKline and AstraZeneca, with whom they have developed a novel inverse-problems approach to improving their production-line sensing of drug crystallisation. *Tant* is pioneering novel research in the area of ultrasonic tomography and experimental design for industry (with formal support from EDF, National Physical Laboratory (NPL), National Nuclear Laboratory, Rolls Royce, OnScale and the Institute for Healthcare Improvement (IHI)). She is currently developing extensions to this work for inspection of additive manufacturing processes with a multi-disciplinary team based at the Advanced Forming Research Centre (AFRC), the Centre of Ultrasonic Engineering (CUE), and Georgia Institute of Technology.

Analysis (Head: Mao, 13.6 FTE)

Applied Analysis: Innovative work in smart and nano-materials technologies involves computational models that lead to fundamental mathematical questions (existence and well-posedness, stability, qualitative properties of solutions) that fall within the remit of Applied Analysis. The group members' expertise in spectral analysis, coagulation-fragmentation equations and homogenisation theory has enabled them to supplement and guide numerical and experimental work in the AFRC and a KTN industrial internship with Procter & Gamble on the mathematical modelling of spray-drying, while their expertise in network modelling and analysis underpins work in Mathematical Ecology.

Numerical Analysis: The group is one of the four largest (along with Bath, Manchester and Oxford) and most well-established groups of its kind in the UK. Their research is focused on the construction and analysis of computational methods for algebraic and differential equations arising in a wide variety of application areas, equipping them to make important contributions across all the University's strategic research themes. Current examples include Measurement Science & Enabling Technologies (regarding sensor networks with NPL), Advanced Manufacturing & Materials (regarding electric heating in collaboration with the AFRC), and Ocean, Air & Space (regarding unsteady vortex-dominated flows). The group has been enhanced by two recent appointments, *Pestana* and *Arrigo*, both of whom specialise in numerical linear algebra. Numerical Analysis continues to be an area of strategic growth to capitalise on the opportunities provided by the widespread upsurge in the importance of data science and associated technologies and, in particular, Strathclyde's position at the heart of the newly-launched City of Glasgow Innovation District (GCID). Since 2014, group members have secured substantial grants from funders including EPSRC, Technology Strategy Board, Cancer Research UK, Leverhulme Trust and Horizon 2020

(see Section 3). Externally, these researchers are also recognised for organising the longest-running and largest international conference on numerical analysis (see Section 4).

Stochastic Analysis: Research by this group on stochastic differential equation (SDE) models for option values in energy markets, stochastic numerical solutions for nonlinear energy models, and time-series models for financial data contributes across many of the University's strategic research themes, notably Energy and Health & Wellbeing. The group is led by Mao and has an internationally acknowledged research capability in the mathematical modelling of stochastic systems. In particular, several popular numerical methods for nonlinear SDEs, including the tamed Euler-Maruyama (EM), the stopped EM, and the tamed Milstein methods, and adaptive EM methods have recently been developed based on pioneering work by the group.

Strategy & Implementation

Overall, our research is targeted directly at the development and application of Mathematics and Statistics to create significant impact in both the academic and non-academic worlds. We have a Research and Knowledge Committee (RKEC), chaired by the Research Director, responsible for developing, leading and delivery of research and impact at a Departmental level. The committee is populated by the heads of the research groups, research leads, and the KE Director. Due to growth in our PGR student cohort, in 2016 we established a separate Postgraduate Committee (chaired by the Postgraduate Director), which enabled RKEC to focus on strategic planning for research and impact activities. Both these committees report to the Executive Committee, chaired by the Head of Department, which is responsible for all aspects of the general management.

Our focus is on carrying out research in key areas where we have proven track record in research quality (e.g. stochastic analysis, liquid crystal modelling, and numerical analysis), while developing new areas of research in line with the strategic aspirations of the Department and University (e.g. drug manufacture, digital health, and the One Ocean Hub). Our recruitment strategy is crucial to the realisation of this strategy: new academic staff are hired with a strong emphasis on their strengths relating to specific research themes (see Section 2). Additionally, we place a focus on a collaborative ethos of interdisciplinary research, encouraging staff to work closely with colleagues from the Faculty, University, other academic institutions, charities, government bodies and industry (see Section 4). Since REF2014, we have created a Strategic Grants Initiatives Fund, comprising approximately £20K annually to support staff with the development of innovative research proposals. This fund has enabled research visits both from and to the Department, and visits to industrial partners for scoping collaborative opportunities. Over the next five years, we will actively target particular opportunities for new external collaborations in line with our research priorities, particularly with exciting new developments being spearheaded by Strathclyde such as the National Manufacturing Institute for Scotland (NMIS) and the Medicines Manufacturing Innovation Centre (MMIC), which require multi-faceted contributions from the Mathematical Sciences and Statistics.

Our research achieves impact beyond academia through extensive research partnerships with industry and public sector organisations (see Section 4), as exemplified by our three impact cases studies. Members of Health and Ecology Modelling collaborated with Public Health Scotland and others to develop surveillance techniques and provide policy advice regarding managing seasonal and pandemic influenza, Covid-19 and Human Papilloma Virus in Scotland. Numerical Analysis researchers collaborated with a digital marketing company on communication network analysis, providing the algorithms for new commercial software, which has been used by major companies such as Sky, Twitter, and Jewson in social media campaigns. Researchers in Mathematical Ecology have worked extensively with national and international agencies on fisheries and marine stewardship, assessing the sustainability of fishing and fish stocks in Europe, USA and Africa.

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Our commitment to achieving impact in industry and the public sector is further illustrated by our well-established policy of offering commercial KE services to external organisations across sectors, including Continuing Professional Development (CPD) and expert consultancy. Such activity is coordinated and led by our Statistical and Mathematical Advice, Research and Training (SMART) consultancy unit. Recent examples of KE impact include the following:

- Upskilling quality assurance in the manufacturing sector: Bespoke training provided to Scottish Leather Group and an international medical devices company to help improve their product quality. In the latter case, 30 UK staff attended three successive courses with 7 US staff attending the final course.
- Statistical modelling for a UK national regulation agency: Resulted in new methodology and AI algorithms for maximising the use of sparse data, and enabled the agency to provide more accurate financial projections and planning pertaining to particular regulatory programmes.
- CPD courses in mathematical modelling and statistical methods for teachers: Commissioned by the Scottish Qualifications Agency (SQA), these courses provided teachers with the knowledge required to deliver a new Scottish Higher Mathematics qualification. In 2019-2020 these courses were delivered to over 500 teachers across Scotland.
- CPD in statistical modelling for NHS staff: A bespoke course for health care professionals who want to upskill in statistics and data analysis. In 2019-2020 this course was delivered to 134 participants.

