Unit of Assessment: UoA12 Engineering

1. Unit context and structure, research and impact strategy

Unit context and structure

The Department of Engineering and Design (EAD) at the University of Chichester (UoC) was conceived in 2014. Engineering was chosen because it matched with government funding strategy from the Coast to Capital Local Enterprise Partnership (LEP) and with HEFCE (now the OfS). As a result, it addresses the strategies of the LEP and the OfS. In 2018 the GBP35 million 'Tech Park' building was completed, and Department of EAD moved into the Tech Park with state-of-the-art laboratories and facilities. Engineering subjects are offered to help fill the skills gap in the West Sussex 'coastal strip,' which is a comparatively deprived area compared to other parts of West Sussex and is heavily reliant on seasonal tourism. In particular, the initiative is aimed at helping underrepresented groups to access engineering HE. The Tech Park and engineering at Chichester University, West Sussex's only university, are now able to provide local and regional businesses with high quality engineering graduates that will help to 'upskill' their work forces and facilitate a shift from low wage, seasonal tourism to higher value technology-related employment. The Department has a significant proportion, around 50%, of students who are enrolled on the Degree Apprenticeship programme and who work in local and regional businesses. This provides a route for direct knowledge transfer from university research to local industry, helping make surrounding businesses more profitable. Being a newly developed department, our long-term strategy is to build upon this pool of undergraduate students as a stepping stone to further develop postgraduate programs and research.

The Department of EAD is aligned to the Concordat to Support Research Integrity and operates a Researcher Code of Conduct. In effect, research currently undertaken at the Department of EAD is underpinned by the highest standards of rigour and integrity, including honesty, integrity, co-operation, accountability, training and skills, as well as safety.

The Department of EAD makes use of the institutional repository, ChiPrints, in order to showcase the excellent research output of the department, making it available to the public and to the research community worldwide in a searchable database.

The staff returned to this Unit consist of 8 full-time academics from the Department of EAD. In addition, Professor **Simeon Keates** joined the Vice-Chancellor's Group of the UoC in 2020 (as Deputy Vice-Chancellor with Responsibility for Research & Innovation) and is a strong advocate for the Unit. All academics are involved in research, with a diverse range of research interests, including materials science, renewable energy, fluid dynamics, high voltage materials, control, manufacturing and electromagnetics.

Research within the Department is undertaken across 3 multidisciplinary areas, which together cover the broad sweep of current and cutting-edge enquiry in engineering and design:

- **Mechanical Engineering** – microwave and millimetre-wave sensing (**Harmer**), medical physics/engineering (**Harmer**), materials science (**Bhabha**), manufacturing (**Taylor**), and engineering design (**Keates**).
- **Electronics and Electrical Engineering** – artificial intelligence (**Keates**), renewable energy technologies (**Wang**), biomass (**Chin**), nanotechnologies (**Alhabill**), and control engineering (**Edet**).
- **Product Design** – waterjet cutting and laser cutting technologies, and 3D printing technologies (**Cutler**).

As a department, we have taken advantage of our youth, and the fresh thinking it has made possible, to build an academic environment that is inherently research-focused from the bottom

up, from blueprints to buildings. Our structural agility, rapid expansion, community focus and world-class infrastructure, backed by substantial University investment (see Section 3), make our Unit a unique and forward-looking context for a wide variety of engineering research, at all levels.

Research and impact strategy

In 2018, building on our previous strategic plan, the UoC laid down an ambitious new strategic plan for the period of 2018-2025, with a new vision for garnering national and international recognition for excellence in teaching, research and innovation. Integral to this was the University's continuing acknowledgement of its special position as the only higher education institution (HEI) in West Sussex, which anchors our initiatives in economic, social and cultural terms. In this way, we tackle global challenges and perspectives through the prism of a unique and specific sense of 'place'.

