Institution: Manchester Metropolitan University

Unit of Assessment: B15 General Engineering

a. Overview

i. A major strength of the research carried out at MMU is the emphasis placed on multi-disciplinary and interdisciplinary activities. Nowhere is this more so than in the field of General Engineering research, which combines activities in areas including simulation and control, imaging and sensing, vehicle dynamics, computational flow dynamics, renewable energy, microbiology, bioengineering, sustainability, surface engineering, polymer engineering and materials engineering. The research is coordinated by the Dalton Research Institute (DRI) in the Faculty of Science and Engineering and involves staff in the School of Engineering, the School of Science and the Environment and the School of Healthcare Science.

Since 2008 we have recruited 52 new staff associated with the DRI, specifically targeted because their research skills meet the strategic remit of the DRI (see below). Consequently, our research structure combines well-established research groups with international reputations with embryonic groups formed, in part, from newly recruited staff. We have a number of 'specialist' groups, which are linked together through more 'generalist' cross-cutting themes. This approach inherently promotes inter-disciplinary research and provides a flexible, inclusive environment for all staff.

The main research activities in General Engineering take place within a number of research groups:

- *The Surface Engineering and Advanced Materials Group* (Kelly, West, Colligon, Vishnyakov, Potgeiter, Banks, Caffyn, Tosheva, Haider)
- *The Sensing and Imaging Group* (Bowring, Harmer, Wang)
- *The Computer Modelling and Control Group* (Alhussein, Keshmiri, Li, Adebisi, Bierbrauer)
- *The Bioengineering Group* (Cooper, Feng, Andrews, Payton, Flechsig)

b. Research strategy

i. Strategic Plans: The DRI aims to be a world class Research Institute that delivers high impact outputs which support the economic and social development at regional, national and international levels. Research carried out in the DRI will be submitted to 3 units of assessment; General Engineering, Computing Science and Informatics and Earth Systems and the Environment. Our broad strategy since RAE2008 has been to continue the development of the existing main research areas and to extend the cross-cutting interdisciplinary collaborative activities linking across all research activities within and beyond the DRI. In view of this, in order to support and complement the recognised strength in biomechanics in the Healthcare Science Research Institute (HSRI), we have also actively recruited new staff with expertise in the biomechanics/bioengineering field. This has led to the establishment of new, but dynamic research group in this area, who collaborate strongly with colleagues in the HSRI.

Approximately £6M of QR money from RAE2008 was reinvested back into activities supported by the DRI during the REF period. Of this total some £2.5M was invested to support and develop activities at the engineering/materials interface, such as infrastructure, core staffing and studentships. The research group leaders and UoA coordinators hold regular group meetings and report regularly to the DRI Director. The faculty strategic research plan sets a number of key performance indicators in research and innovation during the REF period and beyond. These include: increasing the number of PIs named on research proposals by 20%, increasing research grant income and expenditure by 100% and increasing the number of postgraduate research students by 30% over the period 2012 to 2017. The plan targets a move away from conventional research groups towards innovative translational research themes, which reflect the broader challenges being encountered at local, national and international levels. Within the DRI, such themes, which may include 'Sustainability', 'Security' and 'Healthcare' will be identified at a series of sandpits to which all research active staff will be invited. This approach will capitalise on, and enhance our inherent strengths in multi-disciplinary research already demonstrated within the Research Institute structure.

Engineering and Materials research is vitally important to regional (e.g. aerospace, food technology, chemicals) and national industries. Investment in this area is, therefore, a major

element of the University's research strategy. In the REF period, MMU invested funds of over £2.5M for studentships, Research Fellowships and Professorships in this area. The Sensing and Imaging Group and The Surface Engineering Group were major beneficiaries of the £0.5M invested in the establishment of new laboratory facilities in the John Dalton Tower. These facilities now include a purpose built PVD laboratory to house the deposition and analysis facilities of the Surface Engineering Group (Kelly) and a substantial laboratory space, with millimetre wave equipment, for the activities of the Sensing and Imaging Group (Bowring).