2. People

Our staffing strategy follows directly from the research strategy, with a central objective of growing the quality and number of staff in our areas of strategic importance (see Section 1). Specifically, our staffing strategy addresses succession planning, sustainability of our research groups, and assists KE with external partners to maximise our research impact. A key route to achieving these goals has been co-investment aligned to the University's strategic funding routes, the Chancellor's Fellowship (CF) scheme and the Global Talent Programme (GTP), which have been very successful in attracting high-quality international researchers to the Department. Specifically, since 2014 we have recruited three Professors under the GTP scheme – *Kleczkowski* (2018), *Majumdar* (2019) and *Gomes* (2020), and eight staff members through the CF scheme – *Banas* (2015), *Kavanagh* (2015), *Eom* (2016), *Waurick* (2017), *Barry* (2018), *Chen* (2018), *Tant* (2019) and *Das* (2020). In addition, we have recruited four Lecturers through our normal departmental recruitment process – *Pestana* (2015), *Foondun* (2016), *Wray* (2017) and *Arrigo* (2019). The high quality of these researchers is evidenced in Section 4, and their involvement in the different research groups is outlined below.

Health and Ecology Modelling

To build on our unique capabilities in this area (see Section 1), we have grown the group from 4.4 FTE at REF2014 to 7.1 FTE at REF2021, including the appointments of *Kavanagh*, *Barry* (0.6 FTE), *Gomes* and *Kleczkowski*. In particular, *Kleczkowski* is key to our succession planning for the longer-term leadership of this group. Bolstered by Strathclyde's new Ecosystems Stewardship sub-theme, and being aware of an external funding environment with an increasing focus on the global challenges facing our oceans, we have also invested in our strong technical expertise in mathematical modelling of marine ecosystems, growing the Marine Science group from 1.4 to 3.4 FTE through the appointments of *Banas* and *Chen*. The health-related research of *Barry*, *Kavanagh* and *Young* (2.3 FTE) is submitted within UOA3.

Continuum Mechanics and Industrial Mathematics

Owing to the strategic importance of the research area, we have invested in new expertise via the appointments of *Das*, *Majumdar*, *Tant* and *Wray* to offset retirements and other departures during

the REF period and growing the group from 9.2 to 10 FTE. We anticipate this growth continuing in line with University-wide investment in initiatives such as the CGID and the NMIS.

Analysis

The quality, reputation and size of the group (17 FTE) has ensured continued strategic staffing investment, reflected in the appointment since REF2014 of *Arrigo, Eom, Pestana* and *Waurick*. Also, research in Stochastic Analysis, which underpins our very successful MSc programmes in Finance, Actuarial Science and Applied Statistics, has been strengthened by the appointment of *Foondun*. The research of *Steingrimsson, Kitaev* and *Bevan* in Combinatorics is submitted within UOA11.

Recruitment

Each staffing case to replace an existing post or create a new post has to include a detailed business case and description of alignment with research strategy at Department, Faculty and University level. Positions are widely advertised, which has helped to attract considerable interest from candidates worldwide. We always select the best candidates regardless of origin and have never encountered problems obtaining visas for non-EU applicants. 15 out of the 35 staff (33.1 FTE) submitted to REF2021 originate from outside the UK. The current staffing contract profile for UOA10 is shown in Table 1.

Table 1. Current Staff Profile

Staff Contract Level HESA	Numbers of Staff FTE	% of Eligible Staff FTE
F1 Professor	11	33.2%
I0 Reader/Senior Lecturer	9.7	29.3%
J0 Lecturer B/Senior Research Fellow	9.4	28.4%
K0 Lecturer A	3	9.1%

An important additional component of our staffing strategy is the appointment of Academic Teachers (ATs) to reduce the teaching and administrative workload on Academic Research staff, and thus grow our capacity to deliver our research objectives; we have grown this category of staff from 2 to 6 FTE over this REF period. We have also appointed a KE Director to directly support staff in deriving impact from their research.

Personal Fellowships

To develop staff at all stages of their careers, we encourage and support them in applying for personal fellowships, which has brought additional resource to the Department to help achieve our strategic research goals and diversify our research income streams. A robust internal peer review process offers extensive feedback on proposals and mock interviews with colleagues from other departments and/or universities if appropriate. A reduction in teaching load and relief from some academic administrative duties is granted to staff securing funding for teaching replacement, with 7 fellowship holders benefitting since 2014. Staff have been awarded 13 individual research fellowships since REF2014 (see Section 4). These prestigious fellowships have raised our national and international profile in several ways. For example, *Majumdar's* fellowship enabled her to establish long-term links with the leading experimental group led by Lagerwall (Luxembourg), and together with Walker (Louisiana), they organised an international research workshop at the Institute

of Computational and Experimental Research in Mathematics (Brown), while *Ramage's* fellowship led to new research links with Nichols (Mathematics) and Lawless (Meteorology) at Reading.

Career Development and Support for Staff

We play an active role in the career development and training of our staff at every stage of their careers. All staff have an annual one-to-one meeting with the Head of Department when their career aspirations and development and support needs are discussed. Staff also have the opportunity for regular support by a more senior colleague who can provide guidance on all aspects of career development. All new academic staff set aims and objectives within their first six months in addition to participation in the university-wide Accountability and Development Review (ADR) process (see Institutional Statement). In addition, new appointments at a junior level are all assigned a mentor to advise them as they follow the institutional Academic Career Development Framework. During this REF period, we have seen ten promotions - with four members of staff being promoted to Professor (*Dolean, Greenhalgh, Mackenzie, Mulholland*), one being promoted to Reader (*Banas*), two being promoted to Senior Lecturer (*Kavanagh, Pritchard*), and five being promoted to Lecturer B (*Pestana, Waurick, Wray, Arrigo, Tant*). In addition, two members of professorial staff were re-zoned upwards, and three academics received contribution pay awards. If the annual ADR discussions identify a strong case for promotion, then the Head of Department meets individually with the staff member to give detailed guidance on the process in order to ensure that all of the cases put forward have the greatest possible chance of success.