These overarching strategic aims are evident within the Department of EAD in the following ways:

1. Since its inception, the Department of EAD's main strategy has been to recruit research-active academics and establish innovative research in the areas of renewable energy and sustainable development, and innovative sensing technologies. In particular, Prof. **Keates'** arrival at the UoC as a DVC with institutional responsibility for research indicates the University's ongoing commitment to Engineering research. **Keates'** extensive experience in previous managerial roles, as Dean of the School of Engineering and the Built Environment at Edinburgh Napier University and former Deputy Pro-Vice-Chancellor of the Faculty of Engineering and Science at the University of Greenwich, will help in implementing research strategy in the Department of EAD.
2. Each member of the Unit is encouraged to publish their research work in high quality research venues. As a result, to date, across the REF2021 assessment period, researchers at/affiliated with the Department of EAD have produced a total of 85 research outputs, including 36 journal articles, 3 books, 2 book chapters, and 4 patents. Most recently, **Keates'** collaborative paper on 'A 10:1 Bandwidth Cryogenic Quadruple-Ridged Flared Horn Design for Reflector Antennas in Radio Astronomy' won the Best Paper Award at the Advancing Technology for Humanity conference in Malaysia (2020).
3. The Department of EAD plays an important role in providing skilled graduates and research expertise and facilities to the region. It is well placed to develop multiple areas of research which will support local and regional business through knowledge transfer activities. For instance, in 2019 **Taylor** worked with a local company, SI Protec, to simulate the behaviour of a food-grade polymer (Zytel FG133F1) spring to replace the current steel spring in drinks cans, in order to reduce the weight of the overall product and reduce both manufacturing and transportation costs.
4. We have developed innovative research in emergent fields, including, notably, in the screening of footwear at microwave and millimetre-wave frequencies; non-destructive remote inspection of structures; insulation materials with high dielectric properties; and strategies to reduce carbon footprints via the smart management of renewable energy, in combination with electric transportation (see REF3). This rapidly expanding body of research has already afforded us national and international repute. For instance, 'Remote detection and measurement of objects' (US Patent App. 16/458,885), and 'Method and system for determining dielectric properties of an object' (US Patent 10,921,428).
5. We have undertaken extensive interdisciplinary and cross-disciplinary research, and ongoing research collaborations at both the national and international level, in the area of millimetre and micrometre wave detection, fuel cells, insulation energy management systems for integrating electric vehicles and low carbon technology. Our national collaborators include Newcastle University, University of Southampton, University of Cambridge, University of Kent, University of Strathclyde, Manchester Metropolitan University, Northumbria University, University of Bradford, Edinburgh Napier University, University of Greenwich. Collaborators at the international level include NIT Vellore, India, University of Chinese Academy of Sciences, University of Ourgla, Algeria,

Technical University of Denmark, National Technical University of Athens, National Astronomical Observatories (Chinese Academy of Sciences), University of Chinese Academy of Sciences, Ajmam University, Nanjing University of Information Science and Technology, Xi'an Jiaotong University, Wuhan University, and University of Mascareignes, Mauritius.

6. We are aiming to achieve sustained and strategic inward University investment, to which end we are developing outstanding laboratory facilities, with new and diverse equipment available to our research community.
7. From 2017, we set the target to increase the size and diversity of our academic team, bringing together established and up-and-coming early career researchers (ECRs). In this way, we have both fostered internal collegiality and interdisciplinary, whilst keeping faithful to our institution's core commitment to providing an excellent staff experience.
8. Our aim is to create a vibrant and distinctive research environment for PGR students, and make postgraduate research high quality, personalised, accessible and aspirational.
9. Finally, we have also taken measures to ensure that PGR students engage actively in research throughout their individual projects and dissertations. These include 'PhD Days' as well as internal and external invited talks.

Future research strategy

We will consolidate and further build upon the sharp upward trajectory of the Department of EAD, through both new academic appointments and improved cross-disciplinary excellence in research and innovation. Specifically, our future objectives are:

1. To establish distinctive research groups that embody the research expertise within the Department. The Department of EAD is planning to develop 2 research groups: one in renewable energy and sustainability, and the other in microwave and communication technologies. The aim of these research groups is to conduct practical research to help the local economy and companies.

   The renewable energy and sustainability (RES) research group will specifically concentrate on issues related to the electrification of the local/national transport, optimising the distribution of charging stations and maximising the use renewables in order to promote eco-economy and contribute to the decarbonisation targets set out in the Paris Accord. In addition, it aims to promote multidisciplinary research by integrating the expertise of our academics in the Department of EAD in material science, sensors and design to develop new efficient batteries and storage devices. We also plan to work concurrently with other departments within the University on research to promote eco-tourism.

   The microwave and communication technologies research group will undertake research into the development and adoption of 5G communications technology. It will also continue research and development into the field of remote detection and microwave/millimetre-wave sensing (see REF3).

