Institution: Brunel University

UoA: 12 – Aeronautical, Mechanical, Chemical and Manufacturing Engineering

a. Context

The impact of our research reflects the culture of promoting research and enterprise '***for the benefit of individuals and society at large***', as stated in Brunel's Royal Charter of 1966, that has characterised the University from its inception. This initial commitment to "impact" created an institution with an applied research focus and an educational programme in which nearly all students studied on sandwich programmes. Our multidisciplinary research themes are serving non-academic beneficiaries across different sectors in the private and public domains, but can be broadly characterised in the following manner:

Applied Mechanics: national infrastructure providers, construction consultancies, energy companies (oil, gas and nuclear), medical device manufacturers, and the transportation sector (automotive and aerospace). The companies and organisations we engage with range from SMEs to nationwide organisations, and globally distributed companies. Although large-scale, mostly these are niche applications to solve specific problems. In the case of our work with airport operators, the impact also has a geographical dimension. Staff in this theme have also had impact by contributing to Codes of the British Standards Institute. Our impact is achieved mostly through the provision of modelling software and design services.

Energy and Environment: food manufacturing and retail, energy systems, buildings management, and transportation (automotive). Service providers along the food supply chain varying in size significantly from SMEs to multinationals. Refrigeration and energy recovery equipment manufacturers tend to be SMEs, but the impact is made in the large-scale supermarkets. Impact in this theme is generated by the production of new devices and operating methodologies. Companies in the automotive sector also vary from SME component manufacturers to car and truck makers who are global entities. The bus and coach manufacturers are smaller. Our impact has been generated through the design of new components and whole engines. Staff in this theme have also had impact by contributing to professional design and operating guidance and standards through national and European professional organisations.

Materials: BCAST's work on nucleation-centred solidification is supported by a pool of SMEs spanning the entire supply chain, including materials suppliers, materials processors, equipment manufacturers, recycling companies and final component manufacturers. Particular success has been in the automotive sector. WCMP's work on biodegradable materials, including biopolymers, polysaccharides, cellulose and nano-biocomposites, has found a wide range of applications including packaging and construction, while the impact of our work on nanomaterials, electroluminescent displays, nanostructured carbon, and polymer extrusion has been delivered at different places along the manufacturing process.

b. Approach to impact

Our approach to impact exemplifies the ethos of the University and is linked into the University Strategy for Achieving Impact. The Research Support and Development Office (RSDO) provides the central support for each School's and the University's impact strategy and activities.

Whilst the nature of research (even applied research) suggests that not all projects will achieve significant impact, we can influence the likelihood of success. We achieve this by embedding beneficiaries throughout the project development and execution stages to understand how programmes can be shaped or primed to be able to pull through the elements suitable for exploitation. This approach has benefits in both directions.

Impact has been incorporated into the academic promotion process for MCRs and SRs. For ECRs, the start-up funds require the recipient to engage with the University's programmes on achieving impact, with the expectation that they will gain confidence in creating opportunities to interact with non-academic beneficiaries. To facilitate this process and create opportunities for impact to develop, we operate mechanisms with specific purposes or aimed at different groups of staff or beneficiaries. Whilst the activities are common to other UoAs, our exemplars are:

Strategic Partnerships:

Brunel has entered into strategic agreements with TWI, Jaguar-LandRover (JLR) and Constellium. RSDO provides personnel and expertise to support the development of strategic relationships with industry and other beneficiaries. Long-term relationships with companies, by definition, have

impact whether the benefits are financial, reputational, or serve as part of the company's long-term strategic objectives for product or process development. An example of how we have achieved impact through our strategic partnerships is that of JLR. JLR started a research collaboration with BCAST which won several grants. The success of this collaboration has led to JLR making a substantial financial contribution to establish a unique national scale-up facility for light metal casting to be hosted by Brunel in the new Advanced Metal Casting Centre (AMCC). The AMCC will provide high performance light alloys, resource efficient casting technologies and component innovations to meet the long- and mid-term needs of the whole of the UK automotive industry.

Entrepreneur in Residence:
In late 2009, Brunel appointed David Riley to implement a programme of engagement with staff to foster entrepreneurial culture and encourage commercial engagement. The activities concentrated on SMEs and were to introduce staff to SME networks, facilitate introductions with specific companies, to teach staff about the drivers, barriers, and risks to SMEs taking part in R&D, and to help staff understand the culture within an SME and thus how to make the case to an SME to take up an invention or new process. Measures of success include the increased level of SME participation in our EU projects and the subsequent exploitation of the outcomes and deliverables.

Advisory:
We encourage senior researchers (SRs) to seek out and take up roles in appropriate companies. We see our external Advisors as part of a reciprocal partnership as this allows industrialists and other beneficiaries to present their technological and business challenges and our staff to discuss potential programmes that might address them. Two examples: **M. Fan** is a Building Research Establishment Associate providing expert advice on sustainable construction, and **Bhattacharya** is Non-executive Director of Sharda Motors, India.