Staff have access to a variety of financial support to help initiate research: CF's receive a £10K Starter Grant, while new Professors receive a £25K New Professor's Fund. New staff can also access funds via the research groups, which are allocated an annual budget for conference attendance and training.

All staff have access to a wide range of CPD courses under Strathclyde's Programme in Research and Leadership (SPIRAL) and the Organisational and Staff Development Unit (OSDU). Research staff benefit from support that meets the Concordat to Support the Career Development of Researchers, with the University receiving reaccreditation in 2016 of the EU HR Excellence in Research Award. Our senior staff periodically audit the quality of staff publications and provide individual feedback and support, particularly to Early Career (EC) researchers. We also run a series of Research Grant Workshops (see Section 3) which enable staff to develop their grant-writing skills, to keep informed about funding opportunities, and to access peer support and feedback on applications – all of which supports staff development.

Fixed-term contracts are only used where funding is limited to a specified period or where the post was created to deliver a specific time-limited project. We comply with the Fixed Term Employees (Prevention of Less Favourable Treatment) Regulations 2002, and staff who have been on fixed-term contracts for over 4 years will normally be switched to open-ended contracts. During this REF period, all Academic Research staff have been on open-ended contracts, while all of our Postdoctoral Research Assistants (PDRAs) have been on fixed-term contracts. Our PDRAs are funded from a variety of sources including EPSRC, NERC, EC and Marie Skłodowska Curie. Three former PDRAs have secured permanent positions on open-ended contracts with us, with *Corson* becoming a Teaching Associate, *Arrigo* winning a three-year Leverhulme Trust Early Career Fellowship before becoming a Lecturer, and *Tant* being awarded a three-year EPSRC UKRI Innovation Fellowship before being appointed as a CF.

We have several ways of developing the impact generating qualities of our staff. A particularly successful approach has been through encouraging staff to take up joint appointments with other organisations. We have staff holding joint appointments with, for example, Health Protection Scotland (*Robertson*), NHS Scotland (*Young*), and the Animal and Plant Health Agency (*Kelly*). The

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knowledge exchange is two-way, enabling research at the University to be applied directly to operational settings, as well as enabling practical applications to inform the development of University research. We also encourage staff to take part in wider cross-institutional initiatives, such as the GCID, which reaches out to business in targeted sectors. Our KE Director assists staff with developing KE activities, and we have facilitated connections with external organisations through arranging events and workshops based around particular applications.

Support for PGR Students

During the REF2021 period, we recruited 98 students with 68 completing their PhD, and a further 9 currently working on corrections. This compares with 70 students being recruited with 42 completing their PhD, and a further 3 graduating with an MPhil during the REF2014 period. While we have typically recruited around 10 new PGR students each year, in 2019-2020 we recruited a total of 21 new PGR students partially due to *Chen*, *Cook*, *Heath* and *Speirs* winning NERC DTP SUPER studentships. We participate in the University's Research Studentship schemes (see Institutional Statement): the Head of Department, Postgraduate Research Director, and PhD Studentship Coordinator select the strongest applicants and proposals. During this REF period, 49 of the Department's 98 PhD students were funded from external sources including APHA, The Carnegie Trust, Capita, Cancer Research UK (CRUK), EPSRC, Horizon2020, The Leverhulme Trust, NERC, MASTS, Marine Scotland, and NPL. Our PGR students are based across all of our research groups, with 41 in Health and Ecology Modelling, 25 in Continuum Mechanics and Industrial Mathematics, and 32 in Analysis.

We follow the University's Policy and Code of Practice for Postgraduate Research Study, which sets out guidelines covering the student-supervisor relationship, research governance and ethics, and training and development. Our students benefit from participation in Strathclyde's Postgraduate Certificate (PGCert) in Researcher Professional Development, which is awarded along with their degree at the conclusion of their studies. All of our PGR students have at least two supervisors, and are mentored by a third staff member not otherwise involved in the project. Progress is monitored every 3 months in year 1 and every 6 months thereafter, complemented by regular assessments of research and training. At the end of year 1, a research report assists the Department to determine progression, and during year 2, students present their research to their contemporaries, write a substantial research report, and sit a "mini-viva". For the majority of students whose funding extends beyond 36 months, a draft thesis or detailed thesis plan with attached papers is required in year 3. At each of these stages, the Postgraduate Research Director reports to the Postgraduate Research Committee, which authorises progression, organises corrective action, or recommends transfer to a lower-level qualification. These proactive strategies ensure that the training a student receives is at the appropriate level and matched to their needs. The training programme is flexible and may be adapted to suit changes in needs and research direction. During this REF period, a number of students have taken time away from their research and training for personal reasons, such as mental health issues, caring for parents, and maternity leave. We supported all of these students and each subsequently successfully completed their degree.

Generic and core skills training are embedded from the start of our PGR programme. In particular, we deliver a compulsory module on Research Governance and Organisation in the Mathematical Sciences. The innovative module provides discipline-specific provision in this area and equips PGR students with key but rarely taught skills necessary to become effective research professionals. Students learn about publication, collaboration, authorship, citation and professionalism in the Mathematical Sciences, and submit reflective assessments. We are also a member of the Scottish Mathematical Sciences Training Centre (SMSTC), a joint venture between all research active Mathematical Sciences departments in Scotland (originally funded by EPSRC in response to the 2004 International Review of UK Mathematics). The SMSTC (whose current Director is *Pritchard*) is an invaluable resource and offers both generic and discipline specific training to all PGR students in

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Scotland, regardless of their funding source. The training provided by SMSTC consist of two-hour lectures once a week for ten weeks, on core modules organised into four themes, Analysis, Applications of Mathematics, Probability & Statistics, and Structure & Symmetry in which students complete graded assignments. Supplementary modules, which can be at a more advanced level, are also offered and are often taken by higher-year PhD students. We have a PGR Training Coordinator who provides both students and supervisors with information and advice about the requirements of the PGCert, and monitors student progress.

Having a minimum of two supervisors for each student allows Early Careers staff to gain experience of supervision by acting as a second supervisor with a more experienced primary supervisor. EC staff are also actively encouraged to apply for studentships through the University's Research Studentship schemes, where preference is often given to Early Careers staff.

