Institution: Coventry University

Unit of Assessment: 10

a. Context

Research within the Unit is focussed on two strands: Magnetohydrodynamics (MHD) and Statistical Physics. The main types of impact are: economic; policy and services related; and public awareness and understanding. **Key beneficiaries** include industrial partners employing electromagnetic fields to process liquid metals, public and higher-education policy-makers, the transport industry, as well as audiences amongst the general public, external to the academy.

b. Approach to impact

The Unit has adopted a two-fold strategy for generating impact. It identifies, develops and accepts opportunities to disseminate its curiosity-led research to non-academic audiences, including practitioners, industry and the wider public. It also undertakes applied research, and consultancy with, and for, industrial collaborators. To ensure that all opportunities to generate impact are followed through, the Unit has made full use of the University's support for external-facing activity.

i) Dissemination of curiosity-led research

The dissemination of **Kenna**'s research on 'critical mass' of research groups (output [**RK2**] and **case study 10.2**), and of his Leverhulme-Trust funded work on the network structures of mythological and epic narratives [**RK4**] are two examples of the first approach.

The University engaged the company *Communications Management* to issue a press release following the publication of [**RK2**]. The University of Nancy (Lorraine) also issued a press release in France. **Kenna** accepted subsequent invitations to give interviews and write articles for a large number of influential practitioner publications (**case study 10.2**). Further publicity was generated by the European Physical Society through (a) their "Highlights from Previous Volumes"; (b) including the paper in EPL's "The Best of 2010", which is their "key marketing material and sent to conferences around the world" and (c) Europhysics News. Such publicity caught the attention of wider policy-making communities. To ensure that this interest translated into impact, **Kenna** accepted invitations to discuss with influential bodies, e.g., Thompson Reuters, who brought the work to the attention of the Department for Business, Innovation and Skills (BIS). Similarly, Professor Thirunamachandran (former Director for Research, Innovation and Skills, HEFCE) ensured that the work was known to Sir Alan Langlands, the then CEO of HEFCE. **Kenna**'s co-author highlighted the policy implications of the research to Sauvons l'Université, a campaign group in France. An article by them was picked up by the French Conseil National des Universities who "are confident that this work will have a real impact on the methodologies used in the evaluation of researchers".

Kenna has produced papers (including [**RK4**]) which have increased the awareness of, attitudes to, and understanding of mythology and epic literature amongst the wider public outside academia. This work also impacts on those who interpret cultural heritage for audiences external to the academy. The significance of the research may be gauged by a Humanities in the European Research Area (HERA) 2013 report entitled "Recognising the Value of the Arts and Humanities in a Time of Austerity" which stated "The work of Mac Carron and **Kenna** provides an example of how digital techniques and technologies, applied to literary works, can open up a new field of inquiry. [...] This work is of interest to those concerned with social networks, but also to philology, archaeology, and linguistics. By investigating these poetic works, they have maintained the importance of continued support for research in the humanities, but also expanded the notion of what humanities research is or can be". The significance of the impact is indicated in many popular media reports worldwide. For example, in an article about **Kenna**'s research, the Russian mass-media polit.ru reports "One of the promising directions in modern interdisciplinary research is the use of mathematical modelling in history, comparative mythology and other humanities".

The reach of the work is to tens of millions of people outside the academy, via print, radio and online media. Through this, non-academic audiences received new cultural understandings of the origins and universality of mythology and epic narratives and their places on the spectrum from the real to the imaginary, as well as the power and broad applicability of the mathematical sciences. Interviews include on BBC Radio 4's Material World programme (2.5 million listeners); BBC Coventry & Warwickshire; and New Hampshire Radio, USA (161,000). Print media includes The New York Times (circulation 1.3 million); Daily Telegraph (1.4 million); Times (1.3 million); Daily