2. To increase the number of high-profile staff leading the development of research in the recognised areas. The Department of EAD's short-term plan is to recruit further world-leading academics who will reinforce and contribute to the development of the aforementioned research groups. The long-term plan is to recruit academics to develop research in eco-economy in order to support the local economy. In particular, the objective is to conduct research in the area of city planning, cycle path development and optimisation, and waste management. The guiding force for this is to build upon our already close relationship with West Sussex County Council and Arun District Council over matters ranging from highways and planning, to student accommodation, education, place-making, regeneration and economic development.

3. To encourage national and international research collaboration, cross-disciplinary research among staff both within the Department and with other UoC departments and

institutes (e.g., on the psychology of visual disturbance). We have already undertaken research collaborations with several national and international institutions. In particular, our international research collaboration has led to our involvement in the organisation and sponsoring of the International Conference on Environment-Friendly Energies and Applications, Bulgaria, 2021. Keates was also the General Chair of the 15th International Conference on Manufacturing Research (September 2017, Greenwich, London).

We aim to develop our Bognor Regis campus into a centre of excellence and innovation in STEAM, taking advantage of regional funding to create a 'cultural hub' that benefits the reputation of the University, whilst generating regional growth.

4. To deliver training programmes on grant application writing and income generation. Funding bodies such as UKRI will be invited to provide training to staff.

5. To encourage staff to engage in income-generative activities. A dedicated experienced staff member in the Research Office will be appointed to disseminate bidding calls and support bid writing and submission.

6. To establish collaborations with industry partners to undertake collaborative research and development and facilitate the transfer of knowledge and technology. We already have well-established links with local industries through the degree apprenticeship route, such as with Honeywell and Rolls Royce. The aim is to capitalise on these partnerships to explore opportunities for collaborative research.

7. To increase the number of PGR students pursuing engineering research in West Sussex. The Department of EAD's plan to encourage and incentivise good honours BEng students from UoC to register as PhD students. This will be done by providing a number of PhD studentships. In addition, the Department of EAD plans to establish a match funding scheme with local companies to increase the number of PhD students. Additionally, the possibility of having joint PhD degree schemes is currently being explored with other universities under our national/international collaborations (e.g. Northumbria University, UK).

8. To provide and deliver new Master's degrees in Mechanical Engineering, and Electronic and Electrical Engineering, to develop students' potential for doctoral research. The Department is planning to develop new programmes in Engineering Management and Environmental Engineering, which include courses in low carbon technologies and waste management, by 2022. This is in line with our long-term strategic plan to develop research in eco-economy.

As such, the Department of EAD, as well as the UoC as a whole, is increasingly putting research at the heart of everything, acknowledging the value of academic enquiry in and of itself, and the mutually reinforcing nature of research and teaching. By investing as we have, in line with the broad strategy outlined above, we are building an innovative and future-proof environment that will continue to bear fruit for decades to come.

2. People

Staffing strategy

Since the establishment of the Department of EAD, 8 members of academic staff have been appointed to conduct teaching and research across the areas described above. In line with our Department's broad staffing strategy of fostering diverse and innovative talent, and thus developing a robust research culture, each of these 8 staff is research-active and holds a PhD degree. Careful consideration has also been taken to ensure equal opportunities and promote diversity and gender balance. The Department of EAD has a comparatively balanced gender

and diversity profile, with 37.5% of its academic staff being female and 62.5% being from the BAME community.

The recruitment of staff in the Department of EAD is carried out by taking into consideration our research strategy to develop research in renewable energy and microwave/millimetre wave technology. In addition, these staff are recruited to complement the expertise of each other. More precisely, the following staff were appointed in this REF cycle: 2017 (**Harmer, Taylor**), 2018 (**Vanessa, Alhabill, Bhabha**), 2019 (**Wang, Edet**).

The profile of each staff member is briefly summarised below:

As the Head of the Department of EAD, **Harmer** has overseen our research strategy and led the research development of advanced sensing technology based on microwaves and millimetre-waves. **Harmer** has substantial experience in electromagnetics, with work in the optical, microwave and millimetre wave bands. He has developed technology and intellectual properties (patents) through his research which have been fully commercialised. He is a co-founder of Plymouth Rock Technologies PLC., a publicly traded company operating out of the US. PRT develops security screening technologies, some of which have been developed based on **Harmer**'s research. Recently, **Harmer**'s research has diversified to include health-related areas.