All of our PhD students are supported financially by the Department to present their research at international and national conferences and workshops, with the vast majority of our PhD students going on to publish their work in international journals. Students within the Health and Ecology Modelling Group who are associated with MASTS also benefit from twice-a-year retreats for students from across the MASTS community which provide a variety of training experiences. Some academic staff and PGR students are members of the Centre for Mathematics Applied to the Life Sciences (CMALS, run jointly with Glasgow), which organises poster competitions, visits to experimental labs, and regular meetings and seminars. We also have an energetic Society for Industrial and Applied Mathematics (SIAM) and Institute for Mathematics and its Applications (IMA) Student Chapter which helps to promote the application of mathematics in industry through the organisation of social and academic events.

The quality of our PhD programme and Departmental support is evidenced by the ongoing success of our recent PhD graduates. For example, in addition to *Tant* securing a CF at Strathclyde (2014), *Wachtel* (2016) secured a position as Professor at Instituto Tecnológico Autónomo de México, *Bosy* (2017) as a Research Associate at Imperial, *Al Mukahal* (2018) as a Lecturer at King Faisal University, Saudi Arabia, *Lu* (2018) as a Lecturer at Donghua, China, *Cai* (2019) as an Assistant Professor at Nottingham, and *Dong* (2019) as a Research Fellow at Warwick.

Equality and Diversity

We fully support and endorse the University's Equality and Diversity Policy and comply with it in all recruitment processes and Departmental activities. We have our own Equality and Diversity Committee which seeks to promote greater awareness of equality and diversity issues within the Department, and which makes policy recommendations to the Executive Committee. All staff undertake diversity awareness training, which includes courses on Diversity in the Workplace and Understanding Bias. We adhere to the London Mathematical Society (LMS) Good Practice Scheme, and are fortunate to have an Honorary LMS member (*Davies*) as a champion in this regard. At the close of the REF2021 period, 27% of eligible staff were female, compared with 24% at the close of the REF2014 period. We have made notable progress in promoting and recruiting female talent into senior roles, with 18% of our current Professors female, compared with 0% for REF2014. The last three years has seen significant progress in our efforts to improve gender balance, with eight women being appointed to a range of positions including three CFs and two PDRAs, and three women being appointed to chairs since REF2014. These include *Gomes* and *Majumdar* through the GTP scheme, while *Dolean* (who joined in 2013) has recently been promoted to Professor.

The University seeks to support staff in achieving a health work/life balance, recognising that many have family or caring responsibilities. Several policies exist to assist staff, including: flexible working options (which include changes of working hours or working pattern), family-friendly leave (which covers maternity and parental leave), adoption leave, shared parental leave, emergency and unpaid

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leave for family reasons, and special leave. During the review period three members of staff have benefitted from the maternity leave policy. Two members of staff took a year of maternity leave, and made use of the “Keeping in Touch” days, while another is currently on leave and will return after 9 months. Even before the current Covid-19 pandemic necessitated a wholesale shift to remote working, the Department had a culture and policy of informal flexible working where staff were enabled to work at home provided that it did not interfere with the smooth operation of the Department. There have also been two requests for contractual changes to working practices from staff during the review period, both of which were approved. The University’s Carer Policy (see Institutional Statement) also enables staff who have a caring responsibility to benefit from support options including flexible working, homeworking, and special leave, which help staff to continue to be effective in their role. Care is taken not to exclude anyone from Departmental activities by choosing days and times when colleagues working part-time are able to participate.

3. Income, infrastructure and facilities

In keeping with our overall aim of generating research with real-world impact, our research income is primarily and deliberately obtained in collaboration with colleagues from other disciplines and institutions, including industry partners. We encourage such interactions by widely promoting relevant funding opportunities and supporting staff in the preparation and review of applications. New strategies in this area since REF2014 include the creation of our Strategic Grants Initiatives Fund (see Section 1) and strengthening our internal peer review procedures to ensure that applications submitted are of the highest quality. Rather than peer review being dealt with on an *ad hoc* basis, all potential grant applicants are now required to complete peer review documentation which describes any external peer review process and, if required, allows the Research Director to set up an appropriate internal process. Peer review is now compulsory before costings can be approved by the Head of Department. The benefit of this strategy is reflected in the success rate of research applications since REF2014, as given in Table 2.

Table 2. Application Success Rate

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Overall
Unsuccessful	25	15	20	13	15	25	113
Successful	11	12	12	12	10	10	67
Success Rate	31%	44%	38%	48%	40%	29%	37%

Staff are also encouraged to make use of frequent University-wide initiatives. For example, grants from Strathclyde’s International Strategic Partners Fund have been used to establish new links with academics at Waterloo, Chalmers and Delft. Also, staff members are frequently involved in funding bids with Strathclyde Research Centres such as the AFRC and Continuous Manufacturing and Crystallisation (CMAC). We have also introduced a series of Research Grant Workshops to raise the profile of grant-writing activities, including sessions addressing particular aspects of grant-writing such as demonstrating potential impact, “speed dating” to meet potential new collaborators, and sessions delivered by internal and external colleagues on relevant research topics. These sessions are open to all staff and PDRAs, with probationary staff strongly encouraged to attend.

Our strategy of focussing on collaborative, applicable research is reflected in our research funding profile, which shows income from a diverse range of sources across research councils, UK government, charities, industry and other external agencies (Table 3). Specifically, since 2014 we have obtained support from over 35 different funders, ranging from traditional sources to more

unusual agencies such as C B Dennis British Beekeepers' Research Trust, National Oceanic Atmospheric Administration, and the US non-profit agency Long Live the Kings.

Table 3. Range of Funding Sources

Funding type	Amount (£K)
UK Research Council	5,429
UK Government	1,527
International	1,226
UK Charity	1,181
UK Health & Hospitals	424
UK Industry	213
UK Other	91
TOTAL	10,091

Table 4. Awards Total by Year (£K)

Period	Awards total (£K)
2013-14	529
2014-15	2,431
2015-16	1,029
2016-17	2,468
2017-18	1,428
2018-19	881
2019-20	1,325
TOTAL	10,091

Ten major awards (worth over £300K) have been obtained since 2014:

- **Heath (co-I), Global Challenge Research Fund £18.2m** - One Ocean Hub; the largest ever single grant awarded to Strathclyde (2019);
- **Higham, EPSRC Research Fellowship £643K** – Data Analytics for Future Cities (2014);
- **Robertson, Chief Scientist Office £604K** - Scottish Healthcare Associated Infection Prevention Institute (SHAIPi) – with SIPBS (2014);
- **Higham, EPSRC Programme Grant £566K** - Inference, COmputation and Numerics for INsights into Cities (ICONIC) - with Imperial, Oxford and Manchester (total grant £2.9M) (2016);
- **Mulholland, EPSRC £517K** - iNEED (including Nondestructive Evaluation in Engineered Design) – with EEE (2016);
- **Banas, NERC £497K** - Arctic PROductivity in the seasonal Ice Zone (Arctic PRIZE) (2016);
- **Banas, NERC £468K** - Mechanistic understanding of the role of diatoms in the success of the Arctic Calanus complex and implications for a warmer Arctic (2016);
- **Mottram and Wilson, EPSRC £358K** - Control of free-surface flow morphologies in anisotropic liquids – with Nottingham Trent (total grant £695K) (2019);
- **Dolean, EPSRC £342K** - Fast solvers for frequency domain wave-scattering problems and applications – with Bath (2018);
- **Heath, NERC £308K** - Microbes to Megafauna Modelling of Arctic Seas (MiMeMo) (2018).

