Institution: Newcastle University

Unit of Assessment: UoA 12 Aeronautical, Mechanical, Chemical and Manufacturing Engineering

a. Context

The main non-academic user groups for the research produced by this UoA are professional engineers, scientists, and policy makers. The main types of impact are economic and impact on practitioners and professional services, with these delivered by all research groups in their specialist fields. Over the REF period, our Bioengineering research group has also delivered significant health impacts. Economic impacts are primarily achieved through the development of new products and processes, through spin-outs, licensing, and collaboration with industry. Impacts on practitioners and professionals are, in the main, contributions to formal and de facto industry standards, with health impact achieved through changes to clinical guidelines.

b. Approach to impact

The main mechanisms by which the unit interacts with non-academic users are (i) collaborative research grants, both industrially and University led; (ii) through consultancy; (iii) through the formation of spin-out companies and licencing of IP; and (iv) through participating in policy and standards committees.

These various mechanisms are managed across the University as a whole by Research & Enterprise Services (RES). RES supports academics through managing the contractual, legal and financial aspects of research, commercial services, intellectual property, and consultancy. RES administers two programmes designed to specifically promote impact:

- The Newcastle University EPSRC Impact Acceleration Account, which aims to stimulate the uptake of EPSRC research outputs into society, which has, for example, provided follow on funds to further develop an innovative CO_2 sequestration scheme to the stage where commercial exploitation will be possible.
- Newcastle University Innovation Projects. To specifically encourage new industrial collaborations the University runs small innovation projects, which give companies the opportunity to undertake small scale feasibility, proof of concept, product development or testing projects as a first step to building collaboration over a longer term. Eight of these projects have been completed in the UoA in the REF period, with project values ranging from £4k to £84k, with small local companies (e.g. Sabre Rail Services Limited) and larger multi-national organisations (e.g. MMI Engineering).

b.1 Industry Facing Research Centres

Where there is sufficient volume of industrial contact within a particular sector and over an extended period this has been consolidated into specific industry facing research and technology centres, and UoA12 at Newcastle has four groups which work almost exclusively within specific industrial areas.

i) The *Biopharmaceutical and Bioprocessing Technology Centre* (BBTC) works closely with the industrial base, in particular through the *Engineering Doctorate (EngD) in Biopharmaceutical Process Development*. Since 2009 the BBTC has run 57 EngD projects with industrial partners, including Astra Zeneca, GSK, Unilever and Novartis, with 30% of the projects in collaboration with SMEs. This has included research on the characterization of hydrocarbons and the prediction of crude oil properties in collaboration with Intertek. This has resulted in Intertek filing patents which it estimates will provide income of £1-5M over the next five years. In addition research on plant cleaning with Heineken has saved £2M in operating costs at their Hereford site, through reduced water and chemical use, and reduced downtime. Heineken now plan to extend the new approach across their sites worldwide, and are continuing to collaborate through further studentships.

ii) The *Gear Technology Centre – The Design Unit* (DU) carries out industrial research, consultancy and standards development related to gears and power transmission. DU turns over £250k per year in direct industrial funding, with significant contracts in period from Rolls-Royce (£640k) and Scania (£400k). A specific test rig design has been licensed for manufacture and distribution within China to CPCM in Beijing, and the University has received £100k from this agreement in the REF period. Two of the impact case studies are related to DU, and give further details of their long-standing research collaboration with the Navy, and their significant input into international standards development for gears.

iii) The *Newcastle Centre for Railway Research* (NewRail) has a turnover of £2M per year in rail and transport related research, all of it carried out in collaboration with industry and funded through

FP7, Rail Research UK, the Rail Safety and Standards Board, and TSB awards. Direct industrial funding with NewRail is £100k per annum, with significant impact through the development of international standards, as described in one of the impact case studies.

iv) Marine Technology research activity is long established at Newcastle and focusses on ship design, hydrodynamics and sustainable shipping. Research within Marine Technology led to the establishment of Stone Marine Gurdesan Ltd, a joint venture in which the University holds a 2% equity share, and which has raised over £4M to establish a foundry for propeller manufacture in Turkey. Collaboration with boat builder Alnmarintec on deep-V hull forms has been exploited commercially in the manufacture of six new craft. The innovative design offers an excellent combination of ride quality, load carrying capacity and speed, and was first demonstrated on a full scale craft in 2009. Alnmarintec won an order in excess of £2M from the Port of London Authority for four harbour patrol launches which were completed in 2011. Alnmarintec also won a further contract (from Briggs Marine & Environmental Services, value £0.75M) to build a vessel which is used in research and survey for the UK Environment Agency. This vessel was launched in 2011. The same innovative design was also used in the production of the University's research catamaran, "The Princess Royal".

b.2 Wide Ranging Industrial Collaboration, Direct Industrial Funding and Consultancy

Beyond these specific industry facing groups there is significant industrial interaction across the whole of the UoA. This has included:

