Institution: Anglia Ruskin University

Unit of Assessment: 15 General Engineering

a. Overview

Engineering research is carried out in the Departments of i) Engineering and the Built Environment (also contributing to UoA 16) and ii) Computing and Technology, both within the Faculty of Science and Technology. The central focus of the submitting unit is **engineering modelling**, a theme which links research performed in three areas: i) electronics and telecommunications, ii) medical engineering, and iii) engineering analysis, simulation and tribology. Solutions to market-focused problems are provided for manufacturing, automotive, electronic, medical, software and telecommunications engineering. Collaborative partners range from local SMEs to multinational corporations. Highlights of the research include:

- modelling of improved hip replacement fixation techniques which has reduced i) patient recovery time by 3-5 days (£1,200 equivalent per operation), ii) revision hip surgery (required due to cup loosening) by 50%, and iii) costs of cup implants – a further saving of £1000-£1300 per operation. Over 1 million hip replacements have been conducted since 2000, using this fixation technique.
- the design of a crash test barrier which has set international standards. The collaborative research with Cellbond Composite resulted in the development of an *Offset Deformable Barrier,* used by EuroNCAP and car manufacturers (like BMW, GM) worldwide for testing the frontal offset impact. This further led to the design/development of a "pedestrian friendly" car bonnet.

A particular strength of the research is the engagement of the researchers with industrially and government funded projects and with the medical community. The unit of assessment has successfully secured 6 industrially sponsored research degree studentships during the REF period.

b. Research strategy

The strategic plan of the submitting unit is informed and driven by the Research and Scholarship Strategic Plan of the Faculty of Science and Technology, which in turn is driven by the institutional Research and Scholarship Strategy and our Corporate Plan. Strategically, in the REF2014 period, our objectives were to:

1. Attract appropriately qualified staff;
2. Develop an appropriate research culture;
3. Increase the volume and quality of research outputs;
4. Increase the volume and quality of research and consultancy income;
5. Foster a sustainable and thriving postgraduate research culture;
6. Maximise the end user engagement with and impact of the outcomes of the research.

To attract appropriately qualified staff, Anglia Ruskin took the strategic decision that all newly appointed staff should be qualified to doctoral level. Within the engineering team, 91% of staff have doctorates, within the submitted unit 100%.

In developing the research culture, Anglia Ruskin has clear goals in its Corporate Plan, 2012-2014, reflected in its Research and Scholarship Strategy 2012-2014: for example, that 'every member of staff engages in research or current professional practice in their academic discipline'. Staff within this unit benefit from, *inter alia*, writing retreats for preparing papers and bids, regular research seminars and engagement with Faculty and University research activities, the annual Faculty Research and Scholarship Conference and the annual University Research Conference. Further, researchers are expected to attend and present posters, papers, invited papers and Plenary Lectures at National and International Conferences.

To increase awareness of research funding opportunities and to optimise bidding for funds, we hold, with the assistance of colleagues in Research, Development and Commercial Services (RDCS), workshops on the content of the calls for funding, for example FP7 calls. We are developing a training programme around Early Career Researcher (ECR) access to external funds.

The volume and quality of the engineering research outputs has increased from 71 per annum in 2008-9 to over 100 per annum in 2013 and includes refereed papers, technical reports, EU project reports and project reports related to industry based research and consultancy. Our external

income has more than doubled from £170K per annum in 2008-9 to £388K per annum in 2013. These objectives are informed by Faculty and Corporate targets which are formally reviewed on a monthly (Faculty), quarterly (members of the corporate management team) and annual (Research Committee) basis.

The postgraduate research culture has been fostered in a number of ways. We have maintained around 28 doctoral students throughout the REF period, ensuring the sustainability of our doctoral environment. The number of countries from which the candidates in Faculty are drawn has increased from 20 in 2009/10 to 25 in 2012/13.

Engagement with end users of the research is achieved through research projects including those funded by the European Union, businesses such as Jaguar, Ford and A-One Medical (the Netherlands), SMEs, Knowledge Transfer Projects (KTPs) and Knowledge East of England Projects (KEEPs), hospital trusts in the UK and hospitals overseas.