Our 132 research, studentship and fellowship awards since 2014 include investigators from all the other four departments in the Science Faculty, six of eight departments in the Engineering Faculty, three departments in the Humanities & Social Sciences Faculty, and two departments in the Strathclyde Business School. Furthermore, 58 of these awards involved joint applicants or project partners from external institutions (Table 5).

Since the University introduced a KE career pathway, we have employed a full-time KE Director. The Director undertakes marketing of services, costing and pricing of projects, negotiations with clients, client liaison, management of projects, technical delivery on some projects, and management reporting of KE activity. The key source of support for impact activities is our SMART consultancy

Unit-level environment template (REF5b)

unit (see Section 1), managed by the KE Director and guided by a management board. Income generated by SMART is reinvested in staffing positions, studentships, and other research activities.

Table 5. Awards by Collaborator Type

Collaborator Type	Number of Awards
UK Educational Institution	28
UK Industry, Commerce, Public Corporation	11
UK Health & Hospital Authority	6
EU Educational Institution	4
Overseas Educational Institution (non-European)	4
UK Research Councils	2
UK Central Government	1
UK Public/Private Partnership	1
UK Charity	1

Our staff benefit from several University-wide facilities that support impact generation (see Institutional Statement). A key example is NPL which established a strategic partnership with Strathclyde in 2015. Specific interaction has included a two-day research and impact scoping workshop (including colleagues from Surrey) which resulted in multiple grant proposals being submitted. Also, a week-long joint programme on the Mathematics of Measurement was held at the International Centre for Mathematical Sciences (ICMS) in Edinburgh in 2017. We have hosted three joint Strathclyde-NPL studentships, and Forbes (NPL) was recently appointed as a Visiting Professor jointly with the Department of Computer and Information Science.

Our research facilities were refurbished substantially in 2009, creating several new meeting and seminar rooms, designated space for academic visitors, and a new Departmental library. A designated video conferencing facility, used to deliver post-graduate classes as part of the SMSTC, can also be used by staff for research meetings with remote collaborators. We employ two staff dedicated to providing IT support, one of whom has specialised software engineering skills and assists with turning researcher-generated code into distributable software packages. We also have access to wide-ranging IT services at a University level, including the research information portal PURE, and the online file-sharing facility Strathcloud. We also have access to shared University facilities such as ARCHIE-WeST, a regional supercomputing centre for the West of Scotland set up in 2012 and dedicated to research excellence and economic growth. Its main computer ACRHIE was upgraded in 2018 and comprises more than 2500 INTEL Skylake 6138 cores for distributed parallel computing, two 3TB RAM large memory nodes, and 210TB of high performance GPFS storage. Several of our research groups make use of this £2.4M facility, with *Tant* and co-workers having 335K core hours funded through various grants which require use of commercial software (Matlab and OnScale), commercial compilers (Intel), and their own bespoke software, and *Dolean* having 300K core hours funded through an EPSRC grant using the open source Freefem software.

4. Collaboration and contribution to the research base, economy and society**Research Collaborations and Networks**

As described in previous sections, collaboration lies at the heart of almost all of our research activities. In addition to extensive national and international individual research collaborations, staff are active in a variety of larger research networks with external partners. Our SMART consultancy unit (see Section 1) also helps to drive the development of external relationships that offer the opportunity for two-way translation of knowledge and deeper research collaborations. Highlights include:

Health and Ecology Modelling

Health Statistics has a long-standing strategic partnership with Health Protection Scotland (HPS) for the provision of expert/research level leadership in statistics. This provides HPS with a higher level of statistical expertise than is generally available in NHS Scotland, giving HPS direct access to researchers and PGRs working on relevant research areas. In addition to the Scottish Government Covid-19 Advisory Group mentioned earlier, *Robertson* is a member of the European Medicines Agency/Medicines and Healthcare Products Regulatory Agency Vaccine Safety EWG COVID group, and contributes to Public Health Scotland Research and Modelling Team for Covid-19. He also serves on the Executive and Implementation Group of the Scottish Healthcare Associated Infection Prevention Institute (SHAIPi), and is a member of the Scottish Centre of the UK Health Data Research Network, the I-MOVE European Research Network for Influenza Vaccine Effectiveness, and the I-MOVE+ European Network for Influenza and Pneumococcal Vaccine Effectiveness. *Kelly* has a joint appointment with APHA that provides benefits in terms of PhD projects, publications, CPD courses and an immediate pathway to impact regarding veterinary epidemiology and risk assessment. This includes the development of risk assessment models which have been used to guide policy on rabies control regarding pet movements into GB and more recently contributions to risk assessment in relation to Covid-19. In this later case, assessments focused on international travel and the movement of animals and their products. *Young* and *Barry* work closely with NHS Greater Glasgow and Clyde on the design and analysis of medical research studies (as a result of the interdisciplinary nature of their work they are submitted within UOA3).

In Mathematical Ecology, *Banas*, *Heath* and *Speirs* lead several national and international collaborations on various aspects of Marine Science. Current partner universities include TU Denmark, Middle East Technical, Princeton and Southampton, along with other organisations such as the Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research, German Ministry of Education and Research, and the Institute for Marine Research, Portugal. *Banas* and *Heath* are also leading players in the BASIN Programme (a joint EU and North American programme in marine ecosystems in support of the Global Earth Observation System of Systems Initiative), and the International Council for the Exploration of the Sea, an inter-governmental Marine Science organisation meeting societal needs for impartial evidence on the state of and sustainable use of our oceans and seas. Nationally, they are key players in MASTS and are active in the NERC Changing Arctic Programme and NERC Marine Ecosystems Programme. On land, *Kleczkowski* uses mathematical models to study human, animal and plant diseases, soil and terrestrial biodiversity, and climate change. Specific projects include developing a Plant Health Outbreak Decision Support Framework for DEFRA, and work on the impact of climate change on the spread of pests and diseases in Scotland for the Scottish Government. *Greenhalgh* has worked on mathematical modelling of a wide range of medical and biological problems, including modelling of a new mosquito trap with an SME in Malaysia, and dengue vaccination and hepatitis C databases in Brazil.

