Institution: University of Brighton

Unit of Assessment: B12 Aeronautical, Mechanical, Chemical and Manufacturing Engineering

a. Overview

Since 2008 Automotive Engineering at the University of Brighton has strengthened and enhanced its position as a vibrant research area combining robust science with applied innovation. We have sustained our track-record in transforming the design of next-generation energy-efficient power systems for the passenger and industrial vehicle market. Additionally, we are now engaged in world-leading research into the engineering of military vehicles to be deployed in 'theatres' of war/peace. Our laboratory facilities, considered to be the foremost in Europe, have also been expanded to include new digital test-beds that are unique in the world. The research is currently organised through two Research Centres:

- *The Centre of Automotive Engineering (CAE):* Building on a 20-year partnership with Ricardo UK Ltd – through the university's Sir Harry Ricardo Laboratories (SHRL) – this team leads work on novel low carbon internal combustion systems having direct environmental impact through greater fuel efficiency and CO_2 reduction.
- *The Vetronics Research Centre (VRC):* Building on a 10-year partnership with the UK Ministry of Defence (MoD), this team leads work on military vehicle electronics (vetronics) systems engineering so they combat more effectively life-threatening situations as well as reduce the burden of costs involved in developing their integrated digital sub-systems.

Between 2008 and 2014 our growing reputation for world-leading research has been supported by: a +260% increase in research income from £2.3m to £6m (growing from £499k to £715k per FTE); a doubling of research active staff, and; the generation of multi-million pound contracts for our industrial sponsors and partners who take our ideas to market.

b. Research Strategy

Since RAE2001 we have worked in strong partnerships with industry to develop the University of Brighton as a leading centre for research into energy-efficient power-systems for the passenger and industrial vehicle market. Our performance in RAE2008 [70% at 4*/3*] was an important step towards achieving this ambition. Since 2008 we have continued to strengthen this work and have expanded our portfolio to include research into the engineering of human-centred environments for military vehicles. During the census period some of our firsts have included:

- development of next-generation car engines that have economy benefits of 40% over traditional naturally aspirated models and 15% against reported best-in-class technology
- the adoption by major manufacturers of heavy-duty engine research that yields a 50% reduction in emissions without sacrificing fuel economy
- development of the world's first Vetronics Standards for military vehicles and for Emergency Services Criteria as the only academic contributor
- the creation of the only approved test facility in the world for certification of MilCAN Standard devices, and which supports the £4bn UK MoD FRES Scout and £3bn Warrior upgrade procurement programmes

Since 2008 our progress has resulted in significant advances both to the infrastructure supporting our research and in our research performance. In 2008 we identified four areas of strategic priority (partnerships, facilities, appointments and income), against which we have achieved the following:

Partnerships: Having identified our collaborations with industry as a strategic priority we established, in the census period, substantial new partnerships with, for example, Petronas (effect of bio-fuels upon fuel consumption and CO_2 emissions), BP Global Fuels (fundamental processes central to fuel atomisation), Jaguar, Landrover, Denso (2/4 switching engine) and QinetiQ (prime contractor for military vehicle systems integration). We have also secured joint funded research studentships (BP Marine) and CASE (BP and Delphi) as well as new collaborative projects resulting in KTPs (eg Proper Energy Ltd and Ricardo).

Facilities: Over the census period we have invested an additional £1.8m in equipment to provide new capabilities in optical and data acquisition in test engines (with Ricardo) and have created a new dedicated laboratory to host unique test bed facilities for certification of military electronic standards and for the simulation and modelling of networked electronics (used also by the MoD Defence Science and Technology Laboratory (DSTL) and QinetiQ).

Appointments: A strategic approach to appointments was taken to ensure that a demographic balance was maintained between researcher career stages and new expertise secured. The appointment of STIPIDIS to a Professorship brought high-level expertise in vehicle electronics and systems integration along with a research team of 11 early-career and established researchers.

Income: Our priority over the census period was to balance the research income gained from government and industry and, overall, to see an increase of 20%. The unit has continually surpassed its annual income targets with the total expenditure to date being almost equally balanced between government schemes (RCUK, EU, UKGov) and industry investment. In RAE2008, total expenditure was £2.3m, whereas in REF2014 it is £6m, growing from £499k/FTE to £715k/FTE.