The objectives of this unit, in the coming period to 2020, are that it will:

- Sustain an overall 50% growth in the quantity of research outputs, with 20% having quality recognised as internationally excellent quality or better;
- Increase its research income by 10% year on year until 2020;
- Increase the proportion of staff applying for funding from 70% to 100% by 2020;
- Increase the number of registered PGR students to 35 by 2020;
- Become the provider of choice to end-users in the area of engineering modelling, with at least 40% of the business arising from "repeat" business.

The focus of the research is likely to continue in the same subject areas. Interdisciplinary and multidisciplinary research will be encouraged.

c. People, including:

Staffing strategy and staff development

As research within the unit grows it will be supported, where appropriate, by the appointment of postdoctoral researchers and postgraduate research students funded by the research income streams. Additionally, the academic staff compliment will be grown in accordance with the student base in the host Departments. The Faculty is also in the process of appointing a Professor of Medical Engineering to lead this subject.

In achieving the planned growth in the unit's research strategy, we take advantage of the many internal and external staff development opportunities. These include research seminars and attendance at University and external conferences and events. Internal staff development sessions are offered by the Faculty, RDCS and Human Resource Services. Online research training courses, hosted by Epigeum, are also available to all staff and students. Staff development is informed by the Concordat to support the Career Development of Researchers, as evidenced by Anglia Ruskin being awarded the "*HR Excellence in Research*" badge in 2013. As part of that process, we undertook a gap analysis which we are now working to address, ahead of the review of the award in 2015. Early career researchers have access to specific funding for staff development, organised by HR Services. Feedback from staff who participated in the Careers in Research Online Survey (CROS) 2013 showed that Anglia Ruskin staff feel their contribution to a variety of research activities is more highly valued and recognised, than the sector average, and that they were better integrated into their research community. Similarly, Anglia staff felt better informed about key research strategy and policy in the national environment, such as the REF, the RCUK's 'Pathways to Impact' expectations, the three Concordats on Research Integrity, Public Engagement and Research Careers, as well as the HR Excellence in Research Award."

All academics have a Research and Scholarship plan which is developed and resourced through appraisal. This sets SMART targets around income generation and research and scholarship outputs, commensurate with the career stage of the appraisee. Mentors are identified to support colleagues. All new staff have a mentor. Academics applying for readerships or professorships are strongly encouraged to have a mentor who provides advice in developing their application, for which clear guidelines are published.

Clear guidance on expectations of supervisors is published for all staff supervising postgraduate researchers. Staff new to supervising at ARU must attend supervisor training and all supervisors are required to undertake continuing professional development. ARU runs workshops and an annual conference for supervisors. Compulsory training is provided for all Chairs of Vivas and for Convenors of Student Monitoring meetings. As noted above, all newly appointed staff must have a doctoral qualification.

Staff can apply for well-funded sabbatical periods of up to 6 months in support of research and scholarship. Since 2008 two members of staff in this unit (Mootanah and Cirstea, S) have benefitted from this University Sabbatical Scheme. Through the 'Enterprising Academics' scheme, there is opportunity to develop relationships with business/research "end-users" in cognate subject areas**.** Further, colleagues are encouraged to participate in the activities of professional bodies.

International visitors support and strengthen the research portfolio. During the assessment period these have included three visiting research fellows, two visiting scholars and seven academic visitors who have undertaken research and enhanced our research environment visits ranging from one to six months duration.

Our equality and diversity policies apply to our staff and students and are for everyone, whatever their backgrounds or personal beliefs, all being expected to comply. All staff must undertake the online equality and diversity training. Support of equality and diversity within the submitting unit is informed by and in line with University policies and procedures. Colleagues are supported by a comprehensive suite of documents made available centrally by HR.

Research students

From an average number of 28 research students, there have been 24.5 doctoral completions during the census period. Students are recruited through a number of different routes. Since 2008, 11 Faculty and University research studentships and bursaries have been awarded on a competitive basis to students in this unit. Some international students apply and are recruited following the recommendation of our graduating PhD students. This is particularly true for Middle East students, funded either individually, through their employers, or through their respective government agencies. Senior Faculty staff actively promote opportunities for doctoral research, for example through the "Science Without Borders" programme. Other students are recruited to projects funded by businesses, to address their specific research questions. With dedicated accommodation, students are focussed in clusters on both campuses in order to provide a "community of learning" and mutual support network.