IP Management:
We are able to better target support to achieve impact with our patenting activity because the University strategy is to only file an application if there is a business case for the invention. We do not file patents speculatively for all inventions that our staff bring forward. For the protection and commercialisation of IP that originates from inside Brunel, RSDO arranges seed funding, sector-relevant management support, and patent filing. Staff in this submission hold over 85 patents. Due to the University's patent strategy, we have achieved significant take-up of our patents through product development or licensing arrangements. Two examples are: 1) members of BCAST developed and patented high shear melt conditioning processes embodied in twin screw and rotor-stator forms and have built and installed a number of these units of various sizes adapted for integration with different casting processes; and 2) **Zhao** devised a regenerative braking system for buses and coaches and licenced to Yuchai Corporation.

Consultancy:
We encourage staff to take-up consultancy opportunities, especially where novel techniques or solutions can be deployed. The University has a 'Consultancy Lifecycle' process which follows up contracts in part to check how effective that piece of work was for the client and to see how it could be extended. Further work has included extended consultancy, joint projects, and patents. Each year, our staff in this submission will visit over 150 students placed in industry. This allows them to remain in contact with the needs of our industrial partners, and helps identify opportunities for consultancy, short courses, contract or collaborative research, as well as opportunities for staff exchange between industry and academia. For example **Tarverdi** conducted consultancy in 2008 for InterfaceFLOR Ltd which led to a TSB award and the invention of a twin screw extrusion technology to pulp and refine cellulose fibres, now exploited by the company worldwide.

Training for Staff:
We consider confidence-building as an important step in the effective learning of the impact agenda. We do not take the view that academic staff will 'just know' or 'pick up' how to achieve impact. We offer a dedicated programme for ECRs as part of their probation. All grades of staff are offered training in the various aspects of 'Research Impact' – how to recognise and capitalise on opportunities, demonstrating the wide variety of ways in which impact can be achieved, the barriers to engaging with non-academic beneficiaries and strategies to overcome them, and business and legal aspects. Exemplars:

- RSDO helps staff draw up 'Personal Impact Plans' as part of the promotion process.

- In 2013 we piloted the 'Brunel Impact Academy' to target ECRs and MCRs who want to improve their understanding of how best to work with companies.
- The in-house *Impact Toolkit* which is designed to be a 'self-help' package.
- Training in public engagement provided for PGRs, postdoctoral fellows and staff of all levels.

c. Strategy and plans

With the requirement for impact embedded in our Royal Charter, Brunel will remain dedicated to creating and improving the socio-economic impact of its research. By maintaining a strong culture of business engagement, Brunel has the ideal base from which to build further capacity to collaborate effectively with beneficiaries and to respond to changing business landscapes in the global context. Our strategy aims to build upon existing strengths in terms of research excellence, strong collaborative projects with major industrial players, and a record of achieving impact in a number of sectors. We will seek to institutionalise relationships to create strategic alliances. Working at a corporate level will require a change in the way in which our academics and their industrial counterparts work to both accelerate impact, and increase its value to the nation.

Building on our current strategic partnerships, by 2020 we will be working with a small number of major strategic partners who come to Brunel for all their research services, and whose research needs Brunel commits to fulfilling. This approach changes both the nature of the active relationships from academic-industrialist to university-industry and the way in which academics are involved in the commissioning and planning of research.

Our impact strategy is keyed into that of the University and will include using the resources and services provided by RSDO. To ensure and accelerate the exploitation of our research we will:

- build the culture of user engagement in our ECRs by ensuring that user-engagement is part of the mentoring process,
- appoint Theme **'Impact Champions'**. They will be trained and supported to promote impact, mentor project proposals and help identify 'success stories' and case studies,
- involve beneficiaries and end users of research at all stages of research,
- exploit the opportunities opened up by the Brunel EPSRC Impact Acceleration Account,
- put together networks of our beneficiaries to create critical mass for business pull-through,
- address the particular challenges in achieving impact with interdisciplinary research,
- continue to work in partnership with other groups, organisations, and funding agencies to maximise the value of intellectual and financial resources.

The University will:

- measure our success in accelerating impact through defined performance metrics that embrace both take-up by beneficiaries and longer-term cultural change within Brunel,
- introduce 'Knowledge Transfer Leave' to support members of academic staff in spending dedicated periods of time engaging in knowledge exchange projects outside the institution,
- provide additional investment in media relations.

