Institution: Aberystwyth University

Unit of Assessment:11

a. Context

The underlying coherent focus of our research is the development and application of intelligent systems techniques. Non-academic end-users and beneficiaries of our research are far wide-reaching, including both public and private sectors and involving organisations of various sizes. Externally funded projects over the period were supported from end-users locally, nationally and internationally, including for example: AgResearch Ltd, AnalyticCon Discovery, BAE Systems, Bruker BioSpin GmbH, BSI, Cobham, Costain, Crop Design, EADS, Flight Refuelling Ltd, HarvestPlus, Hologic, LECO Instrumente GmbH, Metropolitan Police Service, National Library of Wales, Norfolk & Norwich University Hospital, PAA Ltd, Prosoy, Royal Commission on Ancient and Historical Monuments of Wales, Systems Engineering Innovation Center, Thermo Fisher Scientific GmhH, Unilever, VEZET, Waters/Micromass UK Ltd, and local primary/secondary schools.

A large range of types of impact are of direct relevance to our research, covering economic (the establishment of spin-out companies and interaction with commercial partners), health (through commercial and public health sector partners), public services, society, environment and culture impacts. These types of impact are described in more detail in section b and are linked to our four research groups: Advanced Reasoning Group (Diao, He, Jansen, Jensen, MacParthalain, Price, Shen, Snooke), Bioinformatics and Computational Biology Group (Aubrey, Clare, Gkoutos, Hardy, Hoehndorf, Lu), Intelligent Robotics Group (Barnes, Lee, Neal, Shang, Shaw, Tuci, Wilson), and Vision, Graphics and Visualisation Group (Dee, Liu, Labrosse, Tiddeman, Zwiggelaar).

b. Approach to impact

Historically, there have been two clear strands of non-academic interaction embraced by the Department; these are links with end-users and public engagement.

The interaction with end-users has always had a two-way approach: actively seeking new commercial partners who are expected to directly benefit from our research (with AU's CCS -- Commercialisation & Consultancy Services, providing substantial assistance in this process), or being open to queries from potential end-users through active and proactive engagement in the discussions of how research may be transformed to benefit them (leading to mutually beneficial consultancy). The Department is actively engaged in two initiatives to support local industry: Software Alliance Wales (SAW) provides training for software companies in Wales, and we have trained more than 300 companies in mobile device programming; ASTUTE supports the manufacturing industry, and we work with companies deploying advanced software to improve the their performance. Also, we have used 11 Knowledge Economy Skills Scholarships and Access to Masters (part-sponsored by the European Social Fund) funding to develop new links with industry.

The interaction through public engagement has grown organically, in the first instance through local schools and small public engagement grants, and more recently and more directly through larger projects such as Technocamps. We expect that most larger projects will have a public engagement aspect: e.g. the EU funded IM-CLeVeR project which presented the Department's developmental robotics research at Strictly Engineering (where the work was selected for a specific presentation to David Willetts, the UK Minister for Universities and Science) and FameLab (where it won the regional audience choice award and the judges runner-up vote). We also actively participate in raising the public awareness of the general achievements of computer science and artificial intelligence research; a notable event was that our HoD (Shen) was selected to carry the Olympic Torch for the 2012 Olympic Games in celebration of the centenary of Alan Turing, with an aim to inspire future generations of computer scientists and engineers (which is reinforced via subsequent school visits by Shen with the Olympic torch and Turing stories).

Our current impact strategy was established in a departmental away day in 2011, where the Department identified a series of example (good practice) impact case studies, some of which have since been developed in the submitted impact case studies. Subsequently, departmental away/research days have been used to inform the Department and to provide updates about existing and developing impact case studies (including established external exemplar cases), involving all research active and support staff. Through these activities we have developed an

approach for identifying new impact cases which can cover existing and/or novel research. For existing research projects we learn from associated impact case studies so that novel aspects can be identified and developed. For novel research projects clear impact pathways are always identified, for which the EPSRC model and departmental experience are used. During the life-time of a project (and subsequently when appropriate) the impact aspects are monitored, and support is provided with the collection of evidence/impact beyond identified aspects. Ad-hoc opportunities to impact are discussed with relevant departmental research committee (RC) members and CCS and administrative support is provided, including seeking external advice where appropriate. As part of the departmental strategy we have developed a central repository of example impact pathways/statements.

The Department supports the development of impact through a number of incentives, including small scale funding, access to research overheads, and involvement in a new science public engagement module and media training. In particular, significant proportions of the overheads that PIs are awarded are used for visiting non-academic partners to achieve further impact from research projects (even after the completion of the original grants). Additional departmental resources are available and can be requested through the Director of Research. Public engagement and impact are seen as an important aspect within the Department and is recognised as such in the overall time load model. Impact is further encouraged as it has become part of individual research monitoring meetings.

As indicated above, the Department has strong links with CCS, which provides an interface with potential end-users of our research and consultancy. The University invested in the establishment of a Research Office in 2010 to provide an improved support service to researchers, including grant development and application, improved research finance processes, large research-intensive project management and REF and research monitoring. In addition, the University has recently appointed Professors of Public Engagement in Science and Engagement with Public Imagination, and the Department is developing close working links with these to further enhance the impact related to research.