Mail (1.8 million); Sydney Morning Herald (766,000); Daily News, USA (516,165); Die Presse, Austria (350,000); Business Standard, India (217,000); Science magazine (129,155); Version Final, Venezuela (120,000); Pacific Standard, USA (110,000); Pravda, Russia (100,000); National Herald, USA (80,000); Laboratory Equipment News (66,420); Morgunbladid, Iceland (55,000); KIJK Wetenschap-Technologie-Maatschappij-Historie, Netherlands (52,000); Wired News, UK (49,377); the Czech edition of National Geographic; Věda a technika mládeži (40,000); Westmeath Independent, Ireland (34,000), Finnbay, Finland (15,000); Nordic Page, Norway (10,000). Online reports include from BBC News; ORF (the national broadcaster of Austria); 20 Minutes (France, 4.4 million readers daily); Irish Times (3.9 million unique visitors per month); UPI (2.2 million); Daily Times, Pakistan (1 million); Science Daily (1 million); Science Now (1 million); History News (300,000); Eurasia Review (50,000 daily page views) Iceland Review and many more.

In addition, many articles, reports, discussions and debates have arisen on various discussion forums, including those hosted by Scientific American, Cornell University, the Guardian, the Plexus Institute, Io9 (one of the world's top 30 science blogs according to The Times); and Teachers' Weekly. An invited article in SIAM News (13,000 individual members and 500 institutional members) further boosted interest. All of this has led to the associated paper being downloaded over 3,000 times from EPL's website in 3 weeks, and over 8,500 currently, making it the most downloaded paper in the history of Europe's flagship physics journal and demonstrating an unusually high degree and reach of impact from the mathematical and physical sciences to public knowledge and understanding. The international debate which was sparked by the mythology research has been important in stimulating public discourse about our shared cultural inheritance as well as the intersection of different disciplinary fields and the contributions this makes to society.

ii) Undertaking applied research and consultancy with and for industrial collaborators

Between 2005 and 2009, the Unit led a European network on electromagnetic processing of materials (chaired by **Molokov**) and funded by COST. The pan-European network comprised about 30 industrial partners including CORUS, Alcatel, Alcan, CEA, as well as academic laboratories. During this period, **Molokov** approached Rio Tinto Alcan (RTA) with his high profile research into liquid metal flows and MHD and, six years ago, began a project jointly funded by RTA and the Carbon Trust. The impact of his and **Priede**'s work is described in more detail in **case study 10.1**. **Priede**'s consultancy for Corus on physical vapour deposition on steel strips also resulted in a patent and a prototype device. As a result of **Pothérat**'s reputation and MHD expertise, he was contacted by Doncasters Aerospace Components. He worked with them to design and build an electromagnetic, contactless valve to control the amount of liquid metal alloy poured into moulds during the manufacture of high, added-value parts for jet engines. The solution was implemented and has resulted in a significant improvement in the quality of the finished products and economic benefit to Doncasters.

To generate impact from the Unit's research into transport networks, the University helped von Ferber to negotiate a consultancy agreement with Focal Earth, a logistics company. The consultancy provided the company with an understanding of the most efficient way to transport car parts from production sites around Europe to the assembly line of a major car producer in Ellesmere Port. This enabled the company to assess the feasibility of transferring large amounts of transport to rail from road transport. This transfer will have impact both on reducing road congestion and on reducing the carbon footprint of car production. von Ferber also collaborates with Centro, the West Midlands' transport authority (the West Midlands is the UK's 2nd largest conurbation). Centro have provided big data on all UK public transport routes, stations and stops. Yavors'kii has been hired with a specific remit of boosting the impact of this research into the future and von Ferber and Yavors'kii are currently investigating the resilience of transport flow to traffic jams.