Supporting management structure: The university manages its research through three disciplinary areas: *Life and Physical Sciences; Social Sciences; and Arts and Humanities.* Each area is led by a Director for Research and Development (DRD), who works with the School Research Management Committee to monitor progress against university-agreed Key Performance Indicators (KPIs) as well as delivery of an integrated policy for research staff development and implementation of the Research Concordat Action Plan. The two Automotive Engineering Centres are guided individually by steering committees for the CAE (representatives from the University and Ricardo) and VRC (representatives from the University, UK MoD and industry) that meet quarterly and define and monitor all aspects of the research portfolio including budgets, horizon scanning and future investment plans (REF3a).

Future research strategy: Building on our achievements post-2008, and the strength of our industrial partnerships that have developed over the past decade, we will continue to strengthen our existing research base whilst being alert to opportunities for new, related areas for investment. Our ambition is for the CAE and VRC to continue to dominate two highly-specialised research markets that have high-potential academic, economic and societal gain. In the short (3–5 years) and medium (5–10 years) timeframe, Unit of Assessment B12 will:

- Focus on innovative topics where the CAE and VRC already have an established reputation and position: (i) reduction of core emissions through development of diesel engine technology with cryogenic sprays, and the atomisation and evaporation of liquid fuels to enable design of efficient and clean combustion systems; (ii) translate knowledge on safety and security in the vetronics industry into unmanned and airborne systems (3–5 years)
- Exploit expertise in both the CAE and VRC through joint research in efficient engine technology with automated electronics control as directed by Ricardo UK (5–10 years)
- Deliver a framework to nurture further close collaboration with industry and government, creating schemes such as sponsored secondments, knowledge transfer and dual-training. This close collaboration aims to have a focus on managing and exploiting impact (3–10 years)
- Identify research capability gaps and accordingly increase integration with other academic disciplines such as Computing (embedded computing with VRC) and Mathematics (computational modelling with CAE) to further interdisciplinary research (5–10 years)
- Increase research profile (staff, outputs, income) by 30% and address confidential publication challenges through work with the MoD (3–5 years)
- Develop the leaders of tomorrow through staff development and targeted investment in our early-career researchers. This includes investment in University, Doctoral College and School-funded studentships (see Staffing strategy)
- Make significant investment in infrastructure to deliver the university's Research Concordat Action Plan for career development. Ensure that our processes for the allocation of research support and reward remain transparent and that the principles of Athena SWAN are embedded in engineering (see Staffing strategy)

c. People, including:

I. Staffing strategy and staff development

The staffing strategy aims to produce an environment of encouragement and freedom that promotes innovation on an established base of robust science. Both the CAE and VRC operate a flexible and informal structure that embodies an ethos of team working that enables a focus on project goals and allows all participants the opportunity to contribute. The team comprises three professors, two senior members of staff, four Early Career Researchers (ECRs), 14 research fellows/officers and 17 research students. The staffing strategy is owned and managed by the steering committees for the two Centres and prioritises six aims:

Retain and reward existing staff who are central to our core areas of research strength: All new appointments are selected strategically either to meet the local REF GPA requirements for established (STIPIDIS) and early-career researchers (CHARCHALAKIS, COREN, MORGAN), or recognition of 'rising-stars' and offering them opportunities in emerging areas of excellence (eg, MORGAN – cryogenic sprays). The professorial promotion criteria were revised in 2013 to provide an enhanced career framework, clear expectations and an extended remuneration scale. A new university Intellectual Property Policy introduced in 2013 provides a transparent reward scheme for undertaking consultancy work.

Recruit outstanding and talented researchers who bring fresh ideas and insights: Recruitment materials have been revised and redesigned by our central marketing team to ensure they attract the highest-quality applicants and give clear and transparent descriptions of the roles and supporting resources we offer – both intellectual, financial and in terms of the research environment. The university first used these materials in 60 PGR scholarships on offer from 2012. A recent appointment (ELTON – late 2013) was recruited through the new procedures. The acquisition of the VRC in 2011 brought specialised and security-cleared staff from a range of backgrounds including nine EU or overseas expert researchers.