Just before the present REF period, the DRI received £1M in SRIF funding for new instrumentation, which supported the provision of a world-leading analytical electron microscope and micro-Raman facility. This unique facility was the centre-piece of a successful application to the EPSRC 'Access to nanoscale research equipment' call in December 2008 (with Kelly as PI). Under this call, UK academics can apply for free access to our state-of-the-art facility and receive expert interpretation of their samples. Since 2008, 41 academics from 20 UK institutes have benefited from this service. The provision of this award was an acknowledgement of MMU as a centre of excellence in this field and the continued support of this facility beyond the REF period is part of our future strategy to forge new research and enterprise collaborations with academics and industry.

ii. Position in relation to RAE2008: In RAE2008, Engineering and Materials research were submitted to separate UoAs. Within General Engineering, two groups were identified; the Rail Transport Unit and the Imaging and Sensing Group. The Materials submission was based around three groups: The Organic Polymer Materials Group, The Surface Coatings and Characterisation Group (which incorporated the Surface Engineering Group) and The Advanced Materials and Characterisation Group. Staff changes and changes in strategy have meant that this structure has evolved. For example, Surface Engineering and Advanced Materials have amalgamated and the Rail Transport Unit has moved to Huddersfield, however, research into rail-related issues still thrive within the Sensing and Imaging Group and the Surface Engineering Group in the areas of inspection and Non-Destructive Testing of rail and tramway networks, and piezoelectric sensors for track applications. Elsewhere, due to retirements and relocations, polymer-related research no longer takes place in a separate group, but once again, research in this area is still continuing through industrially sponsored PhD and KTP programmes operating through the Surface Engineering Group in the areas of atmospheric plasma processing for improved polymer film barrier properties, the development of conversion processes and the development of composite wind turbine blades. Our new structure of 3 well-established groups and one new group, linked together by cross-cutting themes is intended to:

- provide an inclusive environment for engineering and materials-related research;
- promote inter-group/theme collaborations to build on our strengths;
- provide an agile configuration to respond to staff changes and new calls for proposals;
- provide an open forum for discussions on all research-related issues;
- aid Heads of Divisions/School when recruiting new staff.

More specifically, the stated objectives for research in General Engineering and Materials in RAE2008 were to increase the number of research active staff, research income and research students. We also aimed to identify further industrial areas of application of our research and to improve collaboration with other academic institutions and within MMU. Individual collaborations take place with many universities, including: Newcastle, Liverpool, Oxford, QMUL, Southampton, Manchester, Leeds, UCLan, Lappeenranta, Aachen, Cleveland, TU Delft, and Trente. Within MMU, there are strong links between bioengineers and biomechanics, surface engineers and microbiologists and between experts in computer vision and AI within the School of Engineering and the School of Computing. Research Council, Government, EU and Industry funding has significantly increased over the period. The current aims for General Engineering Research within MMU are:

- To build on our excellent research work for industry and use this to set up new research opportunities (for example by combining expertise in non-destructive testing with computer vision applications for rail and tramway inspection and rail vehicle behaviour);

- To continue the recruitment of new research active academic staff to support the research activity in our key strength areas (since 2008 all appointments are required to be research active);
- To support the growth in staff holding externally funded research grants;
- To continue to increase the overall amount of funding from Research Councils, EU, Home Office (and other Government funding) and Industrial Research grants;
- To increase and strengthen the links with internationally leading Universities and to undertake further joint research projects.

Researchers submitted to General Engineering carry out research over a range of applied topics, for example a development that aims to improve the crashworthiness of vehicles, through to the condition monitoring of wind turbines. Novel developments in radar and image recognition (the subject of 19 patents by the University) are being applied to detect concealed weapons and threat items in a bid to improve our National Security. Commercialisation of much of the patented technology is well under way. Other industrially sponsored research includes the development of improved treatment and conversion processes for polymeric web. Going forward, a new area identified for collaborative research across this unit and beyond is hydrogen fuel cells, ranging from the reforming of fuel derived from waste products, through electrolyte materials research to the use of smart grid technologies for integration into existing infrastructure. MMU's lead role in the Greater Manchester Hydrogen Partnership will provide excellent opportunities for identifying partners and seeking external funding.

