Institution: University of Manchester

Unit of Assessment: UOA 12b Mechanical, Aerospace and Manufacturing Engineering

a. Context

The UoA's research Themes of *Nuclear Engineering*, *Innovative Manufacturing*, *Aerospace Engineering*, *Climate Change*, and *Bio-engineering* are aligned directly with user groups in the nuclear, manufacturing, aerospace and healthcare industries, and with policy-makers and influencers. These are the main non-academic beneficiaries of the research, though other opportunities have been pursued when they have arisen. The main types of impact are:

- **Economic,** through insights, processes and guidance, that underpin energy security and improved products in *Nuclear Engineering*, *Innovative Manufacturing*, *Aerospace Engineering*;
- **Public policy and the environment**, though influencing public debate and government policy on *Climate Change*;
- **Healthcare**, through improved investigations and devices in *Bio-engineering.*

b. Approach to impact

(i) Mechanisms for engaging with users

Impact is a key component of the UoA's research strategy. It is led by a Director of External Affairs (Mativenga), who is a member of the UoA's Research Committee, and works with Research Group and Theme leaders to maximise the impact of their research. The UoA's research Themes in *Nuclear Engineering*, *Innovative Manufacturing*, *Aerospace Engineering*, *Climate Change*, and *Bio-engineering* are strategically aligned with user groups in the nuclear, manufacturing, aerospace and healthcare industries, and with policy-makers and influencers, providing an effective framework for engagement – with a research agenda that is relevant to users, and clear pathways to impact. Within this framework, we use a number of mechanisms for engagement.

Strategic partnerships. We seek to form enduring relationships with key user organisations, allowing long-term planning through the development of shared research agendas, and agile response to opportunities, based on established trust relationships. Each such relationship is managed within the UoA by a senior academic. The UoA also benefits from institutional strategic relationships that are led by senior academics, and managed by the University's Business Engagement Team. Examples of important UoA-level relationships, all of which involve multiple projects, are with: EDF, in *Nuclear Engineering* and *Modelling & Simulation*, where they have funded a chair and research fellowship in solid mechanics modelling, and provided access to supercomputing facilities and simulation software; the Office for Nuclear Regulation, in *Nuclear Engineering* who fund a Chair and Research Fellowship in nuclear graphite technology and have established a preferred provider relationship with the UoA; Rolls-Royce in *Nuclear Engineering,* who support a University Technology Centre in nuclear technology; Westinghouse, in *Nuclear Engineering,* who fund a Chair in nuclear fuels technology; BAE Systems and Rolls-Royce in *Aerospace Engineering* and *Innovative Manufacturing*, with a longstanding collaboration in cleaning and bonding technologies. At the University level, there is a strategic relationship with BP that is of direct relevance to this UoA. They have recently committed $100m to an International Centre for Advanced Materials, focussing on harsh environments, centred on Manchester, with Cambridge, Illinois at Urbana-Champaign, and Imperial as spokes.

Targeted knowledge transfer. At a more tactical level, we engage with individual companies or consortia on a project basis, using a range or mechanisms. Typically such activities are led by an individual academic, often with support from the UoA or University. Often these relationships can grow into more strategic partnerships, and we always seek opportunities to encourage this. *Industrial Doctorates*, funded by CASE awards, the Engineering for Manufacture, Nuclear Engineering, and Nuclear First EngD/DTC programmes, or directly by industry made up around 23% of our doctoral training cohort over the assessment period. They provide an effective mechanism for exploring opportunities for impact and building relationships, whilst enhancing students' experience. Industry partners have included EDF, Rolls-Royce, Airbus Operations, BAE Systems, and the National Nuclear Laboratory. *Collaborative projects*, either publicly funded, or funded directly by industry provide a mechanism for exploring specific common objectives and developing more mature relationships. Examples in the assessment period include: SAMULET, a TSB-funded project with Rolls-Royce, BAE Systems, and GKN on environment-friendly

manufacturing; the Nuclear Advanced Manufacturing Research Centre, a TSB Catapult with Sheffield University, with over 30 industry partners including Rolls-Royce, Westinghouse and Tata Steel; CARBOWASTE, an EU-funded project with 28 partners including AMEC, AREVA NP, Doosan Babcock, and Pebble Bed Modular Reactor Ltd, on treatment and disposal of irradiated graphite. *Knowledge transfer projects,* where during the REF assessment period, the University has held first a Knowledge Transfer Account (KTA) and then an Impact Acceleration Account (IAA) – both funded by EPSRC. These funds have been used to develop opportunities for impact, with each award based on a specified body of work. Typical activities include, engaging with new users, developing prototypes or proof of concept, applying an existing method to a new field, and developing CPD material. The UoA has held 7 of these awards in the REF period in areas as diverse as business opportunities for *Climate Change* research, laser processing, and applications of graphite. Two Knowledge Transfer Partnerships have also been funded: in computational modelling for oil-gas phase separation, and metrology for turbine blades. For follow-on, the University also has proof of principle and venture capital funding schemes, which are described in more detail below. Other mechanisms include *Consultancy* and *Continuing Professional Development (CPD)*. Both are valuable as low-barrier approaches to establishing new relationships. Staff have provided consultancy on over 70 occasions in the assessment period for organisations including: AMEC, Bombardier, EDF, Magnox, Friends of the Earth, and local authorities. We also provide CPD courses on research topics, including courses in this UoA on Maintenance Engineering & Asset Management, Turbulence Modelling, Machining, and Impact & Blast Effects, all regularly attended by 20-30 engineers.