Continuum Mechanics and Industrial Mathematics

In Fluid Mechanics, group members collaborate with Bain (Durham), Cimpeanu (Warwick), Narayanan (Florida), Sefiane (Edinburgh), Stone (Princeton), and others. Nationally, in the UK Fluids

Unit-level environment template (REF5b)

Network, *Mottram* and *Wilson* lead the Special Interest Group (SIG) on Fluid Dynamics of Liquid Crystalline Materials (2016-2020), and *Wray* is an Impact Champion for the SIG on Multiphase Flow.

Our researchers in Liquid Crystals form one of the largest centres worldwide for mathematical modelling of such materials, as reflected in their long list of national and international collaborators. Leading scientists in the area including Gartland (Kent State) and Virga (Pavia) have collaborated with the group, and *Mottram* and *Wilson* have a long-running collaboration with Brown (Nottingham Trent) which recently led to a significant EPSRC award in partnership with Merck Group (2019). *Majumdar* co-leads the Bath-Oxford-Strathclyde (BOS) Network on Anisotropic Materials, and the Special Interest Group in Liquid Crystals, Elastomers and Biological Applications for the European Consortium for Mathematics in Industry (ECMI).

In Wave Propagation, group members have a long-standing collaboration with CUE, primarily working on inverse problems associated with ultrasonic non-destructive evaluation, and have collaborated with many international industrial partners, such as IHI Corporation (Japan), Doosan Babcock (UK), and Orthosensor (USA). The tangible outcomes of these collaborations include development of a bespoke software package (currently being tested by IHI employees), joint publications and access to industrial data and facilities. *Mulholland* and *Tant* were also members of the team which secured funding for the new Future of Ultrasonic Engineering (FUSE) CDT, a collaboration between Glasgow and Strathclyde, in 2019. *Tant* has undertaken secondments to both NPL and OnScale, and has forged a new relationship with colleagues at the AFRC. *Tant* has also continued to grow the Wave Propagation group, securing a new PDRA funded through a joint project with CUE and two new PhD studentships, one of which is supported by the IHI corporation and funded by the EPSRC Future Innovation in Non-Destructive evaluation (FIND) CDT, a collaboration between Strathclyde, Bristol, Imperial, Manchester, Nottingham and Warwick.

Analysis

Researchers in Applied Analysis have a number of individual high-profile collaborators, including Crooks (Swansea), da Costa (Universidade Aberta, Lisboa), Drmota (TU Wien), Neukamm (TU Dresden), and Woracek (TU Wien). *Waurick* was a co-organiser with Baasch (Hamburg), Trostorff (Kiel) and Seifert (Clausthal) of the 23rd Internet Seminar on Evolution Equations (2019-2020), which disseminated the latest research in evolutionary equations to a worldwide audience. Other collaborative work includes research with Procter & Gamble on coagulation-fragmentation phenomena.

In Numerical Analysis, several new collaborations have been established since REF2014. One highlight was the award of an EPSRC Mathematics Programme Grant (*Higham*, 2016) which led to a new research network with Imperial, Oxford and Manchester. A second new EPSRC-funded collaboration was established with Bath (*Dolean*, 2018), and *Mackenzie* formed a new research partnership with the Beatson Cancer Centre funded by UK Cancer Research. There have also been new links forged within Strathclyde, with *Barrenechea* and *Pestana* starting new projects with AFRC and Electronic and Electrical Engineering (EEE), respectively. *Barrenechea* is also co-organiser of the Scottish Numerical Methods Network. In addition, *Higham*, *Mackenzie* and *Ramage* have established new collaborations with Forbes at NPL and these have resulted in funded EPSRC ICASE and University PhD studentships.

In Stochastic Analysis, researchers have established close links with several Chinese universities and companies, including Donghua, Huazhong, Northeast Normal, Shanghai Normal, and Qingdao Luze Real Estate Group Co Ltd (who funded a PhD scholarship). *Pan* is also developing an in-country PhD programme with South China Agricultural University, and *Mao* is on the Technical Committee of the Control Theory (TCCT) Stochastic System Control Network.

Unit-level environment template (REF5b)

Visiting Professorships

We have an active Visiting Professor (VP) programme, whereby internationally leading individuals engage with the Department in a variety of ways, such as delivering research lectures, advising on grant applications, and collaborating on specific research projects. VPs include *Bird* (Edinburgh, 2012-present), *Brunner* (Newfoundland, 2003-2016), *Gartland* (Kent State, 2009-2017), *Cuminato* (São Paulo, 2019-present), *Duff* (STFC-RAL, 1987-present), *Forbes* (NPL, 2019-present), *Sefiane* (Edinburgh, 2015-present), *Picard* (2004-present), *Banasiak* (Pretoria, 2013-present), and *Walton* (Texas A&M, 2008-2018). These appointments have provided co-supervision of PhD students (Forbes and Sefiane); enabled closer involvement with HPS and the health service in Scotland (Bird); as well as joint publications between the VPs and department staff (Picard (9), Cuminato (8), Banasiak (8), and Sefiane (5)). Our own staff also hold several external visiting positions, for example, *Majumdar* is a VP at Bath and IIT Bombay and a Visiting Fellow at Oxford, having previously held a Chinese Academy of Sciences President's International Fellowship (2016) and Distinguished Grey Fellowship (Durham, 2016), while *Kleczkowski* is an Honorary Professor at Stirling.

Other International Activity

Many individual international research collaborations with researchers across several countries have already been mentioned above. Other notable links include *Majumdar's* Department of Science and Technology project with IIT-Delhi to fund bilateral visits, a Royal Society Newton Fellowship with Peking in China, and a Daiwan Foundation small grant with Tohoku in Japan. Regarding research-related training, *Greenhalgh*, *Grinfeld*, *Knight*, *Lamb* and *Pritchard* have taught postgraduate courses and/or supervised students at various African Institute Centres for the Mathematical Sciences (AIMS) in Cameroon, Ghana, Rwanda and South Africa. Also, *Grinfeld* has taught at MSc-level schools mainly funded by the Centre International de Mathematiques Pures et Appliquees (CIMPA) in India, Laos and The Philippines.