The University's Deputy Vice Chancellor, **Keates**, has overall university-wide responsibility for research and innovation. He remains an active researcher, currently supervising 5 PhD students at a number of universities. His areas of specialism include user-centred design, inclusive design, robotics, machine-learning and human-machine interaction. He gained his PhD from Cambridge in Rehabilitation Engineering and has worked in both industry and academia, including a spell with the team that developed the IBM Watson system and a subsequent one designing airport systems for Air Canada.

Taylor (Principle Lecturer), with extensive expertise in early detection of component failure, oversees the development of teaching and research in Mechanical and Material Engineering. He has worked closely with industries and conducted numerous materials engineering projects. Recently, **Taylor** has specialised in working in litigation cases, mainly surrounding cycle component failures. With cycling being a highly competitive area for manufacturers, they are always working towards high performance products as a means of capturing specific markets, and this has led to numerous design and manufacturing issues, resulting in failures when designs are taken to extremes, or when there is a breakdown in quality control. Many failures have resulted in serious injuries and inevitable claims for compensation. **Taylor** has specialised as working as a specialist expert witness in the field of mechanical failure analysis.

Cutler (Senior Lecturer) leads our research in the area of water-jet cutting. Close collaboration links have been established through the development of this particular research area. She was the lead Glass and Ceramic Engineer at Meyer Tool Cincinnati USA, working on 3- and 5-axis water-jet machines, exploring their parameters for delicate materials across craft and design disciplines. In particular, she has written a book chapter providing specialist knowledge on glass cutting to a chapter on waterjet cutting in 2018.

Alhabill (Senior Lecturer) joined the Department along the route of Electronic and Electrical Engineering, to advance the research of dielectric material for high voltage insulation systems. **Alhabill** has carried out research in high voltage power engineering since 2014. His research demonstrates the enhancement of the electrical properties of the insulation material with the incorporation of nanoparticles, which leads to its application in the high-voltage direct current (HVDC) transmission cables in renewable energy transmission.

Bhabha (Senior Lecturer) jointed the Department to lead the research on the advancement of polymer composite material and its application in waste recycling. More specifically, his research expertise lies in material testing and material design tools for roto moulded parts using finite elements methods. He has developed innovative methods for blending and manufacture polymer

composite materials via dry blending, 2 roll milling, twin screw extrusion compounding and plastic moulding. In addition, **Bhabha** also has extensive experience on the assessments of chemical agents for polymeric composites using mechanical testing, scanning electron microscopy and energy dispersive x-ray.

Wang (Senior Lecturer) was appointed to lead research in power systems with an emphasis on the integration of renewable energy and electric vehicles. **Wang** has 10 years of experience implementing technically advanced research and economically feasible solutions to real-life projects on renewable energy, electric transportation and smart energy management. She worked closely with various wind turbine operators from 2010 to 2013 during her PhD and carried out original research into condition monitoring and fault prognosis methods on modern wind turbines, both onshore and offshore, based on their SCADA data. Since 2014, **Wang** has focused on the integration of electric vehicles, renewable energy sources, and energy storage in the smart grid, aiming to demonstrate its technical and economic feasibility, and to facilitate the transition to a low carbon and sustainable economy in European cities.

Edet (Lecturer) was specifically appointed to advance the control theory and its application in both Electrical and Mechanical Engineering, which would in turn promote interdisciplinary research. **Edet** specialises in a niche topic of research on the control of fractional order systems. In particular, he has proposed innovative designed methods for fractional order predictive PID controllers with applications to distillation processes.

Chin (Senior Lecturer) joined the Department of EAD to develop the research of renewable energy with a focus on biomass and solar energy. Her research interests lie in the area of ignition risk of biomass dust layers and solar chimneys. In particular, she has characterised biomass self-ignition characteristics during handling and storage. Additionally, she has evaluated the performance influence of solar chimney power plant variation of the canopy and tower height.

