Institution: University of Derby

Unit of Assessment: 12- General Engineering

1. Unit context and structure, research and impact strategy

1.1 Introduction and development since 2014

General Engineering at the University of Derby brings together researchers in mechanical, electrical, electronic, built environment and sound engineering. Researchers work across these disciplines to make significant contributions to research that address regional, national and global industrial challenges. The Unit of Assessment (UoA) is based in the College of Engineering and Technology (CoET) and works closely with colleagues in UoA11.

UoA12 has undergone significant changes since 2014, with the identification of research priorities, the restructuring of research groups and substantial capital investment in facilities. In 2014, the launch of a purpose-built Institute for Innovation and Sustainable Engineering (IISE), led by **Stewart P** (2014-), **Wood** (2015-) **and Maligno** (2014-), introduced a collaborative working environment for academics to align research with industry challenges. Facilities in UoA12 were further enhanced in 2017 by a £12.5M STEM centre for the College of Engineering and Technology, with dedicated research and teaching facilities. The appointment of senior research leaders **Le** (2015-), **Yang** (2016-), **Zoras** (2016-) and **Kharaz** (1999-) resulted in the strengthening of the identified research priorities: (a) Mechanical and Manufacturing, (b) Sound Engineering (c) Built Environment and (d) Electrical and Electronic Engineering. This investment increased research capacity and capability, enabling enhanced industry engagement.

The strategic investment has resulted in a significant increase in income generation, (£4.31M in REF2021 against £320k in 2014) and more opportunity to work collaboratively with industry: **Wood and Maligno** working with local and national companies on materials and manufacturing (see Additive Manufacturing Process Developments for the Transport and Regulated Industries, REF3, 12-2); **Hill** (2012-) **and Wiggins** (2002-) impacting both technology and health awareness in sound engineering (see Democracy of Sound- Impact in Immersive and Live Audio Applications, REF3, 12-1); **Hamza** (2015-) working nationally and internationally to improve composites in the construction industry. The Investment has ensured the broader staff base has grown through strategic appointments, early career researchers and investment in 20 Graduate Teaching Assistants (GTAs). This has resulted in an increase of staff with significant responsibility for research (SRR) from 13 to 19.8 FTE. The growth in research active staff in UoA12 has produced a steady growth in publications throughout this assessment period, with over 350 publications since 2014, more than 150 of which are in peer-reviewed journals.

1.2 Research objectives and strategy

The aims of the University's Research Strategy 2014-2020 are well articulated in the Institutional Environment Template (REF5a, 2.1). Arising from these, UoA12 identified the following strategic objectives:

1. Improve the research environment through substantial investment and increased external funding income.
2. Increase the range, quality and quantity of research for the benefit of student learning and business engagement.
3. Expand research capability by active engagement with industry in the City and Region, through knowledge transfer, training services and research consultancy.
4. Strengthen the postgraduate research provision by enhancing the sense of postgraduate community and the programme of research training support.
5. Embed the Research Ethics Policy and recognise scholarship and research as an integral part of the University's Developmental Performance Review (DPR) process.

Professors Le, Yang, **Wood** and **Zoras** have overall responsibility for coordinating research across UoA12, ensuring it aligns to the Institutional Strategy (REF5a, 2.1), enabling the building of a vibrant research environment that supports staff development, PGR education and experience and informs the academic curriculum. The Professors work across the UoA to ensure research is an integral part of the staff development and review process described in Section 2.

The role and reputation of the research groupings has significantly increased since 2014. A mentoring scheme (REF5a, 3.4.2), supported through QR funds, has increased group membership and engaged academics previously inactive in research. This has ensured that all academics in the area are aligned to a research group and are engaged with the research priorities.

Reputation and visibility have improved through increased publications and conference presentations given nationally and internationally. Since 2017, researchers in the UoA have received circa £600k to fund research projects and to energise the dissemination of research in engineering. Many of the published outputs and impact examples submitted by the UoA for REF evaluation have been part-funded using this mechanism, which has shown good value for money. The University also provided a Research for Learning and Teaching Fund (RLTF) with a value of around £450k in the submission period, with funded projects awarded by competitive application. UoA12 researchers are actively engaged in the College Research Ethics Committee, which ensures all research-based activity adheres to the University's Ethics Policy (REF5a, 2.1).

