Institution: **Heriot-Watt University (HWU)**
Unit of Assessment: Sub-panel 32: Art and Design
1. Unit context and structure, research and impact strategy

Research Unit Context & Structure

Established in 1883, the School of Textiles and Design (SoTD) is one of five Schools in the University. SoTD is located in Galashiels in the Scottish Borders the heart of the textile industry in the UK. Art and Design research at Heriot Watt University sits at the nexus of textile technologies and sustainable design and practice. Our aim is to be leaders and innovators in the field of textile technologies and practice-led design. Over the past five years, we have continued to be a leading centre of research in these areas using the University's global network to extend our activities beyond the UK.

Our research has underpinned interdisciplinary innovation and rigorous scholarship and we have contributed to international networks, conferences and academic publications. Our research community includes doctoral and post-doctoral research assistants, and early career and experienced researchers. Over the REF period we have continued to extend our industry collaborations across the design and technology communities, e.g. Mirolink, GoreTex, Johnstons of Elgin, The Harris Tweed Authority and Iron Ocean. We have widened our reach through international networks e.g. the *Association of European Textile Universities* (AUTEX), ArcInTex (the European design network) and the *Materials Knowledge Transfer Network* (KTN) and the *E-Textiles* network.

Research Strategy & Structure

Our ambition of research excellence has been guided by a set of core values and key principles:

- To undertake research that addresses significant global challenges with the aim of developing increased future environmental sustainability.
- To seek partnerships that can help to address complex interconnected challenges leading to genuine and beneficial impact on society and industry.
- To provide a supportive research community and encourage career development based on equality and diversity.

Research Themes

We continue to develop and extend the thematic areas described in our 2014 REF submission of textile technologies and design. Across both areas, our research has focussed on health and well-being applications, including environmental, ethical, and human-centred design. In addition, researchers have explored the development of new textile materials and processes. Across the research themes there is considerable crossover, tackling key challenges through applying both science and social science methodologies informed by practice-led design approaches.

Textile Technology

Our theme of Textile Technology is centred on new advanced flexible materials with applications in the health and security sectors (**Macintyre**, **Malins**, **Stylios**, **Sun**) working in collaboration with our industry partners. Our research has been foundational to the development of the smart textiles

industry. Led by **Stylios**, this group's work was among the first to develop wearable sensors that could be embedded into textiles for health monitoring purposes. **Stylios'** research has led to commercial development with Selex/Galileo, MiroLink, Ltd. and TrueTex of a smart vest for the armed forces which contains an ECG to monitor heartrate.

The focus from REF 2014 on new textiles and processes research has continued to evolve around Nano Textiles and has led to the unit being a leader in the new area of nano spraying for the infusion of colour (**Stylios**).

In collaboration with The Moredun Institute, Scottish Royal Zoological Society and J&D Wilkie, Ltd., **Macintyre** developed '*Bovine Bumbags*' in response to an identified need to improve animal and staff welfare whilst gathering Cryptosporidium from infected calves to make live vaccines for the Dairy and Beef farming industries. **Macintyre** has also pioneered the use of compression garments used to treat conditions such as lipoedema and hypertrophic scarring, which affect millions of people globally each year (Spentex, Therapist Support Laboratory Australia, Uriel, see Impact Case Study: *Pressure Garment Design Tool*); additionally, we are one of two centres of excellence in the field of medical compression products globally through collaboration with industry and health providers.

Another important area of the unit's technical textile research, led by **Sun**, has focused on textiles developed for use in extreme environments and under extreme conditions, such as body armour for personal protection and offshore extreme cold survival garments. As part of this research, a collaboration with the School of Engineering and Physical Sciences developed safety garments from an '*Offshore Survival Garment*' project which won the Offshore Achievement Awards '*HSE Innovation Award*' in March, 2019. This project was funded (£214,910) by the Oil & Gas Innovation Centre (OGIC) and Dundee-based company Iron Ocean, Ltd. The results of this research led to the development of an offshore survival system: 'Centurion 3', a three-layer upper body garment that produces heat when immersed in cold water, designed to be worn under a conventional offshore survival suit. Though delayed by COVID-19, this system also has shown potential application to military and sport/leisure sectors and forms the basis of one of our impact case studies. **Sun** continues to work with the U.K. government's Defence and Security Accelerator DASA and the Ministry of Defence, collaborating within the unit and with colleagues in the University's Institutes of Chemical Sciences (UoA B8), Photonics and Quantum Sciences (UoA B9) and Sensors, Signals and Systems (UoA B12).

