Institution:	University of Northumbria at Newcastle
Unit of Assessment:	10 - Mathematical Sciences

a. Context

Research in this Unit benefits schools, the NHS, national and international health organisations and professionals, and the general public. Impact is delivered to society, culture and creativity through public engagement in two fundamental areas of research: (a) nonlinear waves and integrable systems, and (b) magnetohydrodynamics. Health impacts arise from our cross-cutting interdisciplinary research theme in biomathematics. The Unit has also achieved research impact in the areas of knowledge exchange, professional services and the economy.

b. Approach to impact

Overview of Process

The Unit approaches impact in the following manner:

(i) ***Understanding impact*:** All staff joining the Unit attend a mandatory "Introduction to Impact" workshop within six months of arrival. This ensures they have a good understanding of what is meant by impact, its importance and how to achieve it.

(ii) ***Developing a database of contacts:*** Details of industrial and professional contacts, non-academic users and networks are registered in a University database, which records the main areas of interest of the non-academic users, named contact details and a history of previous interactions. Evidence of previous impacts is also logged. This database has developed substantially during the REF period, and is now our primary catalogue of impact-related data and materials.

(iii) ***Championing impact:*** The Unit has an "Impact Champion" who has an overview of all the impacts and research that the Unit is generating, and acts as an advocate for impact. The Impact Champion (currently Professor Angelova) manages and develops the impact database, runs the "Introduction to Impact" workshop and helps researchers make initial contact with users and audiences (via the contacts list in the impact database and by providing advice on how to approach and communicate with the target audience). The Impact Champion acts as a catalyst for turning *research collaborations* into *collaborations to deliver benefits from research*, i.e. facilitating that initial interaction with key users.

(iv) ***Supporting and enabling staff to achieve impact from their research:*** After the initial interaction with non-academic users has been made, the relationship between researcher and users is developed and driven by the researchers themselves. The researchers are supported by the Impact Champion (and experienced senior staff) who provides guidance, evidence logging and identification of suitable institutional resources (e.g. HEIF funding).

Selected Examples of Impact by Type / Key Specific Relationships

[1] Health Impacts (e.g. EU FP7 Applied-Orientated Health Research Projects)

Professor Angelova is PI of the FP7 project "*Models for ageing and technological solutions for improving and enhancing the quality of life*" (FP7-PEOPLE-2009-IRSES 247541, 2011-2014) and Co-Investigator on "*Enabling environment: modelling well-being in ageing*" *(*MRC Lifelong Health and Wellbeing Cross-Council Programme, G0900012, 2009-2010). In these projects, doctors, physiologists, gerontologists, ageing population groups and health practitioners have participated in discussion groups, data collection, dissemination, assessment, evaluation and implementation of results. Primary beneficiaries of this work are older people and those with mobility/frailty issues.

Professor Angelova has applied the Targeted Projection Pursuit method (TPP, developed at Northumbria) to Telecare service data from the Northumbria Healthcare NHS Foundation Trust. Exploitation of the TPP method enabled call centre managers to establish the volume, type and frequency of calls, to identify users at high risk, and has transformed the quality and efficiency of the service, while operating within the same budget.

Drs Janetta and Jackson (Northumbria University) worked with Medical Physicists at Newcastle upon Tyne NHS Hospitals Foundation on mammographic data. They applied an image-processing technique more usually associated with radio astronomy to medical imaging (e.g. Jannetta *et al.*,

2004, *Physics in Medicine & Biology*, **49**, 4997). Here, breast cancer image restoration was optimised using the Maximum Entropy Method. This led to a positive change in the awareness and understanding of the North-East NHS medical physics community.

[2] Public Engagement / Impacts on Society, Culture and Creativity

The Unit is committed to public engagement, and staff regularly communicate their research in a variety of ways with the general public. Evidence-gathering mechanisms are used to calibrate and improve impact from these presentations including *(a)* audience surveys and evaluation data; *(b)* user feedback and testimonies; *(c)* recording the numbers/type of audience; *(d)* real-time audience interaction via the TurningPoint audience response system; *(e)* structured interviews before/after with (same) members of the audience; *(f)* web-based materials and measuring the number of downloads/access. E.g. Drs Lombardo, McLaughlin and Sommacal presented public lectures at the 2012 Newcastle Science Festival (premier annual science event sponsored by Newcastle City Council and Wellcome Trust).

In addition to the data/evidence gathered at or after public lectures, we have sustained engagement with audience members (who are invited to leave contact details - mainly email addresses - alongside their evaluation/feedback forms). These members of the public are then contacted and re-engaged at one, three and six month intervals in order to measure changes in behaviour and understanding of science. Our public lectures are free and attract an audience from a wide range of ages and social-economic backgrounds.

[3] Knowledge Exchange

A series of specialist workshops on Wavelet Analysis were developed by the Unit during the REF period, and the workshops were attended by (registration-fee paying) external clients and industry members. In addition, in 2012 the Unit held a knowledge exchange workshop entitled "*Mathematics of Human Biology*" (sponsored by London Mathematical Society), attended by local companies, e.g. CEO Will Dracup of Nonlinear Dynamics Limited. The Unit hosted the 2013 International Conference of the Royal Statistical Society, attended by delegates from international industry and commerce.