Each member of staff is encouraged to develop research in the area of their expertise, as well as to carry out interdisciplinary and collaborative research with academics both within the Department and with other UoC Departments and Institutes. As a result, the following has been achieved:

- 7 out of the 15 submitted outputs in REF2021 are products of interdisciplinary research. An example of the interdisciplinary collaboration within the Department of EAD is the paper entitled 'Thermography at Millimetre Wavelengths for Security Inspection of Footwear' (published in 2020), which combines **Harmer's** expertise in millimetre wave technology and **Bahbha's** knowledge in material science.
- 12 out of the 15 submitted outputs in REF2021 are results of collaborative research with national and international institutes. Our national collaborators include Newcastle University, University of Southampton, University of Strathclyde, Manchester Metropolitan University, Northumbria University, University of Bradford, Edinburgh Napier University. Collaborators at the international level include NIT Vellore, India, University of Chinese Academy of Sciences, University of Ourgla, Algeria, and University of Mascareignes, Mauritius.

Staff development

All staff members in the Department of EAD go through an annual Performance Review and Development Plan (PRDP), in line with University-wide standards for continual professional development and support. The PRDP process is designed to facilitate an evaluation of individual staff members' performance in teaching and research to date, assess/discuss their experiences, agree on future goals, and identify what bespoke institutional support can enable them to thrive. Depending on the outcome of the PRDP process, the staff member may be provided with formal training opportunities, and/or mentoring, within the UoC's official mentorship scheme. The UoC also operates a process of application for promotion to Associate Professor and Professor, as a means to support and develop a research culture within each Department. This process has benefitted the Unit specially in guiding and focusing its future research strategy in renewable

energy and microwave technology. In particular, research-active staff have been given balanced and reasonable teaching loads to facilitate and develop their research activities. They are also financially supported to disseminate their research at conferences.

A broad range of training and development opportunities are provided through a centrally-organised programme of events, that run at the UoC throughout the academic year. There are regular supervision meetings among academic staff within the University to exchange and discuss PhD supervision experience across all the Units. Of particular relevance to the Department of EAD is the Postgraduate Certificate in Higher Education Practice (PGCert), a programme in Higher Education teaching and research practice for new academic staff with the research module requiring attendees to complete a draft of a first grant proposal. In this respect, **Alhabill** has obtained his PGCert, and **Wang, Chin** and **Edet** are in the process of gaining this qualification. In addition, **Bhabha** is studying towards an MBA qualification. These training opportunities and staff development programmes have provided opportunities for new and early career researchers to undertake various administrative and managerial roles in research within the Department. In particular, **Wang** has been given the role of REF Champion and Doctoral Degree Coordinator in order to oversee the research plan and activity within the Unit.

Equality and diversity

The UoC is committed to promoting and supporting equality and diversity within its research community. This is evidenced by its Inclusivity, Equality and Diversity Annual Reports, published each year since 2009, which summarize the equality, diversity and inclusivity experience and activity for each academic year, and which set out ambitions for future years.

It is well-known that there is a lack of diversity and a sizable gender disparity in engineering. Currently, in the higher education sector in engineering, only 12% of females and 8% of males are from the BAME community (statistics from the Women's Engineering Society). The members of academic staff within the Department of EAD are ethnically diverse, with 37.5% White British, 25% Chinese, 12.5% Asian or Asian British-Indian, 12.5% Arab and 12.5% Black or Black British-African. In addition, we are proud of our balanced gender of 37.5% female. These are well above the aforementioned average figures in the engineering sector.

The Department's strategy of pursuing a vibrant and sustainable research workforce is further reflected in the fact that 62.5% of its members of staff are between the ages of 30 and 39. The remaining members of staff are composed of senior/experienced members, with 2 in the age group 40-49, and 1 over 60. The senior staff members have led the Unit's approach to mentoring the more junior staff concerning their careers and in getting the Department up and running. All 'Category A' staff are appointed on a permanent contract basis, in accordance with UoC policy. Research leadership positions are provided based on merit and experience, regardless of race, gender and age.

Though there are no members of research staff with known disabilities in the Department of EAD, the Tech Park and both UoC campuses have been designed with accessibility in mind, with automatic doors, ramps, lifts and disabled toilets etc. Dedicated mentorship is in place to look after mental health and staff well-being. Moreover, cover support is made available for staff on parental or sick leave.

The Department takes advantage of a variety of compulsory training provisions, including on unconscious bias, and Equality, Diversity and Inclusion, provided by HR.

