Institution: Brunel University

Unit of Assessment: 10 Mathematical Sciences

a. Context

The Department's plans regarding economic and societal impact are built around three main research areas: applied statistics, computational mathematics and financial mathematics. In all three cases, the economic impact occurs through engagement and collaboration with industrial end users across a wide spectrum, ranging from large global institutions such as BP to SMEs such as Optirisk Systems Limited, London, and public sector bodies such as Barts Health NHS Trust. The non-academic user groups for each of the three main areas of impact and their relationship with research activity are outlined below.

- Applied statistics (AS): Researchers in this area specialize in bioinformatics, financial risk measurement and lifetime data analysis. In keeping with this broad spectrum of research activities, the non-academic beneficiaries are diverse. Brunel applied statisticians have received funding from the public sector (BBSRC, EPSRC) as well as from the private sector bodies. Recent private sector partners include Xenomorph Software Limited (2009-2011, £98166, for developing time series models in data analytics for financial sector) and 5one Limited (2011, £5900, for developing a demand change model in the retail sector). Externally funded workshops oriented towards end users are regularly organized by the Brunel applied statisticians. Senior researchers from an SME, TMD Technologies Limited, recently attended a workshop on Reliability and have since offered KTP funding for research on statistical methods for quality control.
- Computational mathematics (CM): The Department hosts Brunel Institute of Computational Mathematics (BICOM, founded in 1976). Its research on visco-elastic solid deformation has been supported by funding from EPSRC as well as the private sector (including Autotype International Limited and John McGavigan Plc). Its industrial impact on the use of bio-degradable polymers forms the basis of one of the Department's impact case studies. Currently, the main focus of research in CM is finite element and boundary element methods to solve two specific classes of problems: the diagnosis of coronary artery disease via computational modelling and the simulation of high speed machining processes to determine safe process parameters. The former project is in collaboration with Barts Health NHS Trust. The latter project has several German industrial partners, including Airbus Deutschland, Bilz GmbH and Titex-Prototyp, and has led to the development of safe machine settings which avoid damage caused by the machining tool slipping out of its holder.
- Financial mathematics (FM): Over the last decade CARISMA (the Centre for the Analysis of Risk and Optimisation Modelling Applications), a Brunel portal for industrial contracts and applied research, has collaborated extensively with the finance industry and with the risk measurement and optimisation divisions of other industries. This collaboration takes two forms:
  i) Researchers in the Department participate in specific research projects involving measuring, managing and optimising risk for clients such as BP (2005-2007, £62500), Kidde Plc (2005-2008, £75000) and Ravenpack (2008). Collaboration with Kidde Plc, which pertains to new ways of measuring certain non-financial risk, forms the basis of one of the impact case studies submitted for this UOA and has resulted in a company with over 50 Billion USD turnover changing the way it sells explosion protection installations worldwide.
  ii) The Department runs annual industry-outreach events and workshops on financial modelling which are attended by both industrial and academic researchers. These events and workshops serve as a platform for a longer term interaction with industry. In the last few years they have led to one major consultancy contract (with BP Plc for joint modelling of market risk and credit risk) and one offer for post-doctoral KTP funding (TMD Technologies, on statistical methods for quality control).

b. Approach to impact

Since its inception, Brunel University has had a culture of actively engaging with end users. This is reflected in its Royal Charter, which mentions one of its objectives as to advance "research and enterprise for the benefit of individuals and society at large". Training for impact planning and review is mandatory for all new staff at Brunel and is also available to established staff. An

individual's contribution to the Department's impact is an important element in annual performance appraisal and in academic promotion decisions. Brunel supports serendipitous creation of impact by offering potential users free access to research outputs via an on-line archive (Brunel University Research Archive or BURA) and via an open access publishing fund. In addition to subject teaching and research in mathematics, and in keeping with the institutional culture, generating and sustaining impact outside academia is a core part of the Department's activities. The Department approaches developing impact through a sustained and two-way interaction with the non-academic users of the research. The interaction is chiefly through events which bring academics and practitioners together: this includes externally funded bi-annual workshops on lifecycle analysis (AS), annual industry-outreach events to meet quantitative analysts in the City for discussing user-driven research problems in finance (FM) and the triennial MAFELAP conferences (CM) which are attended by both industrial and academic researchers. These activities are used as a platform to build longer term relationships with industry which are beneficial to both sides and generate impact. As two examples to illustrate this, funding for a doctoral student (2005-07, £62500 from BP Plc) and an offer for a post-doctoral researcher funding (2013-14, £149000 from TMD Technologies Limited) specifically resulted from decision makers in industry attending relevant workshops at Brunel in FM and AS respectively. Another form of industrial collaboration involves arranging industry internships for doctoral students; such as that with Optirisk, London, 2010.

In addition to the activities directed towards end users outside Brunel, CM and AS researchers are in the process of strengthening collaboration with the School of Engineering at Brunel which, in turn, has a closer relationship with end users.

