Institution: University of East Anglia

Unit of Assessment: 10 – Mathematical Sciences

a. Context

Our research has non-academic impact in a number of areas**: economic impact through improved performance of existing businesses** who utilise the results of our research**; impact on the built environment** through our development of improved understanding of natural phenomena such as wave action; **impact on society** through our interaction with government and engagement with schools and the general public.

b. Approach to impact

Links with Industry: As a pathway for delivering non-academic impact from our research, we encourage our researchers to develop strategic relationships with industrial end-users and beneficiaries. These relationships allow the research to develop in conjunction with the end-user, and are facilitated through a number of mechanisms.

The Centre for Interdisciplinary Mathematics (CIMR), http://www.cimr.uea.ac.uk/, was established by the School of Mathematics in 2000 with the remit to provide industry, business and academic partners direct access to the research expertise within the School. This Centre facilitates contact with academic and non-academic partners through joint seminars and joint research projects. This has resulted in six consultancy contracts within this REF period. For example, researchers have worked with the company *Structure-Flex Ltd.* to improve the design of water-filled bags which are used to test cranes.

The European Study Group with Industry (ESGI) hosts week-long meetings that provide a forum for industrial scientists to work alongside academic mathematicians on problems of direct industrial relevance. Members of the School have a long-standing engagement with ESGI, which has provided us with a springboard for many interactions with industry. As a result, our research has been applied to solve real-life problems. For example, in 2011 Whittaker and PhD student Deacon developed models for the behaviour of silicon melt in an induction furnace for the Norwegian company *Elkem Solar*, to help them understand and predict the effects of altering the amplitude and frequency of the applied magnetic field.

The 85th ESGI meeting was held at UEA in April 2012. This particular meeting delivered pathways to solutions to seven problems posed by industrial partners. As a direct result of this meeting, we have been awarded an Industrial CASE studentship with the Atomic Weapons Establishment (AWE). A number of PhD projects have been inspired by problems discussed with industry, either through ESGI or CIMR.

The success of our approach of active engagement with industry is evidenced by two recent EU FP7 awards: (Tools for Ultra Large Container Ships - TULCS (€3million) and SMart Aircraft in Emergency Situations – SMAES (€4million)).

Engagement: Our public engagement is achieved through direct contact with schools, teachers and government.

Personal briefings to MPs that demonstrate the importance of mathematics research provide significant impact. Džamonja paired with the Norwich North MP as part of a Royal Society-funded scheme. This led to a number of briefings and visits. For example, an invitation to the House of Lords in 2009 where Džamonja, Hammerton, S. Stevens and Ward (now at Durham) gave presentations led by their own research and opened a discussion on modern mathematics and its relevance to the country's future.

Engagement with local schools and teachers is facilitated through visits to, and from, UEA which expose students and teachers to some of the School's research interests. Example topics as diverse as the Mathematics of Sport and Aircraft Modelling. The School is actively engaged with the Mathematical Association, where Cooker is the Chair of the Norfolk branch. We host the UEA Faculty of Science Outreach Officer who works directly with the School to maximise our

engagement with local schools, through research projects and research presentations resulting in the popularisation of mathematics.

Presentations to the general public based on our research are a prime route to increasing public understanding and appreciation of the importance and relevance of mathematics research. For example, UEA holds an annual Showcase Event in Norwich City Centre. In 2013, S. Stevens gave a talk entitled *The unreasonable usefulness of pure mathematics: Algebra and Number Theory – what are they and what are they good for?*

c. Strategy and plans

The School is further expanding contact with industry and businesses and has identified key strategic areas of investment. An example is the recent work of Hammerton on radar detection of landmines, through a PhD student working with the multi-national aerospace and defence company *Cobham plc.* This work offers a very promising opportunity to use Hammerton's expertise in wave propagation and scattering to make a significant impact, in particular in differentiating buried mines from features such as animal burrows.

Executive and financial support for impact: There is a commitment at all levels within UEA to support impact from our high-quality research. At Institutional senior management level there is a pro-Vice Chancellor with a dedicated portfolio of research, enterprise and engagement to ensure priority is given to maximising impact in all guises. The PVC chairs the University Enterprise Executive comprising Faculty Associate Deans for Enterprise; the latter work with Schools through the Faculty Enterprise Executives to develop priorities and activities.

Enterprise and engagement in the School is managed by the Director for Enterprise and Engagement and the Director of Research, both of whom report to the School's Executive Team and School Board. Faculty are regularly informed by emails and at School Board of opportunities to engage with industry or to consultancy.