Contributions to External Policy Research

Our Marine Scientists continue to play an important role in informing the Scottish Government's Marine and Fisheries policy, with *Heath* currently the Chair of the Scottish Government/Clyde Marine Planning Research Advisory Group and a member of the Scottish Parliament Cross Party Group on Fishing. Additionally, *Kleczkowski* is a member of the Scientific Advice and Response Team at the Scottish Government Plant Health Centre, and *Gray* is co-Chair of the COLOSS Honey Bee Colony Loss Monitoring Group. *Cook* is co-author of the European Commission publication "European Red List of Marine Fishes", a review of the conservation status of European fish species published by the European Commission. Our health sciences researchers play key roles in guiding the policy and practice of HPS, with *Robertson* a member of the HPS HPV Epidemiology and Surveillance Committee, the Vaccine Preventable Diseases Epidemiology and Surveillance Committee, the Department of Health SPI-Modelling Committee, and the Ethics and Data Safety Monitoring Committees of the International Breast Cancer Group. Also, *Barry* is an expert statistical member of the West of Scotland Research Ethics Committee. In education policy, *Pritchard* authored the Scottish Mathematical Council (SMC) report "SQA Qualifications in Mathematics and English (1986-2018): A Statistical Overview". Staff are also involved in setting strategic and funding priorities, e.g. the EPSRC Sandpit on Understanding the Physics of Cancer, Sheffield, 2016 (*Mackenzie*), EPSRC Strategy Meeting for Data Science/Big Data Research, London, 2016 (*Ramage*), and EPSRC Working Group on The People Pipeline, 2012-2015 (*Davies*).

Additional Impact-Focussed Activity

The Department's SMART consultancy unit has had regular success in supporting a variety of organisations, as illustrated by the following examples (not captured in our Impact Case Studies), with some companies' names withheld for confidentiality:

Unit-level environment template (REF5b)

- A series of statistical CPD courses for a Japanese manufacturer of medical devices, helped it improve quality assurance procedures for its manufacturing processes (2018-2020).
- Mathematical consultancies for a Japanese company developing algorithms for non-destructive testing techniques (2018 and 2019).
- Modelling the likely annual number of cancer patients and required chemo- and radio-therapies up to 2025, to assist future demand planning for the West of Scotland Cancer Network, Scotland's largest cancer centre seeing around 8,000 new patients per year (2017).
- Investigating key factors affecting the sales of products for a major Scottish retailer of bottled drinks, with particular focus on the weather, promotional activity, price and competition (2015).

External Fellowships

Departmental staff have been awarded 12 individual research fellowships since REF2014: EPSRC/RCUK Digital Economy Established Career Fellowship (*Higham*, 2015-2019), Royal Society Newton Advanced Fellowship (*Mao*, 2017-2020), EPSRC-UKRI Innovation Fellowship (*Tant*, 2018-2021), Leverhulme Trust International Academic Fellowship (*Majumdar*, 2019-2020), Leverhulme Trust Early Career Fellowship (*Arrigo*, 2019-2022), Leverhulme Trust Research Fellowship (*Barrenechea* 2019-2020, *Greenhalgh* 2015-2017, *Mackenzie* 2014-2016, *Ramage* 2017-2019, *Steingrimsen* 2018-2020, *Wilson* 2013-2016), Royal Academy of Engineering Intelligence Community Postdoctoral Fellowship (*Knight*, 2019, for le Gorrec), and H2020 Marie Skłodowska Curie Postdoctoral Fellowship (*Higham*, 2016, for Tudisco). Other notable external Fellowship honours include three Fellows of the Royal Society of Edinburgh (RSE) (*Higham*, *Mao*, *Stewart*), one Fellow of SIAM (*Higham*), and four Fellows of the IMA (*Mottram*, *Mulholland*, *Ramage*, *Wilson*).

Contributions to National and International Professional Societies

As expected from our focus on collaborative and interdisciplinary research, staff are active over a range of professional societies. Highlights include:

Senior Roles in National and International Societies

Ramage is an elected member of the Board of Trustees of SIAM, *Higham* was President of the SIAM UK and Ireland Section (2015-2017), and *Mackenzie* was Vice President (2017-2019). *Ramage* and *Pestana* were Vice President and Secretary, respectively, of the SIAM Activity Group on Applied Linear Algebra (2016-2018). *Pritchard* is a Trustee and Member of the Executive of the Joint Mathematical Council of the UK, *Davies* chairs the LMS Nominating Committee, and *Higham* is a member of the Turing Gateway to Mathematics Programme Committee. As previously mentioned, *Pritchard* is Director (2019-2021), and was previously Deputy Director (2016-2018), of the SMSTC. He also chairs the Qualifications Development Team for the Prospective New Higher in Applications of Mathematics for the SQA.

Prize and Grant Committee Membership

- Awards Committee of the International Liquid Crystal Society (*Osipov*)
- Carnegie Trust Science and Engineering Assessor (*Mottram* - Chair 2017, *Ramage*)
- Global Challenges Research Funding Strategic Advisory Group (*Majumdar*)
- Newton International Fellowships Committee: Physical Sciences (*Estrada*, *Osipov*, *Wilson*)
- IMA Leslie Fox Prize Committee (*Higham*)
- The London Mathematical Society (LMS) Prize Committee (*Higham*)
- Royal Society Newton Advanced Fellowships Panel (*Majumdar*)
- EPSRC Peer Review College (*Davies*, *Greenhalgh*, *Higham*, *Mao*, *Mulholland*, *Ramage* – Panel Chair, *Wilson*)

Other Professional Society and other External Committee Membership

- Chair of Royal Statistical Society (RSS) Conference Board (2017-2020, *Kavanagh*)

Unit-level environment template (REF5b)