Research students

As the Department of EAD continues to grow, we have begun carefully to develop and scale up our postgraduate research programme, ensuring that the students we take on are brought into a first-class environment, with all requisite professional and pastoral support. We have a robust recruitment approach for research students. The recruitment panel consists of the Doctoral Degrees Coordinator, the main supervisor and another colleague to ensure diversity. All panels

are gender and ethnicity balanced. Within the REF2021 assessment period, the Department has awarded 2 PhDs to students in the areas of mobile communication network modelling, and solar photovoltaic resilience and shading control, respectively. A third PhD student was enrolled in 2019 and is making strong progress in research related to PV system control and optimisation.

Training and support mechanisms for PGR

Each PGR student in the Department of EAD is provided with a specialist supervisorial team containing at least 2 full-time qualified academic (PhD-qualified) staff members, whose research profiles and expertise complement the prospective research proposal of the PGR supervisee. The supervision team may also include an external supervisor (from academia or industry), chosen to enhance the student's experience and prospects. Every research student takes part in an individualised assessment of their research training needs with their supervisor(s) at the commencement of their postgraduate research studies. In addition, there are University wide trainings for every PGR student, such as article/report writing, research methods, communication, time management, and team-working skills. To create a conducive research environment for PhD students, a 'PhD Day', organised every year, gives them the opportunity to showcase their research findings, as well as to encourage peer-to-peer collaboration and networking. Additionally, pastoral support and student well-being are overseen by the Research Coordinator, who guides students in need to the relevant support offices.

PGR progress monitoring

All research projects are considered by 2 experienced scrutineers, who advise on the strengths and weaknesses of the research proposals presented to the Research Degrees Group (RDG). The research project of each PGR student is approved by the RDG, chaired by the Research Degree Coordinator, 3 months (full-time) or 6 months (part-time) into their candidature. The RDG takes account of the field in which the research proposal lies, the availability of resources, the nature of the University's current research strengths, and the particular needs the candidate may have for specialist facilities. The student then goes through a process of annual review, to monitor their progress and offer any further assistance that may be required. Supervisors monitor student progress throughout and provide regular monthly feedback to ensure that progress is maintained. The student keeps a logbook about the meeting records and the tasks assigned to him. In addition to this, the Research Office hold regular meetings with the PGR supervision team to share good practice and discuss any related issues.

3. Income, infrastructure and facilities

Income

In 2015 the UoC, with the support of HEFCE (Higher Education Funding Council of England) and the Coast to Capital Local Enterprise Partnership (LEP), provided the funding to construct a state-of-the-art 'Tech Park' on our Bognor Regis campus, in order to facilitate and catalyse teaching and research in STEM (science, technology, engineering and mathematics) – particularly within the local area. The Coast to Capital LEP provided GBP8,000,000, as Local Growth Fund, for the project with a match funding of GBP25,600,000 by the UoC and by additional funding partners including GBP2,700,000 from HEFCE and GBP350,000 from West Sussex Council, together with in-kind contributions from industry for its innovative industry-led STEM facility. The objective of this project was to create a pool of highly skilled industry-ready graduates and graduate apprentices from elements of the local population that are currently not engaged in STEM, and in many cases not engaged in higher education. This was an ambitious, long-term project designed to raise aspirations and excite underrepresented groups into STEM careers in an area of low economic growth. Its main impact was to stimulate economic growth in the Coast to Capital area by providing graduates that will contribute to the regional productivity growth through the use of technology, and filling higher level skills gaps in technology companies. In addition, the Department of EAD has benefitted from a capital expenditure of GBP100,000 to invest in research facilities to support the research activities in the established areas.

With over 60% of staff members categorized as early career researchers (ECRs), the Department of EAD is integrating a robust approach to research grant applications into all aspects of its structure and processes. Training programmes are planned in order to support staff for their grant applications. In particular, the EPSRC will be invited in the coming years to train staff in bid writing and conduct mock evaluation panel.

Infrastructure

Digital Technology is the fastest growing sector of the UK and world economies, and for this reason the UoC put forward an ambitious scheme to create Engineering Digital and Technology Park on its Bognor Regis Campus. The Tech Park currently houses the Engineering and Design and Creative and Digital Technologies, alongside the Business School, with the capacity to deliver 500 new science, technology and engineering undergraduate and postgraduate student places per year. In addition, it has created 5,900sqm of learning space. The Tech Park provides a space that is conducive to stimulating research development by providing state-of-the-art facilities in mechanical and electrical engineering and design.

