Institution: Newcastle University

Unit of Assessment: UoA10 Mathematical Sciences

a. Context

Our research is wide-ranging, mostly interdisciplinary, and has led to substantial impacts on businesses, industry, health care and society. The types of non-academic impact specifically relevant to the unit's research are:

Economic Impacts: our statisticians work closely with industrial users to develop new statistical methods which help improve efficiency, profitability and safety of industrial processes. For example, the case study "Faster Fault Tracking for National Grid Gas" describes how data mining procedures that we designed for National Grid have identified gas leakage issues and resulted in large financial savings.

Health Impacts: as members of multidisciplinary teams we apply novel statistical methods and produce new experimental designs for medical trials. These have resulted in verifiable improvements to clinical practice and health outcomes. We have been involved in many studies including: interventions to enhance health and well being in later life (MRC funded, 2010-2015, £2.2M); trials of a `food atlas' for assessing food intake in children (Food Standards Agency funded, 2007-2010, £609K); the effects of School Food Policy on nutrition in Northumberland (DoH funded, 2007-2011, £491K). Clinical trials include: use of prophylactic antibiotics in flexible cystoscopy; the comparison of types of UV-B radiation in the treatment of psoriasis; comparisons of analgesics for the relief of neuropathic pain.

Impact on Public Policy and Society: our research has improved the security of nation states through improved tracing of plutonium in the nuclear fuel cycle. The evidence is described in the case study "Keeping Track of Nuclear Fuel in Reprocessing". Our statistical methodology underpinned a major study on the effects of opencast mining leading to a government report whose recommendations underpin UK Minerals Policy Statement MPS2 (Annex 1) that is still in force today.

Impact on Society, Culture and Creativity: we have a substantial programme of public engagement activities linked to our research in applied mathematics, specifically in astrophysical fluids and cosmology.

Often our research has significant impact through other academic disciplines or in areas which may be further from direct exploitation. For example, our bioinformatics research has had considerable impact on the academic bioscience community, and impact on the non-academic bioscience sector will develop over longer time-scales. Similarly, our research into quantum states of matter is working towards potential applications such as next-generation sensors and ultra-high precision metrology.

b. Approach to impact

Relationships with key users: Contact with industry is primarily through our Industrial Statistics Research Unit (ISRU). ISRU was set up in 1984 in the Statistics Department of Newcastle University as a mechanism for providing concentrated statistical support for the process industry. After many successful knowledge transfer partnerships with ICI, ISRU expanded to provide statistical research, consulting and training. ISRU now work extensively with utilities, such as National Grid; healthcare, such as Newcastle Hospitals NHS Trust; businesses including finance and services as well as manufacturing. ISRU has dedicated staff and is self-financing, enabling a flexible and responsive approach to business engagement. The professional statisticians who work for IRSU conduct and publish original applied statistical research as an important part of their engagement activities.

In addition to the links provided by ISRU, the School of Mathematics & Statistics has a strategy of

encouraging academic staff to work with key users alongside other academic units in Newcastle and beyond. An example is interdisciplinary work between the School and Medical Science departments in Newcastle, Liverpool and Uppsala universities, on the design and implementation of statistical methodologies for medical trials of the effects of vitamin K supplements in stabilising patients' responses to Warfarin treatment. As a result of these trials, vitamin K is now used as part of the treatment regimen by local Trust Hospitals in Liverpool. The work has also led to setting up a database of research results, the "International Warfarin Pharmacogenetics Consortium", based on data from more than 5000 patients across 4 continents. An FP7 programme grant is funding a follow-up trial to test a genetic algorithm for initial warfarin treatments (Clin Pharmacol Ther. 2011, 701-6). It is hoped that this research will lead to a reliable algorithm for fixing the warfarin doses given to children.

Another example of interdisciplinary work is the collaboration between Mathematics & Statistics, Computing Science and The Institute of Neuroscience on a £2.1M Wellcome trust funded project to help the rehabilitation of stroke patients through the use of computer games. Our involvement is to develop statistical methodology and theory to find reliable measures of limb function which permit the proper assessment of the effects of therapy.

We are active members of the international LOFAR radio-astronomy consortium, and partners on the LOFAR planetarium project (2012), which is a RCUK supported project seeking to make radio images emerging from LOFAR projects available for Planetaria throughout the Europe. Through the Centre for Life in Newcastle we present our radio astronomy research to a general audience as part of their regular `Live Skies' series.

An important aspect of our public engagement activity is to encourage young people to study science subjects at School and University. For example, the three Holmes lectures, delivered to over 300 10-14 year olds per lecture in January 2013, were themed around our astrophysics research and featured a live radio-telescope link. Follow-up from these lectures included visits to schools and reports from teachers and pupils have been highly positive.