- Council for Mathematical Sciences (CMS) (2009-2014, *Davies*)
- ECMI Educational Committee (2015-2019, *Grinfeld*)
- European Mathematical Society (EMS) Policy Advisory Group (2014-2020, *Davies*)
- ICMS Programme Committee (2017-2021, *Majumdar*; 2020-2023, *Wilson*)
- IMA Scottish Branch (2014-2017, *Mottram* – Chair; *Mulholland*)
- LMS Research Policy (2011-2016, *Davies*)
- LMS Good Practice Scheme (2014-2020, *Davies*)
- RSE Learned Societies' Group on Scottish STEM Education (2014-2021, *Pritchard*)
- RSS (2012-2020, *Kavanagh*)
- The Scottish Mathematical Council (SMC) (2015-2021, *Pritchard*)

Honours and Prizes

A major highlight for the Department since REF2014 was the award of the Order of the British Empire (OBE) to *Davies* for Service to Mathematics (2014). Other notable honours include awards of the Frederiksz Medal from the Russian Liquid Crystal Society for the “outstanding achievements in the theory of liquid crystals” (*Osipov* 2018); the Hilsum Medal from British Liquid Crystal Society (*Osipov* 2015, *Mottram* 2017, *Majumdar* 2020); the Medal of the 2017 International Scholars' Forum by Shanghai Normal (*Mao* 2017); the Prix Bull-Joseph Fourier 2015 (*Dolean* 2016); the RSE Sir James Black Medal (*Heath* 2017); the RSE Sir Thomas Makdougall Brisbane Medal (*Kavanagh* 2018); the 2015 LMS Anne Bennett Prize and the 2019 FDM Everywoman in Technology Academic Leader Award (*Majumdar*); Royal Society Wolfson Research Merit Awards (*Estrada* 2014, *Mao* 2016); and the 2020 Suffrage Science Award (*Majumdar*). *Mao* (Web of Science h-index 62) is included in Highly Cited Researchers 2020.

Conference Participation and Organisation

Our staff are frequently invited to deliver plenary and keynote lectures at major international conferences, and are very active in conference organisation. A representative sample follows:

- *Arrigo*: XX Householder Symposium on Numerical Linear Algebra (USA, 2017)
- *Banas*: 4th International Workshop on Trait-based Approaches to Ocean Life (UK, 2019)
- *Barrenechea*: International Conference in Boundary and Interior Layers (Argentina, 2020)
- *Dolean*: AARMS Workshop on Domain Decomposition Methods for PDEs (Canada, 2015)
- *Kleczkowski*: Polish Academy of Sciences Institute of Nature Conservation Conference (Poland, 2019)
- *Langer*: 4th Najman Conference on Spectral Problems for Operators and Matrices (Croatia, 2015)
- *Mao*: TCCT Conference on Stochastic Control (China, 2019)
- *Majumdar*: Indian Woman in Mathematics Association Annual Conference 2017 (India, 2017)
- *McKee*: International Conference on Current Trends in Theoretical and Computational Differential Equations with Applications (India, 2017)
- *Mackenzie*: Workshop on Multi-Physics Geometric PDEs using Deformable Surfaces (UK, 2015)
- *Mottram*: SIAM Conference on Mathematical Aspects in Material Science (USA, 2018)
- *Osipov*: 42nd German Liquid Crystal Conference (Germany, 2015)
- *Pestana*: International Conference on Preconditioning Techniques for Scientific and Industrial Applications (The Netherlands, 2015)
- *Ramage*: GAMM Workshop on Applied and Numerical Linear Algebra (Germany, 2019)
- *Robertson*: RSS Annual Meeting (UK, 2017)
- *Sonnet*: Stochastic and Deterministic Mathematical Methods for Biological and Environmental Systems (Portugal, 2017)
- *Wilson*: International Conference on Interfacial Phenomena and Heat Transfer (China, 2017)

Unit-level environment template (REF5b)

Organisation of Major International Conferences and Workshops

Major conferences organised by Department members at Strathclyde include the 26th, 27th and 28th Biennial Numerical Analysis Conference (2015, 2017 and 2019), the MASTS Annual Science Conference (2015, 2016, 2017 and 2018), and the RSS Annual Conference (2017). Other major conferences co-organised by staff include:

- SIAM Conference on Nonlinear Waves and Coherent Structures (Cambridge, 2014)
- Jack Carr Memorial Workshop (Edinburgh, 2017)
- SIAM Annual Meeting 2017 (USA, 2017)
- SIAM Conference on Mathematical Applications of Materials Science (USA, 2018)
- British Society of Rheology Mid-Winter Meeting (Edinburgh, 2018)
- 11th International Conference on Machine Learning and Computing (China, 2019)
- International Workshop on Modelling and Prediction of Harmful Algal Blooms (Glasgow, 2020).

External Editorships and Editorial Board Memberships

Department members have chaired and served on a wide range of editorial boards during the REF period, a representative sample follows:

Editorships

- *Higham*: SIAM Review (Editor-in-Chief)
- *Osipov*: Crystals (Section Editor, Liquid Crystals)
- *Ramage*: SIAM Review (Associate Editor, Research Spotlights)
- *Wilson*: Journal of Engineering Mathematics (Joint Editor-in-Chief)

Editorial Board Memberships

- *Davies*: Journal of Integral Equations and Applications, Royal Society Open Science
- *Greenhalgh*: Bulletin of Statistics and Economics, Contemporary Mathematics and Statistics, International Journal of Statistics and Economics, Journal of Biological Systems, Communication in Biomathematical Sciences, International Journal of Ecology and Development
- *Higham*: IMA Journal of Numerical Analysis, Journal of Computational Finance, Journal of Complex Networks
- *Knight*: SIAM Journal of Matrix Analysis and Applications
- *Langer*: Complex Analysis and Operator Theory, Quaestiones Mathematicae
- *Majumdar*: Mathematics and Mechanics of Solids, IMA Journal of Applied Mathematics, Computational and Applied Mathematics
- *Mao*: Annals of Differential Equations, Advances in Difference Equations, Journal of Cogent Engineering, Journal of Differential Equations and Dynamical Systems, Mathematika
- *Mottram*: Liquid Crystals, Journal of Engineering Mathematics
- *Pestana*: SIAM Book Series on Fundamentals of Algorithms
- *Ramage*: SIAM Journal of Matrix Analysis and Applications
- *Speirs*: Journal of Biological Systems

UOA10 staff at Strathclyde take seriously their commitment to science in society in terms of producing, directing and contributing to the highest quality research in Mathematics and Statistics. This commitment extends to translating that research into useful outcomes for the benefit of society, public sector organisations and industry, in alignment with the founding principles of Anderson's Institute as "A Place of Useful Learning".