Institution: University of Strathclyde

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

a. Context

The University of Strathclyde has an unambiguous ambition to be among the leading technological universities in the world. The successful transfer of research findings to business, public and third sector organisations is inherent in the University's founding mission to be 'a place of useful learning' and an explicit objective of the University's strategic plan. The UoA12 research strategy is fully aligned with this clear ambition and the four Departments in the UoA have extensive external partnerships.

The main beneficiaries, user groups and audiences for UoA12's research include: aerospace engineering and aircraft manufacturers, catalysts manufacturers, classification societies, engineering manufacturing industry and service providers, food and drinks companies, national and international regulatory bodies, oil and gas companies, pharmaceutical and chemical companies, public policy bodies, renewable energy companies, ship operators, shipbuilders and ship-repairers, UK and EU public and society, and utility companies.
The types of impact delivered to and through these beneficiaries include:

- **Economic Impact**: Innovative industrial processes and products; increased productivity, turnover and employment; and reduced industry waste and costs
- **Environmental Impact**: Efficient utilisation of energy sources
- **Quality of Life Impact**: Contribution to public policy; public safety; improved health products; and improvement of transport passenger safety.

b. Approach to impact

Several mechanisms are used to deliver research impact:

Industry Partnership Research Centres: The UoA is currently engaged in four such Centres, working directly with industry and funded or co-funded by specific partner organisations:

- *Advanced Forming Research Centre* was established in August 2009 as a partnership venture between the University of Strathclyde, Scottish Enterprise, the Scottish Government and Tier 1 partners Rolls-Royce, Boeing, Mettis Aerospace, TIMET, Aubert & Duval and Barnes Aerospace. The Centre is located in a custom built 2600 m^2 building opened in July 2010. The initial £25M investment included a £6.5M equipment budget. The AFRC Research Agenda is set by the industry partners in consultation with Strathclyde researchers to meet specific industry requirements. The centre currently employs 70 FTE staff across all areas of activity, as well as company representatives permanently assigned to the AFRC. As of September 2013, the AFRC is engaged in collaborative projects with 20 industrial partners, who have collectively invested over £5M to deliver solutions to their business challenges. Through AFRC, Strathclyde researchers have direct engagement with worldwide industries (>40 companies including BAE Systems, Boeing, Fanuc, Gammastamp, Renishaw, Rolls-Royce) and internationally leading research communities.
- *Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation* was established in 2010 with EPSRC/industry funding of £5.95M. The Centre is in partnership with the Department of Pure and Applied Chemistry, the Strathclyde Institute of Pharmacy and Biomedical Sciences, and with the Universities of Bath, Cambridge, Edinburgh, Glasgow, Heriot-Watt and Loughborough.
- *The Technology and Innovation Centre* is a major industry-focussed multi-disciplinary research initiative aimed at developing new approaches for university engagement with industry partners. The research is divided into four sectors: Low Carbon Power and Energy, Future Cities, Health, and Manufacturing. We are actively involved in funded research in collaboration with colleagues from Strathclyde's Electronic and Electrical Engineering and Management Science Departments, and Industry partners SSE, Scottish Power and Technip.
- *Weir Advanced Research Centre* was established in 2011 following completion of a successful UoA R&D project with Weir SPM, Fort Worth, USA. Funded by the Weir Group (£1.95M for years 1-3), the Centre provides research support to Weir over a wide range of mechanical,

design and manufacturing engineering research areas. 12 academics from the UoA are associated with the Centre, which currently employs 3 FTE research staff in addition to two Weir staff permanently assigned to WARC.

Knowledge transfer partnerships: The UoA has established a position as one of the most successful academic participants in the KTP programme and has engaged in 27 KTP partnerships with companies from a range of industry sectors during the REF period (total funding £2.54M). These projects have provided *economic* (e.g. Henry Technologies Ltd, Highland Spring, Menzies Distribution), *environmental* (e.g. Land Engineering, Sgurr Energy Limited, K J Tait Engineers) and *quality of life* (e.g. Vascutek Limited, Safety at Sea Ltd) benefits to industry partners and the wider community. The UoA has also been successful in securing funding for 11 partnerships at *Emergent* and *Research Exploitation* levels from the EPSRC Knowledge Transfer Account (total value £364k).

Industry driven PhD studentships: These are supported through Doctorate Training Centres and Industry funded PhD studentships. UoA12 hosts or participates in 4 Doctoral Training Centres: Advanced Manufacturing Industrial Doctorate Centre; Industrial Doctoral Training Centre for Offshore Renewable Energy; Systems Engineering Doctorate Centre; Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation Doctoral Training Centre. During the REF period industry has funded or co-funded 80 PhD Studentships (fees and stipend).