1.3 Unit structure- research groupings and leadership

Identifying the main research groupings within UoA12 was a key priority in delivering the strategic objectives presented in Section 1.2. The activity of each is introduced below, and developed throughout this template:

The Institute for Innovation in Sustainable Engineering (IISE) is enhancing and encouraging the development of interdisciplinary and collaborative research, drawing in researchers and innovators from UoA12, the wider University and local industry (e.g. Rolls Royce). **Professors Maligno**, **Stewart P.** and **Wood** (Director of IISE) were all appointed to IISE during the assessment period, to provide leadership to a core team of research and technical support staff including **Gunputh** (2017-) and **Stewart J.** (2017-). The major investment in IISE underpinned the strategic objective to increase funding, industrial engagement and research intensity (Section 2). This has led to the development of metal 3D printing (3DP) solutions for industrial applications in a number of sectors (REF3, 12-2).

The research leads in IISE have adopted a collaborative approach to engage closely with the discipline led research groups (see below), leveraging the benefits of shared facilities and partnering in winning EPSRC, Knowledge Transfer Partnerships (KTPs) and ERDF grants. The expertise embodied within IISE supports the manufacturing and transport sectors, including sustainable design and innovation, advanced manufacturing systems, manufacturing strategy for industry, the built environment, control, instrumentation and embedded systems.

The Mechanical and Manufacturing Engineering Research Group (MMERG) has expanded with the appointment of **Professors Le** and **Yang**. **Le** and **Maligno** lead advanced composites research, helping develop researchers including **Choudhry** (2017-) and **Lu** (2013-) address research challenges in nanomaterials, characterisation of composites and CFRP failure mechanisms**.** Thermofluids research has advanced through **Yang's** leadership and new appointments have brought expertise in advanced combustion processes, **Tian** (2019-), and transitional and turbulent flow simulation, **Ahmadi** (2018-) and **Xie** (2019-). The Group uses advanced simulation equipment to undertake CFD and FEA studies for supporting practical work.

The Electrical and Electronic Engineering Research Group (EEERG) brings together members who offer expertise within the broad and inter-linked fields of electrical and electronic engineering. It is co-led by **Associate Professors Kharaz** and **Shafik** (2009-) and recently appointed lecturer **Diala** (2019-). EEERG members specialist expertise in the areas of

mechatronics, embedded systems, sensors, control systems and efficient applications of electrical power. Among their collaborators, the EEERG work with the National Physical Laboratory.

The Built Environment Research Group (BERG) was launched in 2010. It gained a new research focus in future smart cities, with the appointment of **Professor Zoras** (2016-) to lead research in environmental/sustainable design of cities and buildings, developing and evaluating technology and urban design approaches. **Nguyen** (2016-) undertakes research into advanced materials for the construction industry, including static and dynamic studies on carbon and piezo-magnetoelectric nanoplates. In construction, **Hamza's** investigations into building materials, with a specific focus on self-healing concretes, has led to a Marie-Sklodowska-Curie Grant 'GEOBACTICON' (£175k).

The Derby Sound Lab is co-led by **Associate Professors Hill** and **Wiggins** and focuses on the "democracy of sound", aiming to deliver a consistently high-quality and safe listening experience to all (REF3, 12-1). Work centres on analysis and optimisation of sound reproduction and reinforcement, drawing together expertise in acoustics, digital signal processing, electronics, electroacoustics, psychoacoustics, and sound design. Three strands of research expertise can be identified: (1) expanded and enhanced creative immersive audio technology, (2) enhanced live event listening experiences, and (3) improved understanding of health-related aspects of sound. The Derby Sound Lab has a clear multi-disciplinary orientation and has partnered with music colleagues from the College of Arts, Humanities and Education to deliver annual *Sounds in Space* summer research conferences, covering both the engineering and creative elements of 3D audio.

In all research groups, targeted investment in appointments, studentships and facilities since REF2014 has resulted in opportunities for all students to benefit from a research informed curriculum. Moreover, the research leads' collaborative approach has ensured an agile, multi-disciplinary solution led response to the needs of industry in the City and Region. This has resulted in an increase in both the volume and diversity of external income streams presented in Section 3.

1.4 Enhancing impact

The Strategy to enhance impact within the UoA has concentrated on industrial and international collaboration and enhanced visibility.

1.4.1 Industrial collaboration

UoA12 participates in the CoET Industrial Advisory Board (IAB), which is an important means of communicating with industry (Section 1.3). The IAB has representation from all research groups and industry members include Severn Trent, SNC-Lavalin, Midlands Rail Forum, Rolls Royce, Glenair, JCB, Bombardier, Davis Derby, Network Rail, Miller Construction and Toyota. The IAB is used to help shape the role and involvement of the College with industry and played a significant role in the development of IISE.

UoA12 sustains good links with industry due to its industrially relevant research. Research staff have developed a portfolio of projects funded by ERDF and Innovate UK KTPs, which have proved to be effective platforms for widening industrial collaborations.