Great importance is attached to the link between research and teaching with undergraduate and postgraduate students having the opportunity to carry out projects linked to the related research work, sometimes at the premises of the industrial partners. Indeed, each of our research groups will be contributing units to a new taught Masters course in Mechanical Engineering, due to be launched in September 2013.

c. People, including:

i. Staffing strategy and staff development

General Engineering research active staff in the School of Engineering and the School of Science and the Environment are supported through the allocation of reduced teaching loads. Leaders of research groups, for example, typically have a 50% teaching load. In all new appointments the research experience of applicants and their ability to contribute to one of the established research groups is a major consideration, so helping to build critical mass. The recent HERA framework has resulted in an improved career structure for researchers to progress from Research Associate through to Research Professor. Early career researchers and contract research staff are mentored by more established researchers who also join them in the teams supervising postgraduate students. All support processes and structures for research comply with the principles of the 'Concordat for the Career Development of Researchers' and MMU has been awarded the EU HR Excellence in Research Award in recognition of the quality of these processes. The success of our approach towards ECRs is evidenced by the inclusion of 9 in this unit (42%). The University is fully committed to Continuing Professional Development, and research staff are strongly encouraged to participate alongside permanent employees in the Staff Development Programme. The University's commitment to staff was also recently evidenced by our gaining an "Investors in People "Gold" Award. MMU is the largest of only five Universities to receive such an award, which places us in the top 1.5% of organizations in the country.

The School Research Committees hold regular meetings to review progress and to prioritise and plan activities and to allocate funding. These meetings are attended by the Research Coordinator, the Heads of School and the leaders of each of the research groups. The Research Degrees Coordinator and the Postgraduate Courses Coordinator also attend the centre meetings so that the links between the research activities of the centre and the postgraduate teaching activities of the Schools are ensured.

All new staff undertake an induction programme which, amongst other things, gives guidance on the research procedures in the DRI and the Faculty. Attention is drawn to the rolling programme of competitions aimed at providing seed corn funding for research and enterprise activities, which is administered at Faculty level. This includes an annual studentship competition for, typically, ten

studentships per year, which seeks to establish new collaborative multi-disciplinary partnerships between experienced researchers and new staff. This not only provides a mentoring opportunity for new staff, but since the applications are judged against our strategic goals, also ensures that our successful research areas are further strengthened. Other competitions include the grant accelerator scheme, which provides up to £5k for new staff to conduct preliminary work, which will lead to a full grant proposal, and the Knowledge Exchange and Innovation Fund, which provides awards of £5k to £50k for proof of concept studies that has often led to future income generation schemes. Other important elements of the staff induction programme include training in PhD supervision, chairing examination panels, health and safety and implementing our diversity and equality policies.

An annual programme of research seminars is well attended by active researchers and often includes presentations from external experts (usually from our collaborators) which are alternated with presentations by new staff and research students. Recent speakers and visitors have included, for example, the Home Office Chief Scientist. These scientific exchanges help to maintain the quality and vitality of the research culture.

The University's commitment to equal opportunities is set out in MMU's Equality and Diversity Policy, Vision for Equality and Diversity and Single Equality Scheme (SES). The implementation of these policies is supported in the Single Equality Scheme Action Plan including extensive staff development activities, and has informed other strategies such as the Human Resources Strategy. These policies, along with the Equality Act 2010, guide and inform our approach to supporting the research environment within MMU. Our approach to Equality and Diversity in research is underpinned by principles including transparency, consistency, accountability and inclusivity.

The University provides a range of courses in support of its Equality and Diversity Policy which are mandatory for staff, including designated members of staff appointed to perform functions in relation to Research Management. These include courses entitled:

• "Equal Opportunities and Diversity Essentials" (mandatory for all staff);
• "Managing Diversity e-learning" (mandatory for all managers and supervisors);
• "Disability Equality Action Training for Managers" (mandatory for all managers and supervisors);
• "Disability Equality Action Training for staff" (mandatory for all staff)

Participation in these courses is reviewed through the Professional Development and Review (PDR) Scheme. The University is also providing staff awareness sessions on the REF 2014 Code of Practice. On the theme of equality, MMU also recently received the Athena Swan Bronze award. In line with this, the gender balance in the General Engineering field is strong, with both Division Heads (Electrical and Mechanical) being female, as are 9 out of 28 new staff recruited since 2008 (4 female staff are returned in this unit).