Design Theme

Within the Design Theme, our UoA explores 21st century Textiles and Fashion design with reference to diversity, sustainability and making cultures for resilient communities (**Coburn**, **Jaramillo**, **Kalkreuter**, Keith, **le Guennec**, **Pitsaki**, **Quinn**, **Thomas**). We have taken a critical examination of the ethics of the Fashion Industry and have drawn upon the heritage of that industry to inform future research. In addition, our research reflects upon the importance of practice within the Design discipline, and how this is embedded within industry and future design (**Coburn**, **Jaramillo**, **Kalkreuter**, **le Guennec**, **Malins**, **Schenk**).

Projects have involved working with partners both locally and internationally, funded by the Global Challenge Research Fund (GCRF) and supported by our industry partners. For example, Johnstons of Elgin helped to fund recent travel to Mongolia to study the cashmere supply chain (**Thomas**). GCRF funding has also supported projects working with indigenous textile craft makers in Sri Lanka and India and academic networks at leading institutions in these countries (**Kalkreuter**). Additionally, within the design theme our researchers explore textile heritage and archival resources to inform contemporary culture (**Kalkreuter**, **le Guennec**, **Quinn**), working with organizations such as the

Bernat Klein Foundation, the Museum of Scotland and the new Great Tapestry of Scotland Visitors' Centre to be opened in Galashiels in the spring of 2021.

Our Unit supports research around textile heritage, fashion ethics, and cultural anthropology by using textile archives to inform contemporary practice (**Quinn**, **le Guennec**) Studies such as those undertaken by **Kalkreuter**, with funding from the GCRF, have investigated capturing intangible cultural heritage and investigating how extant making practices interface with 21st century design, with a long-term aim of providing new, sustainable income sources for economically challenged groups. **Thomas**' work brings insights into how fibres from the goats of nomadic herders in Mongolia are used in the luxury fashion industry and the importance of adopting an ethical code of practice for the manufacturing of contemporary fashion. This work has also led to investigations into how the value of contemporary fashion can be shifted to create a longer life for products.

We have formed a consortium of companies to share best practices for technologies to support environmental improvements. As part of this initiative, we have facilitated knowledge transfer workshops working with textile companies such as Johnstons of Elgin, a high-end specialist knitwear company and Alpha Solway, Ltd., a large manufacturer of personal protective clothing. These workshops are facilitated by the unit to generate initiatives that can be taken forward through knowledge transfer partnerships and form the basis of ongoing collaborative research projects.

Strategic collaborations

Our Unit's diverse group has successfully established collaborative networks supporting interdisciplinarity. Examples include **Malins'** work with the Open AAL project, which brings together researchers including those at the University's *Assisted Living Lab* and its *Ageing Lab* and seeks to develop technologies to assist individuals with sensory impairments, using a co-design approach. Our researchers' collaborative, professional networks include those working with photonics and new materials (**Stylios**), medical textiles (**Macintyre**), and craft (**Kalkreuter**, Keith, **le Guennec**, **Quinn**).

Our Unit actively supports interdisciplinary research and encourages collaborations between schools, including the University's Schools of Social Sciences, Engineering and Physical Sciences and the Edinburgh Business School: for example, the successful collaborative research endeavour between **Sun** and the School of Engineering and Physical Sciences entitled '*Textile Waste Disposal Through Thermo-Chemical Processing*' and funded by the Textiles Future Forum and Harris Tweed. This project resulted in a global patent on the process (PCT/GB2018/052494), which has the potential to be further developed with industry partners for the processing of other waste materials.

Impact Strategy

Our unit has initiated, led and delivered collaborative projects funded by the SFC, Interface, Horizon 2020, EPSRC, RSE, Commonwealth UK and the GCRF, worth a total of £2.15M. These projects alone involved 26 companies, four UK universities (University of Edinburgh, Royal College of Art, Napier University, Robert Gordon University) and multiple international Universities (University of Kelaniya, Moratuwa University, University of Jaffna, all Sri Lanka; National Institute of Design and Srishti Maipal Institute of Art, Design and Technology, India; University of Hannover Lower Saxony; University of Tampere, Finland; North Carolina State University, USA; Shinshu University, and Japan, to list a few). Our research has included the development of new fabrics leading to prototype devices and technologies (Mirolink Ltd, Selex/Es). Beyond the UK, we are a founding member of the *Association of Universities for Textiles* (Autex, http://autex.ugent.be) and have close research links with other international institutions such as Shinshu (Japan), Clemson (USA), Age (Turkey), Gent (Belgium), Hong Kong Polytechnic (Hong Kong).

