Institution: University of Strathclyde

Unit of Assessment: 10 Mathematical Sciences

a. Context

The main beneficiaries and types of impact, during the REF period, are given below with indications of the associated research groups (Applied Analysis, **AA**; Continuum Mechanics and Industrial Mathematics, **CMIM**; Numerical Analysis and Scientific Computing, **NASC**; Population Modelling and Epidemiology, **PME**; Stochastic Analysis, **SA**).

Beneficiaries:

- **Government agencies in Scotland and the UK (PME, SA)**: e.g. Health Protection Scotland (HPS), NHS Greater Glasgow and Clyde, Marine Scotland, Veterinary Laboratories Agency, Scottish Government, GCHQ and DEFRA.
- **Technology Industry (AA, CMIM, NASC)**: e.g. Proctor & Gamble, NAG, Wyeth, Shell, Rolls Royce, Hewlett-Packard, Bioinnovel, Doosan Babcock, IDEAS, Cascade, Oasys, Chemtec, Subsea7 and Simul8, MoD, Zinktech.
- **Advertising sector (AA, NASC)**: e.g. Bloom Agency, Counting Lab and Vodafone.
- **Society and schools (AA, NASC, CMIM, PME)**: in Scotland and the wider UK, as well as growing impact in Europe and the rest of the world.
- **Natural environment (PME)**: assisting the wellbeing of the animal kingdom, particularly fish, cattle and companion animals.
- **Financial sector (SA)**: financial risk experts Barrie & Hibbert.

Types of impact:

- **Economic and job creation**: public benefit through food safeguarding and streamlined procedures (at least £17M in increased value), investment in new business systems (approx. £1.25M, including 3 jobs), increased profitability (annual income increase of 50% in one company alone) and direct job creation stemming from implementation of policy and new technologies (tens of new jobs related to new procedures and policy).
- **Public policy**: policy discussions stimulated and new policies proposed and implemented (contribution to 4 major Governmental reviews and tens of smaller commissioned reports).
- **Societal and environmental impact**: improved health of humans (e.g. 7500 fewer cases of blindness following research-driven advice on cataract surgery procedures), animals and the general environment through recommended policy and procedure changes (significance highlighted through Governmental and independent assessment).
- **Improved processes**: new software tools, modelling of new technologies and data analysis algorithms. Improved procedures for effective, efficient government processes (direct collaboration has led to implementation of algorithms and processes).

b. Approach to impact

Our approach to impact is varied, but coordinated at a strategic level. It differs from case to case, recognising that partnerships and forms of impact are often best handled in different ways. When appropriate, we have re-used successful mechanisms and disseminated best practice from similar projects, or types of impact (see below). In this way we have been able to extend the reach and significance of our impact; for example, extending policy advice from UK to Europe and the USA, wider uptake of model and algorithm developments by multinational companies, and substantial growth of several orders of magnitude in numbers of individuals feeling the positive benefit of health related advice.

Through the use of strategic partnerships, flexible departmental resource allocation, academic leadership and the effective use of University and external resources we have received £1.7M of research income from Government agencies (a 100% increase compared to RAE2008) and a 25% increase in industrial funding. During the REF period, 60% of staff in the Department have worked on industrial or government funded projects, compared to around 30% in RAE2008.

Strategic partnerships

In projects conducted with large organisations, such as government agencies, significant man-power is required and this is overseen within the Department by the Head of the relevant Research Group, or their nominee. For example, relationships between Health Protection Scotland, Marine Scotland and NHS are overseen by the Head of the Research Group in Population Modelling and Epidemiology. These are long term relationships which have been nurtured and grown through

investment at Department level for over 20 years. These relationships have now reached a status that we are the primary point of contact between these agencies and academia. Research from the Department (either from specific sponsored research or more generally from outputs) is trusted and regularly used to inform practice and policy decisions that lead to considerable impact in terms of societal change, public cost-saving and environmental and animal welfare (see case studies led by Heath, Gettinby, and Robertson). In the case of Health Protection Scotland, through experienced leadership we have been able to extend and develop projects, and react with agility to new opportunities, e.g. by funding small projects through targeted postgraduate CASE awards and short-term postdoctoral research projects specifically designed to maximise impact. The Department Executive, Dean of Faculty and the university's Research and Knowledge Exchange Services department coordinate activities to nurture this extremely important and long lasting collaboration.

Flexible, Department-level approach to resource allocation and mentorship

All of our most impactful research involves a close partnership between the external organisation and an academic or research team. We are fortunate to have staff members with considerable experience in the transfer of knowledge to particular users, having already developed close professional relationships with individuals and companies outside academia. For new projects, involving inexperienced staff or different types of impact we have developed a structure to deal with and optimise impact when appropriate, offering flexible subject-specific training. Staff are recognised and rewarded for their contributions to generating impact from our research. Rewards mostly consist of the space and time to develop relationships; for instance, for the projects with Health Protection Scotland (HPS), we have been able to release one member of staff for four days a week over a number of years, funded by HPS and the University. In another case, we used pump-priming money from the University to release one member of staff from teaching and administration duties for one year to develop early-stage relationships and investigate short-term funding mechanisms.