In all of our work, we take public engagement very seriously and since 2008 MMU has been a partner in the Manchester Beacon for Public Engagement project (funded by RCUK, HEFCE, Wellcome Trust). Our approach complies with RCUK's Concordat for Engaging the Public in Research and we are a signatory to the Manifesto for Public Engagement.

ii. Research students

All research active staff supervise research students, which currently number 46. Completions have also built up strongly over the period to the present figure of 50.

The Faculty Research Degrees Committee (FRDC) and Faculty Graduate School are jointly responsible for QA monitoring and running appropriate supporting programmes for the training of supervisory staff and postgraduates. Research students join the Faculty Graduate School, which provides an induction process and a skills training programme (e.g. research methods, health and safety, experimental design, ethics, business skills and plagiarism). All postgraduate students are encouraged to publish their work in journal papers and present at external research conferences. In addition to this, regular faculty wide events enable students to present their findings in poster and oral format at an early stage and in a broad supportive atmosphere. Progress is monitored via a Personal Development Portfolio and annual assessment meetings with an independent mentor. The MMU Postgraduate Passport is geared towards students who are close to the end of their research programme, and is geared towards employability.

Graduate School social events are always popular and its committee allows research students to influence decisions on all aspects of research support. Quality control for the overall research degrees process is provided by the Faculty Research Degrees Sub Committee.

d. Income, infrastructure and facilities

The multidisciplinary nature of the staff making up the centre has resulted in a lively team of researchers whose work has achieved international recognition in several areas. Key achievements over the last 6 years are:

- Over 300 publications in international journals or at international conferences;
- 19 patents applied for;
- Staff invited to give plenary or keynote presentations at over 40 conferences;
- Total external research expenditure of £4.5M;
- 50 PhD completions;
- Membership of the Research Centre 'Rail Research UK';
- A substantial number of EPSRC and EU Framework 7 grants;
- A recognised Centre of Excellence for research into key aspects of Homeland Security (the Sensing and Imaging Group).

Commercialisation of research innovations has resulted from many of our projects. For example the Sensing and Imaging Group are developing novel techniques for the remote identification of concealed contraband such as drugs, explosives and concealed weapons via a rolling program of funding from the Home Office, the Metropolitan Police and the Centre for the Protection of National Infrastructure (CPNI). As previously indicated, this Intellectual Property (IP) is underpinned by 19 patents that protect their work. A competition is underway between manufacturers to exploit this IP, with a commercialisation agreement now signed with one of them (Anglo Scientific, October 2013). Work by the Computer Modelling and Control Group integrated the various tools used to analyse railway vehicle interaction with infrastructure and resulted in a Decision Support Tool which is now being used by the railway industry. Technology for the Computer Visual inspection of rails and tramways developed during an EU framework 7 programme (PMnIDEA) is being exploited by a major rail manufacturing company, Alstom, on their trams and trains. Work by the Surface Engineering Group into the development of durable anti-mist coatings for ophthalmic lenses has led to an IP agreement with a North West company to commercially exploit these products.

There are currently 6 Knowledge Transfer Partnership programmes running within the Unit, involving research active staff. As an example, Prof Bowring is the PI of a KTP grant aimed at developing 4G remote sensors for the Rail Industry (with Unipart Rail Ltd), Prof Kelly is the PI on a project to develop conversion processes for aluminium oxide coated polymer web for food packaging (with Bobst Manchester Ltd.).

Since the last RAE we have significantly strengthened our research infrastructure. In particular, the School of Engineering has significantly benefited from a £50 million re-development of the Faculty of Science and Engineering laboratories, and now has a significant new laboratory and workshop block. This re-development has enhanced the infrastructure base, provided modern, state-of-the-art laboratory space, and dedicated space for research and enterprise activities has been created in the School of Engineering. A new round of capital bid funding has been allocated to the School and has been used to provide new surface characterisation systems, vehicle dynamics instrumentation, and microwave and millimetre wave measurement instrumentation.