Our Unit led the *Textiles Future Forum* (TFF), a £750,000 initiative funded by the Scottish Funding Council (therefore ineligible for inclusion in REF4), and supported by Textiles Scotland, Scottish Enterprise, Interface and Highlands and Islands Enterprise. This recognised this Unit's leadership role in textile innovation in Scotland. Part of the funding was for sub-projects requiring match-funding from industry. These sub-projects were competitively awarded by an independent panel and the successful projects from our Art and Design researchers included: Collagen Fibre with Devro Scotland (**Stylios**, £51k), and Thermo-Chemical Processing of Wool with HWU's School of Engineering and Physical Sciences (**Sun** £50K) and the Harris Tweed Authority (£50K). In addition, we were able to make connections between textiles companies and other disciplines at Heriot-Watt for successful projects such as Textile Antennas and Electronic Sensors with J&D Wilkie, Ltd. and Leonardo (**Stylios**, £50k with School of Engineering and Physical Sciences).

An additional industry-facing initiative has been awarded to **Sun** (£45k) over the period for a series of Interface innovation vouchers. Through these projects the school supports micro businesses, fosters partnerships, and provides experience for staff and post graduate researchers working with the sector. Examples of these smaller projects have included: novel hot shave wraps (with LNX Designs, Ltd.), supportive sports socks (with Amazox, Ltd.), reusable and highly absorbent multilayer textiles (with Lilypads Group, Ltd.) and a wearable racket (McPlay, Ltd.).

In addition to textiles and fashion-focused projects, we actively encourage interdisciplinary research. Our researchers are involved in collaborations both with other schools within the University and externally through contributing to national and international networks. Examples include the *Use-Less* consortium between the University of Hannover, Heriot-Watt University and Robert Gordon University. This group is exploring different approaches to the challenges of sustainable Fashion (**Malins**, Keith, **Kalkreuter**, **le Guennec**). '*Distributed Capabilities*' funded by the Royal Society of Edinburgh, includes in its network professional textile designers from across Scotland (**Jaramillo**). We were a founding member of the Scottish Academy of Fashion, funded by the SFC and including partners from all Scottish Art Schools. This stimulated new connections across the country which continue to result in new projects.

Future Strategy

Covid-19 Impact Statement

Our researchers were quick to respond to the Covid-19 emergency. **Stylios** received funding from the National Institute for Health Research (NIHS) to work on the development of protective face mask technology, developing fabrics capable of filtering particle sizes smaller than those of the Covid-19 virus (<90 nanometres), and our workshops were given over to the production of PPE. **Kalkreuter** was able to adapt a GCRF project to an online project working with textile entrepreneurs in India.

There have, however, been three significant areas of future impact:

- Staff have had to continue with full-time work whilst also doing full-time caring and childcare (including home schooling), significantly reducing their productivity. It is anticipated that this will have a medium-term effect on grant income, publications and impact.
- Staff meetings, CPD training and exchanges are currently only available online. This has had an impact on staff development, particularly our ECRs and PhD communities where face-to-face networking at this stage in their careers is paramount.
- The cancellation of lab-based experiments for a significant period has presented challenges to the career development of both our research associates and PhD students, although no-

cost extensions to research grants and funded extensions to PhD studentships have been applied to offset this impact. We anticipate that this will have a detrimental impact on the timing of PhD completions.

To mitigate the challenges created by Covid-19, our Unit and the University have implemented new processes to support our research community; for example, we introduced an online thesis submission and online viva process for doctoral students, which has proven to be effective, receiving positive feedback from both students and examiners. The University also created dedicated web pages containing relevant information in the form of FAQs for the PGRs and undertook the monitoring of its PGRs to assess the ongoing and long-term impact of Covid-19.

The University offered funded extensions to its internally funded research students, replicating UKRI's policy. Our Unit supported students co/funded by other sponsors in approaching their funders to request and justify additional funding, and the University has also established a Covid-19 Student Emergency Support Fund.

