Institution: University of Hull

Unit of Assessment: B15: General Engineering

a. Context

The two research themes in General Engineering, namely Energy, Environment and Sustainable Engineering (EESE) and Medical Engineering (ME), are multidisciplinary activities based in the School of Engineering, and involve many other Departments across the University and external collaborators. Likewise, many groups benefit from the outputs of this UoA. For the EESE theme beneficiaries include: industry, policy makers and the general public; and for the ME theme: patients, the NHS (as an organisation, as well as nursing and medical communities), medical device companies and the general public. The latter is in addition to the advanced research tools that we are developing to support the work of academic and clinical colleagues in the life sciences.

For all these groups there are strong, established relationships that are actively promoting translation of research into tangible benefits at both the strategic and operational levels, i.e. research projects that include academics working collaboratively with industry and/or NHS staff. We aim to undertake innovative research into new products, processes and devices that generate: (1) opportunities for commercialisation, with concomitant job and wealth creation; (2) improved delivery and cost-effectiveness for both industry and the NHS; (3) improved patient care and quality of life for all; (4) a reduction in overall environmental impact from our collective activities.

Engineering has been a key part of the University for over 40 years and is still a priority of the institution. This is demonstrated by the recent investment in staff and facilities to support the introduction of Chemical Engineering, and ambitions for significant further expansion of the School's activities. The expertise of those new staff members in, for example, CO_2 management (reduction, capture, transport and storage) and process and building energy efficiency will provide invaluable local support to the many chemical and allied industries in the Humber region. Furthermore, the University has Health and Wellbeing, and Energy and the Environment as two priorities in its strategic plan, which also reflects the region's priorities. For example, in recent years the city has invested substantially (£250M) in major new hospital facilities and £36M on the North and South banks of the Humber in offshore wind and the wider renewable sectors. The activities within General Engineering directly support both these regional and institutional priorities, as well as contributing to similar national priorities, as demonstrated below.

b. Approach to impact

Pathways and approaches to impact

The School of Engineering actively encourages the interaction of staff with industry and exploitation of their research. To facilitate this it established the **Engineering Innovation Institute (EII).** The EII and its predecessors have received ERDF and similar funding and have an established track record of supporting industry, and promoting and applying the School's research. In the past 5 years, the EII (with a core staff of 4) has worked with over 300 companies and organisations in the region. For example: it used the ME Group's expertise in skull biomechanics and specialist facilities to design and manufacture a prototype protective helmet to prevent newborn babies from developing plagiocephaly (flat head syndrome) with surgeons from Leeds General Infirmary.

The EII's activities were given a significant boost in 2011 by the establishment of the **Centre for Adaptive Science and Sustainability** (CASS), led by **Haywood** (EESE member). Created using £2m HEIF5 funding (25% of the University's allocation), CASS promotes research and collaboration with industry in the renewable energy and low carbon sectors, with a membership of over 60 and annual turnover of ~£4m. Research expertise from the EESE Group is being applied via CASS and in partnership with businesses to a suite of inter-disciplinary projects. These deliver University expertise to the rapidly expanding renewables sector moving to the Humber Enterprise Zone – the largest in the country and specific to Renewable Energy, it was set up to support development of the three largest proposed Round 3 offshore wind farms at Dogger Bank, Hornsea and Norfolk. CASS has recently played a key role in developing the £200m Green Port Hull project, which received planning permission in April 2012. This project aims to build a wind turbine manufacturing and assembly plant on the Humber for Siemens at the ABP-owned Alexandra dock. The University, through CASS, now manages the R&D strand (ca £2.0m) of the associated RGF programme Green Port Growth (£27m), whose aim is to support renewable energy businesses

within the region. The EESE Group's expertise is also being applied to other CASS projects including scour associated with wind turbine gravity-bases (with Costain, Hochtief and Arup), cumulative environmental impact of the east coast wind farms (with SMartWind), fault-tolerant control of wind turbines (with kk-Electronic), wind/turbulence resource assessment using sonar and lidar and tidal resource analysis (with Parsons Brinkerhoff). For the past two years, CASS has been cited by HEFCE in their annual report as a national example of best practice in delivering impact and value by enhancing UK competitiveness through effective knowledge transfer from the HEI sector. In April this year CASS received the Humber Renewables Champion Award for raising the profile of the Humber in the Renewables field.