Training and consultancy: One measure of the range of our engagement is the number of consultancies arising as a consequence of our underpinning research. In the period 1997-2005 ISRU were awarded a series of European Regional funding grants totaling £1.25M to implement the statistical based Six Sigma management improvement methodology in small and medium sized enterprises. Present-day consultancies include Northumbria Healthcare; Draeger Safety UK; Parker Domnick Hunter and National Grid. For example, ISRU have helped Northumbria Healthcare staff to analyse MRSA data and use statistical process control methods to predict the number of MRSA cases. In addition to ISRU's work, we have (regular and occasional) consultancies with various other bodies, including National Nuclear Laboratories, Sellafield Sites and the Quality Care Commission.

Our links with key users can be further evidenced by the number of training courses we deliver. Over the past three years, ISRU has delivered learning and support programmes for over 1000 individuals in service, manufacturing and healthcare environments. Training courses are designed to allow companies to achieve significant improvements in performance through statistically based initiatives, for example: Lean Six Sigma; Reliability Analysis; Design of Experiments; Statistical Process Control and use of the statistical software platform R. Testimonials state that the trainees have achieved cost savings of up to £2M per project as a result of the unit's involvement.

Follow-through: Our consultancy work for the National Grid has led to new statistical methodology and significant financial savings. Prior to our involvement, there was little detailed analysis of patterns of energy balance in the gas transmissions system. In one example, following application of our data mining procedures, they resolved a leakage problem in 2010 resulting in savings of £14M.

Approach to opportunities: We encourage a responsive approach to opportunities and reward proactive engagement. One example arose from a project brought to us by a local fermentation

company BioInnovel Ltd. They use ultrasound time-of-flight measurements to monitor their production processes. The signal can be noisy and was usually filtered in an ad hoc manner, but our statisticians and applied mathematicians were given time and resources to develop a robust filtering method based on Bayesian statistics. We are aiming to expand the technique to have a wider application in the pharmaceutical industry.

Enabling staff: Staff are encouraged to seek out impact from their research and this forms part of the annual performance review. Individuals are encouraged to pursue profitable collaborations and to prepare public engagement activities, and are rewarded with workload credit (our way of allocating time). ISRU staff are employed specifically to deliver research and training in statistics for business users. The unit is self-financing and runs at a profit.

Institutional facilities and resources: We have benefitted from four Higher Education Innovation Fund (HEIF) awards. Two contributed to the LOFAR planetarium project and the project with BioInnovel Ltd. Another was used for a consultancy with biotechnology company Aptuscan Ltd, and the fourth HEIF award was used to support a project with industrial collaborators, combining statistical methods with HRO (High Reliability Organisation).

c. Strategy and plans

The unit plans to expand our innovation culture and support staff at all stages on the route to delivering impact. This will be achieved through the following strategic objectives:

1. To reward research with potential impact, by paying close attention to the exploitation of the research results, and by keeping a careful track of research results that could be used in a non-academic context.
2. To improve the integration of research between our Industrial Statistics Research Unit (ISRU) and academic staff in the School of Mathematics & Statistics. The relationships between ISRU and key-users offer an excellent opportunity to respond to opportunities and further align our research activity with business, manufacturing and healthcare.
3. To strengthen links with other Schools and the University of Newcastle's Digital Institute. The Digital Institute is especially interesting because of their expertise in big data and cloud computing. We recently began collaboration with our first joint PhD supervision in big data analytics, and we see this as an area with significant potential for exploitation.
4. To build on recent grant successes (such as the £5.5M award from EPSRC to a team of engineers, computer scientists, biologists and mathematicians) to explore the potential of microorganisms to provide clean water.
5. To offer a statistical consultancy service to the University's cross-faculty societal challenge themes, namely (1) sustainability and (2) changing age, which have proven importance for the national economy and provide an opportunity to identify genuine methodological challenges requiring disciplinary development likely to lead to impact.

d. Relationship to case studies

The unit has submitted three case studies to REF2014 as exemplars of our contribution to industry, health and society:
1. Keeping track of nuclear fuel in reprocessing: this case study shows how the development of new statistical methods can be aligned to a practical problem of international importance and how research can be linked to consultancy work.
2. Faster fault tracking for National Grid gas: this project shows the importance of contacts with key-users gained through ISRU consultancy work. It shows knowledge transfer of the statistical process control research originally developed for use in the chemical industry.
3. Preventing blood clots in children undergoing kidney dialysis: this study demonstrates the importance of multidisciplinary work between statisticians, clinicians and pharmacologists. It also shows the importance of developing new experimental designs and new statistical methodology.