Institution: University of Bradford

Unit of Assessment: B12 Aeronautical, Mechanical, Chemical and Manufacturing Engineering

a. Context

The main types of impact relevant to the Unit's research are associated with product innovation, product performance, resource and energy management, sustainable systems through provision of advanced materials (polymer processing and products) and automotive systems (brakes, automotive product development, systems and quality engineering processes). End-user impact is increasingly linked to health and wellbeing, evidenced by its recent success as part of the Centre for Innovative Manufacturing in Medical Devices programmes. This is in line with the Unit's research strategy of pursuing research excellence that has application to society, taking fundamental research through to applications in the UK and worldwide strategic areas of advanced materials (one of the eight 'Great Technologies' identified by the UK government), healthcare, and resource efficiency. The Unit recognizes the importance of sustainability for engineering products and systems and the requirement to provide technologies to address the needs of such systems to adapt to environment, industrial, and societal change.

The primary non-academic user groups and beneficiaries for the advanced materials and micro- and nanotechology research activities belong to a range of industrial sectors: chemical, plastics, and medical devices (e.g. Dow Building Products Inc, Smith & Nephew, Eovations LLC, Dow Chemical Company, Bridon Intl, Nylacast), and healthcare. The main non-academic user groups and beneficiaries for automotive and engineering quality improvement research belong to automotive manufacturers and their supply chains (e.g. Ford, Tata Motors, Jaguar Land Rover, Cummins, Bentley, Honda, BMW, Toyota, Bosch, TMD Friction, Roulunds, Meritor, BPW, Alcon).

b. Approach to impact

The ethos of the University of Bradford mission statement *Making Knowledge Work* is central to the Unit's *modus operandi*. We turn exciting ideas into research outcomes of international excellence and we strengthen links with business through effective knowledge transfer. Our approach provides staff with a range of opportunities and incentives to engage with organisations and increase the impact of their research. Impact, knowledge transfer, and business engagement are elements of staff individual annual reviews.

Publicly-funded research activity is a core element of the Unit's activity, complemented by the University's Research and Knowledge Transfer Support (RKTS). The RKTS Business Partnerships team works with the Unit to facilitate Knowledge Transfer Partnerships (e.g. Kestrel BCE Ltd, Microsystems UK Ltd, Invibio Ltd, BAE Systems, Surgical Innovations, Tata Motors). The Unit benefits from the RKTS commercialization team support to protect IP and gain revenue from innovations (e.g. joint ventures, spin-out companies, licensing, and sale of intellectual capital).

Our research involves long-term interactions with industry leading to product development (case study B12-1), increasing impact upon health and wellbeing agendas through our innovative multi-disciplinary approach to product design, recently applied to the development of a novel (smart material) polymeric root canal product that will revolutionise the way treatments are performed (case study B12-2), and fundamental changes to ubiquitous global-reach requirements in safety and environment (improved design for performance delivering lightweight, durable, and quiet brakes resulting in reduced manufacturing and warranty cost (case study B12-3).

With £1.8M funding from Research Councils UK, the Science Bridges China/Global Engagements programme focuses on collaborative research and development, bringing scientists and companies from the UK and China together. The aim is to develop knowledge transfer and training and to support the commercialisation of healthcare-related products, in collaboration with 28 Chinese institutions. The original two themes of Pharmaceutical Science and Medical Technology, including

advanced polymer and biopolymer materials, are now combined into Advanced Materials for Healthcare, which remains one of the three strategic priorities for UK-China co-operation. The programme is also supported by Medilink (Y&H) Ltd, the Healthcare Technologies Knowledge Transfer Network and the UKTI, who form part of the industry-oriented Advisory Board. The Science Bridges China programme involves three of the University of Bradford's leading research and knowledge transfer areas hosted by the Polymer Interdisciplinary Research Centre (IRC). The programme aims to accelerate product invention, design and development by addressing three main activities: 'Open Innovation' project scheme to develop prototypes and products, reciprocal training programmes and developing state-of-the-art knowledge and commercial networks. The IRC is the blueprint for our primary mechanism to impact (via intensive and continual industrial collaborations based upon a high-specification industry standard facility supported by high-quality science).

The Unit is central to three RKT Centres (Automotive Research, Advanced Materials Engineering, Polymer Micro & Nano Technology), and forms a highly exploitative cross-disciplinary team within the Centre for Pharmaceutical Engineering (located in the School of Life Sciences) and the Visual Computing RKT Centre, and links to the sustainability agenda of the Bradford Centre for Sustainable Environments. The RKT Centres contain dedicated teams of specialists from the University, developing the knowledge and capabilities to enable the high-volume industrial linkages to be exploited towards impact, supporting a team of Business Development Managers for this purpose, and adopting an inter-disciplinary approach that integrates technological, organizational, and societal solutions to meet contemporary (innovative and sustainable) engineering challenges.

Research programmes are coupled with open lecture sessions and sector-focussed workshops and forums hosted at the University (e.g. short courses in Polymer Engineering, Thin Film Coating and Drying, Annual Braking Course, Engine Mapping and Calibration, TA Instruments Materials Characterisation Seminar, Shin Etsu Technical Seminar on Solid Dispersions, Computer Aided Process Engineering Forum). Advanced materials activities continue to run a successful Industry Club, a biennial international conference, and biannual UK-China Research Workshops. All of these are open to our PG students.