All staff have 24/7 access to the library facilities, including extensive databases and online collections and training in their use is provided by library staff.

The objectives set in 2008 have been achieved and a strong platform for future growth has been established. Engineering and Materials research at MMU is vibrant, with strong interdisciplinary relationships running through the main groups. Good links have been forged with regional industry in the form of substantial third stream activities and support for research programmes. The essential criteria are, therefore, in place to make further progress in this area over the next REF period and beyond.

e. Collaboration and contribution to the discipline or research base

Collaboration with other academics and with colleagues in industry is encouraged and supported and where funding is needed to support travel, a budget of £2k per year is automatically available to all research active staff. Dr Li chairs our International Committee, which oversees and directs staff visits to many Asian and Middle Eastern countries with a view to establishing new collaborative relationships for research and enterprise projects and for the exchange of PhD students.

Research seminars involving internal and external international and national speakers are held regularly, as are topical Research Colloquia, at which oral and poster papers are contributed by post graduate, post-doctoral and research staff. Several international agenda setting conferences have been held at, or organised by MMU. These include Reactive Sputter Deposition, RSD2009 and The Photocatalytic and Superhydrophilic Surfaces Workshop, PSS2011 (organised by Kelly and West), due to take place again in Dec 2013, and The Nanotech Instrumentation 2011 Users Conference (organised by Vishynakov and Colligon).

A significant set of collaborations is the active research links and ongoing collaborations between the group of Prof Bowring and: Prof Lacey, Chief Scientist at the Home Office Centre for Applied Science and Technology (CAST); with the Metropolitan Police Service (via Deputy Assistant Commissioner Martin Hewitt); with the CPNI (part of MI5); and with DSTL. A short description of the major research groups now follows:

The Sensing and Imaging Group headed by Prof. Nicholas Bowring, has a sustained track record of securing grants in Engineering and Physical Sciences. The group has expertise in laser, microwave and millimetre waves which has led to links with local firms in the medical laser arena, running a number of Knowledge Transfer Partnerships During this REF period, the group led an EPSRC funded multi-centre consortium, developing sensors for concealed weapons such as guns and knives (£540K, EP/D079195/1 and others). This grant led to many substantial follow on funds (~£2M) from the Metropolitan Police Service, the Home Office, MI5 and MOD to further develop these technologies, which are seen as nationally important. MMU and the MPS have now forming a joint venture to commercialise the results of this research, which has resulted in the filing of 19 patents (5 granted to date). The group has links and collaborations with many major companies such as QINETIQ, SELEX, ANGLO SCIENTIFIC and is working with these companies using the licensing of IP developed during the EPSRC collaborative research and beyond. The group formed part of an EU Framework 7 research project, developing rail inspection technologies using computer vision (PMnIDEA), with the aim of making the detection of potentially serious faults more reliable, before they become catastrophic. This too has led to a deployable prototype computer vision rail inspection system now being trialled round Europe and being commercialised by Alstom. The group has had its computer vision and inspection expertise significantly enhanced by the recruitment of Wang (ECR). During this REF period, Dr Stuart Harmer and recently, Dr Neil Salmon have joined the group as senior academics (Readers). Dr Neil Salmon is internationally renowned as a leading expert in millimetre wave imaging for security screening and was previously a prestigious QINIETIQ Fellow. Dr Salmon has come from a non-publishing environment due to the sensitivity of his work and, therefore, his outputs are not listed in our return. However, these appointments signal the strategic direction this research group wishes to take.