Likewise the **Centre for Medical Engineering and Technology (CMET)** was established in 2002 (with £1.8m, led by **Fagan**, ME member) to act as a focus for the University's medical engineering activities, with a membership of 31 and annual turnover of nearly £650k. For example, research expertise from within the ME Group was applied directly through a Royal Society Industry Fellowship with Smith and Nephew (S&N, York) to a number of orthopaedic procedures and devices, but also with S&N Wound Management division (Hull), and indirectly through consultancy services calling on CMET's specialist expertise. Naturally CMET has very strong links with clinicians in both local and national hospitals. Early work of colleagues in CMET (arising from discussions with a consultant at Hull Royal Infirmary) led to the development of the Kingston Speech Valve (one of our Impact Case Studies) and spin out company Avoco Medical, and the formation of a new research group in speech restoration and rehabilitation which is now developing other speech devices and shortly due to start another clinical trial.

More recently, the University's **Centre for Telehealth** (CfT) was established in 2011 with £1.55m HEIF4 and HEIF5 funding. It has a wide membership of nearly 50 staff from across the University, and an annual turnover of £700k. It aims to bring together expertise from across the University, primary and acute care, local authorities, industry and third sector partners to develop new service concepts that will form the future basis for delivery of care in the NHS and elsewhere. The multi-disciplinary Centre provides a range of services to healthcare providers and industry, supported by research and educational expertise. Engineering is a key contributor to the CfT, in particular with the application of lab-on-a-chip technology (with Chemistry) and development of robust, adaptable telehealth monitoring systems (with Computer Science).

Other direct pathways to impact are self-evident in our numerous on-going research and development partnerships with industry, including Airbus (Toulouse), Baosteel (the largest steel company in China), Deimos Space, Doncasters Group, Enertek International, Jaguar Landrover, Rolex, Rolls-Royce, Spencer Group and many others, funded directly by the company or through Knowledge Transfer Partnerships (see below) and other grants, demonstrating that staff are actively involved in, and enthusiastic about, exploiting their research and expertise.

Institutional support

The **Enterprise Centre**, opened in 2008, places the University of Hull at the heart of enterprise activity in the region and nationally. It hosts the University's Knowledge Exchange (KE), the Research Funding Office (RFO) and a number of start-up companies. The RFO provides advice and support for securing research funding, while the KE offers proactive support to secure more development-focussed resources, in particular with an eye to exploitation of that research. For example, the KE helped secure Yorkshire Concept funding: (1) to allow detailed development of the business case for the Kingston Speech Valve (KSV) including an extensive review of the worldwide speech valve market; and (2) exploitation of a computer simulation of visibility in smoke filled environments to aid design of buildings with large public spaces.

The KE has a dedicated officer to promote and administer Knowledge Transfer Partnerships (KTP) programmes, which the School supports and has used as a means of exploiting its research expertise, with 22 partnerships awarded since the scheme's introduction. Expert advice on exploitation and commercialisation, including patent protection, licensing and company spin-outs is also provided by the KE. Over the period, 19 patents have been granted to staff in Engineering, and for example, the KE led the search for investors for the KSV spin-out company. Almost 100 start-up companies have passed through the Enterprise Centre since it opened.

The University of Hull achieved a substantial increase in its allocation of **Higher Education Innovation Fund (HEIF)** under the latest round**;** (47% increase in HEIF5 (2011-2015) compared to HEIF4). This is due to its consistent performance against the income-based funding criteria of the

Higher Education Business and Community Interaction returns. A significant part of this has been used to support the work of Engineering through the investments in CASS and CfT (see above).