We have specific plans for each theme and two which span multiple themes (and UoA). Exemplars from each theme's aims are:

Applied Mechanics: There are two main aims for this theme. First, our rapidly expanding aerospace, aviation, and avionics research will seek inward secondments from industry and outbound secondments with the Brunel Knowledge Transfer Leave scheme. This will enable the aerospace group to build upon current collaboration to work towards creating a strategic partnership with one of our industrial sponsors. The Impact Champion for this theme will focus on opportunities in the aerospace sector. The second exciting prospect for creating globally significant impact is the National Structural Integrity Research Centre. NSIRC has a unique integrated approach to research and PGR training, and results from our strategic alliance with TWI.

Energy and Environment: the CAPF will be using our EPSRC Impact Acceleration Account to create impact along the supply chain. The automotive industry is dominated by a relatively small number of very large conglomerates, but supplied with specialist technologies and sub-systems by SMEs. CAPF will seek to capitalise on current relationships for Brunel to forge a strategic alliance with one or more of the majors. The Brunel-led £12M EPSRC Centre for Sustainable Energy in

Food Chains (CSEF) in part arose from the critical mass of food industry companies and organisations supporting **Tassou's** work. CSEF has a detailed and realistic impact strategy and plan devised in collaboration with the lead industrial partners: Tesco, Heinz, Iceland Foods, Kellogg, and Buro Happold. CSEF will accelerate the deployment of energy efficiency measures into all parts of the food supply chain – from farm to fork.

Materials: The WCMP already has an extensive network of SMEs which regularly take part in programmes. This puts WCMP in an excellent position to assist ECRs in gaining experience of how best to interact with beneficiaries. Engaging with the *Entrepreneur in Residence* will be a target for them. As materials and resource use are central to the 'circular economy', this theme's Impact Champion will bring together expertise from across Brunel. The new national facility that BCAST is starting – the Advanced Metal Casting Centre (AMCC) – will create significant impact as this is integral to the plans drawn up by the initial major industrial partners Jaguar-LandRover and Constellium. This £14M scale-up facility will be available for use nationally and internationally. AMCC was formed as a result of the strategic alliance between Brunel and Jaguar-LandRover; the aim will be to agree additional strategic partnerships as a result of building this unique facility.

The cross-theme plans are:
EPSRC Impact Acceleration Account: is being used for research within the automotive sector, building upon the existing strengths of BCAST and CAPF and their collaborative projects with industrial partners. Our aim is to draw upon researchers with expertise relevant to the automotive sector, but who are not yet working closely with the sector – including Brunel researchers working in Electronic Systems (UoA15). This will achieve demonstrable impact because the programme involves the key beneficiaries at all stages of research, from conception through to industrial realisation. Jaguar-LandRover, BP, Lotus, Ricardo, and Mahle Powertrain are all actively taking part in our IAA programme.

National Structural Integrity Research Centre (NSIRC): part of the rationale for the (Brunel-led) NSIRC is that a national facility has the critical mass, with careful planning and management, to generate globally significant impact. NSIRC has the potential to achieve unique levels of impact because of the founding principle of holistic product design for structural health and condition monitoring, prognostics, and structural health management. The detailed impact strategy and plan has been drawn up with the lead industrial partners, namely TWI, BP, Lloyd's Register, and Network Rail. NSIRC will accelerate the translation of science into commercially relevant products and services. The sectors that we are targeting are: energy, transport, advanced manufacturing and infrastructure – which brings together our researchers from **Applied Mechanics** with those in Signal Processing, Electronic Systems, and Sensors and Instrumentation (all in UoA15).

d. Relationship to Case Studies

The differing types of plans outlined above have been formulated from understanding how staff have achieved the impact described in the Case Studies. The detailed actions have been devised to overcome the barriers that staff encountered or to develop skills that they requested – the University's culture of conducting research relevant to non-academic beneficiaries is a necessary but not sufficient criterion to maximise impact.

The case study '*Robust Design of Micro-Scale Piezoelectric Actuators*' (**Applied Mechanics**) involved a single SME which collaborated on two EPSRC grants.

Collaborating with City Authorities and European organisations led to the impact achieved by '*Creating a Sustainable London by Improving Energy-Efficiency of the Buildings*' (**Energy and Environment**).

The impact from '*Regenerative Engine Braking Device for Buses and Other Commercial Vehicles*' (**Energy and Environment**) and '*Recycling Mixed Plastics*' (**Materials**) was generated by involving the beneficiaries right from the start of the research planning phase.

A short contract to undertake consultancy was the catalyst for the case study '*Improving the Performance of Water Meters*' (**Materials**). This developed into an on-going partnership.

The case studies '*Fabrication of 3D Electro-optic Circuits by Printing*' (**Materials**) and '*Tri-generation and CO2 Refrigeration Systems for Energy and CO2 Emission Savings in the Food Retail Industry*' (**Energy and Environment**) are testament to the value of creating and maintaining a network of long-term industrial collaborators.