The Computer Modelling and Control Group. General Engineering has a very active Computer Modelling and Control Group, led by Dr Albarbar, working in a range of electrical or mechanical engineering fields such as Condition Monitoring using novel algorithms (Adebisi - ECR) and Computational Fluid Dynamics (Keshmiri - ECR). This group has has a substantial track record working in the area of condition monitoring within the Oil/Power industry, particularly electromechanical plant modeling, diagnostics and performance evaluation. The group has a substantial number of active industrially funded research projects including; plant condition monitoring using intelligent and wireless Instrumentation, sensing based on MEMS technologies, structure health evaluation using ultrasonic measurements, wind turbine vibration monitoring and hybrid power systems power management using Artificial Intelligence. The group, particularly Dr Li, is also active in the modeling of railway vehicle dynamics, active suspensions, fault tolerant control, sensing and state estimations. The modeling group has recently been boosted by Dr Keshmiri's arrival from the University of Manchester. His primary research area is CFD where he works in

close collaboration with EdF and British Energy on several projects mainly related to nuclear reactors and renewable energy sources. His research currently focuses on the CFD modelling of environmental flows and biomedical applications.

Bioengineering. Within General Engineering, across two campuses, there is an active and coherent research grouping of ECR's led by Cooper and including Andrews and Feng, in Biomechanical Modelling, Tissue Engineering and Medical Device development. Modelling work includes understanding wave propagation in blood vessels, calculating electric field potential in tissue for nerve/muscle activation, and upper/lower limb biomechanics by methods such as computational fluid dynamic modelling. Assistive medical devices developed through this group's research include next-generation healthcare technology development using rehabilitation robotics to improve motor control in children with cerebral palsy, and using functional electrical stimulation devices to improve gait in post-stroke patients. Tissue engineering using electrospinning methods has also been used to create scaffolds to grow tissue with specific mechanical properties have been used in vascular applications. This group has recently been strengthened by the appointment of experienced researcher Dr Gerd-Uwe Flechsig (formerly at the University of Rostock), with expertise in electrochemical biosensors. Dr Flechsig collaborates with the universities of San Diego, Oxford, Geneva and Brno. He is a Lead Guest Editor for the Journal of Analytical Methods in Chemistry and an Editorial Board Member for the International Journal of Electrochemistry.

Current work is growing all these areas of expertise and expanding to tackle problems in diabetes, strengthening links with the School of Healthcare Science and local hospitals. Internal funding has formed and strengthened the research group and the provision of laboratory space for tissue engineering and rehabilitation robotics will enable this group to grow and attract external funding. A more longstanding collaboration that contributes well to an impact case study is demonstrated by the work of Dr Carl Payton, who has worked with experts in the School of Engineering to use computational fluid dynamics for performance optimisation in swimming and the measurement of anaerobic power and drag in elite swimmers.

The Surface Engineering and Advanced Materials Group is led by Professor's Peter Kelly and John Colligon, working with Dr Vladimir Vishnyakov, Dr Glen West, Dr Craig Banks, Prof Herman Potgeiter, Dr Andrew Caffyn, Dr Lubomira Tosheva and Dr Julfikar Haider (ECR). Kelly and Colligon are leading UK academic exponents of magnetron sputtering and ion beam sputtering, respectively. Colligon has served as Chair and then past-Chair of the International Union for Vacuum Science, Technique and Applications (IUVSTA) Thin Film Division in the period 2007-2013 and has chaired 3 IUVSTA Workshops. He has presented 7 Invited papers and one plenary lecture during the REF period. He continues as Special Issues Editor of the Journal "Vacuum". He served on the Council of the Institute of Physics from 2007 – 2010 and as Chair and Secretary of the Vacuum Group (2010 to present). He is Founder and Series Chair of the European Vacuum Conference, which held its 11th meeting in 2012 and he is on the Programme Committee of the biannual Ion-Surface Interactions Conference in Zvenigorod, Moscow. He collaborated with Sheel at the University of Salford on EPSRC grant EP/G033471/1 (£330k) on Max alloys. Kelly is a member of the EPSRC College, a member of the advisory committees of the PSE and SVC conference series and a session chair at the ICMCTF conference series. He is the UK representative on the EU COST action MP0804 'Highly Ionised Pulsed Plasmas' and leads one of the workgroups in this action. He is on the British Standards Committee for Advanced Technical Ceramics and a member of the Greater Manchester Hydrogen Partnership and was recently appointed to the Science Board of the Hydrogen and Fuel Cells SUPERGEN Hub. He has made 1 plenary (PSE2008) and 7 invited presentations at international conferences in the REF period. The research of Kelly focuses particularly on pulsed magnetron sputtering processes and he has collaborated with Bradley from the University of Liverpool in this area on EPSRC grants EP/F003951/1 (£221k - also with Assender at Oxford University), EP/E003133/1 (£417k – also with Braithwaite at the Open University) and EP/K017306/1(£352k), all of which have industrial collaboration (including DuPont Teijin films, Toppan Printing Co., Gencoa, Teer Coatings Ltd., Innovia Films Ltd and Kentech Instruments). More recently, Kelly and Verran (Professor of Microbiology at MMU) have undertaken interdisciplinary studies of TiN/Ag antimicrobial surfaces for implants (EP/F014325/1; £105k) and TiO_2 photocatalytic surfaces for beverage process surfaces (Matera Plus; £80k, also with Miba Coatings and VTT).

