Institution: University of Sheffield

Unit of Assessment: 13C – Materials Science and Engineering

a. Context

Our principal beneficiaries are commercial and public sector organisations, with whom we have directly collaborated to co-create and transfer research outcomes. In addition, society has benefited from our contribution to public policy, health care and societal engagement. The main types of impact delivered through our research are:

- *Economic impact:* through co-creation of disruptive technologies and acceleration to market or improvement of existing processes and products (e.g. with Rolls-Royce, Seagate, Airbus).
- *Public policy impact:* advancing research insight, to inform policy debate, changing government or corporate strategy (e.g. US Department of Energy, Nuclear Decommissioning Authority).
- *Health impacts*: through creation and translation to clinic of novel therapies (e.g. cell delivery vehicles for vitiligo) or products (e.g. breathable wigs).

We deliver impact across our three clusters of Advanced Structural Materials, Biomaterials & Polymers, and Functional Materials & Devices by cultivating aspiration to meet the needs of end users through translation of fundamental discovery and development into application.

b. Approach to impact

Our approach to impact can be traced to our founding role in the modern University, established to advance the great steelmaking industries of the region through applied science and engineering. True to our founding mission, research in the Department of Materials Science & Engineering (MSE) involves co-production with end user stakeholders, supported by cultivation of long term partnerships to realise research impact. We work with 114 commercial entities: large enterprises (e.g. Rolls-Royce, Siemens), SMEs (e.g. JRI Orthopaedics, Mandeville, ITM Power), and 19 government agencies and charities (e.g. Royal Society, Nuclear Decommissioning Authority (NDA), National Health Service (NHS), US Department of Energy). ***We support an agile approach to achieving impact from research*** through continuing engagement of stakeholders as members of project steering groups, participation as research co-investigators, co-created appointments, secondments, and targeted dissemination of research insight. We identify three typical modes of impact creation:

- ***Strategy-led impact***: *we partner with end users in co-creation of new technology transfer and research environments, to meet national and sector-specific priorities for disruptive technologies.*
- ***Needs-led impact****: we direct research capability to meet the specific needs of end users, through transfer of new fundamental knowledge*.
- ***Inspiration-led impact****: we seek to create opportunities to apply our research insight in new or previously unimagined ways*.

The following exemplars describe the development and nature of our relationships with key users to deliver impact from our research, and the follow through to identify impact.

Strategy-led impact in manufacturing. Our internationally acclaimed research in processing of advanced metallic materials (through IMMPETUS) led us to co-create the Mercury Centre for Innovative Manufacturing and Materials with Rolls-Royce and 3 SMEs. Together, we identified the opportunity to address a national need for advanced near net shape powder manufacturing technology, reducing materials consumption and cost (identified in the roadmap of the Advanced Engineering & Materials Innovation Network). Mercury was created through a grant of £5M from the European Regional Development Fund, matched by £5M from our sponsors and £400k from MSE. We employed a business development manager to develop projects with industrial partners, appointed an industrial steering group to connect end users, and appointed 10 FTE staff to deliver industrial impact. The centre is thriving by every impact metric: £2M order book, 52 jobs created and 72 safeguarded; 85 examples of research uptake by end users, several of which have led to new products or processes; increased turnover of >£4.1M p.a. by end users; 2 businesses created.

Needs-led impact on radioactive waste management. MSE has been involved in co-production of needs led research in radioactive waste management with end users for over a decade. Recognising resonance of our research capability with the mission of the newly formed Nuclear Decommissioning Authority (NDA), we co-created a RAEng Chair in 2010, to provide research leadership in support of NDA strategy. An advisory group was established to connect end user needs directly with academic capability. This interaction catalysed new KTA co-funded research in legacy waste vitrification, demonstrating environmental and safety benefits over established technology (e.g. DOI:

10.1016/j.jnucmat.2013.08.019). [text removed for publication] acted on this evidence by adapting waste management strategy to manufacture vitrified products with a priority shift of expenditure to construct a [text removed for publication] waste processing plant.