1.4.2 International collaboration

International collaboration has been facilitated through winning Horizon 2020, Newton Fund and other international grants. Research leads actively encourage members in the UoA to collaborate with international partners, leading to joint research grants and publications. For example, **Professor Maligno** (IISE) is a member of a European consortium in composite materials and aerospace structures. IISE has also developed new collaborative research partnerships with the University of Lorraine and the Polish Academy of Sciences (IPPT), working on additive manufacturing of nickel-based alloys for turbines (**Wood**). MMERG has hosted several visiting professors from Chinese universities, including Shandong Jiaotong University, Zhengzhou University of Aeronautics, Hefei University and Zhengzhou University. BERG has established links with Brazilian universities through Newton Fund projects.

1.4.3 Increased visibility

The collaborations discussed above have resulted in an increased profile for the UoA and its research. Volume of outputs, grants awarded (Section 3.1) and the esteem factors of the members of the UoA (Section 4) further enhance the visibility of the UoA.

1.5 A view to the future

Along with colleagues in UoA11, members of UoA12 have a significant role in a new manufacturing focused innovation and technology park (Infinity Park) located adjacent to Rolls Royce headquarters. A £6.2M investment from the Regional Growth Fund (RGF) has resulted in the building of the Innovation Hub (IHub) on Infinity Park. The IHub is a collaborative venture involving the Universities of Derby and Aston and provides businesses with easy access to the latest academic research and development. It comprises 4700m^2 floor space, space for c30 tenants, meeting and training rooms and a programme of innovation support services. The IHub and the equipment and facilities at IISE, will ensure UoD's future engineering research is strongly aligned with the needs of engineering regionally, as well as nationally and globally.

The Universities of Derby and Sheffield, together with Derby City Council have further committed to investing in a new research facility: The Nuclear Advanced Manufacturing Research Centre (NAMRC) at Infinity Park, accommodating 70 research staff. This initiative is supported by the D2N2 Growing Places Fund. NAMRC will open in 2022, delivering the skills and capability needed by the Regional supply chain and will drive clean energy initiatives in power generation.

The launch of the Rail Research and Innovation Centre (RRIC) in March 2019 with a capital investment of £902k from D2N2 LEP (Derby, Derbyshire, Nottingham, Nottinghamshire Local Enterprise Partnership) further strengthened UoA12's ability to research in advanced composite engineering, design optimisation, engineering system testing and vehicle control. Combined, these funded spaces (IISE, IHub, RRIC and NAMRC) supported by UoA12 research leads provide enhanced collaborative research opportunities between academia and industry, leading to an uplift in innovation, productivity and competitiveness in the Region and beyond, aligned to the Industrial Strategy.

2. People

2.1 Staffing strategy and staff development

The UoA12 staffing strategy is based around providing continual development opportunities throughout the career of a research-oriented student or staff member, from undergraduate to postgraduate student, early career researcher (ECR), senior lecturer, associate professor, and professor. At each stage of development, the individual is supported to understand the opportunities available to them, and the personal development needed to achieve the next step. All staff take part in the University annual cycle of DPR meetings, which evaluate performance and progress to date, and facilitate planning for the future. Staff from the UoA contributing to this REF submission represent all staffing stages of this academic ladder: there are six professors, three associate professors, five lecturers, and four ECRs.

2.2 Academic staff

The UoA has seen substantial investment in research leadership since REF2014. Six Professors with international reputation (**Le, Maligno, Stewart P., Wood, Yang, Zoras**) have been appointed. These have brought leadership for the research groups and research foci in advanced materials and composites, advanced manufacturing technologies, thermofluids, instrumentation and control, future smart cities, the built environment, and low carbon airport ground operation. Three Associate Professors (**Hill, Kharaz** and **Van Bac)** have also been appointed through the internal conferment scheme (REF5a, 3.4.1). Every staff member in the UoA is allocated a minimum of 10% of their time for research, enterprise and scholarship. About 40% of academic staff in the UoA are allocated an enhanced minimum of 20% FTE for research activities, including PhD supervision.

UoA12 research supervisors engage with UoD training in topics such as intellectual property rights, ethics, the student registration process, the supervisor-student relationship and the examination of theses. In addition to these central programmes, College-specific training courses, open to all staff have been developed by the research group leads, aimed at exchange of best practice and developing the next generation of supervisors. The research culture has been enhanced since REF2014 through a monthly seminars programme. This allows all researchers to have a platform to present and share research ideas and challenges. External speakers, industry partners and attendees are invited to ensure staff are part of a broader research environment and to disseminate early research findings.