Facilities

The facilities in the Department of EAD include dedicated labs containing brand new equipment and apparatus to support research projects and teachings for engineering staff and students. The facilities include:

- Double-height interior spaces for delivering engineering design-build-test experiences. More specifically, the Unit have materials testing and measuring equipment, such as the INSTRON E10000, which is valuable to measure material properties when under tension, compression, torsion or cyclically loaded. It also has small table top wind tunnels which provide powerful insight into the qualitative behaviour of flowing fluids.
- Practical project-orientated engineering workshop and teaching facilities.
- Electronics, Mechanics and Fabrication laboratories
- Specialist 3D printers and facilities to teach Computer Aided Design. 3D printing has important components of materials' science, mechanical and electronic engineering along with mathematics and software.
- Hands on education spaces for partnerships with schools and colleges.
- In addition, the library facilities provide a convivial learning space and E-learning resources for engineering staff and students.
- In 2019, the Department also gained a Thru-vision T4, a GBP60,000 millimetre-wave imaging system, to be used in remote sensing research.

The Department of EAD has 2 technicians to support research and teaching activities, and to oversee the health and safety requirement involved in using the equipment listed above.

4. Collaboration and contribution to the research base, economy and society

Collaboration

The Department of EAD encourages and supports its staff with all aspects of collaborative and interdisciplinary research, as a result of which the majority of our members of staff have established national and international collaborations with partners and stakeholders in HE and non-HE institutions.

With extensive experience in both academia and industry, **Harmer** maintains strong collaborative links with Manchester Metropolitan University and Plymouth Rock Technology in the areas of object detection such as concealed weapons, suicide bombs, drugs etc., and which has a strong and immediate application in airports and uncontrolled public space. He is also a board advisor to Radio Physics Ltd/Inc, which is one of the leading companies in the UK focused in stand-off concealed threat detection, pushing out security perimeters and disrupting acts of terror. **Wang** has a continuing research collaboration with Northumbria University, KU Leuven in Belgium, Amsterdam of Applied Science in the Netherlands and VIT University in India, as evidenced by her outputs in the area of renewable energy (see REF2). **Wang** has also carried

out research with industries (e.g. Cenex) and authorities (e.g. Leicester City Council) to explore innovative and effective approaches to decarbonisation, as evidenced by REF3. **Alhabill** works closely with the University of Southampton to advance research in nano-dielectric materials. **Cutler** has collaborated with OMAX corporation, USA, which is a world leading manufacturer of specialised waterjet cutting machines.

The Department of EAD is sponsoring the 6th International Conference in Environment-Friendly Energies and Applications (2021). Members of staff are being encouraged to participate in this conference as it falls within the major theme of research of the academic staff in the Department.

Contribution to the research base

Harmer, a Chartered Engineer (CEng), was elected Fellow of the Institute of Physics (IoP) in 2013, and appointed as the Fellow of the University of Cambridge's Centre for Science & Policy (CSaP) in 2013. His research dedication to concealed weapons detection has resulted in over 20 patents, and the related technology on microwave and millimetre-wave sensing has led to some 60 journal publications and conference proceedings. In addition, **Harmer's** research on concealed weapon detection technology has showed successful trials with the UK government and the US Army. Based on the research, **Harmer** licensed the resulting intellectual property to Radio Physics Ltd/Inc, which produces and sells commercial devices for concealed weapon detection.

Keates is a Fellow of the IET and a Senior Fellow of the HEA. His expertise in artificial intelligence, human-computer interaction, and building robots, has led him to compete in the BBC show Robot Wars. He is the author and editor of numerous books covering a range of topics as diverse as countering design exclusion, finite element applications and brandjacking. In addition, he worked at the Accessibility Research Group at the IBM TJ Watson Research Center, and at ITA Software (now part of Google) designing airport systems for Air Canada.

Wang is the Managing Guest Editor for a special issue in *Renewable Energy* (reputable Q1 journal) on 'Renewable Energy to Drive Sustainable Electric Transport: Synergies, Challenges and Opportunities'. She has also been a member of the international Scientific Committee of EFEA (IEEE International Symposium of Environment friendly energies and applications) from 2018. In addition, **Wang** is a regular reviewer of international journals and conferences, such as *Renewable Energy* and *Applied Energy*, published by Elsevier.