Leveraging academic leadership in impact

The impact from projects in the technology industry and other businesses, such as in the financial and advertising sector, are often one-to-one relationships with additional research resource drafted in when needed, for example through postgraduate CASE awards or funded postdoctoral positions. This is the mechanism for most of the impact derived from research in the Applied Analysis, Continuum Mechanics and Industrial Mathematics, and Numerical Analysis and Scientific Computing groups. Impact is transferred into companies over a longer term and has been aided by the employment of specialist staff who have been postgraduate students or postdoctoral researchers in the Department (e.g. activities with Subsea7 and Bloom Agency), or the licensed use of IP, models or algorithms (e.g. Zinktech and Cascade - both with projects based on Department research that have attracted six figure £ sum investment). In many of these cases, the advice from the Vice-Dean Knowledge Exchange, who is a member of the Department, has proved invaluable.

Use of University resources to maximise impact

The main central University support for knowledge exchange and impact is through Research and Knowledge Exchange Services (RKES). RKES provides professional services to optimise impact generation, including identifying and protecting IP, supporting funding applications and developing engagement with businesses, organisations and strategic partners. Staff in the Department have used all of these services. For example, with Zinktech (the company which is at an early stage of commercialising the liquid crystal display invented in the Department) RKES assisted the process of patent filing, allocated a member of their staff as commercialisation manager, identified and led the application for Scottish Enterprise Proof of Concept funding, assisted in drafting Business and Commercialisation Plans, orchestrated input from external commercialisation experts, involving the Strathclyde Entrepreneurial Network, and eventually led the sale of IP to Zinktech and the investment in Zinktech by venture capitalists. We have also used EPSRC KTA Research Exploitation Partnership awards and EPSRC Impact Accelerator funding to fund secondments and knowledge transfer and to escalate company and academic engagement (e.g. with Bloom Agency).

Using external resources and networks

The Department has also made extensive use of other mechanisms to assist in knowledge transfer

and impact generation. Particularly successful has been the interaction with the Industrial Mathematics Knowledge Transfer Network, on whose scientific committee two members of the Department sit. We have received funding for postdoctoral research, Industrial Secondments and a number of postgraduate CASE awards. Examples of success have been the CASE award with Hewlett-Packard, which later led to a major EPSRC/HP funded project, and produced modelling tools which were transferred to HP and used in the development of novel display devices. On average, the Department has received funding for three CASE awards per year, and these have been very successful in developing relationships and training PG students in collaborative research.

c. Strategy and plans

Future strategy:

The Department has been fortunate to have close links to industry and government researchers for well over 20 years. In the future, we will continue the successful strategy of investigator-led, area-specific management of impact, overseen by experts within Research Groups and the Executive Committee. This model can be adapted as some of our external relationships mature, with more structured and managed approaches introduced as needed. Furthermore, we continue to make improvements for future impact generation. A major new strategy will be to enhance the internal provision for supporting staff to achieve maximum impact from their research, embedding knowledge exchange training within the staff appraisal scheme and workload model. An increased need for mathematical and statistical research from external companies and agencies has led us to plan to use EPSRC DTG/DTP funding to enable more CASE awards to be allocated to staff. Finally, we will take advantage of the University's Researcher Development Programme so that, by 2015, all PGRs will have the opportunity to engage with external agencies relevant to their research work, with around two thirds undertaking secondments and placements.

Future University initiatives:

The level and reach of impact has steadily increased during the REF period (see the Case Studies for examples) due to the initiatives mentioned above. We expect a further significant step-change to be made in the next few years through the launch of the Technology and Innovation Centre (TIC) at Strathclyde in 2014. This is the University's single biggest investment in research capacity, enabled by an £89M investment, supported by Scottish Enterprise and the Scottish Funding Council. The TIC will provide a focus for larger collaborative projects with space designed to allow industry to co-locate with academic research groups with shared facilities. The TIC spans a number of research themes, and the Department's Research Groups will be involved in the majority of these: Advanced Engineering & Manufacturing (current project joint with CMIM and NASC), Advanced Science & Technology (input from CMIM), Bionanotechnology (existing collaborations with AA), Health Technologies (PME part of coordinating committee with involvement from SA) and Photonics (projects with CMIM) themes. Other large initiatives which the Department are involved in include the Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation (EPSRC £3M; HEFCE £11M; Industry £22M), involving members of the CMIM group working on inverse problems in material science, and the Future Cities Demonstrator (TSB £34M), involving members of AA and NASC working on large data-set analysis.

Summary: The Department has clear plans to further increase the level of impactful research, building on existing links that have previously delivered substantial impact benefits and forging new knowledge transfer relationships through initiatives such as the TIC.

d. Relationship to case studies

All four of the case studies are a direct result of the approach the Department has taken to improve the reach and significance of our research. The case studies on Cod Stocks and Control of Infectious Diseases are a direct result of long-term strategic partnerships with Government agencies. The case study on Cataract Surgery is an example of academic leadership in impact with commissioned research by the European Society of Cataract and Refractive Surgery (ESCRS). The case study on computable measures for large, dynamically evolving communication networks that have benefited Bloom Agency would not have been possible but for the use of University resources (i.e. IP and contract advice as well as Knowledge Transfer Account and Impact Accelerator funding) to maximise the scale of the impact.