Provide a research environment that stimulates innovation and minimises constraints: Staff are given exposure to new working practices through secondments (eg BEGG to Ricardo UK Ltd and HEIKAL to the University Technology Petronas, Malaysia), the inclusion of external experts (eg visiting faculty, Turo and Gun'ko; visiting professor from industry, Jackson, Group Technology Director, Ricardo Plc. The specialist research Centres facilitate working in small teams, with interchangeable skills that can adapt to urgent projects quickly and efficiently (eg confidential specialised study on hardening unmanned ground vehicles: within five months commissioned by the Defence Science and Technology Laboratory (DSTL) and delivered by the VRC in collaboration with the Defence Academy at Cranfield).

Ensure fairness in the allocation of support for research and career development: During the census period, the university research environment has been enriched by investment of £8.8m in research sabbaticals, doctoral studentships, early-career support schemes and innovation grants that are available for all academic and research staff (PT/FT, fixed-term/permanent). A new £10k Rising-Star Award is available for ECRs together with a ring-fenced ECR Conference Support Fund of up to £750 per year. A 0.2FTE Early-Career Ambassador was appointed in 2012 to facilitate staff development for postdoctoral research assistants and new academics, including an annual ECR Conference and the annual Future's Bright Conference (now in its 4th year). The Centres' leaders, HEIKAL and STIPIDIS, provide guidance in the form of ECR mentoring and annual personal research reviews for all staff to aid their career development. Examples of staff who have benefited from this tailored mentoring programme include: BEGG, who was appointed from research fellow to principal lecturer within four years, CRUA, who progressed from a mechanical engineering graduate to principal research fellow within 13 years, and Summers, who was recruited by ARM Ltd from a research fellow post; SAZHINA was awarded a four-month sabbatical in 2009 that resulted in work supporting a successful EPSRC grant application (EP/K020846/1).

Implement a proactive and effective local Concordat Plan: We have developed a Research Concordat Action Plan that is recognised by the European Commission through the award of an *EC European Human Resources Excellence in Research Award*. One broad set of indicators for

the impact of our Action Plan is provided by the 2013 Careers in Research Online Survey (CROS; 46% return rate from University of Brighton compared to 26% nationally), which shows:

- 91% of University of Brighton respondents say they are integrated into the research community (78% nationally)
- 96% of respondents are given the opportunity to present work at conferences (81% nationally)
- 57% of respondents say they are treated equally compared to other staff for promotion and progression (37% nationally)
- 64% of respondents engage with policy-makers and end-users (30% nationally)

Engage staff in a commitment to equality and diversity: The University gained the Athena SWAN bronze Award in April 2013. All staff must take part in an online training programme in equality and diversity, with 1,146 having completed the training since its inception in 2013. The 2013 Careers in Research Online Survey (CROS) showed 91% of respondents felt that the University of Brighton is committed to equality and diversity (compared to 86% nationally).

c. II. Research students

The university has made significant strategic changes to the environment for research students as part of developing the next generation of researchers. All PhD students are now based within the Brighton Doctoral College (BDC) that was established in 2011 under the leadership of a new Dean who is responsible for postgraduate research. A recent QAA report (March, 2013) noted: '*since its [BDC] establishment the trajectory of almost all success indicators has been upward*'. Two (1.5 FTE seconded senior academics) Directors of Postgraduate Studies oversee the application-to-graduation process for all PhD students in the Science and Engineering Doctoral Centre that has 158 PhD students. Because of the specialist nature of the VRC's work (eg confidentiality, security, and intellectual property) the DSTL supports the VRC by sponsoring security clearance of new staff/student recruits as well as the appropriate handling of restricted material.

The BDC has ownership and overview of the research learning environment and manages all applications and recruitment, monitors progress, and contributes to and organises university-wide training programmes. All new students receive full needs-analysis training to establish each student's skills profile, which is then mapped against the Vitae Researcher Development Framework (RDF). Formal training is provided via the university RDF within the BDC and all graduate students are required to evidence that they have engaged with this training to develop the competences set out in the RDF. Further developmental opportunities arise through participation in the BDC's annual science and engineering conference, which is student-led and organised (over 100 attendees in 2013). Up to £1,200 is available to all BDC students, whether RCUK-funded or not, from a new PG Conference Support Fund established in 2012 that encourages presentations at conferences and workshops.