All doctoral students have a minimum of two supervisors. With support from their supervisors, students each year prepare a Personal Development Plan from analysing their training needs using Vitae's Researcher Development Framework (RDF). In developing their research skills all students attend compulsory training appropriate for the different stages of their PhD. This includes training on writing their research proposal, ethics, intellectual property, academic presentations and writing, and preparing for the viva. All students who teach must also take a three-day 'Learning and Teaching in Practice' course. A wide range of face-to-face and online training is available for research students. The students from cognate subject areas are now focussed in hubs, to engender a "community of learning". They are required to attend and present regularly at departmental seminars, the annual University's Research Student Conference and the Faculty's Research Conference, thus being able to practice skills developed in their compulsory training. We have also introduced a faculty programme of PGR and staff development around good research practice and processes involved in doctorates. With departmental and faculty funding, students are encouraged to present their research at International Conferences. Students within the submission are regular prize winners at University, National and International Conferences. Research student, Kimmitt, won the Best Paper award at CEEC'12. Carpanen and Reisse have also won several prizes internally and internationally. Feedback from students participating in the Postgraduate Research Experience Survey (PRES) (2009, 2011, 2013) has shown that the student experience has improved significantly. In both PRES 2011 and in 2013 our respondents rated their overall experience of their research programme at Anglia Ruskin more highly than the sector average.

Anglia Ruskin's Research Degrees Regulations, reflecting the Quality Code from QAA, provide a

clear regulatory framework. Students' progress is carefully monitored by the Faculty Research Degrees Subcommittee with an annual monitoring review meeting, usually face-to-face, convened by an experienced supervisor external to the supervising team. In their first year research students have two review meetings. Students are required to present their Personal Development Plan and a log of their supervisions at these meetings. The outcomes of monitoring meetings are reported to the Faculty Research Degrees Subcommittee and then at university level through Research Degree Subcommittee. Students for a doctorate must also be successful at Confirmation of Candidature, in which the candidate shows they have the potential for a successful outcome at the doctoral level. In 2013, the University implemented the use of "Progress Platform", where all of the monitoring and reporting data can be recorded in one central repository, thus improving information flow across the various offices responsible for research degree students. Within the Faculty, our monitoring process has resulted in a 97% retention rate of PGR students in the academic year 2012/13.

d. Income, infrastructure and facilities

Infrastructure and facilities

In support of medical engineering, the University has built (2008) and equipped (£381K) a laboratory modelled upon the facilities at the New York Hospital for Special Surgery. This is the only such laboratory in the UK, allowing us to undertake cutting edge research that would otherwise not be possible. Facilities include computational modelling and simulation packages (Abaqus, ANSYS, MIMICS, CATIA), scanning electron microscope for surface and wear analysis, mechanical testing equipment (Instron 8874, Bose ElectroForce Biodynamic), force and pressure measurement devices (AMTI, emed-x, Pedar) and a movement analysis system (Vicon). The simulation and testing facilities enable the evaluation of the relative performance of different surgical practice/implant designs and rehabilitation and treatment methods for different pathologies (joint disease, venous ulcers, gait abnormalities) and allow the identification of improved treatment methods and implant designs.

The engineering analysis team benefits from laboratories supporting mechanical engineering (CNC machines, numerically controlled lathe) and industry-standard software for Design, Finite Element Analysis and Computational Fluid Dynamics, low flow rate atomizers, tensile testing machine, scanning electron microscope and rapid prototyping facilities. HYPERWORKS, LS-DYNA, ANSYS and PAMCRASH are used for modelling vehicle structure and impact barriers during crash tests.

Research facilities also include specialist laboratories dedicated to Electronics including: a range of Electronic Design Automation packages, FPGA/DSP/Microprocessor boards, optical 3D scanner, electrical machines and drives test bed, solar panels, renewable energy converters and a small wind turbine. New high specification digital media and recording studios have recently commissioned.