Faculty and Department co-investment funding programmes: The UoA has jointly funded a number of Strategic and start-up projects, including KE grants up to £50k and KE micro-grants up to £5k, which have enabled researchers to pump-prime and/or accelerate KE and Industry engagement. Industry partners have included BAE, Blatchford, Capital Steel, Ceramco, Harris Tweed, the NHS, Reactor Technologies, Rolls Royce, Safety at Sea, Scotoiler and Vascutek.

Engineering Consultancy and Support Services: UoA12 has an established track record of providing substantial consultancy services to industry. Clients include: British Waterways; BAE Systems Submarine Solutions; Weir SPM, Innovative Solutions for Sport, BP Exploration, British Council in Kenya and Uganda, Marine Biopolymers, Mars, European Maritime Safety Agency, Maritime and Coastguard Agency, Rathburn Chemicals, and Scottish Water. Projects include: the assessment of the performance and survivability of marine and offshore renewable energy devices for SMEs; and assessment of SOLAS2009 damage stability standards of ships.

Contribution to Agenda Setting Organisations: UoA staff are engaged in a wide range of agenda setting activities. Typical examples include: British Standards Committees PVE/1/15 Design Methods and TDW/4/7 Technical Product Realisation; Chartered Quality Institute; Design Society Advisory Board; Food Standards Agency; International Advisory Board for the Japanese Institute for Cell and Materials Science, Scottish Government expert panel on Building Regulations; Scottish Renewables Marine Energy Advisory Group; UK National Space Technology Strategy Group: Adviser to UK Maritime Coastguard Centre on IMO activities on Stability and Safety.

Examples of UoA12 Interactions and Relationships

- Consultancy services provision to Highland Spring since they were an SME employing 90 people with a turnover of £12M. A KTP agreement and research collaboration in the area of performance management contributed to Highland Spring becoming the fastest growing UK bottled water business, now turning over £80M and employing 400 people.
- An initial R&D project on Hydraulic Fracking Pump design with Weir SPM led to a rolling consultancy programme with Weir, generating income in excess of £500k.This led directly to the establishment of the Weir Advanced Research Centre (WARC) at Strathclyde.
- The Clyde Space KTP, winner of the Scottish “Best Partnership Award” 2011, has led to on-going UoA staff secondment to Clyde Space.
- Impact on global catalyst manufacturers relates to UoA work on nanomaterials for catalysis and process analytics through the Centre for Process Analysis and Control Technologies.
- Provision of consultancy services to Terumo Vascutek Ltd. Led to development of a co-funded

PhD scholarship, 2 year Research Associate funding and a KTP.

Operational Agility

UoA12 has also been proactive in developing its staff profile and research infrastructure to support research and research impact. Specialist infrastructure includes:

- **Advanced Materials Research Laboratory**: collaboration with the Faculty of Engineering to develop new materials characterisation and testing research facilities (£3M funding).
- **HPC Clusters:** a University-level partnership with the Universities of Glasgow, Glasgow Caledonian, West of Scotland and Stirling to establish a regional centre of excellence in High Performance Computing for Academia, Industry and Enterprise in the West of Scotland.
- **Kelvin Hydrodynamics Laboratory**: assessment of survivability of damaged ships, fluid structure-interaction for slender structures, sporting fluid dynamics and marine renewable energy. Provides of testing services to the UK tidal and wave energy industry, providing highly repeatable and controllable conditions for testing of wave and tidal energy devices.

Staff Support

The UoA has implemented several staff development/motivation programmes related to impact and external KE, including:

- Training courses and mentoring in growing KE activities
- Lunchtime KE seminar series
- Annual KE awards to staff (£5k first prize)
- Targeted appointment of Visiting Professors/Researchers from industry

The University KE Professional staff category offers a Knowledge Exchange career path from Associate to Professorial level. This recognises and rewards staff who achieve research impact through engaging in transfer of research to external partners.

c. Strategy and plans

The UoA's Research Impact Strategy is to continue to operate and enhance the approaches to impact detailed in Section b and to further accelerate and grow strong research partnerships with external stakeholders through the University's flagship Technology and Innovation Centre (TIC). TIC represents both a research impact philosophy and a physical environment. From 2014, it will bring together up to 1200 researchers, engineers and project managers from academia and industry via a new-build £89M state-of-the-art facility, structured to deliver outward facing, collaborative and cross-disciplinary research focussed on real-world needs.

