Institution: University of Wolverhampton (UoW)

Unit of Assessment: UOA12

a. Context

This UoA is composed of staff from the Faculty of Science and Engineering (FSE). This Faculty's Engineering research, and resulting impact, is coordinated by the Engineering and Computer Science Research Centre (ECSRC). ECSRC is organised into research clusters or groups. The ones relevant to this submission are the Engineering Research Group (ERG), Midlands Simulation Centre (MidSim) and the Pervasive Computing Research Group (PCRG). The purpose of this multidisciplinary centre is to provide for cross fertilization of research in closely related fields, and has resulted in opportunities for development and exploitation of research. In addition to the research centres, FSE maintains 'Centres' or 'groups' which provide a direct route for research to non-academic users. These are: the Capparo Innovation Centre (CIC), which contributes to research and impact, by primarily engaging in commercialisation activities; the Innovative Product Development Centre (IPDC), on the Telford Campus, which engages with industry, primarily in the UK, to provide product solutions and rapid manufactured/prototype parts; the IT Futures Centre (ITFC), first established as an ERDF project to encourage IT adoption work in the West Midlands region and beyond. ITFC has developed into a technology transfer network throughout the region. In addition FSE manages the Midlands Manufacturing Club (MMC) which provides a UK Midlands network forum to promote FSE's manufacturing services (including consultancy) to industry and applied 'Engineering' research.

Since 2008, there has been a significant increase in productive international partnerships with the academic community. For example staff exchange visits and research collaboration have occurred with universities in South Korea, New Zealand, China and Germany. The main impact has been economic with the main beneficiary being UK industry. This has been achieved through applied research programs and resultant technology transfer. This includes KTPs and technology engagement programmes with end-users such as Rapid PD and ATEP (details in the impact case studies) and NTAILS. A particular success has been the level of KTP activity with 25 KTPs managed over the assessment period 2008-13 and some feature in the two impact case studies, i.e. Powell and Harber in the DMLS/M Case Study and Advanced Chemical Etching Ltd and Burcas Ltd in the ADB Case Study. Further impact has occurred with the EC funded project "Farm to Fork" using RFID sensors to aid food traceability (principal Investigator: **Newman**). This project provides economic benefit to the industrial partners and will have increasing benefit on health and well-being. More recently an EC funded project has started that is providing a risk assessment system for manufacturing and construction companies with accompanying economic impacts (led by **Oduoza**). Further details on these projects are given in Section 5: Environment.

b. Approach to impact

The unit's approach has always been to interact fully with potential end users, in the UK and overseas, as a means of enabling the research undertaken to be adopted but also as a means of external interactions aiding the generation of ideas for progressing research in the future. To enable this approach the academics operate in a wider environment which is composed of academics, technicians and technical consultants employed to work with companies and the unit's researchers. In addition the University has a group of staff that work with the unit handling engineering related enquiries and building partnerships (the Business Solutions Department), e.g. Knowledge Technology Partnerships (KTPs). The level of KTP activity has been a particular success for the University (with an approximate 90% acceptance to application ratio) and for the ''Engineering' Unit in providing project solutions to UK industry that add to wealth creation. The Business Solutions Department manages the KTP grant application process and works closely with academics, with a background that matches the needs of the collaborating company, on the grant writing. As part of the interaction with potential end users a range of 'services' are made available to external organisations, these services stem directly from the Unit's research activities and typically include:

- Technology reviews (via IPDC, CIC, MidSim, ITFC).
- Assessing the intellectual property potential of ideas and aiding their capture through for example patents of ideas/processes (via CIC).
- Aiding in the development of technology licence agreements, and spin-out companies (via

CIC, ITFC-NTAILS).
- Materials selection (CIC and ERG)
- Building virtual models and undertaking the associated analysis including Finite Element Analysis (FEA) (via ERG and MidSim).
- Product and tooling developments (via IPDC and the Manufacturing Club).
- Developing physical prototypes: plastics and metals (via IPDC).
- Product testing (via ERG and IPDC).
- Enhancing production and shop floor efficiency (via ERG and the Manufacturing Club).
- Adoption of IT systems, sensor networks and RFID technologies (ITFC-NTAILS).

These activities are promoted externally via standard University marketing, Unit led seminars and also through the Unit's Manufacturing Club (www.westmidlandsmanufacturingclub.co.uk), established in 1999, the Caparo Innovation Centre (http://www.caparoinnovationcentre.com/), established in 2006, and the Midlands Simulation Group (MidSim), with the latter making use of the Midlands Aerospace Alliance (MAA) network. The West Midlands Manufacturing Club, founded in 1999, is a not-for-profit organisation dedicated to supporting the growth of manufacturing in the West Midlands region. A unique collaboration involving industry, a centre of excellence and the University of Wolverhampton, the Manufacturing Club aims to provide manufacturers, product designers and innovators with a one-stop-shop solution for all their manufacturing requirements. For example, services available include support on Manufacturing Systems, Lean Manufacturing, New Product Development, Computer-Aided Design/Manufacturing and Rapid Prototyping. The club has 300 member companies (http://www.westmidlandsmanufacturingclub.co.uk/index.asp). Members of the club have the opportunity to participate in a manufacturing network that is supported by World Class Manufacturing knowledge and expertise. Some of the services that can be accessed via the Club are delivered by the IPDC, i.e. rapid manufacture and prototyping and CIC for commercialisation activities, e.g. IPR, patent searches and product development.