The School supports the award of research funds for work and facilities specifically aimed at producing impact (for example, for this unit one award of *c*. £500k supported the development of the hybrid powertrain engineering centre in which engine tests are carried out for UK and overseas commercial clients). The University recently established a Braking Research Laboratory as the hub of a UK-based 'Centre of Excellence' in Brakes and Braking to work collaboratively with industry and academia, to place the UK firmly at the forefront of international braking research.

c. Strategy and plans

The strategy and plans of the Unit reflect fundamental and modern engineering research with a strong emphasis on application, leading to quality and sustained impact outcomes by *Making Knowledge Work* through effective knowledge transfer between ourselves and private, public, voluntary, and community sectors, with regard to grand challenges captured by Horizon 2020, the Eight Great Technologies (Willetts, Policy Exchange 2013), and similar horizon-scanning visions.

We continue to liaise with the University's RKTS section to provide pathways to impact. The RKT Centres that we are part of provide Business Development Managers and it is our goal to maximize industrial collaborations via this route. This will facilitate focus toward the following areas:

- Exploit international research partnership and frameworks (e.g. Science Bridges China) to support impact 'reach';
- Expand use of our successful Industry Clubs and network affiliations: UK Micromoulding Interest Group (www.ukmig.com), Nanofactory (www.nanofactory.org.uk), Bradford Industry Group (www.polyeng.com/polyeng2/bradford-industry-group/) to support impact 'significance';
- Cement and strengthen our 'blue chip' industrial partnerships to support sector influencing activity and realise our strategic *modus operandi*: modern engineering research with a strong

emphasis on application;
- Seek opportunities to engage with commercial organisations and key strategic partners across the public and private sectors. This includes MoUs to strengthen strategic partnerships. For example, the Mechanical and Process Engineering research group continues to support the research component of the MSc in Engineering Quality Improvement (started as a partnership with Ford of Europe to increase understanding and capability of its engineering staff in Quality Engineering and has underpinned subsequent senior careers in the Industry, created vibrant long-term research collaborations and sustained the quality of the industrial know-how;
- Business Engagement: strengthen our links with business through effective knowledge transfer and to become the first point of call for local companies requiring innovative engineering solutions. The Unit embraces the development of the University's new physical space for business collaboration as this will provide increasing opportunities to develop this Unit's relationships with local, national, and international business;
- Staff and Student Engagement: by encouraging and providing practical support for students and staff to be involved in enterprise and new business development. For example, (a) *Process Improvement of Cellular uPVC Building Products* (Kestrel BCE Ltd.) (b) Development of a Manufacturing Failure Mode Avoidance Framework (BAE Systems), (c) Advanced Braking System Design for Full Electric Vehicles (Tata Motors European Technical Centre).

At an institutional level the university has an Impact Coordinators Group, comprising the Directors of Units of Assessment and those involved in authoring impact case studies, which aims to develop these case studies and also to spread awareness of impact into all areas of research. The Group encourages research directors to actively seek areas of potential impact and to develop these for the future, inviting people to come forward with their current research or plans.

d. Relationship to case studies

The three selected case studies illustrate a long-term approach to multi-user engagement and demonstrate the Unit's global reach and significance of impact (with research impact on a variety of users that include business, individuals, and policy makers, reflecting the variety of impact delivered). Case studies exemplify the circle of engagement with users in research development, analysis, critique, and implementation. They evidence the broad nature of our impact within industrial, environmental, health, and scientific spheres.

1. New polymer products addressing:
   a) Sustainable resource management: replicating the structure of wood (exhibiting a fibrous nature due to oriented polypropylene) with key performance enhancements in weathering resistance, toughness, and reliability, together with supporting a high precision, controlled large scale manufacturing process through to commercialisation;
   b) Health: shape memory polymer implants matching conventional tissue fixation devices with significant additional benefits (reduced patient trauma and total cost). By using a smaller incision they offer improved access and faster patient recovery time, and being smaller devices they improve product placement (anchors) by reducing initial device footprint. They reduce product inventory as an expanding device is able to cover a range of hole sizes;
2. Health and economic growth: a manufacturing process developed by Bradford researchers has revolutionised root canal treatments (when coated with a hydrophilic polymer, the highly-filled hygroscopic material enabled UK company DRFP to develop a new endodontic technique, *SmartPoint*, reducing failure rates from 11-30% over five years to approximately 1%, with lower levels of post-operative pain as compared to conventional techniques. DRFP has grown from 3 to 12 employees in 4 years, with 150,000 points manufactured annually.
3. Manufacturing and brake design analysis: fundamental changes to ubiquitous needs in safety and environment (improved design for performance delivering: (i) lightweight, durable, and quiet brakes resulting in reduced manufacturing & warranty cost; (ii) bespoke high-impact CPD via the annual "Braking of Road Vehicles" short course run at Bradford since 1997, Jaguar Land Rover Technical Accreditation Scheme, and FORD Systems Engineering Excellence through Design programme.