The TIC partnership model, which provides a robust framework for new and distinct models for industrial engagement and research transfer, has been implemented in UoA12 prior to opening of the physical facility through the launch of several pilot projects. These include the Weir Advanced Research Centre (WARC) in 2011 and the Low Carbon Power and Energy Theme Offshore Windfarm with Technip, Scottish Power Renewables and SSE Renewables in 2012.

Plans and Objectives

- Maintain the UoA's position in the UK top 5 for Engineering KTPs, aided by continued close association with the **West of Scotland KTP Centre**.
- Utilise the University's Impact Acceleration Account (established Oct 2012, £1.86M EPSRC funding) to enable, accelerate and enhance links with industry, including partnership research programmes, two-way secondments, studentships, pre-proof of concept projects and the creation of new start-up businesses.
- Develop new research and consultancy partnerships with small businesses through **Strathclyde Links,** a Scottish Government and EDRF funded programme to facilitate business introductions and provide support, funding, and networking opportunities.
- Engage with University and Faculty **KE Development/Strategy Programmes** to support new KE provision. These programmes provide pump-priming and launch funding to establish and underwrite innovative new KE activities.
- Establish at least one new **Doctoral Training Centre** in the Unit within the next two years.
- Utilise the **Faculty Strategic Research Funding** grants programme (£20-50k awards) to develop multidisciplinary projects with external partners to achieve specific impacts.

d. Relationship to case studies

Relationships with partners and the development of impact are fostered over many years via a portfolio of mechanisms, successively building on earlier engagements. For instance, the Advanced Forming Research Centre (AFRC) has been independently assessed as having a net impact on the Scottish economy of £3.4M pa. Rolls Royce has reported a productivity gain of 100% for the die life of their aerofoil forging process following research at the AFRC, saving £1M per year. Research conducted at the AFRC assisted an SME to develop a manufacturing process for a stainless steel unvented hot water cylinder through a KTP programme, generating £118k pa for the Scottish economy. Examples of the types of impact mechanisms relating to the case studies are detailed below:

Industry Partnership Research:

- **Long term development of strategic partnerships:** Patient development of relationships with public and private sector organisations transformed space research outcomes into high international impact leading-edge space technology. Research within UoA12 influenced US National Oceanic and Atmospheric Administration and the European Space Agency (Case Study: Novel orbits for solar sail spacecraft).
- **KTPs and consultancies**: The Scottish Manufacturing Advisory Service uses the engagement between UoA12 and Highland Spring as a best practice example and encourages manufacturers to adopt similar solutions. A number of projects ranging from staff consultancy to KTP projects resulted in economic and social improvements for Highland Spring Ltd. and 30 other manufacturers (Case Study: Sustainable productivity and growth).
- **Partnership working:** Adopting the TIC philosophy of partnership working enabled transfer of research knowledge to engineers/designers in Weir SPM leading directly to improved patentable technology (Case Study: Commercial impact of innovative design).
- **European research partnerships**: Participating in 40 EU collaborative research projects has provided opportunities for European wide impact. A Virtual Integration Platform (VIP) has improved productivity, operational efficiency, working practice and knowledge management within the European maritime industry (Case study: Improved efficiency and design practice)

Knowledge transfer partnerships:

- **Impact through KTPs**: A 6-year Knowledge Transfer Partnership (KTP), with Carron Phoenix, resulted in a new production process leading to £4 million of capital investment sustaining the company's leading position in the market, generating sales revenue in excess of over £50M (Case Study: Economic impact through improved product and process development).

Contribution to Agenda Setting Organisations:

- **Influencing policy:** Policy changes with respect to fluid loading on offshore structures evolved from: an initial series of proposals to EPSRC supported by W.S. Atkins, BP, Lloyds Register, Shell UK, Harland & Wolff and Technip: experimental research performed for BP: and the SAFEFLOW project in conjunction with BP, Shell, HSE, and Bureau Veritas (Case Study: Improved safety of marine structures).
- **Influencing regulatory bodies:** SOLAS 2009 has been largely generated by UoA research. These regulations have had a major impact on the global shipping industry, benefitting over 500M passengers. UoA12 and spin out company *Safety at Sea Ltd* have contributed to the upgrade of over 100 ships, and the design of new cruise ships and passenger-car ferries, owned by companies including P&O, Stena Line, Caledonian MacBrayne, Viking Line, Color Line, DFDS, Irish Ferries, and Blue Star. UoA12 and Safety at Sea Ltd provide regular workshops/training courses to contribute to up-skilling of the European workforce (Case Study: Improving Maritime Safety).
- **Changing government policy:** The development of tidal energy technology has changed both Scottish and UK Government policy via their introduction of programmes, which demonstrate a step change reduction in the costs of marine renewables (Case Study: Nautricity Ltd).