Providing advice and influencing policy. Another significant pathway to impact is through providing research-based advice to commercial and public bodies. In the REF period, senior members of the UoA have held many such advisory roles, including with: The Welding Institute**,** UK Technical Advisory Group on Structural Integrity, European Union FP7 and European Research Council panels, International Academy for Production Engineering, AIAA, Royal Society, Office for Nuclear Regulation, Institution of Mechanical Engineers, European Society of Composite Materials, Royal Aeronautical Society, Government committees (UK, Welsh Assembly). Particularly prominent is the UoA's *Climate Change* research Theme, where public dissemination of research results, and engagement with policy-makers is the primary pathway to impact. The direct influence this has had on UK government policy and legislation is described in more detail in one of our impact case studies.

Developing standards and guidance. In engineering, a key pathway to impact is through developing professional standards and guidance, thereby influencing engineering practice. A key example in this UoA is in Nuclear Engineering, where UoA research has had a significant impact on procedures for assessing structural integrity – specifically the R5 and R6 guidelines, which are nationally and internationally recognised. The impact of our work on safety standards for graphite cores is described in more detail in one of our case studies.

(ii) Follow-through and agility

Our impact case studies are all based on recent research and are excellent examples of follow-through. More generally, we describe above and below mechanisms that provide cradle-to-grave support for realising the impact potential of research, which both encourage follow-through, and are sufficiently responsive to allow an agile response to new opportunities.

(iii) Supporting and facilitating impact

UoA mechanisms. The UoA uses a range of general mechanisms for promoting engagement with users and opportunities for non-academic impact. Key is the explicit inclusion of impact in the UoA's research strategy, and the consequent alignment of research Themes with specific user communities. This user-facing strategy is exemplified in the School of Mechanical Aerospace and Civil Engineering website, which provides an important tool for communicating the UoA's research to a broader audience, generating new opportunities for collaboration. Similarly, the annual postgraduate poster exhibition, attended by a large number of invitees from industry, provides a high-profile mechanism for exposing the breadth of research in the UoA, again generating new opportunities. The School also funds a CPD manager (shared between UoA 12b and UoA 14) to support staff in developing CPD activities.

Support for staff. We recognise that mechanisms to support and incentivise staff in generating non-academic impact from their research are key, and have a number in place. Fundamental, is

that we now have a published, explicit expectation that every member of staff will have an impact plan, discussion and development of which is embedded in the University's Performance Development and Review (PDR) scheme. Impact is also a key component of the New Academics Programme, which is compulsory for all new academics. We also include allowance for impact-generating activities in the UoA's academic load allocation model, avoiding disincentives. The University includes Knowledge & Technology Transfer as an explicit performance category (alongside Research, Teaching & Learning, and Service & Leadership) in its promotion criteria, and this was a critical part of the cases for promotion of Mativenga (Chair, Director of External Affairs) and Bows (Reader). Finally, as well as providing support for staff in commercialising the results of their research, as outlined below, the University also has a generous policy on distributing the proceeds of commercialisation, with 85% of the first £1m going to the individual.

Institutional support. The UoA has access to University-level support that complements local arrangements. The Business Engagement Support Team is centrally managed, operationally devolved, with dedicated staff at Faculty level. They act to broker engagement at all levels, providing a single point of contact for the University, and manage major strategic relationships. They also manage the IAA (was KTA) and proactively promote opportunities for impact. An independent evaluation by Deloitte of the KTA scheme (2009-12) estimated a long-term impact of a 48-fold return on investment, and net gain of 146 jobs. The University's award-winning IP management company UMI^3 provides comprehensive advice and support for spin-out and licensing activities. The £32m UMIP Premier Fund, held in partnership with MTI, is the largest venture fund in Europe, focussed on a single institution. It aims to fill the 'equity gap' often encountered in translating research into commercial success. To complete the pathway to impact, UMIP also provides small Proof-of-Principle (PoP) awards, allowing researchers to validate the commercial potential of their research, prior to seeking equity funding or licensees. There were four such awards in the UoA in the assessment period for: an unmanned air vehicle, aeroacoustic wave pump, energy from a high-power light source, and laser texturing for improved surgical implants.

c. Strategy and plans

The approach described above, exemplifies an emerging strategy, and our plans are to build on, and embed more thoroughly, the good practice we have identified. Key strategies are to:

- Further embed engagement with impact into the culture of the UoA, using both existing instruments (eg PDR, promotion criteria, theme research plans), enhanced with new mechanisms (eg explicit impact KPIs, prizes and recognition for impact achievement);
- Make more systematic use of advice from users in developing research and impact strategies, through involving them in foresight activities, developing an industry club, and formalising arrangements for an overarching Advisory Board.
- Invest more senior staff effort in (selectively) developing both new and existing strategic alliances with key partners, working with BEST to develop clear 'themes for engagement';
- Increase the proportion of PhD/EngD and other research projects, that involve collaboration with users of research, providing more administrative support for engagement activities;
- Make more systematic use of existing funding streams, that already provide cradle-to-grave support for commercialisation of research, enhancing leadership and administrative support;
- Continue to develop the School website, and make more use of other media outlets to promote the research of the UoA to users of research;
- Continue to exploit CPD as a vehicle for engagement, building on the School investment in support for CPD programmes, including active follow-up.

d. Relationship to case studies

UK Reactors Safety and Life Extension: is an example of impact arising from a *Strategic partnership* with the Office for Nuclear Regulation.

Reverse Tapered Hole Drilling for Automotive Fuel Injection Nozzle: is an example of *Targeted knowledge transfer* with Delphi Diesel Systems.

Laser Cleaning for Aerospace Manufacturing: is an example of impact arising from *Strategic partnerships* with BAE Systems and Rolls-Royce.

Aviation, Policy and Climate Change: is an example of *Providing advice and influencing policy*, involving direct engagement with the UK government.