The developed approach has led to the following impacts within the REF2014 period:

1. **Economic impacts** through the spin-out of research and/or close interaction with commercial partners. Over the past years the Department has been involved in a number of spin-outs, including First Earth (Price) and Oncomorph (Zwiggelaar). The autonomous boat research is currently being developed towards spin-out states (Neal). A range of commercial partners, e.g. Cullen-Lenz Associates and Environmental Systems Ltd (Barnes) and 3D Industries (Liu), involve directly funded collaboration. We have projects, such as SAW, which are directly aimed at interaction and growth in the ICT and software sector, and we run annual conferences that attract and train iOS developers worldwide.
2. **Health impacts** through direct contributions to the commercial/public health sector. The Department has seen a growing research base related to health care, where especially medical image analysis (Tiddeman, Zwiggelaar), and skin assessment (Tiddeman) and ovarian/endometrial cancer modelling (Lu) are linked to industrial (Hologic and Unilever) and clinical (NNUH and Nepean Hospital, Sydney) partners, respectively.
3. **Impacts on society, culture and creativity** through simulation to public discussion and public engagement. Public understanding and engagement has played an increasing role within the Department, including Technocamps (Labrosse), which is a £6 million project that provides sessions for young people aged 11-19 on a range of exciting computing-based aspects covering a range of our research topics. The research surrounding the Robot Scientist (Aubrey, Clare) has led to extensive discussions about the role computers can/will play in scientific discovery. Collaboration with the Royal College of Art (Zwiggelaar) has resulted in exhibitions at the Museum of Modern Arts (New York). Another example is the work to address the gender imbalance within computer science (Dee), specifically aimed at 11-16 year old females.
4. **Impacts on public policy and services** through/for government and non-government organisations. Planetary robotics research (Barnes) has directly contributed to UK Space Agency, ESA and NASA policy-making for future Mars exploration, especially with respect to instrument selection. Computational modelling research has started to make contributions to the investigation of serious crime scenarios (MacParthalain, Shen).
5. **Impacts on the environment** through an improved understanding. Close interaction between

the Department (Labrosse, Neal) and the Department of Geography and Earth Sciences has resulted in a better understanding of glaciers and ice-sheets of the world and the effects that climate change is having on them (and vice-versa).
6. **Impacts on practitioners** through direct use of research material. The research related to the Robot Scientist (Aubrey, Clare) has resulted in discussion amongst patent lawyers, which has in turn resulted in considerations to change the way that patents can be awarded in the US. The Department is responsible for revising the formal definition of the SDL-2010, the ITU standard Specification and Description Language. This determines the meaning of telecommunications protocols and the behaviour of telecommunications software worldwide.

c. Strategy and plans

As reflected above, the impact of our work is closely associated with the specific research projects and general interests of our staff. As expected, our public engagement and impact activities have been and will remain to be aligned with the Department's research strategy. In particular:

1. Each new research project will have a clear impact statement/strategy.
2. Impact throughout every project is continually monitored (by the RC) and evidence is collected, verified and analysed.
3. A clearly defined pathway to impact is available for ad-hoc opportunities.
4. Administrative and where appropriate, financial support for impact (through the Department and the Research Office) is ensured.
5. Development of impact will be encouraged through a more formal rewards system, increasing the overall awareness and appreciation of impact.
6. Training on impact aspects will be provided for staff at all career stages (with existing University resources).

Through our improved awareness of impact aspects a number of impact case studies have already been identified for the next REF period, these include impact related to the environment, industrial and medical application areas:

1. Based on the robotic boat research of Labrosse/Neal (see point 5 of section b above) there are currently plans to spin-out a company which would make this technology widely available.
2. The 3D shape research by Liu is leading to underwater pipe scanning and advances in commercial design procedures, resulting in quality/logistic improvements.
3. The road assets research by Labrosse in close collaboration with Costain is likely to lead to a Costain-AU created company that would essentially commercialise the software being developed.
4. It is expected that the commercial interaction between Zwiggelaar and Hologic will lead to the development of IP and incorporation of the technology in Hologic's software tools.

In addition to direct involvement of core-funded staff, we expect the next generation of researchers (both PDRAs and PhD students) to become more involved and aware of public engagement and impact opportunities. For PhD students this will be through a university first-year research skills module on Public Engagement and Impact (Labrosse and Zwiggelaar run this module with the Professors of Public Engagement/Imagination), while for PDRAs it will be part of their CPD.

d. Relationship to case studies

The three submitted impact case studies have direct relevance to examples 1, 3, 4 and 6 in b.

Note that the research underpinning the submitted impact case study on Automated Design Analysis and Generation of Diagnostics was originated significantly before the Department established an impact strategy. As a result, the pathway from research to impact has been complex, including the spin-out, company independence/success, company take-over and software integration, and the presently reported case.

At the other end of the scale is the Advanced Robotics and Computer Vision for Space and Planetary Exploration impact case study. Almost all relevant research was done within the assessment period. There has been positive interaction and feedback between the development of the Department's impact strategy and this case study, especially regarding the collection of evidence and the recognition of additional ad-hoc impact aspects. As such it has been possible to broaden the impact of the underlying research, while simplifying the process of evidence collection and verification.