2.3 Early Career Researchers (ECRs)

The development of a more prominent research culture within the University has increased internal support to develop new researchers (REF5a, 3.4). These include established staff who are new to research and those staff progressing from PhD and early postdoctoral study. Each ECR is linked with an experienced mentor (e.g. **Diala** is mentored by **Kharaz, Tian** by **Xie**). Development activities for ECRs (REF5a, 3.4.4) include masterclasses on key research skills such as publication and bid writing, networking opportunities through seminars and Research Cafes, key skills in research-related areas such as bibliometrics and information technology, as well as developing research impact in wider society. New researchers are particularly encouraged to attend and participate in the research seminar programmes as a means of developing ideas and presenting drafts intended for publication and future conferences, and thereby gaining informed feedback from colleagues.

2.4 Research students

The University has invested significantly in the recruitment of PGR students. Investment in 20 Graduate Teaching Associates (GTAs) has been made since 2015. The number of research students has grown throughout the reporting period, starting initially from a modest number. Students may be self-funded, funded through research projects, or by other forms of sponsorship. There are currently 20 PGR students in the UoA. The number of PhD completions is shown in Table 2.1. Although numbers are modest, encouraging growth is shown in recent years, with further GTAs and others expected to complete soon.

Table 2.1: PhD Completions (HESA)

Ac. Year	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Completions	2	2	2	1	3	5

UoA12 has a strong commitment to assuring the quality of its PGR provision. This is overseen by the College Research Committee (CRC) reporting into the University Research Committee. The CRC monitors student progress, admissions, and related research matters. The University provides a core series of research training support seminars for postgraduates, attended by all on-campus students and made available electronically to those unable to attend. These seminars encompass key research skills and aspects of importance such as the relationship with the supervisor, the registration process, organising the research, thesis writing, presenting talks and intellectual property rights. An experienced researcher or member of the academic support staff gives each seminar. In addition to this series the University also provides two full-day teacher training workshops for GTAs.

Since 2017, postgraduate students have been invited to a University-wide PGR Conference, giving them a chance to practice presentation skills in a supportive environment. It has also enabled a stronger sense of community to develop between students in different colleges. Students from UoA12 have regularly presented at this Conference.

The University holds an annual research conference, which offers the opportunity to network, keep up to date with changes and developments within research as well as hear external experts speak.

This is also when research groups and centres hold their AGMs, developing and setting out plans for the next year.

In 2018 the University introduced PhD Manager. This is used to monitor the progress of PGR students and has enabled the strengthening of postgraduate research provision (REF5a, 3.4.5). Postgraduate students are provided with office accommodation and computing facilities to help with their studies. This is supported by working alongside academic researchers at all points in their careers, and the use of dedicated specialist equipment. For example, PhD student **Soleimani,** supervised by **Zoras,** has been working closely with Research Fellow **Cui** in thermomaterials testing.

2.5 Visiting Professors and industrial advisers

The College benefits from a number of visiting professors with expertise aligned to the research themes identified in Section 1.3. These visiting appointments have provided research training to both staff and postgraduate students and bring with them their own rich network of contacts and experience (Table 2.2).

Table 2.2: Current and recent Visiting Professors

Paul Clarke	Visiting Professor of Aerospace Manufacturing Technology
Dennis McKeag	Visiting Professor in Innovation
Linden M Harris	Visiting Professor of Aero Structures
Patrick Kniveton	Visiting Professor of Engineering Engagement
Peter Goodhew	Visiting Professor in Engineering Education
David Leon Orr	Visiting Professor of Nuclear Engineering Technologies

In keeping with its ambition to deliver industrially relevant research, the College also maintains links with leading industrial practitioners, including senior managers from Balfour Beatty Rail Technologies and a leading consultant for the acoustics of large venues, public address systems, and associated psychoacoustics. These empower the college to focus its applied research skills, and to engage more readily with research relevant to industry.

2.6 Equality and Diversity

The University's commitment to diversity and inclusion is encapsulated in its Equality, Diversity and Inclusion Policy. Supported by our REF Code of Practice. A Committee at UoA level was established in 2017 with representation from each research group, as well as college management, which meets monthly. This UoA Committee monitors the development of ECRs from research skills to publications, the career pathways of part-time and fixed-term staff, and the support for staff to engage in research. The Committee also adheres to the University Code of Practice in the identification of staff with significant responsibility for research (SRR), the selection of output portfolio, and the recognition of wider staff contribution to the impact case studies and research environment.