School support and promotion of impact activities

The School of Engineering actively supports staff in achieving impact from their research in a number of ways. Most obviously it funds the EII which provides a channel to and from industry. In addition, it encourages and where necessary supports financially, individual fellowships. In this REF period, these included one ***Leverhulme Fellowship*** (**Curtis**, 50% funding provided by the School), one ***Royal Academy of Engineering (RAEng) Fellowship*** (Moazen), one ***Royal Society KC Wong Postdoctoral Fellowship*** (Huang), and two ***Royal Society Industry Fellowships*** (**Fagan** and **Mi**). The latter two (for example) allowed Fagan to apply his bone research in Smith and Nephew's Research Centre (York) over a four year period, and Mi to work with Doncasters Group Ltd on solidification technology for nickel superalloys. In addition, **Haywood** was recently awarded a ***RAEng Industry Secondment*** to Spencer Group (based in Hull), and the School of Engineering appointed a ***RAEng Visiting Professor*** in Innovation in Renewable Energy Engineering with the remit, amongst other things, of promoting the University's energy related research to industry and establishing further partnerships between industry and the University. The School makes an explicit allocation of time within its workload model to recognise all impact activities, currently without any limitation on the scale of those activities.

c. Strategy and plans

The School of Engineering will continue to promote application and exploitation of its research. These are already priorities in current research activities, but consideration is now being given to how more impact might be achieved throughout a project's life. To facilitate that effort, the School's Engineering Innovation Institute (EII) will have a closer and more proactive involvement in research activities – to focus in particular on identifying opportunities for exploitation of elements of on-going research, rather than the more obvious longer-term goals of the research. We will promote this by checking that impact is given increased priority during the normal internal grant review process prior to submission, encourage the inclusion of impact appraisals during research progress meetings and introduce an annual EII-led review of impact opportunities on all active and recently completed grants. To support that work, requests for funds to stimulate and accelerate impact will continue to be included in research proposals whenever possible (e.g. RCs), but in addition, direct support will be provided by the School for suitable projects that lack these resources.

We anticipate that more industry-led opportunities for exploitation of current and past research will continue to arise through the activities of CASS, CMET and CfT, and we are confident that these will grow significantly as CASS and CfT become more established and their reputation increases. We also see significant opportunities through our emerging chemical engineering activities and the many chemical and allied industries in the Humber region. Indeed the potential to link with regional companies has been an important consideration in recent staff appointments (e.g. **Zein** and new appointees (due to start shortly) **Stevenson** and **Skoulou**, all have expertise relevant to biofuels industry, while **Wang** has expertise in carbon capture). To encourage this growth, the EII is again being tasked to work with members of the School to identify and exploit new opportunities. Meanwhile we will continue to apply for specific funding to exploit our research, e.g. through YIF (Yorkshire Innovation Fund) and others.

d. Relationship to case studies

The SCONES (stress concentrations and fatigue analysis tools) Case Study highlights the potential opportunities and inspired our current strategy, with core knowledge developed during one project being applied to another application. It originated from earlier EPSRC-funded research to investigate knowledge-based expert systems to improve engineering design and manufacture. Initial investment (of >£1M) by BAE Systems in the BAE Stress Analysis Centre at Hull focussed that effort towards aero-structures, but other potential applications soon became evident. For example, an opportunity arose to apply some of the same techniques to the design of caravan chassis manufactured by local company Bankside Patterson. Pilot work was undertaken, supported by the forerunner of the EII, to demonstrate the potential improvements and led to the award of a KTP grant. The work produced a step change in the design of the chassis and, as a direct result, the turnover of the company trebled and the workforce doubled within three years. In November 2009, the company won the prestigious Insider Growth 100 Award for Innovation.