All research students are initially registered for MPhil and have at least two supervisors and a Thesis Panel to monitor progress. All supervisors undergo dedicated training prior to joining the approved register and this training must be refreshed every five years. Research students receive a minimum of 90 hours (pro-rata for part-time students) of supervisors' time per year. Supervision is complemented by a series of progression points, following the established BDC procedures, ensuring that satisfactory progress is taking place, the supervisory team is fulfilling its responsibilities, and the project will be completed on time. The first progression point is research plan approval, normally occurring four months into the research degree. This is followed by a series of annual progression reviews, which are designed to ensure that the needs of the student and project are being met. Students are expected to submit an application for transfer to PhD and three completed draft chapters after 18 months of study to ensure that they have achieved the necessary level to continue to completion at level 8.

Of the 17 current students in Automotive Engineering, 88% are funded externally through industry/RCUK/EU/UK government (all nine VRC students are funded through MoD, two through the CAE, one through a university studentship and three through BP/Ricardo) and the remaining two are self-funded. Recruitment of PGRs is very much focused on complementing and enhancing existing expertise, ensuring that projects can be delivered. Multi-disciplinarity is also

supported through the appointment of supervisors from different subjects (eg Harris in Mathematics).

The CAE and VRC have an agreed working practice, supported by the BDC, where research themes are addressed by groups of researchers (normally three to four) promoting a team ethos of meeting deliverables; providing a challenging environment in which to develop knowledge of research practices and skills; ensuring students receive the highest level of support, exchanging the best of practices; and fostering cross-disciplinary interchange of ideas and where possible disseminating these to the wider community. The PGR students are supervised on a day-to-day basis by experienced research fellows and weekly by senior staff according to their research thesis plan. In addition to centrally-administered annual training and development, the two Centres utilise their industry partners and government links to further the student experience, skills, knowledge and understanding. For example, VRC students spent time at QinetiQ (Farnborough) as well as using the specialist facilities at the Armoured Training and Development Unit (ATDU) (Bovington) to identify potential research exploitation. Similarly, Ricardo hosts researchers from CAE on a weekly basis.

d. Income, infrastructure and facilities

Infrastructure and facilities: Over the past ten years, the CAE has developed its world-leading (as confirmed by panel feedback from RAE2008) Sir Harry Ricardo Laboratory (SHRL). The SHRL contains more than £6m of specialised test cells for both diesel and petrol internal combustion engines that are continually upgraded using contracts and hardware donations from industry, including principal partner Ricardo (UK) as well as Jaguar, Ford and other automobile industry leaders. Facilities include five fired-engine test cells and two optical engine test cells (~£2m), instrumentation and diagnostics with optical (~£1m) and data (~£0.8m) acquisition equipment. Exclusive access to test-engines and software at Ricardo is made available through partnership agreements.

The VRC occupies a dedicated 250m^2 laboratory that hosts specialised research facilities, including: a vehicle electronics verification and validation rig, Military Controller Area Network (MilCAN) certification test rigs; mobile technology demonstrator; safety critical and deterministic embedded networking test-beds with modelling, simulation, and development kits; and secure distributed network facility. The VRC has unprecedented access within their industrial collaborators laboratories (QinetiQ, Farnborough) and MoD facilities (DSTL Fort Halstead and Porton Down, and ATDU Bovington). For example, VRC members performed field tests on wireless technologies for wireless video Local Situation Awareness (LSA) at ATDU Bovington. During the same project test results were generated using a specialised Def Stan 00 82 Video Distribution test-bed at QinetiQ Farnborough.

Research funding portfolio and future plans: The two research Centres target specific funding streams. The CAE focuses on EPSRC and automotive manufacturers, whereas the VRC focuses on government departments and defence industry. Both Centres work closely with a suite of industrial partners – some of which directly fund the research whilst others make significant contributions-in-kind (REF3b). In the census period, income on more than 50 grants and industrial contracts was >£8m with expenditure of £6m. Six EPSRC, five EU, and one MoD grants/contracts were awarded during the census period, and significant new grants recently awarded include: i) £0.75m EPSRC (EP/K020528/1) led by CRUA in the CAE, and ii) £1m MoD contract led by STIPIDIS in the VRC (DSTLX-1000077466).