Weigel's work on general-purpose scientific computing on GPUs has received considerable attention from practitioners. The Volkswagen Foundation funded **Weigel** and his co-workers in Mainz and Stuttgart with grants totalling €58k to organise international symposia on GPU computing with industrial involvement from AMD, Nvidia and the Portland Group. A collaboration with AMD on the testing and development of future advanced computing architectures is currently being established. With co-workers in Oldenburg, **Weigel** developed a new class of random number generators tailored for GPU computing. These are crucial, for instance, for the increasing adoption of GPU computing in the finance industry as well as in the petroleum sector. Additionally,

Weigel is being consulted internationally by operators of computing clusters regarding the set-up of new GPU based machines.

Use of institutional support

Communications Management brought [**RK2**] to the attention of BIS and to All Party Parliamentary Groups, Research Councils and HE bodies, including the Russell Group, Universities UK, UCAS, QAA, the Leadership Foundation for Higher Education and the Higher Education Academy. As a direct consequence, **Kenna** met and discussed the policy implications of his research with the Head of Research Innovation and Policy at the Russell Group, the Chair of the Quality Assurance Agency for Higher Education, and Policy Advisors at Universities UK. These organisations raised the research and its implications with the Rt Hon David Willetts MP, Minister of State for Universities and Science. The University provided media training for **Kenna** and his student prior to interviews about [**RK4**].

Coventry's Intellectual Property team have worked with the MHD group to file six patents based upon its research since 2008. One patent, for a new induction flow meter, has been fast-tracked to commercialisation (**case study 10.1**).

The University has helped von Ferber to negotiate a consultancy agreement with Focal Earth and issued a joint press-release with Düsseldorf University on his comparative study of the resilience of the London and Paris subway networks. The University has provided funding for von Ferber and Yavors'kii to organise a workshop on public transport, attended by practitioners such as from Centro. Centro were impressed by insight given, in terms of breadth of research and methods, and voiced their strong interest in continued collaboration.

c. Strategy and plans

The Unit's strategy is to build on its successful two-pronged approach to impact described above. This is being supported by a systematic approach to planning, promoting and capturing impact using a JISC-funded (£15k) extension to the University's system which tracks and records impact. This system has been successfully piloted in another of our REF units, and is now live across the University. Specific plans and goals to translate current and future research into impact include:

- Collaboration with Rio Tinto Alcan and Helmholz Zentrum Dresden-Rossendorf will continue. The aim of the collaboration is to generate impact by developing new technologies for the electroprocessing of materials. To ensure dissemination to practitioners, research will be published where appropriate in the proceedings of user-oriented conferences such as Light Metals, as well as in Metallurgical and Materials Transactions.
- Impactful research on liquid metal blankets for fusion reactors will be undertaken in collaboration with the Culham Centre for Fusion Energy, a research organisation owned by UKAEA. Funding from the EPSRC, Culham, and EURATOM will support experiments using the Unit's superconducting magnet, complementary to theoretical investigations.
- **Kenna** has started a new collaboration on scientometrics and bibliometrics with Robert MacKay FRS (Warwick). This will benefit from his established and growing networks of policymakers to generate impact. His pioneering impactful research in mathematical approaches to humanities and **Weigel**'s parallel work on score distributions in sport initiated at Mainz [**MW2**], have both clearly proved interesting to the media and non-academic public. These will be boosted by new postdoctoral scientists and new PhD students.
- Transport and network security research will also be boosted, as an important, rapidly developing generator of publications and impact. The emerging theme of dynamic resilience will find new applications through collaborations with colleagues submitted to UoA7 and separately with Centro. Initial University funding, to be supplemented by external funding, has supported the appointment of a new Lecturer (Yavorskii) to boost the impact of the transport work beyond REF 2014. Building on **Kenna**'s experience above, contact will be made with key organisations, using professional, social, and digital media as well as traditional media to promulgate the work.

d. Relationship to case studies

The Unit has two approaches to impact: engagement with the media to disseminate its curiosity-led research to audiences in the general public beyond academia, and collaboration on applied research and consultancy with companies. **Case study 10.2** is an example of the first approach and **case study 10.1** illustrates the second.