Alhabill's expertise is on enhancing the electrical and thermal properties of polymeric insulation materials used in industry. Such systems enable power transmission and distribution at higher power density without sacrificing electrical and thermal properties, thus highlighting the potential of significant impact, in particular for improving the reliability of offshore wind power transmission. In addition, his research has also provided a critical understating of the electrical behaviour nanocomposites and contributed to the tailoring and designing of the insulation materials to meet specific industry and real-life application requirements. **Alhabill's** work has produced a number of high-quality journal publications, as shown in the REF2021.

Cutler is a leading proponent in industries technologies in abrasive water-jet cutting, such as 3-axis cutting and 5-axis cutting. She is one of the few researchers in the UK to apply 5-axis cutting technology to cut delicate material, such as glass and ceramics, and she is well established with different industries, such as OMAX, to continue to push the boundaries in cutting technologies. **Cutler's** work has successfully showcased the realisation of creative design thinking into engineering in industries. **Cutler** was invited to national and international exhibitions, such as Art and Technology Pittsburgh USA in 2020 and Research solo Showcase National Glass Centre Sunderland in 2018, to showcase state-of-the-art technology on water-jet cutting.

Edet has been an affiliate member of IFAC since 2017. **Edet** presented in the world-renowned control conference – IFAC World Congress in the years 2017, 2018 and 2020, resulting in 3 IFAC journal publications. Edet is a leading proponent in fractional order predictive controllers

with applications which demonstrate improved performance in various process control systems, such as distillation systems and chemical reactors.

Bhabha has put significant efforts into utilising waste materials from powerplants to enhance engineering polymers. This has reduced the amount of waste going to landfill and at the same time increase the stiffness of the Polyethylene (PE), which contributes to environmental sustainability. **Bhabha's** technical and research expertise was presented and well received by the British Plastics Federation (BPF), Alliance of Rotational Moulding Organisations (ARMO) and Society of Plastics Engineers (SPE).

Chin has also participated and presented her works in various international conferences on her research expertise on converting energy from waste, as well as minimising ignition risk during the handling and storage of biomass. **Chin**'s work on the development of alternative fuel briquettes from agricultural waste and improving the utilization of biomass energy has significant impact on the national low carbon milestone achievement.

Contribution to economy and society

Alongside its manifold regionally focused research projects, the UoC contributes significantly to the economy of West Sussex by providing higher-level training and access to world-leading research facilities to prospective local students and companies. Our Department has strong relationships and partnerships with a number of prominent STEM organisations and individuals, including with West Sussex County Council and Arun District Council, over a variety of matters ranging from highways and planning, regeneration and economic development. Some of our major stakeholders in the area of engineering include Rolls Royce Motor Cars Ltd, Ricardo and Solartron Metrology. These stakeholders have been heavily involved in the curriculum design. We aim to further strengthen this industrial partnership to research and knowledge transfer, in particular with economically and socially impactful companies, such as Bowers & Wilkins.

It is well-known that there are significant gaps in the education and skills of young people in higher education in the West Sussex region. Data from the '*Gaps in young participation in higher education*' showed that some places local to the University perform poorly in terms of young people's entry into HE and the pressing need for consistent, focused, targeted, progressive and impact-driven outreach and widening participation activities in schools and colleges. In effect, Sir Michael Wilshaw, in 2014, has drawn attention to the fact that the distribution of underachievement has shifted away from big cities and is now most concentrated in 'deprived coastal towns and rural, less populous regions of the country'. However, this analysis should also be placed in the context of the University' recruitment pattern of high proportions of first generation to HE students and students from low income households.

Based on the above, the Unit has followed the University strategy to:

1. Develop and lead an evidence-based, progressive framework to STEM access and outreach for young people from primary age, up into schools and colleges.
2. Collaborate with FE Colleges including integrated programme pathways from FECs into HE and HEIs.
3. Undertake a STEM Skills CPD programme for teachers, assistants and advisors in schools and colleges.
4. Support an industry-led curriculum.
5. Lead an HEI widening participation STEM partnership to co-develop research and share practice with local industries as it develops for the benefit of the rest of the HE.

As mentioned earlier and evidenced by the output collection in REF2021, our staff have generated publications in high-quality journals, some of which have led to significant impacts on the UK economy and society. As detailed in the impact case studies (REF3), **Harmer's** expertise on microwave and millimetre-wave sensing based concealed weapon detection has created a positive impact on the health and wellbeing of people. Likewise, research conducted by **Wang** and **Alhabill** has demonstrated how carbon footprint reductions can be achieved via the smart utilization of renewable energy.