Objectives for the Future

Excelling in research and enterprise with a focus on impact is one of five themes within the University's Strategy 2025. As part of this strategy the University will bring together interdisciplinary groups of researchers and resources to form a number of new Global Research Institutes (GRIs). Our unit will contribute to this strategy through the development of projects which connect to the University's key initiatives, taking advantage of the interdisciplinarity connections, collaborations and facilities that support the existing projects discussed above. The University has identified five GRIs, two of which already exist, and three which are currently in development. These include the *National Robotarium* (robotics and artificial intelligence), the *Lyell Centre* (earth sciences research, specifically the marine economy), *Net Zero* (carbon reduction and climate change), *Medical Technology* (bringing together technologies for health and well-being), and a centre for *Social Inclusion*. Our researchers will actively collaborate with colleagues within these GRIs.

The following table shows the relationship between the global challenge, key areas of focus for the UoA, and the University's corresponding GRI. Working in collaboration with these larger clusters of researchers will increase our UoA's research power, leading to greater levels of impact. The areas of research are all supported by interdisciplinary research, either led by or contributed to by our researchers.

Global Challenge	University-Wide Global Research Institute/s (GRI)	School of Textiles and Design Research Focus
Health & Well-Being – Healthy Aging	National Robotarium (existing)	UX & UI Design Medical Textiles Smart, Wearable Textiles
	Medical Technology (planned)	
Sustainability	Net Zero Carbon (planned)	Sustainable Entrepreneurialism, Co-Design / Design Management / New Making Practices / Exploration of Heritage
Social Inclusion	Inclusive Society (planned)	Sustainable Entrepreneurialism, Co-Design / Design Management

As part of its forward strategy, our unit will continue to expand its capacity for interdisciplinary research by, for example, bringing expertise in user experience design to support projects involving

robotics (Human-Computer Interface design) or the creation of sensor-enriched textiles across a number of applications, i.e. marine biology, medical garments, or sports textiles (**Macintyre**).

We aim to further build on the core strengths of our research base with the rationale of focusing on global challenges. To facilitate this, we will grow our specialist expertise in advanced flexible materials to support a new and emerging industry creating smart, technical textiles and new materials whilst providing a focal point in the South of Scotland for this area of growing global importance. Our focus will continue to be on the development of future technologies whilst seeking to be environmentally responsible. This includes projects which look for alternative sources of sustainable fibre, fibre to fibre recycling and exploring manufacturing processes that minimize impact on the environment, all helping to reduce the environmental consequences of the traditional fashion and textile industries. For example: the school has recently funded a newly established project, through its James Watt scholarship fund, examining fibre shedding from textiles to help to minimise the contamination caused by microplastics in the environment (**Macintyre**).

We will increase the focus of our research around key areas, all with an overarching theme of human-centred sustainable design, wherever possible working in collaboration with other groups within and outwith the University: for example, developing processes for the textile industry which reduce carbon emissions or micro-plastic release into the environment.

We will maintain and increase our research capacity by ensuring that all new academic posts are research active. This includes the creation of three Bicentenary Professorial chairs to be appointed in 2021-22, representing a major investment in our future research and underpinning our commitment to the expansion of our research community. These will be aligned with the University's strategy and drive even stronger collaborations between our Unit and other parts of the University. The chairs will be in the following areas: advanced flexible materials, sustainable design, and virtual design. Core to the rationale of these new posts is a focus on research designed to address global challenges.

Research Governance

Research Management in our school is undertaken by the Director of Research (**Malins**), who reports directly to the Head of School and the University's Deputy Principal for Research and Innovation. Research support is provided by the University's Research Engagement Directorate (RED) Team, supplemented by local, flexible 1 FTE administration on the Borders Campus.

We have a Unit *Research Committee* chaired by the Director of Research (**Malins**), which meets each semester, of which all active researchers are members. The Committee enables all members to be kept informed on the progress of funding applications, promotes attendance at academic conferences and oversees the ethical review process, all of which contribute to a vibrant, inclusive, and creative research environment. Its remit is to help implement the University's research strategy, to actively promote opportunities and communicate research success. The Unit has representation on both the *University Committee for Research and Innovation*, UCRI (**Malins**) and *University Research Ethics Committee* (**Pitsaki**). Our school's research committee includes representatives from our research technicians, our business development officer, a member of the University's Research Enterprise and Development (RED) team and a research student representative, elected annually from the PGR cohort. The School's Research Degrees Committee, on which all postgraduate supervisors are represented, is chaired by the School's Coordinator of Post-Graduate Research Studies (**Macintyre**).