Inspiration-led impact on magnetic hard drives. We published a novel 'exchange spring' materials design for magnetic hard drive media in 2005 (DOI: 10.1063/1.1951053; 219 citations), attracting industrial interest. Seagate were inspired to take up the research, following presentation at the 50th MMM conference (San Jose, USA; 2005), and funded concept development through PDRA and PhD projects in MSE. Our advanced micromagnetic modelling code was applied to read/write head and recording media designs supplied by Seagate, allowing roadblock technical issues of adjacent track erasure to be solved. This led to improved understanding of error-causing mechanisms and changed procedures for designing read/write heads; the PhD student who worked on the project was recruited as a Senior Design Engineer at Seagate, Northern Ireland. The research enabled Seagate to deliver their range of enterprise hard drive products, with sales of [text removed for publication] units in 2012-13; (average unit price US$63.50; estimated economic impact > [text removed for publication]).

Our research has also benefitted society, culture and creativity by informing and changing public opinion. For example, our Nuclear First DTC co-created the interactive Nuclear Dialogues art installation with the Royal Academy of Art; shown at EPSRC Impact! Exhibition (footfall >1200) and Wellcome Trust Window (footfall >450,000); acclaimed by UK Crafts Council and international Co-Creating Cultures project as *"wittily engaging"* and stimulating *"intense debate among visitors"*.

Mechanisms to foster research impact. MSE engages with a diverse and diffuse user base and therefore exploits a variety of mechanisms for effective engagement to foster research impact.

***Shaping external strategy and capability*.** Staff participate as *members of external advisory groups,* providing a route to influence and impact the development of external organisations, policies, and standards. Our staff hold >30 such positions, e.g.: Provis, Chair of Réunion Internationale des Laboratoires et Experts des Matériaux Technical Committee; Gibb, Government Committee on Radioactive Waste Management; Rainforth, EPSRC Technical Opportunities Panel.

Partnership and networking. New relationships with end users are established by attendance at external conferences, speculative inquiry, or participation in external networks (e.g. EPSRC Nuclear Champion Network, Materials & Nanotechnology KTNs). We use the *Sheffield Engineering Gateway* to broker new relationships with commercial sponsors and this has supported the award of 8 KTP projects. *Consultancy* provides a rapid way of engaging with end users to meet defined needs and is supported by a simple approval process, streamlined negotiation of terms and conditions, and low overhead rate; collectively we have undertaken 136 consultancy activities since 2008, with a value of £417k. We target *partnership and collaborative funding mechanisms*, to enable co-creation of new knowledge and uptake by end users leading to application; awards of this nature total *ca.* £9.2M, comprising 23% of overall research income, including: 39 research contracts (£4M), 24 KTPs (£3.1M), 11 Knowledge Transfer Awards (£634k), 16 iCASE or sponsored PhD/EngDs (£1.5M). We have used Sheffield's EPSRC KTA account to support co-creation of research with end users; for example, with Mandeville of London, we integrated new benign adhesives into breathable wigs for alopecia and cancer sufferers (benefiting 500 individuals), with Mandeville stating "our clients are much happier" with the new products. We exploit *sponsored academic staff positions* to sustain long term, mutually beneficial, research partnership with key end users, e.g. NDA, POSCO and Tata.

Knowledge transfer and exchange. We exploit a variety of mechanisms to enhance knowledge transfer and exchange through facilitating mobility of researchers. In addition to commercial contract research (e.g. Seagate example above), we use *KTP, EngD and iCASE projects* to embed research students and staff into external organisations, supporting co-creation and uptake of new knowledge. Exemplars include: KTP with Sarantel to co-create glass ceramic antennas for GPS enabled hand held devices, with estimated sales of [text removed for publication] (2011-13) and winner of best KTP Prize 2009; KTP with AVX, on new X8R capacitors, leading to sales of >[text removed for publication] units and revenue of >[text removed for publication] (2012-13); EngD with National Nuclear Laboratory to co-create ceramic processing route for plutonium wasteforms, which contributed to award of the IChemE Chemical Engineering Project of the Year Prize in 2011. *Secondment opportunities* are facilitated by releasing staff from departmental duties in order to engage in knowledge transfer activities in external organisations, e.g. Matcher to Michelson Diagnostics Ltd (6 months, supported by RAEng Secondment Award), leading to a collaborative EPSRC grant to accelerate commercial