- 17 Knowledge Transfer Partnerships (KTPs) from over the REF period, covering manufacturing (with industrial partners Pearsons, Brushtec, and Deepdale Solutions), composites (Ford Aerospace, Wellstream International, Uponor), bioengineering (JRI Orthopaedics, Peacocks Medical Group), ship and marine remotely-operated-vehicle design and operation (Safinah, Royston, SMD), chemical and biochemical process monitoring, control and scale-up (Avecia, Sellafield, CPI, Palintest), and new product development (Nano-porous Solutions).
- 10 industry led Technology Strategy Board (TSB) funded projects, with a total value of over £1M in funding to the University, covering: the design and manufacture of large, complex welded products; modelling nanocomposite materials; structural composites from waste; multi-material joining technologies; pharmaceutical process development; inkjet technologies for printed circuit boards; and improved turbomachinery, combustion and transmission systems with industrial consortia including Rolls-Royce, Bombardier, Vestas Wind Energy Systems, Doosan Babcock Energy, ThyssenKrupp Tallent, and GlaxoSmithKline. A newly awarded TSB programme led by Jaguar Landrover will develop ultra-lightweight vehicle transmissions.
- Consultancy income over the REF period of over £10M, including large multinational organisations such as Pilkington, David Brown, and BAE SYSTEMS and smaller companies such as BEL Valves, SMD, and Smith Electric Vehicles.
- Direct industrial funding of research has totalled £7.8M over the REF period, and makes up around 20% of our total research funding. The REF period has seen significant growth in international industrial funding, up from 5% of total industry funding in 2008 to 26% in 2012.

These collaborations with industry have led to significant impacts relating to the development of new products and processes. Examples are:

- Work with Metalysis, an SME supplier of rare earth metals and alloys to develop a new titanium and tantalum extraction process. This was based on consultancy and TSB funded research undertaken in collaboration with Metalysis to develop a new electrochemical reactor system for tantalum production. The research resulted in a family of patent applications (WO2012104640; WO2012066299; WO2012066298; WO2012066297; WO2010146369; WO2010131000; all name the Newcastle investigator Wright as inventor or co-inventor) from Metalysis and on the basis of these patents Metalysis raised £12M for a production plant. This plant was completed in 2012, creating 20 jobs, and investment is being sought to further scale-up the process.
- Research into a novel type of shoulder prosthesis led to a new design of joint replacement for the shoulder which was patented (WO2008087415). This led to a KTP with JRI Ltd (now JRI Orthopaedics) to commercialise the new design, with IP licensed to JRI, and the VAIOS shoulder system was first implanted in 2010. Over 300 VAIOS prostheses have now been implanted into patients in the UK, Germany, Norway, Poland, Australia and New Zealand, with over £1.5M in sales. The product won two high profile industry awards: Best New (Mechanical) Product at the British Engineering Excellence Awards in October 2010; and the Design Futures Innovation Award at the Medilink Healthcare Business Awards in November 2011. Approval

from the US FDA is currently being sought for the product, and patent protection for the design has been obtained in the USA, Canada, Australia and New Zealand.

- Work as part of the EC funded project HISMAR (Hull Identification System for Marine Autonomous Robotics) led to the development of a robotic system for cleaning, maintenance and light construction work on offshore structures and vessels. This has been patented in Singapore (139280), and further patent applications have been made in Europe and the UAE. The IP has been licenced to Norhull AS in Norway, who have developed a product called the SteelCrawler, with a full product launch planned in 2014.
- Research into performance monitoring of marine diesel engines with engine manufacturer Wartsila has been evaluated on a full scale oil supertanker, and subsequently systematically adopted by Wartsila to evaluate the effectiveness of new engine developments.
- Collaboration between the University and Peacocks Medical Group on additive manufacture within the EU funded a-footprint project which developed a new £500k manufacturing cell within Peacocks Medical Group. Peacocks Medical Group developed a new product line of advanced foot orthoses which exploit the capabilities of the new manufacturing cell and launched this line in July 2013. Further collaboration through a new KTP project will focus on developing new "smart" orthoses, and innovative orthosis designs from the University and Peacocks Medical Group feature within the *3D: Printing the Future* exhibition at the National Science Museum, launched in October 2013 and running to June 2014.
- Research on particle resuspension modelling is being used within the nuclear power industry as part of safety assessments. Reeks developed the CIRCD software to model particle resuspension within nuclear reactors, which in the event of a severe accident would be a primary safety concern, and this is now used by EDF Energy and Magnox as a necessary part of nuclear safety assessments. Reeks' particle resuspension model is also used by the French Institut de Radioprotection et Surete Nucleaire in its severe accident code.
- Over the REF period industrial funding (mostly from Rolls Royce Power Engineering and BAE Systems) in excess of £100k has been awarded to support commercial and security sensitive projects relating to environmentally assisted cracking of steels, using unique high temperature testing and exposure facilities. Projects have considered alloys for nuclear power generation system development, and failure mode analysis in modified combat vehicles.

b.3 Spin-out Companies, IP Protection and Licencing

Impact has also been achieved during the period through the establishment of spin-out companies:

- GAP Technologies was spun out in 2011, to commercially exploit polyHIPE materials as reactor materials and in agricultural applications. PolyHIPE materials are nanostructured microporous composite foams, which can act as process intensification aids in a range of biological and chemical processes and patent applications for the production of these (PCT/GB2009/002403), and for their use as a soil enhancer (PCT/GB2009/002380) have formed the basis of a series of patent families which will be exploited through the company.
- Five-quarter. Spun-out in 2010 to develop underground coal gasification with carbon capture and storage. The company has secured licences from the British Government, which allow exclusive access to 400 square kilometres within which approximately 2 billion tonnes of gas source rocks exist under the North Sea, off the coast of Northumberland and Tyneside.
- NewCell Technologies spun-out in 2008, which is developing, with TSB funding, membrane materials for fuel cells and electrolysers.
- Royenface, spun-out in 2010, to exploit patented electrochemical patterning technology within the microelectronics industry.
- Work with an earlier spin-out, ITI Energy, has continued through the REF period through collaboration in an EC FP7 project (COPIRIDE; 228853). ITI Energy spun-out in 2006, and is now valued at £20M, employs 25 people, and sells gasification technology. The company has licensed six patent families from the University (25 patents in total).

In total over the REF period 14 patents have been granted (10 UK, 2 Australia, 1 New Zealand, 1 USA), with a further 24 submitted and in process (9 UK, 5 Europe, 4 USA, 2 Gulf States, 2 China, 1 Canada, 1 Germany), and these will form the basis for future IP exploitation.

b.4 Standards and Policy

In any professional engineering discipline standards are the key mechanism by which research can be translated to improved professional practice, and three of our impact case studies (gear, rail

vehicle, and pipeline repair standards) showcase the impact research at Newcastle has had on international standards development. In addition, our research has also played a significant part in influencing the development of clinical guidelines for specific types of joint replacement, and this has had significant international impact as detailed in the metal-on-metal hip implants impact case study.

Researchers across the UoA participate in a number of advisory boards for national and international bodies, and through these roles support the development of de facto standards and the dissemination of best practice. Over the REF period this has included contributions to the: Academic Board of Chemical Innovation KTN; BBSRC/EPSRC Bioprocessing Industry Club; BRITEST; MoD Low Signature Propeller Industry Forum; International Towing Tank Conference Advisory Council; 26th ITTC Special Committee on Surface Treatment; Lloyd's Register Technical Panel for Naval Ship Rules, International Ship and Offshore Structures Congress; ITTC Ocean Engineering Committee; ISSC Natural Gas Storage and Transport Committee; Lloyds Register Technical Committee; ASME-OMAE Offshore Technology Committee; Scientific Advisory Committee for PHEBUS International Severe Accident Experiment; International Railway Research Board; European Railway Research Advisory Council; Advisor to European Commission DG-Research; Scientific Advisor to MoD; British Gear Association Executive and Technical Committees.

c. Strategy and plans

Engagement is a key part of Newcastle University's mission, and supporting the industrial base is a key part of the research strategy across the UoA. There is a strong heritage of engagement and impact which we aim to maintain and grow. Our specific policies for achieving this are:

- To continue to support and facilitate active staff participation in relevant agenda and policy fora and to contribute intellectual leadership to inform debate and policy.
- To continue to encourage staff to engage actively in relevant professional networks.
- To support academic staff to increase the number and scale of interactions with business and industry at a regional, national and international level through consultancy, the provision of CPD, collaborative Research and Development, contract research and partnering to exploit our intellectual property for the benefit of society.
- To facilitate knowledge exchange to and from a wide range of organisations through KTPs, CASE studentships and secondments.
- To continue to support academic staff and research students to produce and grow spin out and start-up companies from the institution's research and knowledge base.
- To forge deeper and longer-term partnerships with industrial partners.
- To build institutional and individual capacity for engagement by providing initial and continuing professional development to support engagement.
- To ensure engagement activities are taken into account in workload models.

The University engagement strategy embeds support for this into academic career structures through training and recognition of engagement activity within workload models and promotions policies, and recognises that developing and maintaining relationships are key to delivering impact. The Schools in this UoA are committed to continuing to impact on industry and society by supporting staff in building relationships with industry and stakeholder groups (including maintaining support for their industry facing research groups), and through facilitating and recognising industrial collaboration, consultancy, IP exploitation, and participation in policy and standards committees as the primary means by which impact occurs.

d. Relationship to case studies

Of the five impact case studies three are related to international standards development (gear, rail vehicle, and pipeline repair standards), one to product development (naval gears), and one to clinical policy development (metal-on-metal hip implants). This range of types of "impact" indicates a high level of understanding and use of the breadth of possible impact mechanisms within the UoA over the period. Three of the impact case studies (gear and rail vehicle standards, and gear noise) come from two of our industry facing research and technology centres, which indicates that the long term relationships with industry and regulatory bodies that these centres foster is valuable in informing the development of research programmes which will go on to have significant impact.