Introduction

Delivery of our research strategy is underpinned by our ambitious staffing strategy. The University's Strategic Plan requires that a greater percentage of staff conduct research and scholarship at an international level and deliver research-informed teaching. Our staffing strategy reflects this, and we have moved our Unit's staffing to a greater proportion of staff on Teaching and Research contracts with allocated research time. This has allowed us to increase our research capacity over the review period by approximately 40%. This includes the appointment of early career and experienced researchers (**Jaramillo**, **Malins**, **Pitsaki**). Our community of researchers represents a broad spectrum of approaches including laboratory-based, experimental research through to design-led ethnographic and practice-based forms of research.

People Support and Development

We enable and support all staff and students' research ambitions by maximising access to time, training, travel, equipment and facilities. This has especially benefited our ECRs. We also operate an annual Performance Development Review (PDR) process with an emphasis on personal development. We follow the principle of recruiting, selecting and retaining the best – in part by ensuring vacancies are advertised globally -- and via personal approaches to high calibre staff in our strategic areas. We operate a mentoring scheme for new academics to ensure that senior academics connect with and support junior colleagues.

High-level monitoring and review are achieved by regular staff survey and data collection (e.g. registration data for career development courses). Regarding equality and diversity, we require all staff to attend training and to implement the principles of equality and diversity across the school. We strongly support staff equally in terms of development and promotion, a policy which has resulted in improved gender balance across the unit: 40% male, 60% female. This aids our efforts in making sure that selection panels, boards and committees are representative.

Studentship Allocation

We use industry funds and *James Watt Scholarships* (HWU own fund) to support early career researchers. Our James Watt Scholarships scheme attracts international students who are linked to our three key priority areas. In total seven studentships have been supported in this way between 2014 and 2020.

Training and Development

The School has a training and development budget which is allocated to specialised training needs of individuals through the PDR process and a regular programme of training is available through the *Research Futures Academy* in RED.

The aim of the academy is to support doctoral students and early career researchers to develop skills and competencies to enhance their personal and professional capabilities and future employability.

- Postgraduate Certificate in Academic Practice (PGCAP - focus on early-career staff)
- Learning Enhancement and Development Skills (LEADS) courses for Approved Tutor and Approved Teacher status (focus on research students)

- Researcher Development: the academy offers an extensive programme of bespoke training courses designed to increase research capability and success. Courses include Research Ethics, Advanced Research Methods and Statistics, Grant Writing and PhD supervision.

Research Students

We use the above mechanisms to build on a backbone of weekly meetings of individual student/supervisor teams, from which the main discussion points are recorded on a centralised system, aiming to ensure a stimulating and collaborative programme for all our students. High quality supervision is assured by the regular meetings that enables any student who appears to be falling behind, and/or not engaging sufficiently, to be easily identified and appropriate follow-up action taken by the school Director of Postgraduate Research Students (PGRS, **Macintyre**). Formal progress monitoring takes the form of an annual report and presentation, both of which are assessed by an internal panel. An interview takes place with the internal assessor and the student and a formal report is written by the internal assessor and the student's primary and secondary supervisors.

The standard experience for a research student whose studies were within the 2014-20 period included participation in conferences and workshops, internal presentations, internal progression reviews and short training courses. All of our Unit's PhD students have access to a budget for research expenses up £800, such as conference attendance or miscellaneous equipment.

Equality and diversity

We adhere to the principles of full equality and diversity in all aspects of our operation. The University was among the first in the UK to receive the HR Excellence in Research recognition from the European Commission in 2010 and we have now held this award for ten years. We hold an institutional level Athena SWAN Bronze award. Our commitment to equality and diversity goes beyond this. For example, University wide activities are overseen by the Equality and Diversity Advisory Group (EDAG). This group is made up of representatives from across the University community. A critical path to achieving the equality and diversity targets is to ensure everyone from across the University community understands how they contribute to a culture of 'Inclusion for All'. This requires all staff, researchers and PhD students to complete the basic ethics and diversity awareness training, but also provides the option to extend the training with other workshops, covering various issues in diversity, equality and bias, offered through the University's Research Futures Academy.

In terms of recruitment, we have a twin approach of using the normal advertising avenues, but then also tasking our senior staff to proactively approach prospective under-represented groups. We also ensure gender balance and representation of under-represented academics groups are involved in the selection process. This, along with our training on unconscious bias that all interview panellists must attend, has resulted in a fair and transparent recruitment process.