EDI data on staff submitted for REF is shown in Table 2.3. The diversity in ethnicity in this UoA is strong with submitted staff across all BAME categories and more representative than the eligible group. This indicates EDI practice in staff recruitment, retention and research support has been effective during this REF period. The age ranges of staff submitted to REF correlates well with the eligible group. Staff submitted in the 35-44 range are slightly higher, mainly due to the recruitment of Early and Mid-Career Academics appointed to support growth in research. The under-representation of female staff in this UoA is an ongoing concern and whilst the data indicative of the subject area it remains a priority to improve. EDI actions and data and are considered on a regular basis at College CRCs to ensure progress is being made.

Table 2.3: Proportion of UoA12 eligible and SRR submitted staff by E&D characteristics and contract information (% FTE)

	Submitted	Eligible
Gender		
Female	9	13
Male	91	87
Disability		
Disabled	0	<5
Not Disabled	100	98
Ethnicity		
Arab	0	<5
Asian	20	13
Black	5	<5
Chinese	25	12
White	34	61
Other/ mixed	15	8
Refused	0	<5
Contract Type		
Permanent	91	83
Fixed-Term	9	17
Age		
25-34	10	9
35-44	30	22
45-54	39	42
55-64	20	22
65 +	0	5

3. Income, infrastructure and facilities

3.1 Research income

Overall income figures are shown in Table 3.1 show a total income of £4.313 million over this REF period. The diverse range of income reflects the research environment that is building fundamental research to engage with industry on projects tacking regional, national and international challenges. Key funding highlights during this REF are:

- SYSDYMAT: SYstems Science based design and manufacturing of DYnamic MATerials and Structures (£343k, EPSRC, **Maligno**/ **Le)**.
- GEOBACTICON: The efficiency of bio-self-healing concrete within ground conditions. (£175k, Marie-Sklodowska-Curie, **Hamza**).
- SSUCHY: Sustainable structural and multifunctional biocomposite from hybrid natural fibres and bio-based polymers. (£145k, Horizon 2020, **Maligno**).
- MATRIX: Method to Analyze composite materials suiTable for SLP structures with the aim of Reducing the Impact on the required eXperimental testing campaign. (£320k, Horizon 2020, **Maligno**).
- TMAP: Thermoplastic Monomer to Automotive Parts (£239k Innovate UK, **Maligno**).
- Low-Cost Precision Micro-Spectrometer for Agricultural and Food Security Applications. (£89k, Innovate UK, **Kharaz**).
- iTrend dialysis research (£896k, charitable funding by MStart, **Stewart P.**).
- 3D Printing of Obsolescent Parts (£156k, National Grid contract research, **Wood**).
- Cutting Fluids under field performance conditions (£146k, Rolls Royce contract research, **Wood**).
- Advanced coatings for tubular processes (£145k, EFS contract research, **Le**).

Table 3.1a: Research income during the REF period (£, 000's)

Year	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Amount	19	276	500	795	1161	748	814

Table 3.1b: Research income by source (£, 000's)

Source Name	Income
UKRI Research Councils, Royal Society, British Academy, Royal Society of Edinburgh	19
UK-based charities (open competitive process)	70
UK-based charities (other)	21
UK central government bodies/local authorities, health and hospital authorities	1,468
UK industry, commerce and public corporations	2,111
UK other sources	177
EU Government bodies	298
EU industry, commerce and public corporations	149
Total (£, 000)	4,313

The engagement with local and regional industry through ten Knowledge Transfer Partnerships (KTPs) worth £1.5M and six Innovate UK projects (£525k) is further supported with a portfolio of five ERDF projects (£6.1M) and consultancy projects with regional businesses in the region of £2M. These form a core component of the UoAs industrial engagement, and provides an essential mechanism towards further research, publication, and major grant applications.

The industry funding has supported key areas of strength in our Region, helping support large OEMs and their supply chain, across key sectors such as transport equipment manufacturing. **Wood** and **Maligno** have applied knowledge gained in advanced manufacturing and materials (REF3, 12-2) to address challenges in aerospace businesses through KTPs with ICON Aerospace (£150k) and Florida Turbine Technology (£153k), the Innovate UK project Arachne (£35k), and seven manufacturing consultancy projects with Rolls Royce (£487k). **Stewart P.** and **Kharaz** applied advanced instrumentation expertise to support SilentBloc to develop rail vehicle condition monitoring systems through a KTP (£145k). Businesses in the automotive sector have benefited from advanced composites research carried out by **Maligno** and **Sharif** through the Innovate UK project TMAP (£239k), and KTPs with EPM (£137k) and SHD Composites (£116k).