The Caparo Innovation Centre (CIC) is collaboration between Caparo plc and the University which provides new product development services to businesses and independent inventors. Based at Wolverhampton Science Park, the CIC is staffed by a team of product and business development professionals covering the critical range of engineering, marketing, design and business skills. Some achievements: A partnership between industry and higher education; the UK's only open innovation centre for independent inventors; 791 inventor approaches over a 7-year period, In excess of 50 consultancy reports for industry; winner of the "Innovation for Environmental Sustainability" 2011 Lord Stafford Award. (Envirotile); winner of the Open Collaboration category at the 2010 Lord Stafford Awards; finalist in the Business Support of Universities category at The Engineer Technology and Innovation Awards 2008 (sponsored by BAE Systems); finalist in the Achievement in Innovation category at The Lord Stafford Awards 2009 (Caparo Rightfuel); Double Gold Award Winner in the Industrial Innovation category at the British Invention of the Year Awards 2008 – Alexandra Palace, London (Caparo Rightfuel); successful provider of innovation support via European Funded programmes since 2006. In providing a comprehensive service to industry and inventors CIC accesses the academics, technicians and facilities of FSE's Engineering department. This is seen to be of particular benefit to the academics in the Unit in raising commercial awareness of their research and its resulting impact to the wider community.

There have been several University projects designed to improve business competitiveness both at a regional and European level. A good example with respect to impact is the regional project, supported by the European Regional Development Fund entitled New Technologies for Advanced Identification and Sensing (NTAILS). The NTAILS project assists regional businesses in adopting sensor network and RFID technologies. The project has provided assistance to over 40 companies which have allowed them to improve their businesses through the adoption of these new technologies and change their business processes or adopt new ones based on these technologies. The weblink http://www.it-futures.com/ntails/ provides further information on NTAILS and successful case studies. NTAILS is integrated with IT Futures (http://www.it-futures.com/).

c. Strategy and plans

The unit will continue to concentrate on economic impact but there is planned growth in impacts related to health and the environment. Strategic investment is already taking place in facilities e.g. the new £21m Science Centre at the University of Wolverhampton's City Campus (http://www.wlv.ac.uk/default.aspx?page=36684) and it is this Science Centre where research activity will most influence health and environmental impacts. Engagement with end-users will

continue to be a priority, mainly UK industry, but with increasing international collaboration. The two impact case studies reflect a research engagement in high value manufacturing and this approach will be extended into bioengineering and chemical process engineering, e.g. oil and gas technology. The creation of the Faculty of Science and Engineering (FSE) is important here as one of the aims of FSE is to facilitate better use of resources and effective interdisciplinary and multidisciplinary team working.

Current and future research: New materials for Additive Layer Manufacturing (ALM) based on metal, polymer and composite systems. A better fundamental understanding of laser melting and solidification in ALM to provide design solutions in complex shapes and to overcome problems such as residual stress (collaboration will take place with the ALM community for this research). Diffusion bonding and superplastic forming of advanced alloys. Bioengineering applications, e.g. implants (polymer and metal) made by ALM and biomechanical dynamic simulation of implants for hip, knee and shoulder. Signal processing, brain-computer interfaces, biometrics, neural-networks, genetic-algorithms, and image processing analysis. Robotics and control systems. Chemical process engineering (e.g. for oil and gas industries). Engineering and manufacturing management, e.g. risk management and analysis. Transportation Engineering. To achieve this Professors and Readers will lead research teams. Strategic appointment of new Readers and Professors who are regarded as 'Research Leaders' in selected fields and capable of developing research teams will take place to expand the research base.

International collaborations will increase. This will involve two-way interaction; visiting academics will be encouraged and reciprocal visits made by engineering staff. The aim is to enhance the international nature of our research through joint research projects and maximise research opportunities with partners. The University provides funding for international activities and networking. Links to education are also relevant as our overseas partner institutes, in Singapore and Sri Lanka already utilise our teaching materials that have been influenced by our research. Expansion will take place into PG research provision, PhD and MPhil, with existing and new partners. This PG research will also be linked to local industry in the respective companies and, it is anticipated, that many of our UK partner companies, and all academic partners, will network and engage in potential business opportunities with the respective international partners. Our experience of KTP management and delivery of technology transfer programmes will be useful here to share with partners.

This strategy and associated planning are aimed at ensuring that our research activities enhance teaching and academic development and that our students benefit through research informed curricula, engagement with research active staff who are leaders in their field and exposure to projects which demonstrate the impact of our research with industry, business and the professions.

d. Relationship to case studies

The case studies have been selected as they epitomise the Unit's engagement in high-value manufacturing and end-user engagement that contributes now and in the future to wealth-creation impacts for the UK. The University was the first adopter of the Direct Metal Laser Sintering/Melting (DMLS/M) technology in the UK resulting in significant research and knowledge transfer activities in the UK and globally. This accounts for £2.5M of capital investment within the UK and is currently the largest concentration of this technology worldwide. The research undertaken has led to international collaborations and contributed to REF2 outputs for **Stanford** and **Kibble.** Instrumental to the selection of this case study was the £1M of funding from Advantage West Midlands (AWM) to the University for the project "Process Innovation For Rapid Product Development". Research has involved process optimisation, analytical simulation, materials development (including MMCs) with UK and international partners. Application research engagement has been in Automotive (including F1), Aerospace, Medical and Jewellery sectors. The second case study involves Laminate Manufacturing and diffusion bonding (DB). Applications are in automotive, medical, chemical and high value manufacturing sectors, e.g. heat exchangers and fuel cells. The University has researched and developed, with industry partners, a rapid affordable diffusion bonding (ADB) process involving direct heating to provide appropriate temperature and stress states for pressing titanium and aluminium) sheets together. Investment is taking place in the partner companies to exploit the technology. A breakthrough has been achieved in the chemical machining of three dimensional structures for laminar flow technology assemblies in aluminium and titanium, that can be built by ADB. The research has given REF2 outputs for **Spence**.