In terms of valuing and supporting, we offer our academics a six-month sabbatical/study leave that is aimed at supporting people who have had a period(s) of maternity or other unexpected leave or have taken on a substantial administrative role. The study/sabbatical leave support covers all teaching and administrative responsibilities, leaving the academic to focus 100% on their research. We also support flexible working by having a policy in place regarding suitable timings for important and regular meetings that takes into consideration child and caring needs.

Selection of Outputs

We ensured full equality and diversity in the preparation of the REF2021 submission by:

- Creating and maintaining a gender, race and age/experience balance of internal review teams;
- Ensuring all our outputs were reviewed by external experts chosen by our internal review teams;
- Creating a supportive working environment for the team (in person and, latterly, remotely) that encourages freedom of expression, mutual respect and shared value/understanding of the critical importance of the preparations and the REF process;
- Ensuring that all members of the REF Team had completed unconscious bias training; and
- Embodying career development and training as a reason for inclusion in the REF Team.

3. Income, infrastructure and facilities

Income

Our total income reported in REF4 in this assessment period is £1.7M (nearly £250k per annum over the period). This compares to £140k per annum in REF2014. In addition, our REF4 figures do not include research and innovation investments reported separately in HESA such as £750k from the Scottish Funding Council (to establish the *Textiles Futures Forum*), A further £745K of infrastructure investment has been from industry, livery companies and the University. Dedicated research spaces have been adapted to meet our strategic research needs, this included laboratories and workshops, testing and presentation facilities, studio and desk research spaces specifically for PhD and ECRs, together creating a vibrant research environment for design and technology research. As an historic building, '*The High Mill*' which hosts our School, following previous refurbishment has had a further £290K of investment in the upgrading of the space and facilities, allowing the development of a social/collaborative space for staff to come together and develop ideas. Alongside the investment in space, significant investment in CAD hardware and software (£284K) was made to provide our staff and students with the latest technologies for research in design, garment, fashion, weaving, knitting, and printing. The research environment is further strengthened by a rolling programme of updating and training, to continue to support these areas with the most current technologies. The research activity is supported with a team of 10 technical staff supporting our specialist facilities, students and staff. Our strong industry links have resulted in industry partners being extremely generous in their donations of yarns and materials and equipment benefiting the School from in kind donations in the region of £250K. Finally, we have a significant historical collection archive of Textiles which has been utilised in research projects with national and international archives and in collaborative projects with industry.

Infrastructure

The GRID

Another significant University investment benefitting the unit was in the GRID building, which is our new flagship facility to advance our global research and entrepreneurship. This facility was designed using an open space collaboration model to allow broad cohesion between academic disciplines, industrial partners and our global community.

Figure 1: GRID Building adjacent to Loch at the Edinburgh Campus

The GRID is positioned at the heart of our Edinburgh campus, and it constitutes an investment of £19M by HWU. The facility has many joint networked spaces where staff can discover, tackle challenges, and explore their intellectual passions. Of particular interest and use to the unit's researchers and industry partners is that the GRID includes spaces to explore originality (Creative Studio), to quickly prototype with the latest 3D and rapid prototyping technologies (Flex and Maker Studios), to fully develop industry collaborations, visualisation and prototyping. The GRID also includes flexible and immersive learning and teaching areas complemented with the enterprise area to encourage interaction and design-led education. One of our main motivations for this facility was HWU's interest in empowering its staff and students to collaborate across disciplines and fully develop their ideas, from the conception to launch in a global market. Most recently this has benefitted ideation workshops urn with our industry partners. For example a workshop bringing together the senior team from Johnstones of Elgin with design researchers, engineering researchers and computing science researchers and generating over one hundred individual project ideas which were narrowed down to twenty new projects, that could be taken forward as collaborative development projects. This investment and strategic focus on engaging with industry at the University level is demonstrated in our submission which shows annual research income from industry increase more than 10-fold from REF 2014 (£5k/annum to £54k/annum).

Facilities

Our research is supported with a wide range of laboratories and workshops which enable us to research anything from fibre, yarn, knit, weave, dye, finish, make-up including whole garments, design and pattern cutting both manual and automatic, print (screen and digital) fully conditioned measurement and physical testing of textiles to specialised facilities such as chemical synthesis, nanofibre production, scattering SEM, microelectronics/wireless, performance yarn production (melt and wet spinning), filtration. We have a dedicated SMART lab, both design and technical research studios and a rich archive of Scottish Textile heritance. Dedicated technical staff service these laboratories, support users and maintain samples of raw materials as well as equipment maintenance.