Beyond the transport sector, **Wood's** additive manufacturing expertise has supported National Grid in maintaining their systems (£207k); the advanced control requirements needed for the development of renal care medical devices has been addressed through the iTrend project led by **Stewart P.** (£896k); and the Innovate UK project with Hevasure (£22k), led by **Kharaz**, has resulted in a UK patent with a US patent in progress.

The funding from industry has supported a research environment with the track record and impact pathways needed to secure funding for fundamental research from EPSRC, with 3 projects totalling £409k since 2017. This funding supports more fundamental research in advanced materials, manufacturing and instrumentation control, which broadens the knowledge base to support future business interactions.

Whilst there are many opportunities in the Derby region, with its engineering strengths, the reputation of the research area is international and the work of **Maligno** and **Hamza** has led to 5 international projects (£696k) funded through the Newton Fund, Horizon 2020 and Marie-Sklodowska-Curie, each bringing clear benefits to partners and communities in Brazil and Europe.

3.2 Infrastructure and facilities

The launch of IISE in 2014 included a dedicated building, funded by the University (£2M) with 1760 sqm of dedicated research space at Lonsdale House, in close proximity to the University Enterprise Centre and near to the main engineering site at Markeaton Street. Investment in high specification manufacturing equipment has been important for supporting translational research activity with regional industry. IISE have a dedicated manufacturing environment with a 5-axis CNC machining centre, a 4-axis EDM wire cutting facility and advanced 3D printers allowing Selective Laser Sintering of superalloy metals (Renishaw AM250), and printing of mixed polymers (Stratysys Object 30: Connex3) and carbon fibre composites (Markforged Mark One). The manufacturing facility is enhanced through a high precision test environment to evaluate manufactured components. This test facility includes precision tensile testing (Shimadzu AGS-X 100kN), 3D scanning, coordinate measurement and surface testing.

The STEM centre has purpose-built research laboratories to support key areas of technology focus across UoAs 11 and 12. The University committed an additional £1.1 million investment in equipment to support the academic disciplines. BERG has benefited from equipment to evaluate concrete compositions, tensile/compression testing, facilities for controlling concrete cure and mixing, and a 10m x 0.3m flume to evaluate flow across a range of channel designs and features. MMERG share facilities with IISE at Lonsdale house and both have benefited from increased investment at the Markeaton Street site. A dedicated composites facility, with resin transfer moulding equipment, an autoclave supporting composite preparations, and an evaluation suite with impact test, microscopy and strength testing, all support the work of **Le**, **Sharif** and **Maligno** working across IISE and MMERG.

Derby Sound Lab used the investment to expand their capabilities with a Hemi-Anechoic chamber. This chamber, compliments the 32-speaker sound laboratory and performance space, enabling high standard subjective and objective evaluation of audio transducers, systems and signal processing algorithms derived by **Wiggins** and **Hill** in (REF3, 12-1). The Sound Lab shares instrumentation facilities at the STEM centre with EEERG. The Investment in EEERG has included state-of-the-art systems for developing embedded controllers, digital signal processing and test environments for static and mobile robotics and automation systems.

The Markeaton street site is shared with the College of Arts, Humanities and Education, fostering a culture of engineers, designers and artists can work together on interdisciplinary projects. This is particularly pertinent for collaboration with UoA 32 in the field of sound engineering and music technology. Colleagues in IISE, MMERG and BERG also share the Scanning Electron Microscope Facilities with UoA7 to support characterisation of metals, plastics, composites and concretes.

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

4.1 Industrial collaboration

Research in the UoA is often collaborative with researchers from industrial partners. As examples, engagement with two companies is described below, both secured and led by **Professor Wood**.

Florida Turbine Technology (FTT) Ltd was initially engaged in a two year Innovate UK KTP project. The research output demonstrated a method to fabricate a complex high precision aircraft engine component measuring 605 mm outer diameter in a superalloy by additive manufacturing (AM) to improve efficiencies in new engine development programmes. The research project was then continued for the client and supported by funding from ERDF Enabling Innovation to optimise the AM process parameters.

National Grid maintains 12,000 km of pipeline and pumping station assets to supply gas across the UK. Although stocks of spare parts are retained, these items are diminishing and costly to stock. The supply of replacement parts is still heavily dependent on traditional and time-consuming manufacturing practices. This impacts directly on the service the industry supplies due to the downtime (outage) of an asset. The two-year feasibility study with Premtech Ltd demonstrated

application of digital-based tools by remanufacturing obsolete parts in assets that suffered an outage. An end-to-end workflow for AM was demonstrated and a workflow practice established.