Our staff can access financial support from a number of sources to support enterprise and engagement activities. The University Enterprise Executive provides direct financial support for impact from research through the distribution of a proof-of-concept fund (£120,000 pa) to help establish potential markets and commercial viability, and a strategic fund (£450,000 pa) for the next stage of development. At a Faculty level, financial support is available via the Associate Dean for Enterprise who has an annual budget of £30,000 to pump-prime aspects of small-scale enterprise activities such as the support costs of meetings with industrialists and market research related to impact activities.

Support and incentives for staff: The School has a policy of consciously increasing the impact of our research, where appropriate.

Bespoke training is available for researchers to help maximise impact from their research in line with the National Researcher Development Framework domain D3 '*Engagement and Impact*'. The University's Centre for Staff Education and Development provides a range of courses and workshops to staff, such as '*Engagement and Research Impact*', '*Generating Impact from Intellectual Property*', and '*Pathways to Impact*', which are delivered by external experts as well as staff from the institutional Research and Enterprise Service.

The importance attached to wider impact activity is reflected in the University's probation and promotions criteria where impact is a key component. The School actively encourages researchers to use the institutional study leave system to provide the time and opportunity to exploit the results of their research to secure future benefits.

Through our annual appraisal systems we regularly assess and review the impact activities of all staff. Through our workload model we ensure that sufficient time is allocated to both establishing and maintaining relationships with industrial colleagues, and developing subsequent impact.

Administrative support for impact activities: The University has a dedicated Research and Enterprise Service to support academics. The service provides Business Development Managers to assist academics in identifying initial opportunities for commercialising research; Commercialisation Managers to develop these opportunities further by protecting intellectual

property rights, negotiating licenses and establishing and supporting spin-out companies; and Consultancy Managers to negotiate consultancy contracts between external partners and individual researchers.

UEA has a highly proactive marketing and communications team who work closely with the School to publicise the results of our research, ensuring that it reaches the widest possible audience.

Norwich Research Park: Important to our future strategy is our membership of the Norwich Research Park which comprises six partners: UEA; three BBSRC-funded research institutes (Institute of Food Research, John Innes Centre Genome Analysis Centre); the Sainsbury Laboratory, and the Norfolk and Norwich University Hospital. This unique clustering of expertise gives the School of Mathematics an opportunity for developing impact beyond academia in each of our specific research areas. For example, we are working with colleagues at the Institute of Food Research to develop a mathematical description of the digestive processes within the gut.

Enterprise activity at UEA is supported through membership of *Norwich Research Partners LLP*, which links the University with strategic partners on the Norwich Research Park.

In March 2011, H.M. Treasury announced an investment of £26million for further development of the Norwich Research Park. This sum is being invested in infrastructure, and in particular a new *Centrum Building* will provide office and research space for entrepreneurial activity. In addition, the creation of a new £14million Enterprise Centre, funded by European Regional Development Fund, UEA and BIS, will provide added focus for developing new commercial activity from research undertaken across the Research Park. This will bring together existing business-facing activities and provide a suite of new initiatives around five major themes: encouraging innovation; stimulating enterprise; enhancing skills; promoting employment; and supporting business.

d. Relationship to case studies

The studies chosen exemplify our approach to impact, specifically collaboration with national and international industrial partners. They were chosen also to show how our internal culture of interdisciplinarity and collaboration form a key part of our impact strategy, as the projects described often benefitted from informal collaborations with School staff members.

Improving Aircraft Safety in the Presence of Ice Build-up: The School supported **Dr Peter Hicks** through a fully-funded PhD studentship, to work with **Cooker** and **Matthews** on volcanic lava domes. **Dr Hicks** was subsequently employed as an EPSRC-funded Postdoctoral Research Associate in the School, working on aircraft icing problems with **Purvis**. He was later seconded to *Aerotex* based on experience gained at UEA.

Safety on the Sea: The School is distinctive in the UK in terms of the number of experts in violent flows and fluid-structure interactions. Access to this combined expertise was instrumental in ensuring that the lead investigator, **Korobkin**, was able to maximise the impact of his research. Importantly, the School supported research visits to partners on the study and has part-financed the PhD project of **Moritz Reinhard**, the most recent PhD student to work on this project.

The Violent Forces on Coastal Structures due to Storm Waves: The School supported **Cooker** with two periods of study leave to develop the research and the impact of his study and financed two PhD students: **Simon Cox** (1998) now a professor at Aberystwyth University, and **Melanie Oakes** (2005).