[4] Impact on Professional Services

Dr Sommacal's collaborative work with Professor Calogero (Visiting Professor) has been recognised as an important tool for understanding Chaos and referenced in the Wolfram Mathworld Encyclopedia: http://mathworld.wolfram.com/Chaos.html.

[5] Economic Impacts

In 2011, a doctoral student in the Unit, Helen Gibson, (supervised by Prof Angelova) applied the TPP method to Companies House data as part of an Industrial Mathematics KTP Programme entitled "*Modelling propensity to buy for UK business*" (in partnership with Level Business Limited). This revealed a number of key insights into the data, including visualising relationships between companies and Local Authority departments, and implementing an algorithm to 'rate' company directors.

Evidence of follow-through from these activities to identify resulting impacts

The Unit deploys specific evidence-gathering mechanisms and approaches in order to maximise impact from its public engagement presentations. The Unit has a policy of gathering evidence/data of the benefits of our public engagement, and this has allowed us to measure the impact of our public engagement; this enhances our activities beyond public dissemination.

Use of institutional facilities, expertise and resources in undertaking these activities

The University has a well-articulated strategy for HEIF2011-15, user-led research and its commercialisation. HEIF funding is targeted to convert research and learning ideas into commercial opportunities, staff exchange, consultancy, or to establish and build links with external organisations. University support includes: (i) *Commercialisation Development Projects* (e.g. the Unit was awarded funding to develop our series of specialist workshops on Wavelet Analysis); (ii) *Innovation Project Awards* to build partnerships with industry/business (e.g. the Unit used this to build its relationship with the NHS); (iii) *Networking Fund* (e.g. the Unit used this funding stream in developing its Industrial Mathematics KTP Programme with Level Business Limited); (iv) *Engagement Event Funding* (e.g. the Unit was awarded funding to pursue evidence-based impact

through public engagement at schools).

The University has a dedicated Public Engagement Manager who facilitates impact activities underpinned by research. Training in public engagement and media training are offered to all staff involved in public-facing activities. The University also has a dedicated Innovation and Knowledge Transfer Centre to help facilitate and support research impact. The Unit is in contact with the Centre for advice and experience to determine when and where our software/techniques are thought to be of potential benefit to companies and industry, e.g. the Centre gave advice and recommendations regarding the development of our specialist workshop on Wavelet Analysis. In addition, the University has nine Business Development Managers with specific sector portfolios (including Health and Wellbeing and Energy and Environment). These staff work with the Unit to identify possible research stakeholders and research commercialisation opportunities. In this way, we are able to react and adapt to impact opportunities.

c. Strategy and plans

Our approach to impact, together with our Pathways to Impact, have informed the development of our strategy for maximising the impact of future research. We are planning significant future impact working with global health practitioners (e.g. Tunstall Telecare; CITT-Global; South African Medical Research Council) building on our success of applying the TPP method to NHS data. We will also apply the TPP method to 'Big Data', where we are well aligned with UK and international agendas; taking full advantage of the global data explosion.

Building on our four-step approach outlined above, and to highlight the importance and value of impact (irrespective of funder), the Unit requires all research proposals to address the following questions:

(i) What is the relevance/importance/potential benefit of the research to our non-academic user groups/audiences/beneficiaries, including, but not limited to, the NHS and international health practitioners, public bodies and schools?
(ii) Who will we engage (collaborators and participants) in the research, and how?
(iii) How will we share and disseminate the findings, to whom and when (i.e. what are the mechanisms, the target audiences and the timings)?
(iv) How will we identify, measure/assess and evidence impact?

An internal peer review ensures these questions are fully considered and answered, and this strategy means we are extending current good practice by embedding it in all research. We are also aware that as our research develops, the main impacts and beneficiaries may change. This will be periodically monitored by the Impact Champion and the Unit.

To support our impact strategy in the future, we will (i) secure resources for knowledge sharing and continuous development of public and professional engagement skills, and research methodology skills; (ii) exchange knowledge and expertise in dissemination strategies and mechanisms; (iii) identify new collaborative partnerships while building on existing ones; (iv) grow research and knowledge exchange activities that address user requirements; (v) continue to utilise the impact database. We will also continue to strengthen our public engagement impact by ensuring two-way exchange of knowledge and understanding between Unit staff and the public/communities with the aim of appropriately shaping our research agenda and creating new knowledge. This will build on current approaches such as our extensive evidence-gathering mechanisms (see above). Staff will be made aware of different modes of interacting with the potential users of our research and undergo public engagement and media training as appropriate. This activity is strengthening current practice and is targeted at bringing to fruition several impact activities currently in progress.

d. Relationship to case studies

Case Study One details impact resulting from the TPP mathematical method, developed at Northumbria, being applied to multivariate data from an NHS Social Care Call Centre. The case study details how the relationship developed and how the impact opportunity was recognised, through to the impact being realised.

Case Study Two details an innovative project investigating the positive effects and benefits of engagement with schools. The public engagement takes the form of multiple visits and presentations, and is a good example of our approach to Public Engagement impacts.