Engineering is currently recognised through our University's Corporate Plan as playing a significant role in the Med-Tec Campus based in Essex. This will see the development of a £6M Medical Business Innovation Centre (MedBic), opening in 2014, which will contain engineering laboratories for teaching and research and, at the same time, will bring businesses into close proximity of research activity, supporting the growth of new businesses in the engineering field.

Income

External income has more than doubled in the REF period, growing from £170K per annum in 2008-9 to £388K per annum in 2013. The income sources have also diversified. UK-based Charity income increased from £0 to £45K in the period. The annual funding from UK Government, local authorities and hospital authorities has more than tripled, from £82K to £250K. The funding attracted from UK industry, commerce and public corporations has been relatively stable (around £66K annually). The highest increase in funding was achieved with respect to EU funding, where the annual amount of £20K in 2008-9 has more than tripled to reach £68K per annum in 2012-13, following the strategic efforts, staff training and investment in enhancing EU funding bids.

The external income generation activity is supported by the Faculty Research Income Manager,

who was appointed a year ago, and the more recently appointed Faculty Commercial Manager. The roles of these posts are to increase research and commercial funding across the Faculty portfolio but especially in the engineering area. Institutional support is provided through Research, Development and Commercial Services. IP protection is supported through the University Secretary and Clerk's Office. High end computing facilities will be developed through the inauguration of an *Information Technology Research Institute* in 2014, in the Faculty of Science and Technology. Future financial plans target a further significant increase in the effort to attract external income, with a strong focus on major EU projects, enhance knowledge transfer of the applied research to industrial companies, expand the income sources to include offering CPD/bespoke training, as well as more consultancy.

e. Collaboration and contribution to the discipline or research base

Our research is driven in part by collaboration with a wide range of industrial partners including Calex Electronics, iDash, Sustainable Technology Solutions, ARM, Cambridge Recycling Services, LMK Thermosafe, Sedgwell. Links are are also maintained with universities in UK (Loughborough University, Sheffield University, Nottingham University) and abroad (University Cergy-Pontoise Paris, France, Aalborg University, Denmark, Polytechnic University Turin, Italy, Transilvania University Brasov, Romania, Warsaw University of Technology, Poland, Urmia University Iran). We collaborate actively with other researchers through IEEE, IET, IMechE, BCS, OWASP, Chelmsford Engineering Society, Cambridge Network and Cambridge Wireless.

Exemplar outcomes arising from such collaborations include :-

- Low Carbon KEEPs with Calex Electronics Ltd. on intelligent sensors/control (2012-13). Through the work of our electronics team, the design of a new infrared temperature sensor, branded as *PyroMini,* has emerged.This new product will enable a significant reduction in carbon emissions both by the sensor manufacturer and the end users, giving Calex an advantage over its competitors and enabling customers to improve their energy efficiency.
- Collaboration with Sedgewall Communications to redesign the paging system used by off duty emergency services. The smaller new paging system provides simple messages from the emergency call centre to the off duty officers.
- An FP7 *Research for SMEs* European project *Design of new acoustic absorbers for thermal mass buildings* – "Echo-to-Echo" (2012-14). There are 7 project partners, led by a German SME Nowofol, manufacturing polymer foils. Another 3 companies are involved, expected to implement the results of the research: Acoustic RPG (UK, installers of acoustic absorbers), DeAmp (Norway, manufacturers of acoustic absorbers) and Skaly & Couch (UK, consultants). Our role is to model the new acoustic absorbers and to test them (including building regulations compliance checks).
- An FP7 *Collaborative Project*, where our Engineering team is working as partners in a joint project with 17 other UK universities, NPIA/ACPO and the Metropolitan Police High Tech Crime Unit. The project title is "ECENTRE: Cybercrime Centre of Excellence Network for Training Research and Education". The lead institution is Canterbury Christchurch University and the project runs until 2014.
- An FP6 *Coordination Action*: *Control of Renewable Integrated Systems Targeting Advanced Landmarks (CRISTAL)* (2008-09). Our team initiated the project and coordinated the consortium of 11 institutions, including 3 companies (Sustainable Technology Solutions, Environmental Park Turin, Cummins Generator Technologies). We led the analysis and report on European research on renewable energy systems integration and grid connection, thus contributing to increased awareness and understanding of renewable energy solutions by relevant society groups.
- The research developed in collaboration with impact absorption specialists Cellbond Composite Ltd has resulted in the development of the *Offset Deformable Barrier (ODB).* This is now used by Euro NCAP and most leading car manufacturers worldwide for testing the frontal offset impact. Our research produced the methodology to create the advanced Finite Element barrier model, the certification through experimental test data and it further led to the development of a pedestrian friendly car bonnet. The Cellbond car bonnet design makes use of an aluminium mechanical energy absorber and it is expected to cut the number of fatalities and serious injuries