HWU and Unit Resources to Support Research

University Underpinning Support

In terms of research support for academics the university has a centralised research and business development professional support team (RED) that provides the following:

- **Research Development** - provides specialist support for academic staff seeking to win research funding.
- **The Global Challenge Research Fund** - supports the implementation of the University's GCRF Strategy.
- **Business Development** – works with academics to increase research income from industry and business. This team included a member of staff embedded in the unit specifically for supporting engagement of our Art and Design research with industry.
- **Research Grants Office** – assists academics with their post-award management of their externally funded research grants and contracts.
- **Public Engagement Team-** assists academics in realising the potential of their research results and work through supporting them in undertaking outreach events and disseminating to audiences outside academia (see section 4 for examples of support provide).
- **Policy, Strategy & Impact** – advising on application of research policies such as the use of animals in the '*Bovine Bumbags*' project, working with researchers to feed the latest research to the University communications team, and delivering a workshop on research and impact for all ArchInTex partners (January 2018).
- **Legal Services** – Protecting the interests of the University in its research and knowledge exchange activities, and supporting its Excelling in Research and Enterprise strategy.

We have ten dedicated technicians within the School who support teaching delivery and the technical needs of our research projects.

The University *Information Services Research Support* (ISRS) team also provides guidance, expert advice and hands-on support for all aspects of research and research-related work to research academic staff and schools across the University. ISRS works in partnership with the *Research Engagement Directorate* (RED) and other IS divisions to help facilitate research-related planning, and to meet the needs of both the individual researcher and the wider institution.

The key objectives of ISRS related to the REF are:

- Research Outputs Support: it is responsible for ensuring that all tangible research produced within the University and subsequently published and recorded in a consistent manner and compliant with open-access and REF mandates.
- Support for the use of High-Performance Computing facilities.
- Capability to store, preserve and access increasingly large volumes of electronic research data sets.

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

The School has played a leading role in the transformation of the Technical Textiles sector through the *TechniTex Faraday Partnership* and now *TechniTex, Ltd* (**Stylios**, Board Director 2006 onwards) and has become part of the Materials Knowledge Transfer Network and the Institute of Physics. Our

UoA played a leading role in the *Textiles Future Forum*, bringing industry and academics together to drive innovation. In the final report to government, it was documented that the projects undertaken were set to see a return of an 8:1 ratio for 'gross value add per £ of programme cost'. On a European level, **Stylios** and Keith are invited core members in the European Architectural / Design Network ArcInTex, involving eight core and 12 associated members from across Europe, including the Swedish School of Textiles and the Royal College of Art. ArcInTex brings architecture together with fabric design and construction. We are also a member of Autex with 31 members from 23 countries working in high level textile education and research. The School contributes to both the research base for the discipline and the discipline more broadly as evidenced below, gaining reciprocal benefit as it does so. Globally, 14 keynote addresses have been delivered in the period.

Conference Keynotes, Chairing and Workshops

In terms of academic leadership our academics in the unit have been conference chairs, Keynotes or both.

Keynote Speaker, Panel Chair, Workshop	
le Guennec	XpoNorth Conference, 25th June 2020, panel chair '*Time for play: designing for children*', online.
	'*Childhood studies and material culture: the necessity of an interdisciplinary approach*', International Childhood Conference, Sofia, Bulgaria, 26th October 2018.
Macintyre	Keynote speaker at British Burn Association 2019
Malins	Keynote Speaker at International Conference: Art as Research in Teaching and Learning 31st Aug - 2nd Sept 2016, University of Wolverhampton, UK Participation invited by Professor Ross W. Prior Keynote Title: '*Trialogical Learning: A New Framework for Learning through the Creative Relationship between Emerging Technologies and Multiple Participants*' This led to a peer-reviewed book chapter: Gray, C, **Malins**, J. and Bristow, M.(2018) *The 'epistemic object' in the process of creative doctoral inquiry* in: 'Using Art as Research in Learning and Teaching' (ed. Prior, R) Intellect Books www.intellectbooks.com/using-art-as-research-in-learning-and-teaching
Stylios	CIMTEC 2014; '*A Wearable Computer Platform* Wewear *for Healthcare Monitoring*,' 6th Forum on New Materials, Session FO-9, Wearable and Implantable Sensors and Body Sensor Networks, 15-19 June 2014, Italy.
	ITTC 2015; 6th International Technical Textiles Congress, '*The Electrocarding of Nanoyarns*' Izmir, Turkey 10-12 October 2015.
	ITC&D 2016; 8th International Textiles, Clothing and Design Conference, '*New Measurement Technologies for Textiles and Clothing*', 2-5 October 2016, Dubrovnik, Croatia.