Staff expertise and reputation has enabled the development of important industrial relationships. Example staff engagements are outlined below:

Le developed a multi-layered nanocomposite coating process for corrosion resistant alloys in collaboration with EFS Ltd (Spain). These coatings are applied to critical components that are subjected to sliding under extremely high contact stresses in corrosive environment to reduce friction and surface damage, thereby improving their reliability and durability. The Research has led to the application of a multi-layered surface coating to premium tubular connections operating in high temperature and corrosive fields. The technology has enabled the product to be used in HPHT (High Pressure, High Temperature) fields, which has helped the Company to secure substantial supply orders and safeguard hundreds of jobs.

Lu and Yang provided academic support for a KTP with MSE Hiller Ltd to design and test energy efficient weir plates which enable energy recovery from separated water leaving the centrifuge. The Team used CFD (Computational Fluid Dynamics) simulation tools extensively to evaluate the performance of each design concepts, then accessed 3D printing facilities to manufacture prototype design to conduct preliminary test before fabricating 3D metal parts. The support of the UoD team was crucial in optimising the design and achieving a measured 13.2% energy saving in onsite testing in South West Water, Essex.

Maligno led the Innovate UK project on Thermoplastics: Monomer to Automotive Parts (TMAP), in collaboration with Far-UK, Oxford Advanced Surfaces and Wright & Sons, aiming to develop a new lightweight material for use within structural components for the automobile industry. The material consists of a combination of crimp-free 3-D woven fabric encapsulated in a Resin Transfer Moulding (RTM) based, polyamide matrix resin system.

Sharif and **Hall** supported a KTP project for SHD Composites which led to the development of a new material/product for composite prepreg market. The collaboration has continued in RRIC.

Stewart P. collaboration with MStart led to an iTrend project seeking to improve outcomes of patients suffering from chronic kidney failure by delivering real-time control via novel sensing technologies.

4.2 International collaboration

UoA members are themselves an international community; they enjoy extensive international connections, leading to numerous opportunities for collaboration. Individual contributions are varied, and examples are summarised below:

Hamza's collaboration with Brazilian universities led to a Brazil based seminar, as part of a Newton Fund project. It attracted a large audience from different backgrounds including students, geologists, geo-environmental engineers, and civil/ geotechnical engineers. This Event has clearly enhanced the existing dialogue between scientists and stakeholders on how to tackle natural disaster in Brazil.

Hill led a 14-member working group within the Audio Engineering Society (AES), consisting of leading international academics and industrial partners, which resulted in the publication of AES Technical Document AESTD1007.1.20-05: *Understanding and managing sound exposure and noise pollution at outdoor events*. Through this, he was invited to contribute to the WHO's *Make Listening Safe* initiative, with annual trips to WHO headquarters in Geneva, focused on developing an international regulatory framework for safe listening at live events (planned publication in 2021).

Le and **Hamza** hosted 3 visiting professors from Hefei University China, who visited the CoET from November 2017 until June 2018. The Collaboration led to six joint papers published in prestigious materials and engineering journals.

Lu's collaboration with Shandong Jiaotong University of China has continued throughout this period bringing in several visiting professors.

Maligno has successfully bid in the Bio-Based Industries (BBI) Joint Technology Initiative operating under Horizon 2020 with a consortium of 15 partners from across Europe. His collaboration with UK leading universities (Sheffield, Bristol, Imperial) has resulted in the award of the EPSRC project SYSDYMATS.

Nguyen has been a partner of the "Foreign Talents STI Grants" approved by the Vietnam Ministry of Science and Technology and the World Bank ($107,018). This grant allowed him to lead a team of more than 10 engineers and researchers and facilitated a modern road and highway test centre from the University of Transport and Communications, Vietnam to begin several new research initiatives.

Wood has developed new collaborative research partnerships. With the University of Lorraine he has supervised a PhD student in additive manufacturing of auxetic structures in Nickel Alloy, sponsored by the French Ministry of Education (September 2018 – present). With the Institute of Fundamental Technological Research, Polish Academy of Sciences, through the National Academic Exchange Agency (NAWA), **Wood** is leading a collaboration in Additive Manufacturing of Nickel-based Alloys (2018 - present).

Yang has research collaboration with several universities in China (Beijing University of Aeronautics and Astronautics, Nanjing University of Aeronautics and Astronautics) and Europe (University of Genoa, Universite de Nantes). He was a Visiting Professor at Nanjing University of Aeronautics and Astronautics (2014-2017).

Zoras has research collaboration with the University of Shandong and China University and coordinated the EU project Transboundary Air Pollution Health Index Development and Implementation TRAP in collaboration with Balkan partners for the development of common air pollution related health index in the Balkans cross-border area.