caused by pedestrians being hit by a car. This was tested and verified in an EuroNCAP certified test house. Test results show that the novel design reduces the 'Head Impact Criteria' by 50-60%, hence the energy is absorbed in the collapsing structure. The car bonnet design is being assessed by leading motor manufacturers (commercial sensitivity prevents our naming them).

- Another area of our research led to the development of novel approaches to wash the air using a special atomizer/nozzle system designed by us and industrially exploited by Air Pollution Product Systems (APPS) Ltd in a range of applications aligned to the general efforts made for carbon footprint reduction. That solution won the Lord Stafford Innovation for Sustainability award.
- Collaboration with academics from Loughborough University (Dr Ramin Rahmoni and Professor Homer Rahnejat) has resulted in the development of a tribological simulation package. A joint book has recently been published and industrial exploitation is under development.
- Our engineering team has recently (2013) been successful in securing funding (368K Euros) under the FP7 programme for the project: 'A novel, autonomous and **REV**ersible **I**nflow control **VAL**ve for increased oil production and reservoir recovery rate (REVIVAL)'. In a consortium of seven members, led by Inflow Control, the project involves the development of an in-flow valve to be used in the production of crude oil. Specifically aims are to increase oil reservoir recovery rates and oil production.

Our collaborative research has in turn informed our own research activities and strategy. The FP7 *CRISTAL* project referred to above led to our own increased awareness of renewable energy sources for electricity generation, and we have had solar panels and a small wind turbine installed (initial plans for which were drawn up by one of the consortium partners). The terminals of these power sources are linked to our research lab, and have enabled further work to improve the integrated control of renewable energy sources. Similarly, following our successful KTPs with iDash Ltd., Anglia Ruskin decided to use iDash to supply cloud computing hardware to upgrade our IT network. We made use of this opportunity to expand our areas of electronics research to include cloud computing and System as a Service (SaaS). We were also able to develop three further KTP schemes with iDash.

Interdisciplinary research

Our medical engineering team was encouraged and supported to work in close collaboration with orthopaedic and vascular surgeons, nationally and internationally, to address common degenerative and debilitating problems such as osteoarthritis and venous ulcers. We have developed a new surgical fixation technique to improve the longevity of total hip replacements. This work was adopted by orthopaedic surgeons, through collaborations with the Mid-Essex Hospitals Trust, Broomfield Hospital and Heraeus Medical. The state-of-the-art research has led to a long-term collaboration with the Hospital for Special Surgery in New York (ranked #1 in Orthopaedics in the USA). Ground breaking joint research projects aim to delay the onset and progression of osteoarthritis, through more conservative surgery, to delay the need for joint replacements. This collaboration led to further osteoarthritis collaborative work with several very prestigious universities in the USA including Harvard, Boston and New York.

We collaborate with consultants at Tel Aviv Hospital to improve the rehabilitation treatment for Parkinson's Disease patients experiencing swallowing difficulties. We have also devised mechanical testing protocols and conducted laboratory tests to evaluate the REX cement plug, manufactured by Dutch company A-One Medical and also worked with orthopaedic surgeons from Rinjland Hospital (The Netherlands) to compare laboratory experimental results with those obtained during surgery. This led to the design of an improved implant insertion surgery tool.