The CAE are leaders in using modelling and simulation methods to investigate and optimise complex combustion processes. Examples of competitive grants in this area include: ‘Combustion Tool and Techniques’ (Funder: Ricardo, collaborators Delphi, Petronas and BP; £517k), ‘Molecular dynamics simulation of complex molecules using quantum-chemical potentials: application to modelling fuel droplets’ (Funder: EPSRC, collaborators Ricardo, National Academy of Sciences of Ukraine, Tsinghua University of Beijing, and Moscow Power Engineering Institute of Russia; £335k) and ‘Cross-Channel Centre for low Carbon Combustion (C5)’, (Funder: EU/Interreg IVA, collaborators Ricardo, CORIA, INSA Rouen and University of Rouen; £405k).

The VRC are leaders in ‘Vehicle Electronics Architectures’ and specialise in research on novel concepts on Integrated Survivability (IS), Local Situation Awareness (LSA), Defence Aide Suites

(DAS), safety and security strategies, vehicle integrity with verification and validation methodologies of complex integrated electronic systems for standardisation (UK MoD ref. RT/COM/4/5008, European Defence Agency (EDA) ref. 2012/S 146-243061). The research supports UK Defence Standards 23 09 and 00 82, Vehicle Systems Integration (VSI) Standards and Guidelines, and EU and NATO standards. Collaborators include Selex Galileo, QinetiQ, General Dynamics, Thales, BAE Systems, Adelard, Defence Academy Cranfield, Fraunhofer Institute FKIE, and Rhienmentall Defence Electronics. The VRC, led by STIPIDIS, has received circa £2.5m of confidential contracts in the period since joining University of Brighton, 2011–13.

Significant new recently commissioned projects, which will be delivered in the next three years include: 'Investigation of non-spherical droplets in high-pressure fuel sprays' (Funder: EPSRC and BP, collaborators London City University, 2013–2016; £750k); 'Development of the full Lagrangian approach for the analysis of vortex ring-like structures in disperse media: application to gasoline engines' (Funder EPSRC, 2013–2016; £347k), exploitation of new concepts in IS and DAS forming new MoD partnerships in Active Protection systems (Funder: DSTL, 2013–2015, £997k), and academic collaborations 'Energy Efficiency and Environment: Cross Channel Cluster' (Funder: Interreg IVA, 2013–2015, £210k). With the group of newly appointed ECRs becoming more established, the UoA B12 is planning for a 30% increase in income in the next five years (see future research strategy in Section b). As part of the university's Strategic Plan, the specialist laboratories of the CAE and VRC, together with researcher accommodation, will be incorporated into the £27m refurbishment of the Cockcroft Building (2013–2015), thereby securing access to a thriving and modern academic, digital and learning environment.

Consultancies and professional services: Exploitation of research outcomes and delivery of expert advice to industry underpin all the research activities undertaken by staff in B12. Around 35% of all research income is derived through consultancy and project-specific work for industry. HEIKAL, BEGG and MORGAN are employed as consultants at Ricardo (UK) with HEIKAL also consulting for University Technology Petronas, Malaysia.

Research outcomes and techniques are shared with end-users through specialist training courses (eg the University of Brighton-organised MoD Generic Vehicle Architecture (GVA) training and further influencing wider standardisation (EU and NATO) CPD course that have been delivered to 96 attendees since 2011; STIPIDIS through Defence Equipment and Support (DE&S) at Abbey Wood provides scientific advisory to international co-operation and large procurement programmes – £4bn FRES Scout, £200k Foxhound, and £3bn Warrior upgrade).