4.3 Contributions to the scientific community

UoA members have played a wide range of leading roles in the scientific community, for example as conference organisers, session chairs, journal editors, keynote speakers, chairs or members of professional panels, or advisers to professional bodies. Expertise exercised in this way is brought back to benefit the overall academic community of the College. Example individual contributions are given below:

Hill is Chair of the Audio Engineering Society Technical Committee on Acoustics and Sound Reinforcement; he is Head of Content, Institute of Acoustics Electro-Acoustics Group Committee. Winner of the Institute of Acoustics Young Persons' Award for Innovation in Acoustical Engineering 2019 and has been invited to chair/present on expert panels at 10 international research conferences.

Kharaz is Chair of the Institute of Measurement and Control Council (East Midlands Region) and a member of the Institute's Council; **Kharaz** is member of the Executive Committee of East Midlands Engineering and Science Professionals.

Le is a member of EPSRC peer review college and member of the Technical Committee of ISO/TC67/SC5 and is a Visiting Professor at Shenzhen University, Zhengzhou University of Aeronautics, China. **Le** chaired sessions at ICCS21, Bologne (2018), invited speaker at MechComp2019, Lisbon, Spain (2019) and ICCS22 in Wuhan, China (2019) and is technical

committee member for MatDes2019, University of Oxford, and MatDes2020, Madrid, Spain. **Le** is Editorial Board Member of the Journal of Composite Science.

Shafik is founder and editor-in-chief of the International Journal of Robotics and Mechatronics; a member of the Editorial Board of Journal of Traffic and Logistics Engineering; programme chair and plenary speaker, International Conference on Intelligent Traffic and Transportation 2017/2018; session chair for International Conference in Advances in Manufacturing Research (ICMR 2016), Loughborough University.

Stewart P. has held numerous professional roles, including Chair of the UK and Republic of Ireland IEEE (Institute of Electrical and Electronics Engineers) Industrial Electronics Chapter, member of the Aircraft Electrical Power Systems National Advisory Committee, member of the EPSRC Peer Review College, and is an active funding panel member of the RCUK (Research Councils UK) Energy Programme.

Wiggins was invited speaker at Sound Recording Techniques, MediaCityUK, Salford, UK (2014); organised/chaired Sounds in Space Research Symposium (June 2014, 2015, 2016, 2017); keynote speaker at Institute of Acoustics Reproduced Sound, Southampton, UK (2016); expert panel member in the area of Creative Applications of Sound Field Control' at the 2016 AES International Conference on Sound Field Control.

Wood was keynote speaker for the 19th International Conference on Experimental Mechanics, 2020, Krakow. **Wood** delivered four workshop presentations in 2019 across EU and USA and presented at the DYNAMT workshop in 2019 in Cyprus.

Yang is member of the Editorial Board of the International Journal of Computational Methods and Experimental Measurements and Chinese Journal of Aeronautics. **Yang** was member of the organising committee of the World Congress on Mechanical and Mechatronics Engineering, Dubai (2018), and 2nd International Conference on Fluid Dynamics & Aerodynamics, Rome (2017); keynote speaker at the 5th and 6th International Symposium on Jet Propulsion and Power Engineering (ISJPPE), Beijing (2014 and 2017), and the 3rd Chinese International Turbomachinery Conference, Chongqing (2018). He is featured in the top 160,000 cited scientists out of seven million scientists worldwide according to a research by Stanford University and Elsevier.

Zoras is deputy editor–in–chief of Data in Brief; editorial board member for Energy and Building journal, Elsevier, and Managing Editor of the Special Issue of Energy and Buildings journal "Climatic Adaptation of Building Energy Performance" (2017). **Zoras** was keynote speaker for the 5th International Academic Conference "Places and Technologies", Belgrade, (2017) and Changing Cities IV International Conference "Spatial, Design, Landscape and Socioeconomic dimensions, Crete (2019); and was scientific committee member of the international conference Sustainability in the Built Environment for Climate Change Mitigation, SBE19.

5. Conclusion

The UoA has demonstrated active engagement in research, teaching and income generation. It has a clear vision and ambitious future plans and has energetically implemented a strategy which was put in place in 2014. Academic staff and research students occupy a new purpose-built and superbly equipped STEM building, with other key facilities located at IISE. These facilities have enhanced the University's reputation and credibility with Derby's high-tech industry companies and have been instrumental in the enhanced research funding gained during this assessment period. Targeted recruitment of research active staff has led to the expansion of expertise in the UoA and College. All REF metrics have shown positive growth.