i) *Awards and prestige.*
In 2009 H. Shirvani and his team won the Lord Staffordshire award (innovation for sustainability) for their research work leading to the design of a novel nozzle system. Dr. R. Mootanah is winner of a Translational Research Award in the Orthopaedics Innovation Awards (Dec. 2008, Medical Futures Innovations Award). She also won the Best Podium Presentation at the ARU Medical Engineering Conference (Cardiff: MediTech; 2011). In January and March 2013 our research on

knee osteoarthritis for the Orthopaedic Research Society (10,000 delegates) was awarded best knee abstract and chosen for display at the American Academy of Orthopaedic Surgeons Annual Meeting (25,000 delegates, Chicago). At the Mimics Innovations Award (April 2012) our work entitled "Development and Verification of a Computational Model of the Knee Joint for the Evaluation of Surgical Treatments for Osteoarthritis" was winner of the open category and the paper was one of two selected for publication in Computer Methods in Biomechanics and Biomedical Engineering. Dr. Sufian Yousef was awarded the Research Leadership Award by the International Conference on Reliability, Safety and Quality Engineering, Mumbai, January 2008. He was also awarded the Wireless Security Innovative Research Award by R. V. College of Engineering during the First International Conference on Future Computing in December 2012, India. M. Cirstea is Vice-President for Membership Activities - IEEE Industrial Electronics Society (IES), founder and past Chair of a technical committee of Electronic Systems-on-chip (IEEE IES) and of the UK and Republic of Ireland Chapter of the IES.

ii) *Research evaluators, external examiners.*

M. Cirstea was invited (2012) by the Italian National Agency as research outputs expert evaluator for the Evaluation of Universities and Research Institutes (ANVUR). He was also evaluator for EPSRC (2011), EU mobility grants programmes (2011) and TEMPUS (2008). S. Yousef is regular PhD external/internal examiner to UK (21 students) and Indian (11 students) universities. M. Cirstea was external examiner for 9 research degrees (3 UK, 3 France, 2 Romania, 1 Tunisia). H. Shirvani, R. Mootanah, A. Shirvani, S. Cirstea hasve also examined at doctoral level.

iii) Reviewing publications and editorial activities.

All engineering academics are involved in editing or reviewing journal and conference papers. For example: Raj Mootanah is Journal of Computer Science & Systems Biology Editorial board member; M. Cirstea was appreciated (certificates, 2012) by Editors-in-chief of IEEE Transactions on Industrial Electronics / Informatics for his on-going associate editor role.

iv) Industry support (Knowledge Transfer partnerships), EU projects and patents.

H. Shirvani, M. Cirstea, S. Yousef, R. Mootanah, T. Rowsell, A. Shirvani, H. Mebrahtu are involved with industries through KTPs/KEEPs. M. Cirstea coordinated an FP6 EU project on renewable energy (2007-09, 11 institutions, 3 of which industrial). S. Cirstea is involved in an industry led FP7 Echo-to-Echo project (acoustic modelling). Winckles is partner in an FP7 consortium on a Cybercrime project with Metropolitan Police. H. Shirvani and Mootanah have authored patents.

v) Conference organisation.

M. Cirstea has organised 2 major international conferences as general chairman: i) IEEE ISIE'08, Cambridge, 400+ participants; ii) IEEE OPTIM'12, 200+ participants. He is designated chair for another two: OPTIM'14 and INDIN'15. R. Mootanah organised and chaired: i) MediTech conference (01.06.2011), 65 participants; ii) a special osteoarthritis session for 2012 Computer Methods in Biomechanics & Biomedical Conference, Berlin, 400+ participants.

vi) Invited presentations / publications of prestige.

Since 2008, S. Yousef has been an invited Keynote Speaker to 6 international conferences. M. Cirstea has delivered 6 invited presentations related to *VHDL/FPGA Design* and a short training course on *Introduction to VHDL design methodology* to representatives of companies including Cambridge Silicon Radio, Plastic Logic, Bertrandt, Displaylink.

The unit's publication of most notable prestige is Monmasson, E., *Cirstea, M.N.*: "*FPGA Design Methodology for Industrial Control Systems – a Review*", IEEE Trans. on Ind. Electronics, vol.54, no.4, 2007, pp.1824-1842. DOI: 10.1109/TIE.2007.898281. It has achieved **4,232 downloads since January 2011** (IEEE Xplorer, 19 November 2013) and **423 citations** overall (Google Scholar, 19 November 2013)**.**