uptake of biomedical optical coherence tomography (£1M, EP/I018328/1). *Visiting appointments* are utilised to develop long term relationships with external users, leading to effective research impact and we have 40 outgoing and 21 incoming visiting appointments. Through *conferences and symposia*, we seek to create opportunities for knowledge transfer with end users across the academic community; we have organised 56 such symposia between 2008-12, involving non-academic organisations, with attendance of >3700.
Commercialisation and exploitation. *Commercialisation* of our research is managed by contract with Fusion IP, who develop initial commercial opportunity disclosures to patent, licensing, and spin out. We have exploited commercialisation opportunities to publish 24 patents since 2008.
Staff are enabled and supported to achieve impact from their research by: formal allocation of up to 20% of workload to impact-led activities; promotion to senior grades for excellence in research impact (e.g. Todd, Hyatt, Matcher); and impact workshops at research away days.

c. Strategy and plans
Our core strategy is to *grow the proportion of our strategy-led impact, through alignment of our research capacity and capability to deliver impact across the aerospace, defence, manufacturing, energy, electronics and healthcare sectors*. We will emulate the success of the Mercury Centre, to address strategic national and sector needs by reshaping and expanding the research strengths of MSE, establishing new centres of research and training excellence through co-production with end users and the relevant supply chains, supported by investment of MSE resource to leverage external collaborative funding (e.g. TSB, EU). For example, we aim to co-create a world-first manufacturing capability for plasma facing nuclear fusion materials, through co-production with Culham Centre for Fusion Energy. *We also recognise the opportunity to grow our portfolio of needs-led and inspiration-led research impact, by developing new relationships with public and private sector organisations and exploit early opportunities for commercialisation*. Thus, we have appointed a Department Business Development Manager (DBDM), to support staff in initiating and nurturing new external relationships and streamline the arrangement of research and consultancy contracts. To increase the level and reach of the research impact, we will create and exploit opportunities for co-created appointments, to enhance research uptake and commercialisation; and use or initiate extended networks of collaboration (e.g. Materials KTN, Catapult Centres, EU Technology Platforms), industry consortia (e.g. British Glass), and industry-facing groups of the University (e.g. Advanced Manufacturing Research Centre) to engage external expertise and SMEs. The key risk to delivery of our strategy is a change in government policy or regulation, leading to a paradigm shift of practice within our sectors of impact. To mitigate this risk, we will: exploit a diversity of impact-led opportunities in growing markets; seek strategic influence on relevant advisory boards; network our capability with complementary expertise elsewhere; and maintain strong governance of strategy.
Our future approach to impact is shaped by the *University Strategy for Innovation, Impact and Knowledge Exchange*: we embrace the need to transform our research strengths and structures, and develop sustainable networks, to foster an agile response to the needs of end users, for mutual benefit. Additionally, we aim to stimulate innovation and creation of IP, through engagement with end users, benefitting business and communities in the region and beyond.
To deliver our strategy**,** we have instituted a new Department Impact Strategy Committee to drive our Impact Strategy, chaired by the Director for Impact (Todd) reporting to the Department Executive Committee, and supported by the DBDM. Our external Industrial Advisory Board (meeting annually) provides independent guidance and evaluation of our strategy. We will use institutional resource to nucleate and grow new research groups, support external engagement (HEIF), and accelerate knowledge transfer and commercialisation (Proof of Concept, Impact Acceleration Account funding).

d. Relationship to case studies Our case studies exemplify the diversity of approaches to realise research impact. Cell Tran and Airbus ICSs are exemplars of *strategy-led impact*, evidencing successful introduction of new products and disruptive technologies to market, through partnership and co-production with end users (NHS practitioners and Airbus engineers, respectively). The Ilika ICS exemplifies *needs-led impact*, showing significant impact on products and processes, by engaging with end users to meet specific needs. Deep Borehole Disposal is an exemplar of *inspiration-led impact*, involving promotion of research to address a policy gap opened by a change in government strategy, leading to uptake by the Obama administration.