Engagement with end users is further enhanced by industrial involvement in both undergraduate and postgraduate courses. The Department runs undergraduate 'sandwich' degree courses with a one year industrial work placement, which are very popular with students. The academics in the Department carry out around 50 visits annually to students placed in companies ranging from local SMEs to large conglomerates such as Unilever and IBM. This end user interaction often suggests topics for postgraduate dissertations and helps the staff to remain engaged with the needs of industry. At the postgraduate level, the Department employs industrial personnel as guest lecturers on the `Modelling and Management of Risk' MSc. Currently, Dr Van Vuuren from Fitch Ratings (since 2005) and Dr Choudry from RBS Global Banking and Markets (since 2011) teach on this course and supervise Masters dissertations. This brings industrial practitioners' perspectives on the syllabus and their input helps make the course more relevant to industry.

The Department makes extensive use of institutional support for developing and sustaining impact. Brunel has a dedicated Research Support and Development Office (RSDO) which works with academics to provide support for winning external funding, for workshops (such as those in FM and AS mentioned earlier), negotiating industry secondments and developing CASE studentship contracts. RSDO has developed an impact toolkit to support staff both in completing the "pathways to impact" document required for research council grant applications and in exploiting their research more generally. The Department actively encourages industrial secondments to unlock the benefits of research to end users and also encourages research students to undertake training, available within the University, on awareness of research impact. As an additional institutional support for computationally intensive applications in CM and AS, the Department has a dedicated GPU based high performance computing cluster.

c. Strategy and plans

Overall strategy and management structure

The Director of Research is responsible for coordinating the impact related efforts. The Department has a rolling two year impact plan. An 'impact team' from the three target research areas meets quarterly to discuss progress and to set or revise targets. The emphasis of the impact plan is on building mutually beneficial relationships with end users through activities such as CASE or KTP projects, industry secondments and user oriented workshops. Other ways of engaging industry, e.g. through doctoral student internships and media outreach activities, are also actively explored. The outcomes of these impact related activities will inform future impact generation.

Goal and plans

The medium term goal of the Department is to become a leading national expert in the provision of

research expertise to industry in AS, CM and FM. In order to realise this goal, and bearing in mind the diverse requirements of supporting impact in different research areas, the Department has put the following plans into place.

AS: Researchers in AS have well established collaborations across various departments in the University, including the Department of Computer Science and the Health Economics Research Group (HERG). The purpose of these collaborations is to translate the expertise in statistics into practical applications such as the analysis of next generation sequencing data for finding the molecular mechanisms underlying muscular dystrophy. The collaborative research in AS has resulted in several journal publications and an external grant from the National Institute of Health Research. The Department fosters an environment which encourages such interdisciplinary collaborations, especially between statisticians and researchers from other departments. The Department will also continue to host externally funded bi-annual workshops on Reliability.

CM: The Department runs a very successful triennial conference on the Mathematics of Finite Elements and Applications (MAFELAP). MAFELAP 2013 attracted approximately 350 academics and practitioners from 35 different countries. The conference had separate sessions dedicated to industrial research problems, with topics ranging from computational electro-cardiology to practical simulation models of magnetic nanostructures. The number of sessions dedicated to industrial research problems is planned to increase for future conferences, as is the emphasis on facilitating networking with end-users. It is anticipated that this will help generate new industry-relevant research directions in CM and lead to research collaborations.

FM: The Department holds an annual industry-outreach workshop in financial mathematics and attendance for industrial participants is free. These workshops provide a forum for industrial researchers to highlight interesting problems to which academia may be able to contribute, and for the academics to discuss potential approaches to solving these problems. The aim is to engage industrial practitioners throughout the lifecycle of a research problem, that is, from the initial stages of defining the problem, through its solution and ultimately to dissemination and adoption. The most recent workshop coincided with the launch of a new MSc in Financial Mathematics in 2013.

CM, AS, FM: The Department hosts an annual 'discovery event' which brings together researchers within mathematics from different departments in Brunel. The purpose of this one day event is to 'discover' the complementary skill-sets available in different departments, to explore possible synergies (e.g. between CM and the A*dvanced Computational Mechanics* research group in engineering at Brunel), to develop collaborative research ideas and to achieve a greater research impact than that can be achieved by individual departments. The most recent discovery event took place in April 2013 and included presentations from 20 researchers across the University.

d. Relationship to case studies

The submitted case studies have been influenced by the Department's traditional approach to impact which is built around a two-way interaction with end users in target industries, and the use of institutional support for winning research funding and contract negotiation. The case studies themselves, in turn, have informed the Department's approach to impact. The relationship between this approach and the case-studies is outlined below:

1. The contract which led to the case study on measurement of risk in explosion protection installations resulted from the strong reputation in risk measurement and its applications established by the academics at Brunel. FM and AS researchers continue to work with risk professionals and their reputation has brought in further industrial contracts such as those with Ravenpack (2008) and Optirisk Systems (2010). The planned annual events, all designed to increase interaction with end users, will help to further strengthen the relationship with industry.
2. [REDACTED TEXT]
3. The impact case study on thermoforming was a joint enterprise involving numerical modelling by researchers in CM and extensive experimental input from Brunel engineers. Building upon this success, the Department actively seeks to strengthen existing collaborations and establish new connections with Brunel engineers who are closely engaged with industrial end users.