Vishnyakov has created a world unique combination of analytical tools on a single FEG SEM and now manages this analytical service to the UK academia under EPSRC grant EP/F056117/1 (£220k – with Kelly as PI). In the REF period 41 academics and students from 20 institutes have benefited from this scheme, which has also resulted in 15 joint publications to date. He has delivered numerous plenary and invited presentations at international conferences and is a member of Institute of Physics Council. West also works closely with Kelly and is a member of the Scientific Committee of the European Materials Research Society Conference 2013 in Strasbourg, and is a committee member for the Ion and Plasma Surface Interactions group of the Institute Of Physics. Haider (ECR) recently joined the Surface Engineering Group. His interests lie in the application of lean manufacturing and six sigma techniques to improve quality and manufacturing performance of coated cutting tools and he collaborates in this area with Northumbria University, Goodlife Foods Ltd and SNA Europe UK.

Banks works closely with Kelly in the area of graphene engineering and sensor development. Banks also actively collaborates in the electrochemistry field with Professor Xiaobo Ji, Central South University, PR China, Dr Biljana Sljukic, Technical University of Lisboa, Portugal, Professor Jesus Iniesta, University of Alicante, Spain, Professor Jaanus Kruusma, University of Tartu, Estonia, Professor Orlando Fatibello-Filho, Universidade Federal de São Carlos, Brazil, and Dr Bill Riehl, SCNTE, Fairborn, Ohio. He is a member of "Electrochemical Technology Group Committee – Science of the Chemical Industry (SCI)", an Editorial Board Member of Analytical Methods (RSC) and Honorary Professor at Xiangtan University.

Surface corrosion expert, Prof. Herman Potgieter is an editorial board member of Corrosion Engineering, Science and Technology (CEST), the Journal of Hazardous Materials, the Journal of Radioanalytical and Nuclear Chemistry (JRANC) and the South African Institute of Mining and Metallurgy Journal (JSAIMM). Prof. Potgieter delivered the 35th RSC Dalton lecture in Oct 2009. He is a visiting professor at the School for Chemical and Metallurgical Engineering at the University of the Witwatersrand, Johannesburg in South Africa and the Department of Chemistry at the University of Antwerp in Belgium. Caffyn's work on catalysts for hydrogen production meets the scope of this unit in the area of renewable energy/energy conversion. He has international collaborations in the catalysis field with Bercaw and Labinger at Caltech and Gow and Carmichael at Ecole Polytechnique in France. Dr Lubomira Tosheva, who specialises in the production and characterisation of zeolite materials has successfully collaborated with other departments within MMU (Healthcare Sciences) on interdisciplinary projects in the areas of environmental and sustainability engineering. External collaborations have included Hamburg University, Caen University and University of Upper Alsace. Dr Tosheva (ECR) has written an invited chapter in Ordered Porous Materials (Elsevier, 2009) and has given an invited talk at the 2nd workshop on zeolites in Caen (May, 2013). She has been invited for a 4-weeks' visit to Sofia University in the frames of the FP7 Project Beyond Everest (April 2014).