Fifteen KTPs have been awarded to staff in the School, with 4 to staff submitted in B12 including Rivertrace Ltd with CRUA, and Kalimex Limited with Miche and HEIKAL (REF3a). Eleven consultancy contracts have been commissioned including through our ongoing partnership with Ricardo UK (HEIKAL) and expert advice given to the Norwegian MoD (STIPIDIS). Furthermore, our specialised test rigs offer the opportunity for industry to test independently their products. An example is the VRC MilCAN Certification facility being used by the MilCAN Technical Working Group members (eg General Dynamics FRES Scout vehicle).

e. Collaboration and contribution to the discipline or research base

Our staff promote national and international co-operation, with more than 40 academic institutions and 30 commercial companies from 20 different countries. Our work on military vehicles involves partnership with more than 14 national governments.

Staff have a distinguished track record of scholarly activities through selection and review panels (eg HEIKAL – B12 panel REF2014, SAZHIN – EPSRC Peer Review College, STIPIDIS – American Association for the Advancement of Science), keynotes and invited presentations (eg SAZHIN Keynote lecture at International Symposium on Advances in Computational Heat Transfer; CHARCHALAKIS on Generic Vehicle Architecture at Military Vehicles Conference 2013), journal peer reviews, as well as chairing and organising conferences (eg SAZHIN – member of scientific committee of the International Workshops on Hysteresis and Multi-Scale Asymptotics; CHARCHALAKIS – Military and Aerospace Electronics; STIPIDIS – member of scientific committee for Advanced Automotive Electronics).

All staff are involved in collaboration with other academic institutions, industry and in scholarly activities (eg publications, secondments, funding proposals, presentations in stakeholder

meetings and conferences) mostly with the support of the more experienced staff (eg BEGG, Miche and HEIKAL were runners-up in the Engineer National Award for Innovation for 2/4CAR TSB project). Staff activities include international visiting scholars following sabbatical or Erasmus schemes that enrich the pool of knowledge generated by research (eg Shiskova from the Russia Moscow Power Engineering Institute and Turo from the Czech Republic University of Defence). Our Engineering seminar series attracts leading researchers from the UK and abroad including Prof. A Osiptsov (Lomonsov Moscow State University) and Peter Fussey (Ricardo) as well as upcoming researchers such as Dr Michael Vynnicky (University of Limerick).

The research leaders have fellowships within their individual areas (HEIKAL IMechE, STIPIDIS IET, SAZHIN IOP), editorships (SAZHIN IJESMS, STIPIDIS NATO STANAGs) and strong collaboration through interdisciplinary joint research with many academic groups that include national (eg City, Loughborough, Manchester, Cranfield) and international institutes (eg National Academy of Sciences of Ukraine, Tsingua University of Beijing, FKIE, University of Rouan).

The influence and leadership in the subject area of Automotive Engineering goes beyond typical academic activities, for example, HEIKAL's two-year secondment, heading the Advanced Innovation and Technology Centre, University Technology Petronas (UTP), Malaysia. HEIKAL's role was to lead development of policy and strategy, IP and commercialisation, and assist with the transformation of UTP to gain Research University status. Another example is Jackson, our visiting Professor of Automotive Engineering and a Fellow of the Royal Academy of Engineering, who has influenced research vision and missions as Chair of the UK Low Carbon Vehicles Partnership, Deputy Chair of the UK Automotive Technology Council, Vice-Chairman of the European Road Transport Research Advisory Council (ERTRAC), and who is a member of European Council for Automotive Research (EUCAR), and EPSRC User Panel.

The combination of scholarly leadership and working within government partnerships presents the opportunity to influence national and international practice, standards and future strategic direction. For example, STIPIDIS received the Minister (DEST – Defence Equipment Support and Technology) Acquisition Award 2012 and is a member of the Home Office: Association of Chief of Police Officers (ACPO) Intelligent Transportation Systems (ITS), Single Box Architecture (SBA); and MoD related committees: MilCAN Working Group, Vehicle Systems Integration (VSI), Generic Vehicle Architecture (GVA) Technical Working Group working towards Land Open Systems Architectures. This work goes beyond simple membership, such as in October 2012 when a group of 14 countries (government and industry) through the Military Vehicle Association (MILVA) were brought together to form a NATO GVA standardisation group led by STIPIDIS as Chief Reviewer/Editor to offer a coherent approach on Military Vehicle Electronics procurement.