Keynote Speaker, Panel Chair, Workshop	
Stylios (*continued*)	UTIB International *R&D Brokerage Event in Turkish Textile and Clothing Sector*, 12-13 May, Turkey 2016
	CIMTEX 2016; *Manufacturing Nanoyarns for Conventional and Technical End-Uses*, Symposium L: SMART and Interactive Textiles, 2016 Italy
	UTIB International *R&D Brokerage Event in Turkish Textile and Clothing Sector*, 27-28 April, Bursa, Turkey 2017
	ITTC 2018; 7th International Technical Textiles Congress, '*Fabric Mechanics*;' Izmir, Turkey 10-12 October 2018
	Convenor of Special Sessions on *SMART and Technical Textiles* in International Conferences, i.e. CIMTEC; International Congress on Modern Materials; 2016, 2018,
	UTIB International *R&D Brokerage Event in Turkish Textile and Clothing Sector*, Bursa, Turkey 2018
	E-Textiles Conference 2020; 2nd International Conference on the Challenges, Opportunities, Innovations and Applications in Electronic Textiles, '*A Novel Exempt from Motion Artefact Wearable Vest for Continuous Well-Being Monitoring*', 3-4 November 2020, UK

Editorships	
Malins	Editorial Board for *The Design Journal*
Stylios	*International Journal of Clothing Science & Technology* 2014 – present; Editor in Chief, 6 issues per year – 10 papers per issue.
	Special Issue Guest Editor *Materials: Novel SMART Textiles* doi.org/10.3390/books978-3-03928-571-6
	Special Issue Guest Editor *Sensors: E-Textiles and Sensors* ISSN 1424-8220
Sun	*Journal of Textile Science & Fashion Technology*, editor-in-chief: 25 Sep. 2018 – present https://irispublishers.com/jtsft/editorialboard.php
	Journal of Industrial Textiles, editorial board member: 16/08/2016 – present https://uk.sagepub.com/en-gb/eur/journal/journal-industrial-textiles#editorial-board
	Advance Research in Textile Engineering, editorial board member: 02/09//2016 – present https://austinpublishinggroup.com/textile-engineering/editorialBoard.php
	Journal of Textile Engineering and Fashion Technology, editorial board member: 8/8/2016 – present https://medcraveonline.com/JTEFT/editorial-board

Peer Review	
le Guennec	*Pasold Foundation*: Grants reviewer
	Reviewer: *Enfances, Familles, Generations* [https://journals.openedition.org/efg/]
Kalkreuter	Reviewer: *Craft Research Journal* (Intellect)
	Grants Peer Reviewer: EPSRC, AHRC, Innovatex, EU, USA, Sweden, Belgium, Germany, Greece, Turkey, Azerbaijan, China, Hong Kong
Malins	Reviewer: *The Design Journal*
	Reviewer: IJETA: *International Journal for Education Though Art*
Pitsaki	Reviewer: *European Business Review Journal* (2018)
	Reviewer: Scientific Committee, *Next Wave 21th Design Management Institute Academic Conference* 2018, [Ravensbourne University London, UK, August 1-2
	Reviewer: Scientific Committee, *Design for the Creative Industries Track Coordinator*, 11th European *Academy of Design Conference* 2015, Paris Descartes, April 17-19

Visiting/International Staff

Our strategy is to continue to widen our engagement with world leaders in areas that overlap our interests, and/or help us better engage with global priorities. We have therefore hosted Professor Mahmut Kayar and Professor Ilker Mistik, University of Marmara, Turkey for 12 months over 2017-18, Professor Han Fan, Nanjin University, 1 month 2017, Professor Tao Wan, Nanjin University, 2 months 2018, Professor Shigeru Inui, Shinshu University, 3 months over 2 visits in 2019, Professor Melda Osdemir, Gazi University, Ankara, Turkey, 2 months 2019 and **Sun** hosted a 2-year Commonwealth Rutherford Fellow, Dr Sohail Yasin 2017-2020

Public Engagement

Our researchers are also highly active in the wider dissemination of their research to the public through a range of public engagement activities in the form of lectures, public events, workshops and exhibitions.